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DETAILED PROJECT REPORT (DPR)
FOR REJUVENATION OF BEAS RIVER
THROUGH FORESTRY INTERVENTIONS

VOLUME-I

The Team -Preparation of DPR

Team for Preparation of Beas River Detailed Project Report (DPR)

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Executive Summary

(1) River Ecosystems – Multiple Values, Human Well-Being and Sustainable Development

Throughout history, rivers have been a central feature in the development of human societies as humanity has always preferred to settle close to streams/ rivers so as to take advantage of multiple values provided by them. Since ancient time, settlements and towns have emerged and thrived near rivers. Rivers provide water for drinking, agriculture and irrigation, navigation, transportation, hydropower production, industrial use, fish catch, sand mining and extraction of other products besides disposal of waste and effluents. In addition, in most parts of the world, rivers are being worshiped for their religious and cultural values and in recent decades they have become major destinations for recreational activities. Freshwater resources, particularly rivers are not only important for varied human needs but also essential for all life forms, human well-being and sustainable future. Thus, river ecosystems constitute a significant share of the ‘overall natural capital’.

(2) Rivers – Complex and Dynamic Ecosystems

Streams, rivers and floodplains are most enthralling, intricate, unique, active and vital natural environments amongst diverse freshwater ecosystems. In the perpetual journey from source-to-sea, a river not only crosses the mountainous tract, hills, lands, valleys and plains but also interact with wide ranging object and diverse biota those come across. Rivers are the integral part of the natural landscape and they are natural water courses flowing from origin to a lake, another river, sea or ocean. Rivers are highly dynamic systems and conduits for water, sediments, aquatic organisms and other matter as they move down the river basin. Rivers have been recognized as integrators and centers of organizations within the landscape as they link terrestrial, freshwater and coastal marine ecosystems and all aspects of human culture from their origin to mouth. Rivers make a significant contribution to the larger hydrological cycle as they collect water from precipitation and also release stored water from glaciers through a drainage basin from surface runoff. In the process of flow, a river from its source to sea create diverse habitats for a wide range of life forms and provide three spatial dimensions of longitudinal, vertical and horizontal and one temporal connectivity. Rivers have been viewed as ‘arteries of the catchment’ and regarded as ‘lifeblood’, ‘highways’, ‘pantries of the world’ and even as ‘sentinels’ as they provide early clues and specific signals of human impacts and associated risks.

(3) Rivers – Human Disturbances

In spite of the fact that rivers offer wide range of essential goods and services to the humanity, they have been exploited more than any other type of ecosystem for thousands of years. Often, rivers are impacted by natural disturbances (drought, cloud burst, storm, flood, tsunami, forest fire, tectonic movement, earthquake, etc.). Increasingly, natural disturbances are altered or replaced by human disturbances, mainly arising due to civil engineering measures or creation of physical barriers (dams, reservoirs, barrages, canals, river linking) besides numerous man-made disturbances including deforestation, agriculture expansion, landfills, mining, industrial effluents, waste and sewage disposal, road network, construction near shore lines and stream banks, etc. Human development has resulted in a significant decline in the health of rivers resulting due to altered and reduced environmental flow, fragmentation, pollution, mutilated ‘organs’- the tributaries, the riparian vegetation, the floodplain, the bed, and the biota of the river. In a human dominated country like India with excessive demand of water resources and enhanced biotic pressure/ disturbances, most Indian rivers are in the degraded state and calls for urgent actions towards their restoration.

(4) The Beas River – Conservation Significance

The transboundary Indus River System consists of several major rivers as tributaries that collect glacier/ snowmelt and rainwater from the highest peaks of the Himalaya and carries to the Arabian Sea. The 470-km long Beas River is one amongst them that originates in the north-western Himalaya and flows southwesterly before its confluence with Sutlej River, another major river of the Indus River System. The Beas River is a left bank tributary of the Indus River and the principal tributary of the Sutlej River in India, rises from the Pir Panjal Range and flows through the States of Himachal Pradesh and Punjab before its confluence with Sutlej River. Mythologically, the Beas River attains immense significance owing to the fact that '*Veda Vyasa*' is the eponym of the river Beas, the author of Indian epic the '*Mahabharata*'; who said to have created it from its source lake the '*Vyasa Kund*'. Beas Basin is spread over 20,303 km² and represents 25% and 6.03% geographical area of Himachal Pradesh and Punjab, respectively. Besides, mythological, religious and cultural significance, the river Beas has immense value from the geomorphological, ecological, environmental and economic perspective. The river Basin is characterized by vast range of altitudinal gradient from 325 m to 6,619 m, rugged topography with high ranges and peaks covered with glaciers and massive ice and snowfields. The watershed of the Beas River extends over the mountain ranges of the Greater Himalayas, the Lesser Himalayas, and the Outer Himalayas or Shivaliks. Beas River forms the second largest catchment area in the State of Himachal Pradesh. The river basin is home to diverse forests and they are host to a variety of threatened floral and faunal species. The basin represents two biogeographic zones (the Himalayas and the Semi-Arid zone of the Punjab plains) and harbours a wide range of natural and man-made wetlands including three Ramsar sites (Pong Dam Lake, Harike Lake, and Beas River Conservation Reserve), ten important bird areas and one World Heritage Site (Great Himalayan National Park Conservation Area - GHNPCA) besides several prominent protected areas. In addition, the Beas Basin is home to several sensitive ecosystems viz., glaciers, snow-capped peaks, alpine meadows, high altitude wetlands, riparian forests, etc. The GHNPCA sustains a unique biota and in recognition of its natural biodiversity, ecological and evolutionary processes occurring within this large and compact natural area, the UNESCO has inscribed it as a World Heritage Site in the year 2014. GHNPCA provides habitat for four globally threatened mammals, three globally threatened birds and a large number of medicinal plants, those are high in commercial demands. Prominent faunal species include rare Western Tragopan, Himalayan Brown Bear, Himalayan Black Bear, Musk Deer, Himalayan Tahr, Bharal and Serow. The Snow Leopard is also rarely seen in the interiors of the park. In the downstream area, the Pong Dam Lake Wildlife Sanctuary, Harike Wildlife Sanctuary and Beas River Conservation Reserve are important wetlands/ protected areas and have been designated as Ramsar sites. The Beas River Conservation Reserve harbours a small, disjunct and only surviving population of the Indus River Dolphin within the Indian Territory. Beas River and its select tributaries originating from the Great Himalayas once harboured in abundance the indigenous Mahseer and Snow Trout. Sequential dams/ reservoirs/ barrages and hydroelectric projects on the Beas River and its tributaries from upstream to downstream area have dramatically changed the scenario of agriculture expansion, particularly in the alluvial plains of Punjab State. Beas Basin has potential of 4,877.7 MW (> 5 MW projects) distributed among 51 hydropower projects throughout the Basin. Out of these, 22 projects have already been commissioned, five projects are under construction, 20 projects are under various stages of investigation and planning, and remaining four are yet to be allotted. The Beas Basin across two States has several sites and places of high altitude and adventure tourism and religious significance. Beas River and its tributaries have enormous

potential for food production, irrigation, energy, tourism, and economic prosperity within the region and the country's development.

(5) Integrated Riverscape Approach to River Management and River Restoration

Rivers in India have been altered and depleted drastically in spite they are inextricably intertwined with cultural and spiritual heritage. The current state of rivers cannot be held responsible entirely on the growth of human population and/ or the development of the society overtime. Irrigation development coupled with intensification of agriculture, advent of technologies, forest degradation, deforestation and urbanization in the past century or so are the primary factors responsible for the current plight of rivers. Alteration of rivers has often been carried out with the best of intention but without knowledge of the potential manifestations and repercussions for the diversity, connectivity and ecological integrity of the river ecosystem. 'River restoration', focusing on any action aimed at improving the health of river including improving ecosystem functions and any of the related ecosystem services is widely accepted by most national governments and various stakeholders as an essential compliment to conservation and water management strategies. The concept of river restoration has evolved overtime from one- dimensional responses aimed at addressing on single issue (like water quality) to more sophisticated approaches that involve both 'active restoration' (like planting riparian vegetation, modifying or removing barriers within the river channel, or reintroducing native species) while 'passive restoration' that seeks changing the way human systems i.e., people, government, businesses, and societies broadly operate with the goal of reducing their impact on river ecosystems. The newer approach of river restoration emphasizes on the catchment-level planning and processes while tackling the causes of degradation rather than the symptoms. The holistic strategy towards river restoration focuses on improvement in overall ecosystem integrity, engagement of different stakeholders, understanding the connection between natural processes upstream and downstream, target actions at the root causes of the degradation, use of minimal interventions to reinstate natural processes, and built-in integral robust monitoring and evaluation system as isolationist approaches to river restoration till recent times constrained the river development and management. Increasingly, the rivers are investigated from a landscape perspective, both as 'landscapes' in their own right and as 'ecosystems'. Thus, riverine landscapes are viewed as riverscapes. The landscape ecology places particular emphasis on a spatial heterogeneity, connectivity, and scale, all of which have received considerable attention in running waters. Hence, the landscape perspective of rivers ('riverscape') has emerged. The riverscape approach integrates the elements of flowing water and surrounding lands those have been impacted by human activities and can contribute not only for the sustainability of the riverscape but also for improving and maintenance of vital ecosystem services in the changing environment.

(6) River Conservation as a National Movement

The world is fast changing and transforming. India is no exception and emerging as 'New India'. In the past decade or so, the Government of India has realized growing water crisis as the main impediment in the country's development and in the process of nation building. India is not only committed to fulfill its international obligations towards biodiversity conservation, environmental management, climate change mitigation and adaptation, human rights and other social issues but at the same time the country is fully geared for planned accomplishments essential for nation building and meaningful contribution towards the global agenda on sustainable development. In this direction, management scars and precious water resources and river conservation adopting a holistic approach have become a national

movement. The NITI Aayog has recently prepared a programme for action that charters how to revitalize India's rivers. Accordingly, the Central as well as various State governments have initiated actions to restore rivers. Obviously, foremost and the prominent one amongst them is to restore the national river i.e., the river Ganga. In addition, efforts are on towards restoration of other prominent rivers like Yamuna, Narmada, etc.

(7) Current Task – Preparation of DPR on Forestry Interventions for Restoration of Beas River

Considering the degraded state of the river Ganga, the Government of India, Ministry of Water Resources, River Development and Ganga Rejuvenation has initiated a multipronged approach towards restoration of river Ganga under the National Mission for Clean Ganga and the ambitious programme of Namami Gange in 2014. As a part of this larger programme, the then MoWR, RD&GR (presently Ministry of Jalshakti) has entrusted a major task on the preparation of DPR on Forestry Interventions for Ganga to the Forest Research Institute, Dehra Dun during 2015-16. Thus, DPR was prepared and being currently implemented in five States located along the course of main channel. In recognition of similar plight of other major Indian rivers, the Union Ministry of Environment, Forest and Climate Change (MoEFCC) had entrusted the major assignment to the Indian Council of Forestry Research and Education (ICFRE) and its regional institutes to prepare DPRs on forestry interventions for nine major Indian River Systems. The present DPR is one amongst them prepared through the concurrent exercise undertaken by different regional institutes under the umbrella of ICFRE. The Himalayan Forest Research Institute (HFRI), Shimla has been assigned the task to prepare DPRs of five rivers of the Indus River System originating or flowing through the country. These are Jhelum, Chenab, Ravi, Beas, and Sutlej. HFRI undertook a concurrent exercise on the preparation of DPRs for each of these five rivers. HFRI, being a knowledge management center in the field of high altitude ecology and conservation of diverse forest ecosystems across the Himalayan State – Himachal Pradesh and Jammu and Kashmir and Ladakh Union Territories and its appropriate location was considered suitable for the exercise as it has the multidisciplinary expertise, long field experience and scientific knowledge. The one-year task on the preparation of DPR was commenced in April, 2019 and it was successfully completed in March, 2020.

(8) Preparation of DPR – Aim and Objectives

The proposed project on forestry interventions aims to accomplish the broader goals of management of river ecosystem by ensuring four dimensions of connectivity (spatial-longitudinal, horizontal and vertical, and temporal), enhanced e-flows, biodiversity conservation, improved ecosystem services, and sustained livelihoods. The project intends to adopt multiscale, multistakeholder, multidisciplinary, multi-pronged, and holistic approach for proposed forestry interventions so as to accomplish broad objectives of *Aviral Dhara*, *Nirmal Dhara*, and ecological rejuvenation. The project preparation phase has included the specific objectives: (a) review and assess the existing situation of Beas River Basin, past river management and implications, and lessons learned; (b) identify and involve stakeholders and build consensus for design and development of strategies and approaches; (c) assess ongoing forestry activities by the concerned States engaged in the river management programme; (d) assess potential and possibilities for regeneration, improvement, and restoration of forest catchment; (e) examine the possibility of allied and other income generation activities; (f) assess the potential of cultivation of medicinal plants and restoration of conservation areas and identify appropriate species and suitable sites; (g) identify research and monitoring needs and develop a strategy for future research and monitoring; and (h) formulate strategies, develop approaches and plan activities for project implementation.

(9) Preparation of DPR – The Approach

As stated earlier, the HFRI, Shimla has been entrusted a major task to prepare five separate DPRs in the context of Jhelum, Chenab, Beas, Ravi and Sutlej Rivers. Thus, the concurrent exercise was carried out in two concerned States – Himachal Pradesh and Punjab and one Union Territory of Jammu and Kashmir. Accordingly, the institute has constituted five independent teams, each responsible for preparation of one DPR for the assigned river. Each team included a Senior Scientist, Technical Officers, Project Fellows, and Data Entry Operators. Five teams were supervised by senior officials of the institute. The institute has also engaged a full time Consultant and availed services of various subject matter specialists so as to obtain desired subject/theme specific resource inputs for the preparation of DPRs. The approach towards the preparation of five DPRs during the preparatory phase included seven key steps. These key steps are briefly summarized below:

(a) Project Initiation – Background Analysis/Contractual Analysis: All ‘change processes’ are part of a wider context, a project’s context (overall environment). The project of present nature on forestry interventions for restoration of Beas River is constantly influenced by economic, social and political processes that take place in society. The project planners and implementers thus seek information about the overall picture or the environment, including technical national and sectoral information. Project activities started off by performing an overall preliminary study (pre-study), feasibility study or the inception phase. The pre-study involved the understanding and assessment of project’s external environment by collecting information about various related sectors, states and organizations involved as well as any data that existed about the target disciplines, sectors, themes, etc. Further, it was soon realized that developing an understanding of an intricate and dynamic river ecosystem and its linkages with forests and other surrounding lands requires adequate knowledge of relevant multi-disciplinary subjects and application of various technologies. There is a growing literature on the wider subject of river ecology and management besides a long historical perspective on the management of the each of the major river including the Beas River. Thus, the foremost key step in the present planning exercise was a systematic review of vast available literature on the subject through internet surfing and library consultation. The websites of prominent international, national, state level agencies and organizations dealing with any of the aspects related to river resources and conservation were extensively searched and required information was downloaded for developing the desired insight. The relevant secondary information from related organizations was also collected. The combined effort on the review of literature and collection of background information immensely helped in the contextual analysis. The contextual analysis also provided desired insight on the Beas riverscape and its three sub-environments (physical, biological and socio-economic).

(b) Analysis of Stakeholders and the Consultative Process: The second vital step for successful planning, assessment and preparation of DPR required broader participation of stakeholders at all stages of planning of the project activities. Hence, it was essential to first identify which individuals and stakeholders affect and are affected by the project and which ones should be involved in the planning process. Likewise, it was critical to identify which stakeholders should be informed and involved during and after the project implementation. In the context of present assignment, broad five groups of stakeholders were identified as a part of the Step 1 on the contextual analysis. These five stakeholder groups included: (a) the Target group (primary and secondary target groups and beneficiaries); (b) Project owners and project groups; (c) Decision makers (at different levels, in organizations, at authorities and agencies, local politicians); (d) Experts and subject matter specialists; and (e) Financing agencies (those who sponsored/finance the project as well as state/national or international

financiers who shall support and fund the project implementation. The preparatory phase included the extensive consultative process with identified groups of stakeholder right from the beginning. The Inception Workshop was organized by the ICFRE at Dehra Dun with the soul objective of making teams of regional institutes aware about the task assigned by the MoEFCC, purpose, goals and objectives, approach to be adopted, expected outputs and timelines. This was followed by the Project Launch and Brainstorming Workshop held at Shimla wherein diverse stakeholders from concerned States/UT were involved. Subsequently, sequential consultative meetings were organized at the Forest Circle/Division level in concerned States/UTs so as to make the State Forest Department and other line agencies aware about the project, the approach, field data formats and support required from them so as to achieve the objectives of the preparatory phase. The exhaustive consultative meetings deliberated on a wide range of themes viz., the concept of riverscape, delineation of riverscape boundaries, strategies for project implementation, collection of primary field data, data formats, geospatial analysis of riverscape, prioritization of sites, potential plantation and treatment models, monitoring, etc. Field functionaries were provided adequate trainings on collection of field data and filling of prescribed formats during sequential consultative meetings.

(c) The Beas Riverscape – Situation and Problem Analysis:

The third key step in the process of preparation of DPR was to delineate the Beas Riverscape for the purpose of planning, situation and problem analysis, developing an insight on the riverscape environment, and prioritization of areas for proposed forestry interventions. The background analysis/ contextual analysis and the consultative process adopted at the national, State and Forest Circle levels provided the much desired insight on the Beas River, its basin and tributaries, terrestrial and aquatic biodiversity, past management, associated States, and developmental activities. A riverscape within the larger river basin was delineated. Detailed geospatial analysis of the riverscape using remote sensing and GIS technologies was carried out. The geospatial analysis provided an understanding on the situation of physical attributes – land use and land cover, altitudinal variation, slope, aspect, soil, erosion, forest types and forest cover, fragmentation, etc. The review of secondary information from a variety of sources (national/ state level agencies/ departments, scientific organizations and universities) allowed developing an understanding on the riverscape environment (physical, biological, socio-economic) and identification of challenges, constraints, problems, and threats in river conservation. The situation analysis facilitated developing an insight on state specific challenges and threats as concerned States/UTs wherein the river flows reflected large variations in the physical, biological and socio-economic sub-environments. The consultative process and the sequential meetings with varied stakeholders definitely helped in the identification of focal problems, understanding their reasons/ causes, and effects or implications on the river itself and surrounding lands.

(d) Development of Web Portal - Collection and Analysis of Primary Field Data: Above three steps of the process adopted allowed an insight on the hierarchical organizational structure of the states, river basin, and the forest department. Considering the hierarchical organizational structure of the SFDs and well laid infrastructure of field units, expertise and experience, it was decided that the concerned SFDs will be the nodal agency for the purpose of planning and implementation of DPR. The present project has envisaged collection of primary field data for the entire riverscape with the support of SFDs, Agriculture Department and other line agencies. Prior to the collection of primary field data, the essential requirement was on the development of plantation and treatment models, design of field data formats and software for analysis of field data.

(e) Suggested Plantation and Treatment Models: Based on the earlier experience and strategy adopted in the case of Ganga River, three types of landscapes within the riverscape were visualized for proposed forestry interventions. These were: (i) Natural, (ii) Agriculture, (iii) Urban landscapes. Potential plantation models of varied nature were identified, designed and developed by the HFRI expert team considering the type of natural ecosystems, native vegetation, soil conditions and agro-climatic zones. The purpose of various models planned in the natural landscape was primarily protection, eco-restoration and conservation. Each treatment/plantation model has incorporated details of various proposed activities planned, criteria for selection of sites, planting species, spacing, and cost norms during the establishment and maintenance phases. The multi-disciplinary expertise at HFRI developed altogether 22 treatment/ plantation models specific to natural, agriculture, and urban landscapes in consultation with the SFDs of participating States. Once, treatment/plantation models were finalized, the next step was to design for field data formats.

(f) Design of Field Data Formats: HFRI appropriately modified five field data formats earlier used in the context of Ganga for the purpose of collection of primary field data. Details of these five data formats, types of information required, and the procedure to collect desired information were shared with stakeholders, particularly the forest officials and frontline staff during the consultative process. Adequate soft and hard copies of formats were made and widely distributed to forest officials and other stakeholders during the consultative process.

(g) Development of Software and Web Portal: Envisaging the likely return of a large number of field data formats duly filled-in by the forest frontline staff of concerned forest divisions of involved States and also visualizing that it would be difficult and cumbersome to handle the voluminous data sets efficiently for collation, analysis, synthesis and report generation in a short time available for the preparation of DPR, a vendor was engaged for the purpose of development of desired web portal. The firm developed a software in PHP/Mysql, server Linux based that works on Codeigniter Framework basis. It is a web based and easily accessed via internet. The software can compute cost calculations according to selected specified models for unlimited created models and is password protected. In the software, field data can be entered as per the five specified types of models, viz., natural landscape, agriculture landscape, urban landscape, conservation interventions and supporting activities and can be saved in digital format. The software is capable of generating reports in the desired formats e.g., State-wise, District-wise, Division-wise, Model-wise and Activity-wise, and Annual Consolidated Reports can be generated to obtain insight on year-wise areas under different landscapes to be treated and corresponding costs.

The State Forest Department of two concerned States returned a total of 1639 data sets to the Institute. The SFD, Himachal Pradesh provided in all 1231 formats belonging to 17 Forest Divisions while the SFD, Punjab returned 408 data formats represented by 08 Forest Divisions.

(h) Objective Analysis and Strategic Planning: The consultative process with stakeholders allowed an understanding to develop the long-term vision and goals that indicate the desired direction or pathways for actions and activities. In the process, it was also understood which changes the project can contribute to in the longer term and why is the project important for the society, biodiversity and the river ecosystem. The multi-disciplinary team of HFRI with resource inputs from wide-range of stakeholders was able to decide the goals, objectives, outputs and outcomes that can be attained. The consultative process gave desired insight on the problems in achieving various objectives and identification of priority actions for restoration of the river. Ultimately, the process also immensely helped in firming up the

strategies for implementation of the project. Accordingly, it was decided that the programme implementation has to be concurrent in natural, agriculture and urban landscapes within the riverscape. Further, a variety of conservation and supporting activities would also be required for effective implementation, knowledge management and sharing, capacity development, monitoring, and adaptive management.

(i) Preparation of Draft DPR – Activities, Resource Planning and Schedule: The aforesaid key steps and the process adopted ultimately helped HFRI in the preparation of draft DPR presenting the background information, situation analysis and environment of the delineated riverscape, formulation of strategies, planning of specific activities, resource planning (manpower, equipment and the finances), and year-wise schedule of operations. Draft DPR (Vol. I and II) was shared with two participating States, SFDs and other stakeholders in the state as well as the national level consultation meetings seeking their feedback and valuable inputs. Copies of the draft DPR were also submitted to the ICFRE, Dehra Dun and the MoEFCC, New Delhi and comments were invited. Necessary presentations were also made at ICFRE and MoEFCC.

(j) Finalization of DPR, Implementation and Monitoring: The draft DPR was finalized incorporating the feedback and specific comments received from the respective States, SFDs, ICFRE and the MoEFCC. The Phase I – ‘Project implementation’ has been planned for duration of five years by respective States and SFDs as the nodal agencies. A provision for inbuilt, Results-Based Monitoring has been made for continuous monitoring, organizational learning and adaptive management. The Phase II – ‘Maintenance Phase’ of five year duration would be executed after the implementation of Phase I, primarily with the objective to maintain plantations raised in three type of landscapes and scaling up of the activities and covering of the left over tributaries.

(10) The Organization of DPR

The DPR for Beas River is presented in two volumes. Volume-I deals with the main DPR while the Volume-II provides summaries of two concerned States located along the course of the river. The Volume-I further contains two parts (Part I and Part II). The Part I describes the existing situation of the riverscape and incorporates four Chapters while the Part II deals with the proposed plan and includes four Chapters too. The Chapter 1 – ‘Introduction’ highlights the intricacies and dynamic nature of river ecosystem and elaborates on vital aspects of connectivity, environmental flow, ecological integrity and river health. The Chapter narrates linkages among forests, river, other lands and human well-being and also describes past management of the river. The Chapter also dwells upon the evolving concepts and holistic approach of river basin management and the riverscape, present task on forestry interventions, logical framework analysis, and the overall organization of DPR. The Chapter 2 – ‘Assessment of the Beas Riverscape’ describes the ‘Beas Riverscape’ delineated for the purpose of planning, assessment and preparation of present DPR. The Chapter 2 also presents the approach adopted and its key components. The Chapter 3 – ‘The Beas Riverscape and its Environment’ summarizes the physical, biological, socio-economic sub-environments in the broader context of Beas River Basin, particularly the delineated riverscape along the course of river Beas. The Chapter 4 – ‘Legislative, Policy and Institutional Context’ provides an insight on the existing policies and laws relevant to water, environment, forest management, biodiversity conservation, river management, etc. The Chapter 4 also provides details of various central and state government-level agencies and concerned scientific and specialized organizations that are directly responsible for the policy and decision making, over-seeing and management of activities of associated sectors. The Chapter on one hand examines

critically the existing policies, conventions, treaties and laws pertaining to the themes of the DPR while on the other hand identify gaps, imperatives and future needs from the perspective of various users and those who either influence/impact or are responsible for the management of water resources. The Chapter 4 also provides an insight on potential partner organizations besides the State Forest Department those can either undertake activities relevant to forestry interventions or assist and facilitate various supporting activities. The Chapter 5 – ‘Forestry Interventions - The Objective and Strategies’ in Part II presents the goals and objectives of the proposed forestry interventions and describes the strategies formulated and adopted for plan implementation. The Chapter includes details on different landscapes deciphered within the riverscape for proposed interventions/ treatments and model wise treatment plans besides details on projected targets, model wise extent and cost, and theme plans. The Chapter 6 – ‘Implementation – Mechanism and Sustainability’ summarizes partnership and institutional arrangements for programme implementation besides vital aspects of fund flow mechanism, risk assessment, monitoring and evaluation, and cost effectiveness. The Chapter 7 – ‘Project and Budget Schedule’ provides an overview on the project Budget, cost tables and schedule. The Chapter 8 – Potential Benefits of Forestry Interventions summarizes the likely outcomes and potential benefits of proposed forestry interventions. The last Chapter is followed by references and annexure. As stated above, the Volume-II incorporates States Summaries and provides an insight on the extent of various proposed interventions/ activities, treatment models, Budget outlay and schedule of activities proposed.

(11) Beas Riverscape – The Environment, Development Programmes, Conservation Issues and Implications

Historically, as well as in past two centuries or so, two States along the river course remained in the forefront of all round development, starting from the early process of civilization, forestry and forest management, construction of dams/reservoirs/barrages/canals, establishment of hydroelectric projects, expansion of agriculture/horticulture, development of fisheries, urbanization, industrialization, and enhanced tourism activities. Certainly, rapid and unplanned development severely impacted the natural ecosystems (forests, grasslands and wetlands) in two involved States. Rivers and their tributaries were the worst hit by various human disturbances. In spite of several timely interventions in the form of enactment of relevant laws, formulation of policies, establishment of protected areas, and numerous conservation initiatives/ programmes during past five decades or so, most natural ecosystems including rivers provide much reduced ecosystem services what they once use to offer. The exhaustive review for developing the insight on the environment of the riverscape provided desired understanding of factors responsible for the degradation of natural ecosystems, decline of ecosystem services and associated challenges, problems and threats. The Chapter 3 provides a summary of strengths, weaknesses, opportunities and threats for river conservation and restoration based on SWOT analysis.

(12) Legislations and Policies Relevant to River Conservation

Rivers are intricately linked with forests, wildlife, surrounding lands, and people. Hence, the subject of conservation and restoration of river ecosystem is quite complex. In past five decades or so the Central and State Governments have enacted various legislations related to forests, wildlife, environment, river, etc. and formulated relevant policies. The Chapter 4 enumerates and reviews various legal and policy foundations relevant to river ecosystem and conservation those exist in the country. The Chapter also highlights that how various prominent judgments, directives and other interventions by different Hon’ble Courts including the National Green Tribunal have helped in safeguarding interests of forests, wildlife, rivers, and wetlands besides protection of environment. Despite considerable

concerted efforts made, much needs to be done so as to effectively and efficiently manage rivers and other freshwater resources pivotal for human well-being and sustainable development. The cumulative environmental impact assessment and carrying capacity studies commissioned in the context of prominent rivers are a welcome step. However, maintaining essential environmental flows and vital four dimensional connectivity (longitudinal, vertical, horizontal and temporal) in the context of a river ecosystem is daunting task. The Chapter also summarizes relevant legislations, policies, authorities and definitions.

(13) Institutions and Implementing Agencies – Central/ State Government(s) and Civil Society

The Part 1 of the DPR describing the ‘Existing Situation’ of the riverscape and its environment has appropriately highlighted about the extensive consultative process adopted for the preparation of present DPR. Identification of stakeholders was a prerequisite for the consultative process. Thus, as a foremost step, stakeholders were identified in five broad groups. The exhaustive review carried out for developing an insight on the riverscape and its environment also allowed developing a broader impression about the varied sectors and agencies associated with the management and conservation of Beas River ecosystem. As such, the wider subject of water resources in India comes under the ambit of Union Ministry of Jal Shakti (formerly Ministry of Water Resources, River Development and Ganga Rejuvenation). However, in the past, subjects *viz.*, river conservation, Ganga Action Plan, and wetland management were under the domain of the MoEFCC. Further, recently, the NITI Aayog has directed all Central Ministries to undertake/ contribute for various programmes relevant to river conservation and restoration. Accordingly, the MoEFCC assigned the priority task on the preparation of DPR(s) on forestry interventions for restoration of nine major Indian River systems. Hence, the present DPR on the Beas River is a part of such wider exercise concerning restoration of major rivers undertaken concurrently across the country by various regional institutes of ICFRE.

The Chapter 4 on the Legislative, Policy and Institutional Context narrated the likely role of different government and non-governmental sectors/ agencies at the Central and State levels in execution of the project on proposed forestry interventions and implementation of the present DPR. Considering the vast extent of Beas Riverscape, diverse nature of proposed forestry interventions planned in the present DPR, and sizable Budget outlay envisaged for the project implementation, at the time of finalization of DPR, it was not sure which central ministry would provide the required financial support for project execution and would also act as the Central Nodal Ministry. It is assumed that the MoEFCC may either decide to provide desired funding support for the implementation of the project or may plan to execute the project as a joint venture in collaboration with other concerned ministries. The DPR recognizes that the Forest Department of involved States would function as the primary Implementing Agency at the State level, mainly for two reasons: firstly, the nature of proposed activities fall in the domain of SFD, and secondly, the department has well laid hierarchical organizational structure and physical infrastructure required to implement a project of this nature in the vast extent of Beas Riverscape. In the recent times, the mandate of SFD has enlarged in its scope from just traditional multiple uses of forest to multiple values of forest ecosystems. Diverse roles/ functions of SFDs now cut across different sectors. Hence, the focus of SFDs have gradually shifted from small forest stands/ coupes to large landscapes including protected areas, managed forests, community/ private lands and other lands. Increasingly, SFDs are required to facilitate inter-sectoral convergence so as to accomplish goals and objectives of varied mandates. The interdisciplinary nature of mandate entrusted to SFDs make them a focal point for inter-departmental convergence. The SFDs have been working in close association/ collaboration with varied agencies *viz.*, different line

departments, Gram Panchayats, community based organizations and NGOs. The most promising attribute of the SFD is its ability to adopt a people centric approach in natural resource management. During past 3-4 decades, the SFDs have ensured public participation in both decision making as well as implementation of the decisions through the widely adopted institution of Joint Forest Management. Recognizing the importance of JFM in sustainable forest management (SFM), the SFDs promoted the creation of Joint Forest Management Committees (JFMCs) to restore the degraded forest areas and also to ensure community participation in forest management and wildlife conservation. The JFMCs jointly with the SFDs carry out regeneration, afforestation, protection, sustainable management and utilization of the forest areas allotted to them. Certainly, the formation of such CBOs by SFDs is a welcome move towards the process of decentralization and people's empowerment. Thus, existing JFMCs and other related CBOs (Ecodevelopment Committees, Biodiversity Management Committee, etc.) would be appropriately involved in programme implementation. Further, in recent decades, SFDs have optimally adopted newer technologies (Remote Sensing and GIS, GPS, IT Based Applications, Biodiversity Assessment Tools, etc.) in day to day functioning and such professional competence make them more amenable to capacity development at even shorter notice. In addition, SFDs enjoy a unique distinction by virtue of their professional presence right from the origin of the Beas River in the Great Himalayas to its confluence with Sutlej in Punjab State. The participating SFDs would also involve Central Armed Police Forces (ITBP), Eco Task Force, *Nehru Yuva Kendra*, *Mahila Mandals*, and other CSOs in programme implementation as envisaged in the DPR and considered appropriate by the concerned IAs.

(14) River Ecosystems and Conservation – Need for Research, Monitoring and Knowledge Management Center

The subject of river ecology and conservation, particularly restoration of degraded river ecosystem is multifaceted, intricate and elaborate. A large number of mainly government organizations at the national and state levels in the country are responsible for varied aspects of river ecology and management (e.g., glaciology, hydrology, forestry, wildlife, hydropower generation, irrigation, pollution control, demography, sociology, development, economics, etc.) are working proficiently for decades but in isolation and specifically as per the entrusted mandate of each sector. Obviously, much of the available research and monitoring information is isolated, widely scattered and in several instances obsolete and archival in nature, piecemeal, relevant to specific tributaries/ segments/ stretches of the river. Under the stated situation, it is difficult to develop a comprehensive understanding of complex inter-relationships of dynamic river ecosystems. The thorough review carried out as a part of the present exercise on DPR, it was revealed that varied professional's viz., geologists, meteorologists, climatologists, hydrologists, biologists, ecologists, foresters, agriculture scientists, social scientists, economists, conservationists, etc. have made significant contribution in generating/ providing much desired information on the multiple aspects of ecology and management of river. However, the review also highlighted that there are substantial gaps in the information and overall understanding on the river complexities. Several agencies are also involved in diverse monitoring activities concerning different aspects of river ecology. In spite of notable and concerted efforts for quite some time, India faces enormous challenge as the subject of river conservation and river restoration in particular are relatively newer for the country. Certainly, the task of restoration of major Indian rivers and their tributaries is daunting. Firstly, it essentially requires the desired knowledge and technical know how to deal with the intricate discipline of river ecosystem. Secondly, to succeed in its endeavour, country needs resolute commitment, contribution,

support and participation of all concerned Central/ State Governments, sectors, agencies, and the rural as well as urban populations. There is an urgency to improve, strengthen, and augment knowledge and efforts. Research and monitoring are pivotal to develop the desired information base for setting goals and objectives and evolving strategies besides facilitating policy level interventions and decision making. Regrettably, understanding on interrelationships and dynamic links between forests and forestry with hydrology and river ecology has been ignored in a populous country like India wherein more than a dozen major river systems exist, including the mighty Himalayan Rivers. On one hand it is essential to maintain the 'natural capital' while on the other hand country cannot ignore welfare and prosperity of masses and the overall development. Hence, there is an urgent need to develop a knowledge management center in the fields of forest hydrology, river conservation and river restoration. Numerous rivulets, tributaries, and rivers suffer on account of pollution originating from agriculture, industries, townships, and built up environment. Several countries have taken a lead in developing appropriate tools and techniques such as bioremediation and bio-filters so as to treat polluted waters and recycling. Much needs to be done in this grossly neglected field. In view of this, the present DPR envisages establishing a knowledge management center in the fields of forest hydrology, river conservation and river restoration besides support for multidisciplinary researches and monitoring activities relevant to priority disciplines/ fields.

(15) DPR – Vision, Goal, Objectives, Components, Activities and Logical Framework

The environmental degradation is widespread. Human activities have perilously influenced most world's rivers, their tributaries, associated natural ecosystems, surrounding lands, and in turn the vital life support system. India is not alone in its fight against the declining state of her environment, but fully conscious of its global obligations towards global concerns (degradation of land and water resources, loss of biodiversity, water crises, food security, poverty, malnutrition, climate change, etc.) besides various social issues related to gender, equity, security, and peace. Alarmed at growing environmental concerns and depleting state of natural ecosystem, particularly rivers of the country, the GoI has not only undertaken several initiatives related to policy and law, but has also launched multifaceted innovative programmes towards conservation of vital freshwater resources including management of river ecosystems and river restoration. Certainly, the current degraded and depleted state of most rivers in the country is on account of a wide range of natural and manmade factors. Decimation of diverse forests and other natural ecosystems (grasslands and wetlands) all along the course of river from the origin to mouth is just one of the factors responsible for degradation of river ecosystem. A large number of developmental activities and other human disturbances have been the prominent contributors for the current plight of rivers. Thus, proposed forestry interventions is one of the multi-pronged strategies adopted for the purpose of river restoration.

The present plan aims to contribute towards the clean and healthy Beas River by way of continuous flow (*Aviral Dhara*) and clean water (*Nirmal Dhara*) besides maintenance of ecological and geological integrities. A shared vision emerged based on an extensive consultative process carried out as a part of the larger exercise undertaken to prepare this DPR stipulated 'Various conservation values of the Beas River are identified, recognized, conserved, restored, and maintained in order to ensure the ecosystem diversity, ecological

integrity and healthy river while allowing sustained flow of ecosystem services and other uses/ benefits essential for all life forms and the prosperity of the region'. The mission is to accomplish the shared vision by adopting multi-pronged strategy and pursue of five strategic priorities: (a) address drivers of environmental degradation and arrest biodiversity loss, (b) adopt integrated, innovative and nature based solutions, (c) enhance resilience and adaptation, (d) build alliances and foster synergies, and (e) opt for the right influential models and interventions so as to achieve reduced pressure on biodiversity, restore degraded ecosystems, promote sustainable use of biological and water resources, enhance capacities, mainstream biodiversity, augment policy and law support, and facilitate science based efficient decision making. The implementation plan aims a holistic riverine landscape (riverscape) approach for sustainable management of Beas River, its banks and its riparian areas, within its fluvial system. The Plan envisages four broad goals:

- (a) **Riverscape Management:** Aiming a holistic riverine landscape (riverscape) approach for sustainable management of Beas River, its banks, or its riparian areas, within its fluvial system.
- (b) *Aviral Dhara, Nirmal Dhara*, **Ecological Rejuvenation and Biodiversity Conservation:** Aim to address the drivers and stressors of river ecosystem and promote sustainable use by balancing ecological requirements with the needs of sustainable livelihoods.
- (c) **Improved Ecosystem Services and Sustainable Livelihoods:** This goal aims to specifically seek enhanced ecosystem services so as to maintain sustainable livelihoods.
- (d) **Effective Implementation, Knowledge Management, and Innovative Approaches:** This goal aims to ensure effective implementation of the project, knowledge management, development of innovative approaches (nursery techniques, afforestation/ reforestation, bio-filters and bioremediation), and adoption of appropriate modern technologies.

This Plan aims to fulfill the requirements of above stated four focal areas in a phased manner and visualizes specific outputs and outcomes. Hence, the following objectives are set-forth:

- (a) **Project Objective 1:** To promote an enabling environment for sustainable land and river ecosystem-based management approaches focusing on reduced soil erosion, enhanced forest/ vegetation cover in the buffer zone, enhanced connectivity and e-flow, and ecological rejuvenation of river Beas and its tributaries.
- (b) **Project Objective 2:** To carry out appropriate forestry interventions to restore river connectivity, enhance e-flow, improve water quality, and conserve the terrestrial and aquatic biota within the Beas Riverscape.
- (c) **Project Objective 3:** To promote improved ecosystem services and support sustainable livelihood opportunities for local communities, particularly forest dwellers, fishermen and other vulnerable groups.

- (d) Project Objective 4: To adopt, integrate and implement innovative approaches and modern technologies for rejuvenation of Beas and its tributaries, knowledge management, enhanced capacity, and monitoring and evaluation.

The Logical Framework Analysis (LFA) approach was adopted for the preparation of present DPR. Accordingly, above four project objectives envisage five outcomes and altogether 14 outputs. The Chapter on The Riverscape and its Environment highlighted the challenges, issues problems and threats in achieving the broader goals related to river conservation and restoration based on an exhaustive review and the SWOT analysis. Problems identified in achieving project objectives are: (a) fragility of the Himalayan environment owing to increased seismic activity and active landslides, widespread soil and riverbank erosion, and enhanced sedimentation; (b) harsh climatic conditions; erratic and changing patterns of snowfall, rainfall, and ambient temperature; unpredictable avalanches; retreat of glaciers, increase snowmelt and runoff; and prevailing uncertainties; (c) rugged terrain, steep slopes, and inaccessible areas; and shallow soil depth and low soil fertility; (d) alteration in river course by linking river or diversion of water; sequential physical barriers by construction of dams, barrages, and establishments of HEPs; (e) traditional resource dependence, enhanced biotic activities, and human disturbances on natural ecosystems; limited opportunities for alternate occupations and income generation; unsustainable harvest practices; illiteracy, lack of awareness, and poverty and vulnerable communities; (f) widespread and extensive land use changes and faulty land use; expansion and intensification of agriculture and horticulture; and excessive use of fertilizers, pesticides, weedicides, etc.; (g) encroachment of forest lands, PAs, and other natural ecosystems; and all round rapid developmental activities (highways, road network, cities/towns, irrigation and hydropower projects, transmission lines, etc.); (h) forest fragmentation, enhanced patchiness, habitat loss and degradation of terrestrial and aquatic ecosystems by proliferation of invasive alien species; and decline in productivity and lack of regeneration of native species; (i) erosion of biodiversity values, smaller and isolated populations of threatened species; and reduced distributional range of prominent faunal species; (j) enhanced pilgrimage, mass congregations, and unplanned and unchecked tourism activities; and allied developmental activities and their impact on terrestrial and aquatic ecosystems including rivers, their flow and water quality; (k) fragmentary approach of environmental impact assessment in case of sequential developmental projects and inadequate efforts for cumulative assessments; (l) multiplicity of policies and laws; isolationist, conflicting or counterproductive strategies/ approaches adopted by different agencies/ sectors; lack of sectoral convergence; and lackadaisical law enforcement and implications of judiciary activism; and (m) inadequate researches, databases, and baseline information; ineffective monitoring; lack of technological support, innovations; and inadequate capacity.

(16) Strategies

The developed understanding on the riverscape environment has amply revealed that the riverscape is a mosaic of varied land uses and it includes the: (a) natural ecosystems, (b) rural system predominated by agro-ecosystems, and (c) built-up urban environment represented by

cities and towns. Each of these broad land use category represents significant area of the riverscape with unique conditions and situation, and varied use patterns, ownerships and management needs. Hence, three broad land use categories within the riverscape have been referred as the ‘natural’, ‘agriculture’, and the ‘urban’ landscapes. These three landscapes immensely influence the intricate and vibrant nature of Beas River ecosystem, especially the environmental flow, water quality, and aquatic biota besides terrestrial biodiversity in surrounding lands, and the various ecological processes of the lotic system. Thus, in view of the prominence of three types of landscape elements within the riverscape, a multipronged strategy for proposed forestry interventions addressing specific requirements of each of the land use type/landscape category has been planned for execution. As a part of the broader strategy, zoning within the riverscape is visualized keeping in view three distinct landscape categories and specific targeted forestry interventions are being planned in each of the zone.

(a) Zoning and Lower Order Zone Plans: Forestry interventions proposed in each of the following three lower order zones deciphered are briefly summarized below:

- **Natural Landscapes** – The ‘natural landscape’ constituted the largest zone as various categories of land use/land cover of the natural environment represented nearly 63% extent within the riverscape. Altogether, 15 models/treatment plans focusing on forests, grasslands and wetlands have been proposed in various prioritized sites based on geospatial analysis. Proposed interventions focus on protection, soil and moisture conservation works, control of invasive and alien species, plantations, ecorestoration, bio-filters and bioremediation, etc.
- **Agriculture Landscape** – The second lower order zone (the agriculture landscapes) largely in the rural surrounding all along the main channel and its tributaries constitutes the matrix of the riverscape, predominated by agriculture and horticulture crops mainly on private lands. The purpose of this zone is to promote planting of economic and fruit trees so as to enhance the overall conservation values and other expected ecological functions and ecosystem services. In all, different 04 models in agriculture landscapes have been proposed.
- **Urban and Peri-urban Landscape** – A large number of settlements, towns and cities exist all along the course of the main river and its tributaries. A substantial proportion of the riverscape is thus constituted by the urban/ built-up environment. Proposed interventions in the third lower order zone i.e., the urban landscape include activities related to development of riverfront, ecopark, institutional and industrial estate plantations and avenue plantations. Altogether, 08 models in two States have been proposed for the stated purpose.

(b) Theme Plans: Activities those are common to two or more above stated lower order zones are being referred as the theme plans. Theme based activities are broadly grouped in two categories: (i) ‘Conservation Interventions’ including soil and moisture conservation, riverine and riparian wildlife management, and wetland management; and (ii) ‘Supporting Activities’ including policy and legal interventions, concurrent action research, capacity development, awareness, participatory monitoring, project management and evaluation. The theme based activities have been planned and proposed at the national, state and local field levels. The State level implementing agency i.e., the State Forest Department will be responsible for execution of activities proposed as theme plans while the national partner organization (HFRI, Shimla) will concurrently carry out these activities at the national level. Some of the supporting activities such as project management will be undertaken

simultaneously by the Central Nodal Ministry and the State Project Management Unit (SPMU) based at the headquarters of the concerned SFD and IA.

(17) Project Implementation – The Components, Partner Organizations, and Management

The plan envisages two phases of project implementation. The 5-year Phase 1 on Project Implementation would primarily focus various activities in three types of landscapes, conservation interventions and supporting activities. As stated above, various models, treatment plans in three types of landscapes have been planned including establishment of nurseries, advance works for extensive plantations and actual establishment activities of proposed plantations. Additionally, the Phase II – ‘Maintenance Phase’ of 5-year duration has also been envisaged, specifically for the purpose of maintenance of plantations raised during the Phase 1, scaling up/ replication of efforts in leftover tributaries. The Phase 1 of the project includes the following four components for implementation.

(a) Component 1: Implementation of Forestry Interventions in Two States along the Riverscape - The Component 1 of the Project specifically deals with the proposed forestry interventions in concerned States along the course of river and includes three sub-components: (i) ‘Forestry Interventions’ in three lower order sub-zones *viz.*, (a) Natural Landscape (NL), (b) Agriculture Landscape (AL), and (c) Urban Landscape (UL) adopting appropriate plantation treatment models; (ii) ‘Conservation Interventions’; and (iii) ‘Supporting Activities’. Details of conservation interventions and supporting activities have already been highlighted above under the Theme Plans. The Project also envisages that the SFDs may like to involve the Eco Task Force Battalion(s) of the Territorial Army, ITBP and Civil Society Organizations (NYKS, NSS, Youth and Eco Clubs, *Mahila Mandals*, NGOs, etc.) as important partners in execution of proposed activities as planned in the DPR and also to replicate the reputed community led initiatives such as Seechewal’s pioneer efforts in restoration of holy *Kali Bein* River in Punjab. Further, SFDs may like to involve the Agriculture Department and Municipal Corporation/ Municipal Board for specific activities related to agriculture landscapes and urban landscapes, respectively.

(b) Component 2: Strengthening Knowledge Management and Capacity Development for Forestry Interventions and Conservation of Riverscape - India lacks desired experience in restoration of rivers as it is relatively an emerging discipline for the country. However, efforts are on in this direction. Positive outcomes from any such effort aiming towards river restoration or river conservation are unlikely unless evidence and science based holistic strategies are actively involved in planning, assessment, management and development of rivers and policies relevant to river conservation and restoration. Thus, this Component aims to incorporate science into policy, planning and management for informed decision making that can facilitate positive outcomes of concerted efforts towards sustainable management of rivers and river restoration in particular in India. The HFRI, Shimla has taken a lead in the preparation of present DPR adopting a multistep approach involving active participation of stakeholders. The HFRI is a reputed and established learning seat in the fields of natural resource management and forestry, particularly relevant to the Himalayan environment; those have direct relevance to the river ecosystems. Thus, it is of utmost importance that HFRI is not only involved as a national level partner organization for

facilitating monitoring, evaluation, and capacity development as proposed in the present DPR but also be entrusted the responsibility of major task to serve as the Knowledge Management/Learning Center and to undertake concurrent research related activities essential for conservation and restoration of the Himalayan Rivers. The HFRI also play a pivotal role in building desired national capacity for demonstrating the strong linkages between diverse forests in the Himalayas and rivers ecosystems. The Component 2 specifically seeks to support the dissemination of improved knowledge by strengthening the Knowledge Management Center and capacity development required for conservation of Himalayan Riverscapes within the country by offering best practices for forestry interventions and varied conservation measures as envisaged in the DPR. In addition, the Knowledge Management Center (HFRI) is expected to contribute towards envisaged intervention and activities relevant to policy, advocacy, outreach, monitoring, evaluation, and capacity development. In order to accomplish this, the national level partner organization meant for the knowledge management and capacity development would need to establish a Project Facilitation Unit (PFU) for effective coordination with participating States and the Central Nodal Ministry supporting the implementation of the programme.

(c) Component 3: Scaling Up, Replication in Additional Sites and Maintenance Phase -

The present DPR focuses on the programme implementation on the select tributaries, particularly once the river descends in the plains. The Component 3 plans to support the scaling up and replication of planned efforts in additional sites/ tributaries besides primarily, supporting the maintenance phase of various types of plantations raised in later years (3rd, 4th and 5th years) of the Phase I – Implementation Phase.

(d) Component 4: National Coordination for Forestry Interventions and Riverscape

Conservations - In general, major Indian River systems involve two or more States as the basin of the river and its tributaries is spread over multiple States. Thus, programmes related to river management and restoration requires national level coordination for proposed forestry interventions and various conservation efforts among the participating States or located along the course of main channel and its tributaries. As such, the MoJS is the central nodal ministry for all aspects of management of water resources including river development and restoration of rivers. However, several other ministries are also involved for specific components/ needs. Thus, the Component 4 envisaged national level coordination for forestry interventions and river restoration and visualizes varied activities *viz.*, (a) establishment of the River Decision Support and Management Information System (RDS & MIS); (b) facilitating activities relevant to policy and legal interventions, riverscape level coordination, monitoring and impact evaluation; and (c) administering the implementation of major project on forestry interventions. In order to accomplish this, the Component 4 specifically envisages the establishment of a Project Management Unit (PMU) at the nodal ministry level. The PMU at the nodal ministry would handle the programme implementation, coordination among participatory States, partner organizations at the national and State level besides extending support for the finances required for the project execution.

(18) Implementation, Project Overseeing, and Fund Flow Mechanism

The programme implementation has been planned in two phases of five year duration each. The Phase 1 deals with project implementation while the Phase II primarily focuses on the maintenance of plantations established during the Phase 1. The project visualizes constitution of two Programme Steering Committees (PSCs), one at the national level in the Central Nodal Ministry being referred as the 'National Programme Steering Committee (NPSC)' while the other one at the State level in the concerned SFD/ IA, and being referred as the 'State Programme Steering Committee (SPSC)'. The NPSC and SPSC would be responsible for the efficient execution of the project at the national and state level, respectively. The NPSC would be responsible for approving the APOs submitted by two involved States and a National Level Partner Organization (NPO) in addition to primary functions of overseeing and steering the execution of the implementation plan. The NPMU at the Central Nodal Ministry will be responsible for the release of funds to IAs and the NPO once the APOs have been approved by the NPSC. The Project Facilitation Unit (PFU) at the NPO will follow its own mechanism of governance and will constitute its own monitoring and steering committee for overseeing the project.

(19) Project Budget

The projected financial outlay of the Phase 1 on Project Implementation of five-year duration is Rs. 713.48 Crore. The projected Budget outlay of Phase II (Maintenance Phase) of five-year duration is Rs. 135.71 Crore and Total Budget outlay is Rs. 849.19 Crore. As mentioned above, the project includes four broad based components. Accordingly, financial cost of each of these four components is summarized below:

An amount of Rs 658.14 Crore, which is 77.50% of the overall project Budget, is provisioned for principal component A. This includes total Rs. 707.71 Crore for forestry interventions in three landscapes and Conservation intervention (Sub-component A.1 and A.2) which include Rs. 423.85 Crores for component A.1, Rs.190.20 Crore for component A.2 and whereas, Rs. 44.09 Crore is provisioned for supporting activities (Sub-component A.3).

Component-A: the Sub-component (A.1) on plantations and various treatment models in three types of landscapes within the riverscape is the largest in terms of its spread, extent and quantum of funds provisioned. Rs. 423.85 Crore is provisioned for forestry interventions in three landscapes, which is 49.91% of total Budget outlay of the project. Amongst three landscapes, the obvious emphasis is on Natural Landscapes, thus a sum of Rs.307.91 Crore has been provisioned for proposed afforestation/ reforestation activities in natural landscapes in Beas Riverscape. The projected Budget outlay for proposed plantations in natural landscapes accounts for 46.78% of the Sub-components. The projected Budget outlays for Eco Task Force, agriculture and urban landscapes are of the tune of Rs. 22.43 Crore, Rs. 13.73 Crore and Rs. 79.78 Crore or 3.40%, 2.09 % and 12.12%, respectively of the envisaged cost of the Sub-component.

The second Sub-component on 'Conservation Interventions' (A.2) includes three major types of interventions/ activities. These are: (a) soil and moisture conservation measures, (b) riverine and riparian wildlife management, and (c) wetland management. 190.20 Crore are

provisioned for this subcomponent, which is 22.40% of total Budget outlay. Of this, the Budget outlay for SMC is Rs.160.99 Crore, which is 24.46% allocation of the funds provisioned for Component A. Budget outlay provisioned for Riverine and Riparian Wildlife Management and Wetland Management is 29.21 Crore, which is 4.44% of total Budget of component A.

The third Sub-component (A.3) pertaining to ‘Supporting Activities’ is to be executed by concerned state level IAs. This Sub-component includes seven broad based activities *viz.*, (a) policy and legal interventions, (b) participatory monitoring, (c) adaptive research, (d) capacity development, (e) awareness, (f) project management, and (g) evaluation. A Budget of 44.09 Crore or 6.70% of the component A or 5.19 % of total Budget proposed to the concerned states has been provisioned for carrying out various supporting activities for five-year period.

The Component-B: ‘Strengthening Knowledge Management and enhancement of national capacity for forest hydrology, forestry interventions, and conservation and restoration of rivers would require a sum of Rs. 29.52 Crore or 3.48% of the overall project outlay. The highest Budget amounting Rs. 7.79 Crore has been provisioned for cost of PFU, while Budget of Rs. 6.27 Crore has been provisioned for Research and Development, 3.58 Crore, 2.69 Crore, 1.79 Crore, 1.46 Crore, 0.66 and 0.46 Crore have been envisaged for Scientific exchange, capacity development, policy level interventions, awareness, Monitoring and Evaluation respectively.

The Component–C on the Phase II of the project of five-year duration for maintenance of plantations raised during Phase I of the project has also been planned. The Phase II would also include limited activities related to replication of efforts in additional tributaries/areas and scaling up of the planned effort. A sum of Rs. 135.71 Crore or 15.98% of the total project financial outlay has been envisaged specifically for the Component – C on ‘Maintenance Phase’.

The Component–D pertains to project management at the national level which would include the establishment of National Project Management Unit (NPMU) at the Central Nodal Ministry with the responsibility to oversee, steer and manage this priority project. A sum of Rs. 25.82 Crore, representing 3.04% of the overall Budget over a period of five-year during the Phase I has been provisioned. Thus, it is clear that the major portion of project Budget outlay is meant for field level activities incorporating proposed forestry interventions, conservation interventions and supporting activities to be implemented in concerned States.

A total of 20 Territorial Forest Divisions and 5 Wildlife Divisions in Beas Riverscape, will carry out proposed activities relevant to forestry interventions within the riverscape. A total of 19599.5 ha area of three landscapes, 310 ha area of Riverine and Riparian wildlife management and wetland management and 926315.5m³ extent of soil and moisture conservation in Beas Riverscape is envisioned to be treated under the various forestry interventions.

Thus, it is amply clear that the major chunk (83.34 %) of project Budget outlay is meant for field level activities incorporating proposed forestry interventions, conservation interventions and supporting activities to be implemented by two States (Himachal Pradesh and Punjab). The higher proportion of Budget allocation to the extent of Rs. 633.51 Crore or 74.60% of

overall Budget is meant for the State of Himachal Pradesh considering the fact that a larger extent of the riverscape is located in this mountainous state while a Budget of Rs. 132.14 Crore or 15.56% of the total Budget has been provisioned for the State of Punjab. Altogether, 25 Forest Divisions in two States/IAs will carry out proposed activities relevant to forestry interventions within the riverscape. The Budget allocations to 25 Forest Divisions range from Rs. 0.5 Crore to Rs. 48.20 Crore over a period of 10 years (i.e., Phase I and II). Altogether, a total of 18904.5 ha area in two involved States is envisaged to be treated under the various forestry interventions. The state-wise area to be treated would be 15655.5 ha in Himachal Pradesh and 3249 ha in Punjab.

(20) Project Schedule

The execution period of Phase I and Phase II of the project has been designed and incorporated in the present DPR is of 5-year duration in each case. Thus, the total duration for programme implementation including the maintenance phase is of 10-years. At this juncture, it is not clear when would be the first year of Phase I project implementation. The Government of India may take its own time to decide the Central Nodal Ministry responsible for the implementation of the project and to allocate required funds for the execution of plan. Various proposed activities have been staggered over five years of the Phase I. The experience illustrates that once the Government of India has accorded its approval for the project and earmarked required funds, the first year by IAs would be largely devoted for project initiation, preparatory works, particularly the establishment of nurseries and commencement of various activities related to conservation interventions and supporting activities. The planting material meant for high altitude Himalayan part of the riverscape would be ready in nurseries and earliest available by the end of second year of project implementation. Thus, the earliest effective establishment year of plantations would be the third year of Phase I in high altitude areas. Establishment of plantations is proposed in third, fourth and fifth year of Phase I. The Phase II of five-year duration is specifically designed and incorporated for the purpose of maintenance of plantations and other activities. Considering the fact that most proposed activities are time bound and seasonal in nature, ideally the project initiation after all approvals, Budget allocation, etc. should commence in month of April – May so as to allow adequate time for preparatory works, establishment of nurseries, development of planting material for afforestation/ reforestation in lower reaches of the riverscape before the onset of monsoon season in month of June or so in the next year. Thus, careful scheduling of project commencement would be vital for the overall success and effective implementation of envisage activities. The quantum of activities are expected to be at its peak in third or fourth year of Phase I. The Mid-Term Review (MTR) is proposed in the last quarter of third financial year of the project execution while the Terminal Evaluation (TE) is being envisaged in the third year of the Phase II.

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LIST OF ACRONYMS AND ABBREVIATIONS

ABS	Access and Benefit Sharing
ACF	Assistant Conservator of Forest
AIGs	Alternate Income Generations
AL	Agriculture Landscape
APCCF	Additional Principal Chief Conservator of Forest
APOs	Annual Plan of Operations
BBM	Bhakra-Beas Management
BBMB	Bhakra-Beas Management Board
BC	Before Christ
BCB	Beas Control Board
BCM	Billion Cubic Meters
BCRLIP	Biodiversity Conservation and Rural Livelihood Improvement Project
BMB	Bhakra Management Board
BMCs	Biodiversity Management Committee
BPL	Below the Poverty Line
BRCR	Beas River Conservation Reserve
BSF	Border Security Force
CAG	Comptroller and Auditor General
CAMPA	Compensatory Afforestation Fund Management and Planning Authority
CAPFs	Central Armed Police Forces
CAT	Catchment area Treatment
CBD	Convention on Biological Diversity
CBOs	Community Based Organizations
CCF	Chief Conservator of the Forest
CCs	Completion Certificates
CEO	Chief Electoral Officer
CETF	Central Eco Task Force
CETP	Common Effluent Treatment Plants
CF	Conservator of the Forest
CGWB	Central Ground Water Board
CIA&CCS	Cumulative Impact Assessment and Carrying Capacity Study
CIFOR	Center for International Forestry Research
CISF	Central Industrial Security Force
CITES	Convention on Control of International Trade in Endangered Species of Wild Fauna and Flora
CMS	Convention on Migratory Species
CO ₂	Carbon dioxide
CPCB	Central Pollution Control Board
CPIC	Circle Project Implementation Committee
CRPF	Central Reserved Police Force
CSD	Commission on Sustainable Development
CSOs	Civil Society Organizations
CSS	Central Sponsored Schemes
CTE	Consent to Establish
CTO	Consent to Operate
CWC	Central Water Commission
CWPIL	Civil Writ Pettition

DCF	Deputy Conservator of Forest
DFID	Department for International Development
DFO	Divisional Forest Officer
DIC	District Level Implementing Committee
DoAC	Direct Oral Anticoagulants
DoLR	Decentralized Object Location and Routing
DoRD	Department of Rural Development
DPR	Detailed Project Report
DROs	Deputy Range Officers
DSRs	District Survey Reports
EAC	Expert Appraisal Committee
EAPs	Externally Aided Projects
ECs	Eco development Committees
e-flow	Environmental Flow
EIA	Environment Impact Assessment
ESCAP	Economic and Social Council for Asia and Pacific
ESZs	Eco-Sensitive Zones
ETF	Eco Task Force
FAO	Food Agriculture Organisation
FDAs	Forest Development Agencies
FG	Forest Guard
FPC	Flood Pulse Concept
FRA	Forest Rights Act
FREEP	Forestry Research, Education and Extension Project
FRI	Forest Research Institute
FSI	Forest Survey of India
GAP	Ganga Action Plan
GBEA	Great Britain Environment Agency
GBPIHED	G.B. Plant Institute of Himalayan Environment and Development,
GEF	Global Environmental Facility
GEF/ IDA	GDB Enhanced Features/ International Development Agency
GFR	General Financial Rules
GHG's	Greenhouse Gases
GHNP	Great Himalayan National Park
GHNPCHA	Great Himalayan National Park Conservation Area
GI	Galvanized Iron
GIM	Green India Mission
GIS	Geographic Information System
GIZ	Gesellschaft für Internationale Zusammenarbeit
GoHP	Government of Himachal Pradesh
GoM	Government of Maharashtra
GoP	Government of Punjab
GPS	Global Positioning System
GRBEMP	Ganga River Basin Environment Management Plan
GSC	Gross Storage Capacity
HEP	Hydro Electric Project
HEPs	Hydro Electric projects
HFRI	Himalayan Forestry Research Institute
HKH	Hindu Kush Himalaya

HoFF	Head of Forest Force
HPFD	Himachal Pradesh Forest Department
HPPCB	Himachal Pradesh state Pollution Control Board
IAFs	Indian Armed Forces
IAs	Implementing Agencies
IBA	Important Bird Areas
IC	Installed Capacity
ICFRE	Indian Council of Forestry Research and Education
ICMOD	International Centre for Integrated Mountain Development
IDA	International Development Association
IDWH	Integrated Development of Wildlife Habitats
IFS	Indian Forest Service
IGB	Indus, Ganges and Brahmaputra
IIT	Indian Institute of Technology
INF BN (TA)	Infantry Battalion (Territorial Army)
IPCC	Intergovernmental Panel on Climate Change
IPH	Irrigation and Public Health
IT	Information Technology
ITBP	Indo Tibetan Border Police
IUCN	International Union for Conservation of Nature
IWDP	Integrated Watershed Development Programme
IWMP	Integrated Watershed Management Programme
IWRM	Integrated Water Resources Management
IWT	Indus Water Treaty
J&K	Jammu and Kashmir
JBIC	Japan Bank of International Cooperation
JFM	Joint Forest Management
JFMCs	Joint Forest Management Committees
JICA	Japan International Cooperation Agency
KBAs	Key Biodiversity Areas
LFA	Logical Framework Approach
LIR	Inter-Linking of Rivers
LSC	Live Storage Capacity
MAF	Mission Aviation Fellowship
MAPs	Medicinal and Aromatic Plants
MBs	Management Boards
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Scheme
MIS	Management Information System
MMDR	Mines and Minerals Development and Regulation
MoA	Ministry of Agriculture
MoD	Ministry of Defence
MoDW&S	The Ministry of Drinking Water and Sanitation
MoDWS	Ministry of Drinking Water and Sanitation
MoEFCC	Ministry of Environment, Forest and Climate Change
MoH&UA	Ministry of Housing and Urban Affairs
MoHA	Ministry of Home Affairs
MoJS	Ministry of Jal Shakti
MoM	Ministry of Mines
MoPR	Ministry of Panchayati Raj
MoPR	Ministry of Panchayati Raj

MoRD	Ministry of Rural Development
MoS	Ministry of Shipping
MoS	Ministry of Shipping
MoT	Ministry of Transport
MoU	Memorandum of Understanding
MoUD	Ministry of Urban Development.
MoWR	Ministry of Water Resources
MoWR	Ministry of Water Resources
MoWR, RD & GR	Ministry of Water Resources, River Development and Ganga Rejuvenation
MoYA&S	The Ministry of Youth Affairs and Sports
MTR	Mid Term Review
MW	Mega Watt
MW	Mega Watt
NAEB	National Association of Educational Broadcasters
NAP	National Afforestation Programme -
NAPCC	Nation action Plan on Climate Change
NBAP	National Biodiversity Action Plan
NBM	Planting and Restocking Bamboo (National Bamboo Mission
NCC	National Cadet Corps
NCT	Neo Culture Technology
NERIL	Naik Environment Research Institute Ltd.
NGBRA	National Ganga River Basin Authority
NGO	Non Governmental Organisation
NGRBA	National Ganga River Basin Authority
NGRBP	National Ganga River Basin Project
NGT	National Green Tribunal
NL	Natural Landscape
NLCP	National Lake Conservation Programme
NMCG	National Mission for Clean Ganga
NMPB	National Medicinal Plants Board
NO	Nodal Officer
NPD	National Project Director
NPMU	National Project Management Unit
NPs	National Parks
NPSC	National Level Programme Steering Committee
NR5	National Report
NRC	National Research Council
NRCD	National River Conservation Directorate
NRCP	National River Conservation Plan
NRM	Natural Resource Management
NRSC	National Remote Sensing Centre
NSG	National Security Guard
NSS	National Service Scheme
NTCA	National Tiger Conservation Authority
NTFPs	Non Timber Forest Products
NWCP	National Wetlands Conservation Programme
NWDA	National Water Development Agency
NWM	National Water Mission
NWRC	National Water Resources Council

NYKS	Nehru Yuva Kendra Sangathan
OECD	Organisation for Economic Cooperation and Development
OM	Office Memorandum OM
PA	Protected Area
PBR	Peoples Biodiversity Register
PC	Project Coordinator
PCCF	Principal Chief Conservator of Forest
PD	Project Director
PED	Project Executive Director
PEO	Project Executive Officer
PFU	Project Facilitation Unit
PLM	Programme Logic Model
PM	Prime Minister
PMO	Project Management Office
PMU	Project Management Unit
PSC	Project Steering Committees
PSS	Pumped Storage Schemes
PT, PE	Project Tiger, Project Elephant
PWD	Public Works Department
PWP	Permanent Wilting Point
PWSSB	Punjab Water Supply and Sewerage Board
RBM	Results-Based Management
RBM	Results-Based Monitoring
RC	River Coordinator
RCC	River Continuum Concept
RCC	River Rejuvenation Committees
RDS	River Decision Support
RES	Riverine Ecosystem Synthesis
RET	Rare Endangered Threatened
RFO	Range Forest Officer
RfR	Rally for Rivers
RI	Recurrence Interval
RS	Remote Sensing
RSET	Remote Sensing Envirolink Technologies
RTI	Right To Information
RWC	River Wave Concept
SAARC	South Asian Association for Regional Cooperation
SACEP	South Asia Cooperative Environment Programme
SCST&E	State Council for Science, Technology and Environment
SDG	Sustainable Development Goals
SDGs	Sustainable Development Goals
SEAC	State Expert Appraisal Committee
SECURE	Securing Livelihoods, Conservation, Sustainable Use and Restoration of High Range Himalayan Ecosystems
SEIAA	State Level Impact Assessment Authority
SFD	State Forest Department
SFDA	State Forest Development Agency
SFDs	State Forest Departments
SFM	Sustainable Forest Management
SFS	State Forest Service

SGRCA	State Ganga River Conservation Authority
SLEM	Sustainable Land and Ecosystem Management
SMC	Senior Management Committee
SMEs	Small and Micro Entrepreneurships
SPCB	State Pollution Control Board
SPMUs	State level Project Management Units
SPSC	State Programme Steering Committee
SSB	SashastraSeema Bal
SSF	Special Security Force
STP	Sewage Treatment Plant
STPs	Sewage Treatment Plants
SWOT	Strength Weakness Opportunities Threats
TA	Territorial Army
TDS	Total Dissolved Solids
TE	Terminal Evaluation
TK	Traditional Knowledge
TOF	Trees Outside Forests
TOFs	Trees Outside Forests
UAVs	Unmanned Aerial Vehicles
UC	Unitization Certificate
UL	Urban Landscape
UN	United Nations
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention on Combat of Desertification
UNCED	United Nations Conference on Environment and Development
UNDG	United Nations Sustainable Development Group
UNDP	United Nations Development Programme
UNDP/ GEF	United Nation Development Programme/Global Environment Facility
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCC	United Nations Framework on Climate Change
UOI	Union of India
US	United state
USAID	United States Agency for International Development
UTs	Union Territories
VFDCs	Village Forest Development Committees
VSS	Van SanrakshanSamiti
WHS	World Heritage Site
WLS	Wild Life Sanctuary
WPA	Wildlife Protection Act
WRIS	Water Resources Information System
WWF-India	World Wide Fund for Nature
YAP	Yamuna Action Plan

1.1 Natural Capital – Human Well-Being and Sustainable Development

The world is fast changing and transforming. The UN agencies and global community are aiming for a decent life for all, human well-being, and a sustainable future while most nations have an agenda for rapid development and growing economy. At the same time, there is a growing concern about the severe decline and degradation of ‘common natural heritage of mankind’ or ‘global commons’. The Commission on Global Governance (1995) has included the atmosphere, outer space, the oceans, environment and life support system that contribute to the life as commons and fundamental to human welfare. The global commons are not ‘global commons’, but ‘a global commons’ which operates as a single self-sustaining life-supporting system within which human civilization is constituted, nurtured and reified over time (Hartzog, 2003). Degradation and decline of these commons, particularly the natural capital has led the world to face challenges related to poverty, hunger, water, food and malnutrition, justice, security, peace and human rights. Most of these global challenges are primarily arising due to the loss and attrition of natural resources i.e., forests, grasslands, wetlands, rivers, coastal and marine ecosystems. In general, most developing nations have seen economic progress and social development over recent decades while at the same time global environmental problems have become more acute. Implications of climate change are expected to aggravate the situation. Fast depleting and limited access of vital freshwater resources e.g. lakes, ponds, groundwater, springs, streams, rivers, floodplains and other wetlands is resulting into water crisis in most countries and is being considered as one of the impediments in transition to the UN 2030 global agenda on sustainable development (OECD, 2017).

1.2 Rivers – Complex and Dynamic Ecosystems

Freshwater resources cover <1% of the Earth’s surface and the surface water just amounts to <0.01%. Freshwater environments including rivers are globally important for varied human needs, wildlife and sustainable development (Addy *et al.*, 2016). Amongst diverse freshwater ecosystems, streams, rivers and floodplains are most enthralling, intricate, unique, active and vital natural environments (Naiman and Bilby, 1998; Combes, 2003; Speed *et al.*, 2016). Rivers are the integral part of the natural landscape, and are natural water courses, flowing from source to a lake, another river, sea or ocean. Rivers are highly dynamic systems and conduits for water, sediments, aquatic organisms and other matter as they move down the river basin. River ecosystem refers to both the living (biotic) and non-living (abiotic) components of a river and the riparian zone, and the interactions between them. Rivers are recognized as integrators and centers of organizations within the landscape as they link terrestrial, freshwater and coastal marine ecosystems and nearly all aspects of human culture from source-to-sea in open transport and migration routes. They are part of the hydrological cycle as they generally collect water from precipitation (e.g. rainfall and snow melt) and also release of stored water from glaciers through a drainage basin from surface runoff. Rivers in

the process of flow from its origin to mouth create diverse habitats for varied organisms and provide one temporal and three spatial dimensions of longitudinal, vertical and lateral connectivity (Seliger and Zeiringer, 2018). ‘Longitudinal connectivity’ from source to sea is a defining characteristic of *lotic* (e.g. flowing) water in a river. River also extends ‘lateral connectivity’ to surrounding lands, floodplains and coastal habitats, and exhibits ‘vertical connectivity’ where free-flowing surface water mixes with the groundwater below through the river bed - in the hyporheic zone influencing not only the chemistry and nutrient contents but also, affect smaller organisms that live in the spaces between sediment grains and substratum, even certain macro invertebrates and the development of fish eggs (Boulton, 2000; Malcolm *et al.*, 2005; Addy *et al.*, 2016). Further, in addition to above stated three types of spatial connectivity, ‘temporal connectivity’ all year round is essential for the maintenance of aquatic biota and ecosystem services.

In context of the river, Van der Velde *et al.* (2004) has described five unifying characteristics *viz.*, (a) unidirectional flow, (b) a state of continuous physical change, (c) a high degree of spatial and temporal heterogeneity at all scales, (d) high variability between *lotic* systems, and (e) specialized biota to inhabit matching flow conditions. Generally, a river represents three types of environments from upstream to downstream owing to varied factors *viz.*, climate, geology, glacial history, altitude and land use. Three environments from the origin are: (a) Zone 1- Headwaters, (b) Zone 2 - Transfer zone, and (c) Zone 3 - Depositional zone. Headwaters usually include smaller streams and tributaries that carry water from the upper reaches of the catchment to the main stem downstream. Streams swiftly flow down and cut deep ‘V’ shaped valleys. They are a major source of water, sediment, energy and nutrients as well as being vital habitats in their own right. In the Transfer Zone, lower altitudinal streams merge to flow down gentle slopes. At the lowest elevations in the Depositional Zone, a river meanders across a flat valley, may divide into separate channels (distributaries) as it flows across a delta extending out to sea. All through its course, a river is influenced by varied basin-scale processes, ultimately affecting river flow, water quality, channel morphology and aquatic and riparian biota. Since, rivers integrate all that happens in the basin/surrounding landscapes throughout its journey from source to sea, particularly the impact of human activities, they are being regarded as ‘lifeblood’, ‘highways’ and ‘pantries of the world’ and even as ‘sentinels’ (Wampler, 2012). In short, rivers provide early clues and specific signals of human impact and associated risks. Society can take advantage of early warnings and plan appropriate mitigation strategies to deal with such adverse impacts and likely risks (Karr, 1998).

1.3 River Ecosystems – Human Use and Disturbance

Since time immemorial humanity has preferred to settle close to major rivers so as to take advantage of water for drinking, agriculture, irrigation, navigation, transportation, hydropower production, industrial use, fish catch, sand mining and extraction of other products besides disposal of waste and effluents. Increasingly, rivers have become major attractions for recreational activities. Accordingly, early civilizations were developed on the banks and floodplains of major rivers. In most parts of the world, rivers are being worshipped for their religious and cultural values. The notion of ‘Mother River’, ‘National River’ or a

‘Living Entity’ is found in many nations including India, reinforcing the roles of rivers in sustaining life, fertility and development (McCully, 2001; Speed *et al.*, 2016). In spite, rivers have been offering multiple benefits to humanity by way of varied ecosystem services, humans have exploited them more than any other type of ecosystem for over 5,000 years (Boon *et al.*, 1992; Arthington and Welcomme, 1995; Jungwirth *et al.*, 2002; Richter, 2014). World over, most rivers and floodplain ecosystems have been exploited, modified and polluted leading into decline of their goods and services once they used to offer and ultimately resulting into the enhanced vulnerability of themselves.

River ecosystems often get impacted by natural disturbances *viz.*, drought, cloud burst, storm, flood, tsunami, forest fire, insect outbreak, tectonic movement and earthquake. Increasingly, natural disturbances are altered or replaced by human disturbances mainly due to civil engineering measures or physical barriers *i.e.*, dams, reservoirs, barrages and canals or other man made disturbances including clear cutting of forests, livestock grazing, agriculture, landfills, mining, industrial effluents, waste and sewage disposal, road network, construction near shore lines and stream banks, artificial hardening of lakeshores with retaining walls, etc. With the advancement of technologies and enhanced demands of various user agencies and local communities, the extent and intensity of human disturbance has increased several folds due to either ‘extensification’ or ‘intensification’. On one hand, increased conversion/reclamation of natural landforms *i.e.*, forests, grasslands and wetlands for expansion of agriculture, establishment of sequential physical barriers and hydroelectric projects, built-up areas and urban environment primarily reflect extensification in the context of a river while on the other hand, excessive use of resources *viz.*, fertilizers and pesticides in agriculture sector; exploitation of groundwater; sand and gravel mining, etc. are some of the activities reflecting the process of intensification of human disturbance.



Forest Fire – a major threat in the Himalaya

Human disturbance has caused altered e-flow, fragmentation and pollution of rivers; reduced resultant ecosystem services and even the loss functional integrity. Impacts of human disturbance are evident in the form of excessive sedimentation, nutrient enrichment, alteration of native plant communities and growth pattern, loss of habitat structure and modification to substrate type and loss or decline of wild fauna (Karr, 1994; Dynesius and Nilson, 1994; King *et al.*, 2019; Sprague *et al.*, 2019). In several instances, reduced e-flow, particularly in case of trans-boundary rivers or downstream areas has led to conflict, dispute, political aggression, social unrest and socio-economic fallout. The consequences of river degradation are evident in many river basins around the world. The human dominated country like India with excessive demand of water resources and biotic pressure is no exception and most Indian rivers are in the degraded state and calls for urgent actions towards restoration. A new discipline – the ‘River Health’ referring to the overall ecological condition of river and reflecting the river ecosystem structure, composition, functions and the ecosystem services provided by them is the predominant talk amongst the users of the river, civil society and conservationists.

1.4 The Rivers – Past, Present and Future

Throughout history, rivers have been a central feature in the development of human societies. Settlements and towns have emerged and thrived near streams and rivers because they offer wide range of essential goods and services to the humanity. In spite, humans have high value for rivers; they have been exploited for varied societal needs especially since the Industrial Revolution (Johnson *et al.*, 1995; GBEA *et al.*, 2002; Srivastava, 2007; Addy *et al.*, 2016). As societies have become increasingly urbanized, the pressure placed on rivers has enhanced dramatically leading to wide spread degradation of their natural character, channel morphology and dynamics, loss of characteristic habitats and biodiversity and declined ecosystem services. In general, human development has resulted in a significant decline in the health of rivers and river ecosystems have become the most threatened ecosystems globally. The 21st century witnessed construction of dams, diversion of water through extensive network of canals or linking of rivers, draining of wetlands, over harvesting of fish fauna, deforestation, industrial effluents, and invasion of exotic and alien species, these activities collectively have even altered the major and powerful rivers. Creation of physical barriers and alteration of rivers have often been carried out with the best of intentions, but without knowledge of the potential implications and negative impacts. Streams and rivers in the higher reaches of mountainous region had suffered on account of expansion of road networks, extensive landslides and resultant eroded soils and greater sedimentation. Rivers are highly sensitive to such manmade alterations and other disturbances. Various human activities have significantly influenced the ecological functioning of the rivers. Projections on continued human activities and disturbances and their likely impact give a dismal picture about rivers in future. Recognizing the degradation and impaired ecological functioning of major rivers, the scientific community, river resource managers and several national governments have started thinking and planning about conservation of rivers adopting a holistic perspective *viz.*, basin or catchment management, riverscape and ecosystem based management, linking upstream and downstream, source-to-sea approach and even the concept of river health and providing an impetus to scientific and evidence based river management.

1.5 Need for Scientific Management of River

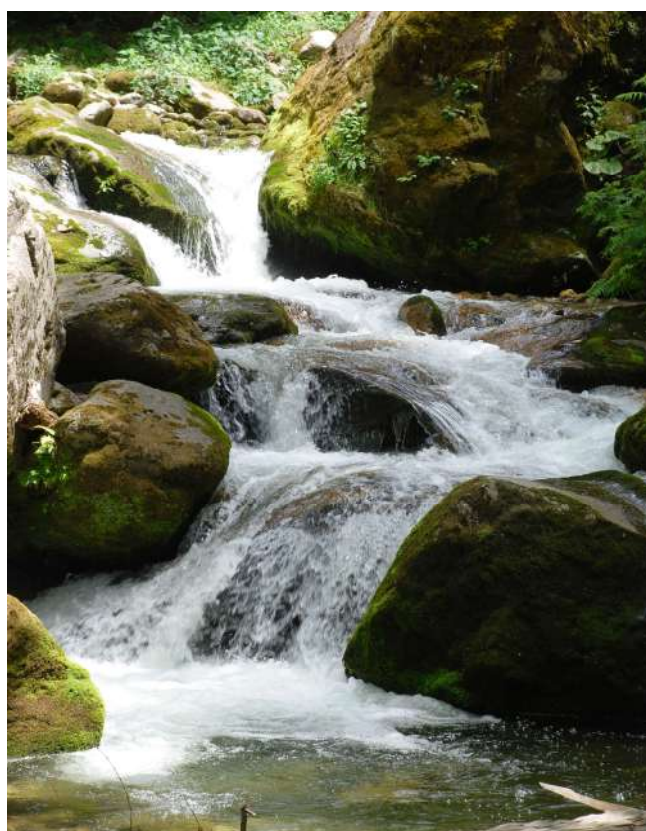
The complex subject of river science, particularly in developed nations and select developing countries has emerged in recent decades, and has made considerable advancements in the concepts, principles, approaches and tools and techniques, especially in light of the anthropogenic disturbances and regulation which have simplified most rivers and resulted into adverse consequences for structure, composition and functions of a river (Neill and Thorp, 2011). River channel complexity is an aspect of fluvial geomorphology that affects diverse facets of river science. A great amount of growing literature on river science exists across the world, especially dealing with river restoration and conservation. The earliest efforts to restore river habitat date back to the early 20th century, and were mostly motivated by the interest of fishery sector. However, with passage of time, a growing influence of evolving policies and the wide range of techniques available has made it possible to achieve different objectives of river management.

The earlier interventions focused on isolationist scientific approaches to management of river degradation and attempted to tackle the symptoms rather than the causative factors, and earlier management efforts focused on the requirements of shorter stretches of river, narrow range of river forms and habitats or species. Only quite recently, river practitioners and the scientific community engaged in river conservation have come to truly understand and appreciate the important linkages between land, freshwater and oceans and associated ecological processes with them. Increasingly, it has been realized by all concerned that *ad hoc* or piecemeal, small scale conservation interventions are unlikely to be able to respond to the growing challenges. The complex and dynamic nature of river ecosystems requires a comprehensive strategy following a systems-based approach, recognizing physical, biological, ecological, socio-economic, political and cultural aspects of the river and human systems those are intricately inter-connected. The newer science of river management calls for integration and involvement of allied multi-disciplinary disciplines *viz.*, geomorphology, hydrology, climatology, landscape ecology and planning, hydraulic engineering, forestry, and aquatic and terrestrial ecology besides social sciences. In a nutshell, river conservation and restoration efforts require involvement of a large number of stakeholders i.e., varied sectors, line agencies, government and non-governmental organizations, varied users and local communities living in the surrounds of a river those now consider physical, biological and socio-economic sub-environments of a river in a holistic perspective. The Potamology (study of rivers) pay greater attention on fluvial and ecological processes and emphasize the riverine landscape perspective as rivers are open ecosystems.

1.5.1 River Ecology

In the perpetual journey from source-to-sea, a river from its origin in the mountainous tract to sea not only crosses hills, lands, valleys and plains but, also interact with wide ranging objects and diverse biota those come across. Thus, a river is much more than the flowing water inside it. Obviously, water is just one of the components of an intricate and dynamic river. Along its entire course, a river is vital resource for sustaining human life but, also for the existence of flora and fauna. Rivers are a dynamic combination of biotic i.e., riparian vegetation and aquatic organisms and abiotic i.e. water, rocks, sediments, riverbed, banks components, all participating in a complex dance from the point of origin to sea where the journey ends. Rivers are viewed as arteries of the catchment. River flow or hydrology is the central driving force of river ecology.

Flow is greatly influenced by precipitation i.e., rainfall and snowfall in the catchment. The climatic conditions like sunshine, temperature alongwith human disturbance like forest fires and deforestation, generally enhance snow and glacier melts. Catchment of rivers often experiences high spatial and temporal variability in climatic conditions. Manmade physical barriers and varied mechanisms created to divert water from rivers generally reduce the environmental flow (e-flow) or its seasonal patterns significantly. In most rivers, altered patterns of temporal variation in e-flows are considered as the primary cause of changes in structure, composition and function of a river ecosystem and dependent biota as either they try to adapt to changed situation or suffer drastic loss or even local extinction. Besides prevailing climatic variability and hydrological processes, geomorphology also dictates how water flows across the landscape or



Dynamic flow in the numerous perennial streams contributing to the Tirthan River

in other words, the hydrology of the river itself. In turn, hydrology affects geomorphology, particularly soil and bank erosion and resultant process of sedimentation. Further, the state and dynamics of terrestrial and aquatic ecosystems can be influenced by the distribution and movement of water through a diversity of mechanisms. According to Sponseller *et al.* (2013), these mechanisms can be grouped into three broad categories wherein water acts as; (i) a resource or habitat for biota, (ii) a vector for connectivity and exchange of energy, materials, and organisms, and (iii) as an agent of geomorphic change and disturbance. In short, water flow influences a broad array of interrelated ecological, biogeochemical, and geomorphological processes that impact ecosystem functions viz., productivity,

decomposition, energy flow and nutrient cycling besides diversity of flora and fauna. A variety of factors *viz.*, land use change, development of water resources or physical barriers, industrial and agricultural expansion, and urbanization or their combined effect not only perturbs the river ecology but also creates enormous challenges for mankind as well as the fragile river ecosystem.

1.5.2 River – Ecological Concepts and Connectivity

Ecological connectivity has become a cornerstone in conservation science and practice owing to the fact that wide spread habitat fragmentation of natural ecosystems has occurred in human dominant landscapes during the era of industrialization, rapid development and urbanization. Globally, habitat loss and fragmentation has been recognized as a single major threat to biodiversity loss. Climate change is expected to aggravate these effects. Corridors are intended to mitigate the adverse effect of changes in land use and climate change by facilitating movement and dispersal of living organisms among patchy resources, among populations or in emerging ‘source and sink’ habitat dynamics in a landscape. The ecological connectivity refers to the spatial and temporal extents to which living organisms and associated ecosystem services, processes and functions can move between different habitat patches (Huber *et al.*, 2018).

The ecological connectivity in the context of a river is of paramount importance for ecological integrity and long term viability of a river ecosystem. The concept of ecological connectivity is related to the functional aspect of the actual connections among different elements of the complex and dynamic river, from energy to matter, for instance, nutrient cycles, movement of floral and faunal populations and genetic exchange (Mallarch and Marull, 2006). As stated earlier, highly dynamic processes and continuous changes in longitudinal, lateral, vertical and temporal connectivity of a river occur and they constitute unique characteristics of riverine landscape. Rivers are a small fraction of the larger catchment or a landscape, yet because of four types of connectivity within the main channel and beyond in the surrounding landscape, they transform substantial amount of solutes and energy-rich materials (Harvey and Gooseff, 2015). A river from source to sea depicts differentially structured river sections owing to different processes. These sections vary in geomorphology, hydrology, biogeochemistry and ecosystems variables. There is a growing interest in developing insight on rivers from the hydrological, geomorphological, ecological and environmental point of view and there is expanding literature on river ecosystem, connectivity and conservation (Van der Velde *et al.*, 2009).

Various ecological concepts have been developed to describe differences in differentially structured river sections. Early attempts to conceptualize how river changed biologically from source to mouth began in the mid twentieth century. Subsequent to the pioneer work entitled ‘The Ecology of Running Waters’ by Hynes (1970), several major concepts and spinoffs have emerged (Thorp *et al.*, 2006 and 2008; Humphries *et al.*, 2014). Various concepts were intended to holistically describe the source of energy and how river productivity change longitudinally, laterally, and with discharge. The River Continuum Concept (RCC) was the first model created to conceptualize the sources and transport of carbon and energy in river

ecosystems (Vannote *et al.*, 1980). The RCC emphasized the longitudinal links in a river and downstream processing of imported organic matter and predicted that fish species richness increases with the stream size. The ‘Fish Zone Concept (FZC)’ defined zones based on resident species. Following this, the ‘Flood Pulse Concept (FPC)’ was described that arose from dissatisfaction with the generality of RCC. The FPC focused on the patterns and processes along the longitudinal axis of permanent, *lotic* riverine environments (Junk *et al.*, 1989; Humphries *et al.*, 2014) and it emphasized the floodplain as the primary source of the material and energy that fuels food webs in floodplain river. Flood pulse was recognized as the catalyst for material transport, primary production, movement of material and energy from the floodplain into the main channel. The stress is on lateral connectivity than on a longitudinal continuum, and the flood pulse is a batch process rather than a continuous process. Subsequently, a ‘Riverine Productivity Model’ was developed because of the perceived underemphasis of the effect and contribution of the edge of large river to production, particularly in the middle and lower stretches of the river, and the inability of RCC and FPC to effectively clarify the structure of food webs.

Thorp (2006 and 2008) attempted to synthesize various river ecosystem concepts developed during 1980-2004 as the ‘Riverine Ecosystem Synthesis (RES)’. Indeed, RES was not proposed as a completely new model. It was an effort to blend existing landscape models pertinent in the context of *lotic* systems. Thus, RES was a conceptual marriage of the terrestrially-derived hierarchical patch dynamics model with eco-geomorphology that emphasizes ecological aspects of fluvial geomorphology. The RES is an integrated framework to facilitate understanding of both: (a) broad, often discontinuous pattern along longitudinal and lateral dimensions from headwaters to great rivers; and (b) local or regional ecological patterns across temporal and spatial scales (Thorp *et al.*, 2006). More recently, Humphries *et al.* (2014) introduced a simple, holistic model that unifies river ecosystem concept and named it as the ‘River Wave Concept (RWC)’. The RWC proposed that river flow can be seen as a series of waves varying in shape, amplitude, wavelength, and frequency travelling longitudinally and laterally. The position of the wave determines the source of organic production or inputs and the storage, transportation, and transport of material and energy. The RWC explained ecosystem phenomenon at different positions on the river wave and uses the wave as a model for river flow.

It is evident that the science of connectivity in the context of terrestrial landscape and *lotic* river ecosystem has evolved considerably in past 2-3 decades. However, still much needs to be learned in order to improve understanding and effectiveness of design and implementation. More researches on species persistence, behavioral ecology, community structure and likely implications of climate change are essentially needed to advance the knowledge on the vital discipline of the river connectivity (Rudnick *et al.*, 2012). Persistence is a vital concept for evaluating what happens to a species and community when connectivity is lost and which connection is important to maintain them. Current information regarding behavioral response of a species to habitat alterations at the local and riverscape level is inadequate. Landuse changes may lead to behavioral responses those differ widely even within *taxa*. The influence of human activities on faunal behavior and connectivity is poorly understood. Habitat loss and fragmentation greatly influence structure, composition and

ecological processes and can lead to trophic disruption, cascading effect or even collapse. Connectivity is considered as one of the most commonly advocated strategy to help species adapt and survive the climate change as it allows species to shift their ranges in response to changing climate. With advance knowledge in the subject, connectivity designs can facilitate the ability of a species to respond and adapt to climate change (Rudnick *et al.*, 2012).

1.5.3 The Riverscapes

Rivers and streams, by their very nature of long ribbons of aquatic habitat are strongly influenced by the landscape through which they flow and inherently difficult to study (Fausch *et al.*, 2002). Hynes (1975) so aptly stated that “in every respect, the valley rules the stream” while increasingly, human activities rule the valley. Habitats, biological diversity and flow of streams and rivers are strongly impacted by land forms and land use within the surrounding valley at multiple scales. The foregoing description has amply highlighted that the rivers are complex mosaic of habitat types and environmental gradients and characterized by three types of connectivity and spatial complexity. Thus, rivers are increasingly investigated from a landscape perspective, both as ‘landscapes’ in their own right and as ‘ecosystems’ (Hynes, 1975; Wiens, 1989; Allan *et al.*, 1997; Ward, 1998; Fausch *et al.*, 2002; Robinson *et al.*, 2002; Allan, 2004). Increasingly, riverine landscapes are viewed as ‘riverscapes’. Leopold and Marchand (1968) used the concept of ‘riverscape’ (or riverine landscape) as early as in 1960s so as to describe broad-scale physical, biological and aesthetic nature of rivers. A landscape approach is particularly important in natural resource management as humans have altered landscapes at multiple scales. Landscape ecology provides a perspective for integrating ecological processes and spatial complexity (Fausch *et al.*, 2002).

The patterns of biodiversity and ecosystem processes along streams and rivers have long drawn attention of the scientific community and the river and stream ecologists also began to use the concepts from terrestrial landscape ecology in developing theories for *lotic* systems (Ward, 1998; Ward *et al.*, 1999; Wiens, 2002; Montgomery and Wohl, 2003; Zhou *et al.*, 2014). Wiens (2002) observed that the river ecologists have been using and applying landscape ecology for a long time, but they were not calling it that way. Landscape ecology places particular emphasis on spatial heterogeneity, connectivity, and scale, all of which have received considerable attention in running waters (Allan, 1995 and 2004). Thus, in recent decades, a landscape perspective of streams and rivers (‘riverscape’) has emerged (Mallard *et al.*, 2000; Sullivan *et al.*, 2007). The notion of riverscape is applied across multiple spatial scales as it recognizes a stream or river, its floodplain (i.e., area of land regularly covered with water as result of flooding), and riparian area (i.e., land adjacent to the stream that directly affects the stream; includes woodland, vegetation, and floodplain) as an integrated ecological unit (Wiens, 2002; Sullivan *et al.*, 2007). Obviously, a riverscape is an interactive, open system, characterized by high level of natural and human disturbances and interconnected ecotones (Ward, 1989; Ward and Wiens, 2001). Channel geomorphology, hydrological flows and connectivity shape spatial and temporal patterns of the riverscape. The approach of riverscape aims to provide a holistic perspective of patterns and processes occurring within the *lotic* as well as in the surrounding landscape. Effective river

management requires developing an understanding of the complex and dynamic interactions between disturbance regimes, spatial heterogeneity and biodiversity as a prerequisite. This involves a comprehensive analysis of the riverscape using RS and GIS and assessment of the riverscape environment (i.e., physical, biological and socio-economic). The riverine landscapes or river ecosystems are amongst the most developed and affected systems by human activities and in turn affect human perception cognition and values of riverscapes (Nassauer, 1995). The riverscape approach integrates elements of flowing water and land those have been severely impacted by human activities and can contribute meaningfully not only for the sustainability of the riverscape, but also for improving and maintenance of vital ecosystem services in the changing environment (Wu, 2013). The riverscape level planning and assessment are considered vital for rejuvenation of degraded rivers.

1.5.4 The River - Ecological Integrity

The global transition from undisturbed to human-dominated landscapes has impacted ecosystems worldwide, particularly freshwater ecosystems (Allan, 2004). Undoubtedly, in past two centuries or so human activities have not only changed the catchments of the rivers, but also altered river ecosystems from source to sea in multiple ways. Resource and environmental managers are always eager to identify and minimize the effects of changes with negative consequences for human society. Notably, rivers integrate all that happens in its course and surrounding lands, their conditions, especially their biological condition and signals about the consequences of human actions (Karr, 1996). In the case of most rivers, the present conditions of rivers amply reflect that much of the region's rich natural capital has been either over spent or degraded to a severe extent. Increasingly, ecosystem based management to river conservation have been advocated and validated as they focus on key processes that enable river- floodplain systems to maintain, repair and regenerate to a certain state (Sparks, 1995; Middleton, 1999). Assessing the ecological 'health' of rivers has been a fundamental and increasingly important issue for management of freshwater resources worldwide. As a consequence, a variety of terms *viz.*, ecological and biological integrity, stream condition, river health, etc. have emerged to describe the status of fluvial ecosystems and their response to human influences and concurrently a vast array of physical, chemical, biological and ecological monitoring approaches have been developed and being used (Karr, 1981 and 1991; Bunn and Davies, 2000; Jungwirth *et al.*, 2000). Definitions of terms such as ecological 'health' and 'integrity' are often the subject of much contention and have been critiqued (Suter, 1993; Wallace *et al.*, 1996; Schaeffer *et al.*, 1998; Bunn and Davies, 2000; Schallenberg *et al.*, 2011).

The composite concept of 'ecological integrity' has become a worldwide phenomenon and is firmly entrenched into the regulatory structure of environmental laws in most countries. It encompasses several ecological components (Barbour *et al.*, 2000). A widely recognized definition of ecological integrity given by Karr and Dudley (1981) emphasized its use in the assessment of water quality and defined it as "the ability of an ecosystem to maintain a balanced, integrated and adaptive community of organisms having a species composition, diversity and functional organization comparable to that of natural habitat of the region". In other words, ecological integrity is perceived as the maintenance of all internal and external

processes and attributes interacting with the environment or ecological processes in such a way that the biotic community corresponds to natural state of the type-specific aquatic habitat following the principles of ‘self-regulation’, ‘resilience’ and ‘resistance’ (Schofield and Davies, 1996). According to Campbell (2000), ‘ecological integrity is an ecosystem property that reaches the highest level when its structure is complete and when all processes inside it work perfectly.’ Healthy ecological systems have a high capacity to resist the disturbance imposed by natural environmental phenomenon and several manmade alterations (Karr *et al.*, 1986; Oliveira and Cortes, 2006).

Schallenberg *et al.* (2011) based on his review of 18 working definitions of ecological integrity cited from the literature, revealed that although there was some degree of divergence in the terminologies used (e.g., naturalness, pristineness and wilderness), four main components i.e., nativeness, pristineness, diversity and resilience arose from most of the definitions that could be related to conservation of natural heritage. Nativeness has been viewed as an important aspect of ecological integrity as a high degree of dominance of native species in a river often equates to high ecological condition or integrity (Clayton and Edwards, 2006). Ecological condition is defined by similarity of a test site to a set of least-impaired reference or control sites (Allan, 2004). Like nativeness, pristineness is a concept strongly linked to a reference state, requiring knowledge of the natural state of an ecosystem. In the context of river ecosystems, connectivity is an important aspect of pristineness. The foregoing sections have already elaborated on the vital aspect of connectivity. It relates to the maintenance of natural migration pathways and allowing recolonisation after perturbation, being a feature of resilience. Diversity of habitats and associated floral and faunal species is an important element of the ecological integrity. Moreover, spatial heterogeneity of habitats is important for maintaining biological diversity. Maximizing diversity in a complex and dynamic river is desirable goal regardless of the reference state, as complexity often relates to maintenance and stability. Yet another key component of ecological integrity is resilience, referred to as ‘self-renewable capacity’ and ‘long term viability’ or the ability of the river ecosystem to revert/exists despite natural environmental fluctuations. Resiliency relates to both structural and functional ecosystem components while adaptation, acclimation and other form of biotic and ecosystem changes are essential for long term viability (Schallenberg *et al.*, 2011).

1.5.5 River Restoration

Rivers have a long history of alteration by humans for multiple uses and benefits (Cairns, 1988 and 2006). Alteration of rivers has often been carried out with the best of intention, but without knowledge of the potential manifestations and repercussions for the diversity, connectivity and ecological integrity of the river ecosystem (Addy *et al.*, 2016). Human development has resulted in a significant decline in the health of rivers resulting into deteriorating flow regimes, discharge of organic and toxic effluents, damaged and mutilated ‘organs’ i.e., the tributaries, the riparian vegetation, the floodplain, the bed, and the biota of the river (Speed *et al.*, 2016). ‘River restoration’ is now a common response to declining river health and its importance to water resource management can only be expected to grow. River restoration is widely accepted by most national governments and various stakeholders as an

essential complement to conservation and water management strategies. However, despite legal mandates, huge investments, emergence of newer approaches and fast developing industry of aquatic and riparian restoration, river ecosystems continued to deteriorate as a result of human influences (Karr and Chu, 1999; Wohl *et al.*, 2005). Now, the discipline of river restoration is at the forefront of the hydrologic or river science and it is fast growing.

Varied concepts *viz.*, ‘restoration’, ‘ecological restoration’, and ‘river restoration’ have come into existence and evolved in past 5-6 decades. The term ‘restoration’ normally implies the act of restoring to a former/original state or position or to an unimpaired or perfect condition. Thus, restoration has both the implications of returning to an original state and to a state that is perfect and healthy (Bradshaw, 1987 a, b, c 1996). The US National Research Council defined restoration as the return of an ecosystem to a close approximation of its condition prior to disturbance. In restoration, ecological damage to the resource is repaired. Both the structure and functions of ecosystems are recreated. The goal is to emulate a natural, functioning and self-regulating system that is integrated with the ecological landscape in which it occurs (NRC, 1992). In ‘ecological restoration’, it should be thought as applying to whole ecosystem.

Broadly, ‘river restoration’ focuses on any action aimed at improving the health of river, including improving ecosystem functions and any of the related ecosystem services. River restoration has been defined as ‘assisting the recovery of the ecological structure and function in a degraded river ecosystem by replacing lost, damaged or compromised components and re-establishing the processes necessary to support the natural ecosystem and to improve the ecosystem services it provides’ (Speed *et al.*, 2016).

Over time, definitions for both ecological restoration and river restoration have shifted from a somewhat idealized notion of returning ecosystem to a natural or pristine state, to more pragmatic and utilitarian approach to viewing and managing (river) ecosystems. Parallely, several terms related to restoration have come into existence and being widely used. These terms are: ‘rehabilitation’, ‘remediation’, ‘reclamation’, ‘replacement’, and ‘mitigation’ and defined by Bradshaw (1996). According to Speed *et al.* (2016), restoration is distinguished from ‘rehabilitation’, which describes measures that address only some elements of change within degraded system, but still aim to return to the ecosystem closer to its original condition. In contrast ‘remediation’ refers to changing to an ecosystem to an alternate condition that differs from both its current and original state, albeit with some improved values and functions. The concepts of rehabilitation and remediation recognize that in several instances, the extent of alterations caused by human over many years, together with the impacts associated with ongoing human activities, make restoring ecosystems to their natural condition either unrealistic or undesirable (Fig. 1.1). In addition, ‘replacement’ is possible alternative option so as to ‘provide or procure a substitute or equivalent in place of the original’. ‘Mitigation’ is nothing to do with restoration. Instead mitigation is ‘to moderate that is harmful, unpleasant or bad’. Probably, in several instances, the term ‘river rejuvenation’ has been inappropriately used to describe an effort aimed at restoring poor health of overexploited and polluted rivers (Shekhar, 2016). It seeks an understanding of the causes for poor health and restoration efforts from source to sink. Rejuvenation has been

described as the action of restoring a river or stream to a condition characteristic of a young river, one with a gradient that is raised by the earth's movement, returning an old age river to a youthful state and which repeats the cycle of the stages once again (Immoor, 2006). However, in parlance of geomorphology, a river is said to be rejuvenated when it is eroding the landscape in response to lowering of its base level. The process of rejuvenation occurs when the river's base level falls (i.e., when sea level falls). This can be a consequence of either a fall in the amount of sea water or the land rising. Both are the result of the comings and goings of ice ages. The effect on rivers is to produce features called “knickpoints” which can be seen as waterfalls and rapids, river terraces and incised meanders (Jackson, 2014).

Catchments of Himalayan Rivers

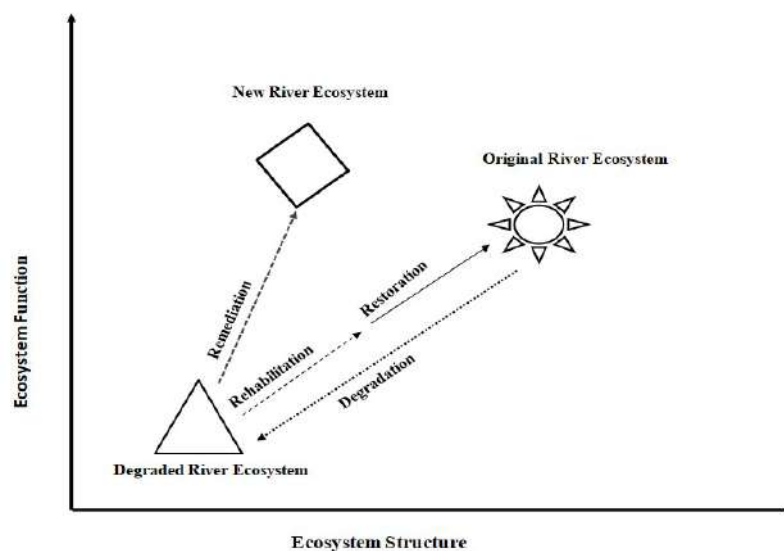


Fig. 1. 1 - One Example of an Approach to Distinguishing between Restoration, Rehabilitation, and Remediation

(Source: Based on Bradshaw, 1996)

The concept of river restoration has evolved over time from one-dimensional responses aimed at addressing on a single issue (e.g., water quality) to more sophisticated approaches that involve both ‘active restoration’ and ‘passive restoration’. ‘Active restoration’ involves direct interventions to modify the river system (e.g., planting riparian vegetation, modifying or removing barriers within the river channel, or reintroducing native species) while ‘passive restoration’ involves changing the way human systems i.e., people, government, businesses, and societies more broadly operate, with the goal of reducing their impact on river ecosystems. This can involve regulatory measures to restrict or mandate certain behavior, education to encourage voluntary changes in behavior or market measures to provide economic incentives (Speed *et al.*, 2016). In short, river restoration or water management strategies all around the world have moved from the engineering dominated *command and control* approach to an integrated ecosystem based approach that relies on the synthesis of the hydrological, geomorphological and ecological data (Downs and Gregory, 2004; Kondlolf *et al.*, 2006; Brierley and Fryirs, 2008; Thorp *et al.*, 2008; Sinha *et al.*, 2013). The command and control approach was followed for a long time and widely used habitat enhancement structures including flow deflectors, rubble mats, boulder clusters, artificial riffles and fish cover constructed from stones, concrete and wood were deployed. However, increasingly ecosystem based approach which is holistic, trans-disciplinary, focuses on ‘causes’ and applied at catchment to reach scale are being used. Obviously, the earlier focus of restoration was on narrow range of river forms, habitat or species and they did not tackle the problem of causes. Most activities were on small spatial scale having limited influence and often required regular maintenance to prolong their lifespan. In the newer approaches of river restoration, emphasis is on catchment–scale planning and processes while having focus on tackling the causes of degradation rather than the symptoms.

The effective river restoration strategy involves three major steps for planning. Firstly, achieve a geomorphological, hydrological and ecological understanding of restoration need within the catchment context. This step helps in identifying the causes of degradation to determine which alterations are limiting natural habitat. The second step focuses on taking into account socio-economic constraints and opportunities. Establishing early dialogue with agencies, land owner and communities is vital to get an insight on likely barriers and gaining support, without it restoration cannot proceed (Souder, 2013; Smith *et al.*, 2014). The third step seeks to define clear goals, timelines for recovery in response to selected restoration strategies, actions and outcomes (Skidmore *et al.*, 2013). Addy *et al.* (2016) have described six key principles those underline the efforts of all initiative to promote restoration (Fig. 1.2). The six key principles emphasize: (a) improvement in overall ecosystem integrity rather than focusing on the single species by using process based techniques; (b) engage different stakeholder groups at early planning stage and involve them all through the restoration process; (c) understand the connection between natural processes upstream and downstream and consider various elements of river ecosystems (e.g., riparian areas, floodplains and the wider catchment); (d) target actions at the root causes of the degradation rather than symptoms; (e) use minimal interventions to reinstate natural processes so that rivers can recover by themselves; and (f) built-in integral robust monitoring and evaluation system to assess outcomes and inform future restoration.

1.6 Rivers – Concerns for Conservation

Running waters, particularly streams and rivers are among the most impacted and threatened ecosystems of the world (Malmqvist and Rundle, 2002; Dudgeon *et al.*, 2006; Asaeda *et al.*, 2009, Sabater *et al.*, 2013). The river science has evolved over more than a century to define threatening trends and mechanisms that cause them. Voluminous and growing literature exist highlighting human impacts on river morphology, hydrology, biology and ecology. Riverine ecosystems have been systematically modified since millennia as they attracted humans for settlement. Historic degradation of river ecosystems accelerated periodically by surges of economic and/or technological power. Riverscapes have been dramatically reshaped to accommodate extensive and intensive agriculture, industrial uses and high density habitation. Harnessing of fossil fuels increased capacity to mechanically move material and enabling society to engineer and reshape the contours of the rivers and the surrounding landscape on unprecedented scales. Amplified access to alternate energy sources, especially hydropower by constructing on an average one high dam (45 m) every day for the past 140 years or so and other forms of river modifications are reflecting the scale of impacts on aquatic biodiversity (Bai *et al.*, 2015; Sendzimir and Schmutz, 2018). Land use changes and various pollutants severely impacted rivers. Industrialization had large scale effect on river uses and their impacts. Deliberate introduction of non-native fishes altered aquatic biota. Geo-engineering of rivers has not only channelized rivers for transport, but also separated channels from their floodplains. The historic evolution of river uses and resulting ecological impacts exhibit distinct temporal patterns. Rivers offer prime examples of freshwater ecosystems impacted by multiple stressors and their interactions especially in complex and hierarchical systems.



Fig. 1. 2 - Key Principles of River Restoration

(Source: Adopted and Modified from Addy *et al.*, 2016)

Degradation of river ecosystems owing to various human impacts has drastically reduced the ecosystem services, once they used to offer. Moreover, global climate change, which may override or magnify some of the impacts, will affect river ecosystems and the society at large. Human adaptation to climatic uncertainty is expected to further alter river systems by likely engineering responses (Vörösmarty *et al.*, 2010). Understanding the history of human impacts and identifying tipping points of degradation of river ecosystems are pre-requisites for developing sound water and river management strategies.

In the context of rivers, water is the master variable as water runs the river. Flow regimes are very important for maintaining the structure, functions and processes of riverine ecosystems. The river flow determines the essentially required dynamics of the four dimensional connectivity of river (Ward, 1989; Sabater *et al.*, 2013; Zeiringer *et al.*, 2018). Water crisis and associated problems arising either due to reduced water flow or non-availability in some seasons, particularly in downstream areas are leading into inter-state river disputes and civil unrest. Likewise, in the case of trans-boundary rivers, there is a growing concern arising due to international disputes amongst the countries sharing water resources of a river.

Dendritic stream-river networks are the backbone of the most landscapes and determine linkages between the terrestrial and aquatic ecosystems. A greater understanding of interactions between landscape conditions over large spatial extents and instream responses would be highly desirable (Trautwein and Pletterbauer, 2018). Rivers have experienced human induced modifications for a long time and in the near future, it is much more likely that human induced modifications will clearly and unequivocally be accompanied by climate change effects (Hohensinner *et al.*, 2011; Pletterbauer *et al.*, 2018). In spite considerable progress has been made in river restoration activities in the last decade or so, much needs to be done as restoration activities are constrained by several factors including the poor understanding of the complex and dynamic river ecosystems; declining environmental flows; and inadequate researches, lack of infrastructure, successful case studies and other resources besides essential prerequisite inter-agency cooperation and support of users, land owners and communities (Sabater *et al.*, 2013; Hjaltén *et al.*, 2016).

1.6.1 Indian River Systems

Rivers, particularly large river systems, constitute one of the most important, essential and vital life support systems that have sustained civilization for >5,000 years, and are projected to be a critical determinant for the sustainability of humanity (Sinha *et al.*, 2012 and 2013). Large river systems are the most important continental geomorphic systems, and are generally defined by one or more of the following criteria: drainage area (A) = 8,00,000 km², river length (L_r) = 2,500 km, average discharge (Q') = 7,500 m³/s, and suspended and dissolve load = 100 mt/yr (Potter, 1978; Hovius, 1998; Gupta, 2007; Sinha *et al.*, 2012). Large rivers also have vast and long-lived deltas. Further, large rivers and their valleys have long time-period alluvial stratigraphic records revealing their development on varied time scales from century to tens of millions of years (Tandon and Sinha, 2007). Based on the stated criterion, nearly 38 large rivers have been recognized across the globe and their locations are shown in Fig. 1.3. Most large rivers face a pandemic deterioration due to

increasing human impact resulting into degradation of river ecosystems, serious threats to biodiversity and water security.

India owing to strategic location on the confluence of different biogeographic realms is endowed with the rich and unique diversity of natural resources; mighty rivers are one of them. India is privileged to have four large river systems *viz.*, Indus, Ganga, Brahmaputra and Godavari (FAO - AQUASTAT, 2011a; Balasubramanian, 2007). The rivers of India have been broadly categorized into the following four groups:

The Himalayan Rivers: The Himalayan Rivers are fed by melt of snow and glaciers and flow throughout the year. During the monsoon season, these rivers assume alarming proportions as they carry enormous sediment and cause frequent floods. The Indus, Ganga and Brahmaputra along with their tributaries form the most important river systems.

The Deccan or Peninsular Rivers: The prominent rivers originating from varied mountain ranges namely Satpura and Vindhyas in the Deccan or Peninsular region of the country are rainfed (thus non-perennial) and fluctuate in volume. Important rivers *viz.*, Mahanadi, Godavari, Krishna, Pennar and Cauvery drain into the Bay of Bengal in the east while westerly flowing Narmada and Tapi Rivers flow into the Arabian Sea.

The Coastal Rivers: The short rivers arising either from the Western Ghats or the Eastern Ghats with limited catchment area, especially on the west coast, south of Tapi and non-perennial are included in this category. Prominent rivers in this category are in parts of Gujarat, Goa, Maharashtra, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Odisha and West Bengal. Important rivers are: (a) Machhu, Bhadar, Hiran, Shingoda, Machhundri and Raval in Gujarat; (b) Vashishti, Savitri, Ulhas, Mithi, Tansa, Dahisar and Vaitarna in Maharashtra; (c) Terekhol, Mandovi, Baga, Zuari, Colval, Saleri, Mandre, Harmal, Sal, Talpona and Galjibag in Goa; (d) Netravati, Sharavathi, Aghanashini and Palar in Karnataka; (e) 44 rivers in Kerala including Chalakkudy, Neyyar, Pampa and Periyar; (f) Thamirabarani, Vaigai, Vellar, etc. in Tamilnadu; (g) Vamsadhara, Nagavali and Sharada in Andhra Pradesh; and (h) Subernarekha, BudhaBalanga, Baitarani and Brahmani in Odisha.

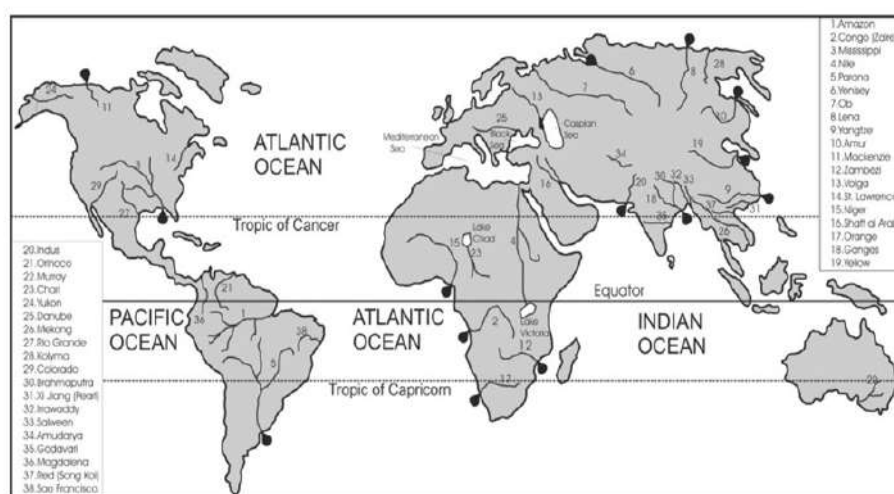


Fig. 1.3 - Major Rivers of the World; Numbers Correspond to the River Names as Listed
(Source: Adopted from Tandon and Sinha, 2007)

Inland Drainage Basin Rivers: A few small rivers originate from Aravalli hills do not drain into sea instead they drain into salt lakes and get lost in sandy desert or the Rann of Kutch. These are Luni, Sarasvati and Banas.

a. River Basins

A river basin is the part of a land through which the main river and all its tributaries flow. It is the basic hydrologic unit for planning and development of water resources of a country. Other terms

used with river basin are catchment area, catchment basin, drainage area, water basin and drainage basin. A drainage basin is any area of land where precipitation collects and drains off into a common outlet, such as into river, bay or another body of water. The drainage basin includes all the surface water from rain runoff, snow/glacial melt and nearby streams that run downslope towards a shared outlet, as well as the groundwater underneath the earth surface.

Rivers form a hydrological mosaic, with an estimated 263 international river basins covering 45.3% of the land surface area of the earth, excluding Antarctica (Rekacewicz and Digout, 2005). Continental aquatic systems from rivers to the coastal zones are considered as major link between the atmosphere, pedosphere, biosphere and oceans within the Earth system with its Holocene dynamics while water and aquatic biota resources are being progressively used and transformed by humans (Meybeck, 2003).

The river basins of India have been classified into three categories; (i) Large river basins having catchment area of $>20,000 \text{ km}^2$; (ii) Medium river basins having catchment area between $2,000 \text{ km}^2$ to $20,000 \text{ km}^2$ and (iii) Minor river basins having catchment area $<2,000 \text{ km}^2$ on the basis of area drained (Rao, 1979). Accordingly, the Indian geographic extent has been divided into 113 river basins including 14 large, 44 medium and 55 minor basins. Concerned government agencies *viz.*, Central Water Commission (CWC), Central Ground Water Board (CGWB), Government of India Web Portal, and River India - Water Resources Information System (India- WRIS) by CWC and National Remote Sensing Centre (NRSC) have described varied number of basins due the fact that various agencies have either bifurcated larger basins into smaller one or clubbed smaller ones as single entity (Chatterjee and Sinha, 2014). However, 14 are large river basins while remaining 99 basins have been grouped into 6 river units. The spatial distribution of river basins is presented in Fig. 1.4 (CWC, 2017). The 14 major river basins in descending order of area are: the Ganga, Indus, Godavari, Krishna, Brahmaputra, Luni, Mahanadi, Narmada, Cauvery, Tapi, Pennar, Brahmini, Mahi, Sabarmati, Barak and Subarnarekha, and they cover about 84% of the total drainage area of the country. The spatial imbalance in distribution of water resources can be appreciated by the fact that Ganga-Brahmaputra-Meghna basin covers 34% of the country's area and contributes about 59% of the water resources while the west flowing rivers towards the Indus cover 10% of the area and contribute 4% of the water resources as shown in Fig. 1.5 (CWC, 2017). The remaining 56% area contributes 37% of the water runoff in various rivers of the country (FAO - AQUASAT, 2011b).

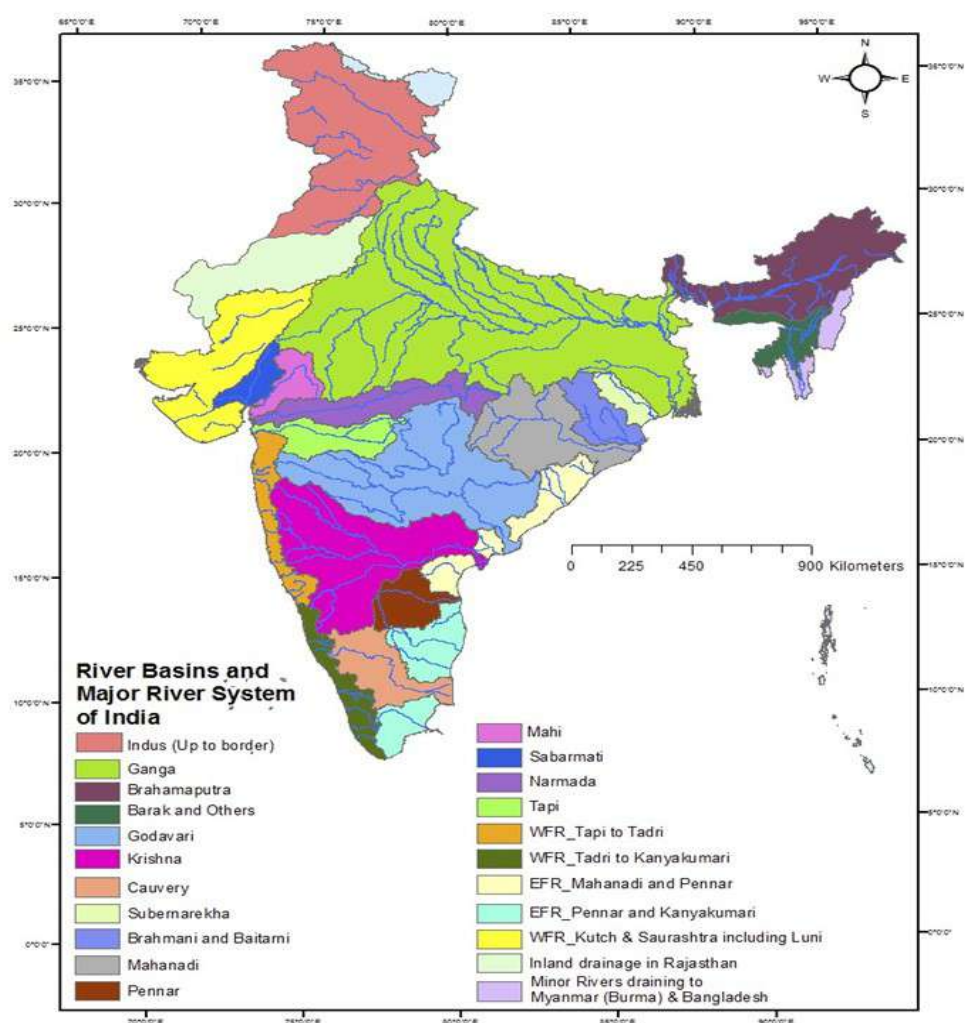


Fig. 1. 4 - River Basins and Major River Systems of India
(Source: CWC, 2017)

Table 1. 1– Area and Population of the Major River Basins Originating in the HKH

River Basin	Area (km ²)	Population in 2010 (million)	Population in 2015 (million)
Amu Darya	6,45,870	27.1	30.18
Brahmaputra	5,28,083	64.63	68.07
Ganga	10,01,090	539.43	580.09
Indus	11,16,350	244.31	268.42
Irrawaddy	4,26,393	40.18	42.87
Mekong	8,41,337	74.58	77.31
Salween	3,63,898	18.19	17.88
Tarim	9,29,254	10.65	11.37
Yangtze	20,66,050	600.92	604.94
Yellow River	10,73,440	192.86	198.02
Total	89,91,765	1,812.95	1,899.14

(Source: Sharma *et al.*, 2019)

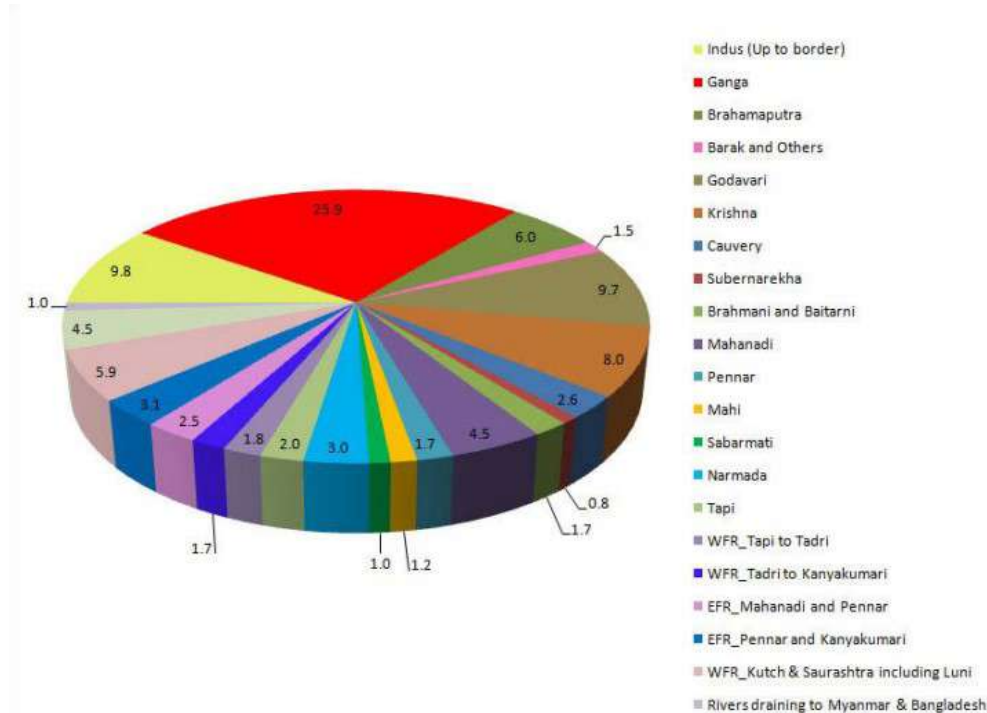


Fig. 1.5 - Percentage of Geographical Area in Each Basin
(Source: CWC, 2017)

b. The Hindu Kush Himalaya – A Global Asset and a Major Source of Fresh Water

Nearly half of the humanity directly depends on mountain resources, primarily on fresh water. Mountains provide a wide array of ecosystem services of global significance including water for people inhabiting the mountains as well as people living in downstream areas of major rivers or their tributaries originating from different hill ranges (Wester *et al.*, 2019). The Hindu Kush Himalaya (HKH), a critically important geo-ecological asset is the origin of 10 major river basins and encompasses over 4.2 million km² area (Bajracharya and Shreshtha, 2011; Bajracharya *et al.*, 2015; Sharma *et al.*, 2019) (Fig.1.6). The HKH area and Tien Shan Mountains together form the largest area of permanent ice cover outside the North and South Poles. Hence, the HKH is being referred as the ‘Third Pole’ or the water tower of the world. The terrestrial and aquatic ecosystems in the HKH are home for rich and spectacular biodiversity. The HKH harbors the world’s highest peaks and home for hundreds of mountains peaks >6,000 m. The HKH region sustains the livelihoods of 240 million people living in its varied mountain ranges and hills (Sharma *et al.*, 2019).

Nearly 1.9 billion people living in the ten river basins having origin in the HKH region also get directly or indirectly multiple benefits from its resources, including the 240 million people living in the mountains and hills of the HKH (Table 1.1). In the context of the Indian sub-continent, three mighty Himalayan Rivers *viz.*, the Indus, Ganga and Brahmaputra (IGB) river systems south of the HKH ranges attain special significance from the perspectives of history, mythology, culture, economy and ecology (Ericksson *et al.*, 2009; Nepal and Shreshtha, 2015). Amongst the 10 major river basins in the HKH region, the Indus River is

one of the longest rivers in Asia and its basin is shared by China (Tibet), India, Pakistan and Afghanistan. It constitutes the second largest drainage with 11,16,350 km² area. Certainly, the Indus River and its tributaries have immense significance for the two human dominated nations (i.e., India and Pakistan).

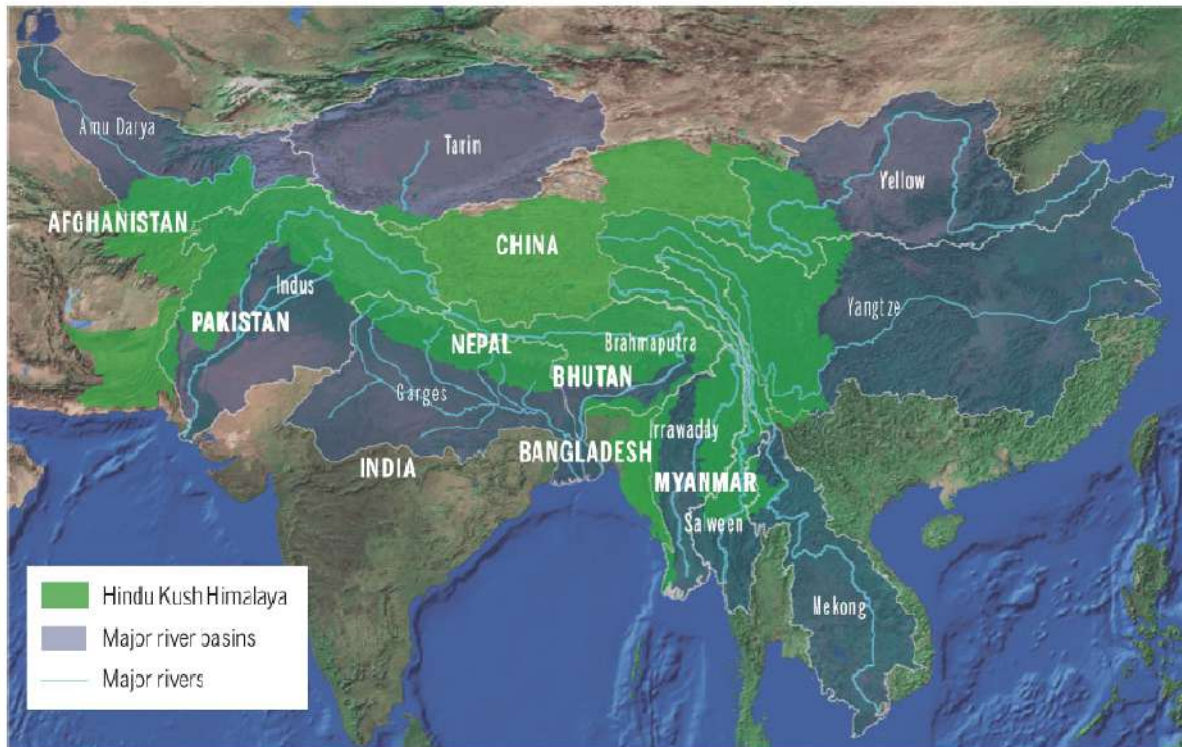


Fig. 1.6 – 10 Major River Basins of Hindu Kush Himalaya
(Source: Sharma *et al.*, 2019)

c. The Indus River System

The transboundary Indus River Basin with the approximate area of 1.12 million km², is located in four countries, of which the largest part is distributed in Pakistan (47%), and substantial upstream parts in India (39%), China (8%) and Afghanistan (6%) (FAO – AQUASTAT, 2011b). According to CWC (2017), the basin in India, the basin spreads over the Ladakh and Jammu and Kashmir Union Territories, Himachal Pradesh, Punjab, Rajasthan, Haryana and Chandigarh Union Territory. Ladakh and J&K UTs share the highest extent of basin area, being 1,93,762 km² (60%), followed by Himachal Pradesh (51,356 km² or 16%) and Punjab (50,304 km² or 15.96%). Rajasthan and Haryana States contribute 5% and 3% extent of the basin, respectively, Chandigarh UT has a minuscule extent of 114 km² or just 0.04% of the total basin area. The geographical extent of the basin is between latitude N 29°08' to 36°59' and longitude E 72°28' to 79°39' with a maximum length and width of 756 km and 560 km, respectively. The basin is bounded by the Himalaya on the east, by the Karakoram and Haramosh Ranges on the north, by Sulaiman and Kirthar Ranges on the west, and by the Arabian Sea on the south (India-WRIS, 2012). The Indus catchment area is unique in the sense that it contains seven of the world's highest peaks after Mt. Everest including K2 (8,600 m), Nanga Parbat (8,100 m) and Rakaposhi (7,800 m) and the world's highest motorable passes viz., Umling La (5883m) and Khardung La (5,359 m). Nearly 55% area of

the Indus River basin within India lies above 3,000 m elevation (India-WRIS, 2012). The land use/ land cover mapping undertaken in the Indian part of Indus River Basin by India-WRIS revealed that agriculture land accounts to 35.8% of the total area while diverse forests covered 15.09% area. Snow and glaciers covered 12.46% area. Wastelands occupied as high as 28.53% area of the basin within India. Grasslands and water bodies represented 4.19% and 1.85% area, respectively while built up land covered just 2.09% area.

The Indus - Origin to Mouth: The Indus River (locally called '*Sindhu*' in India) originates from the lofty mountains of Himalaya at the confluence of the *Sengge Zangbo* (or 'Lion's Mouth', a perennial spring) and *Gar Tsangpo* Rivers that drain *Nganglong Kangri* and *Gangdise Shan* (*Gang Rinpoche*, Mt. Kailash) mountain ranges around Mansarovar Lake in Tibet (China) in the north at an elevation of 5,182 amsl. Firstly, the Indus River flows northwesterly through Ladakh region in India, followed by Gilgit-Baltistan south of the Karakoram Range. Subsequently, the river changes its direction towards southwards and traverses through the alluvial plains of Punjab and Sindh provinces in Pakistan, and finally flows out into the Arabian Sea before forming a large delta. The river feeds the second largest sediment body on the earth i.e., the Indus submarine fan. Total length of Indus River from its origin to mouth/outfall in the Arabian Sea is 2,880 km, out of which 1,114 km flows through India. The Indus River is the twelfth largest river in the world (Ojeh, 2006).

Tributaries: The Indus River System consists of several tributaries that collect glacier, snowmelt and rain from the highest peaks of the Himalaya and carry to the Arabian Sea (Dinar *et al.*, 2007). The Indus River in its long journey from the origin to the Arabian Sea receives several important tributaries on its right and left banks (Ali, 2013). A diagrammatic representation of the flow of Indus River, its tributaries, details on various confluences and prominent dams/reservoirs along with hydroelectric projects has been presented in Fig. 1.8. The Zaskar River is the first major left bank tributary flows into the Indus in Ladakh, and has a greater volume of water than the Indus itself before that point. Shyok River originates in Ladakh, India, joined by Nubra River and flows in the Gilgit-Baltistan before its confluence on the right bank. Hunjza and Gilgit Rivers, originating in the Gilgit- Baltistan also join the right bank.

The Indus River in Pakistan receives five important tributaries on its left bank from India. The Jhelum River originates from Verinag in the Kashmir Valley, Jammu and Kashmir Union Territory of India and flows westerly and enters into Pakistan. Chenab, Ravi and Beas Rivers originate in Himachal Pradesh. Chenab River originates from Chandertal in Lahaul and Spiti in Himachal Pradesh (FAO – AQUASTAT, 2011b). The Chenab River first flows northwesterly through J&K, UT and later in the Punjab province of Pakistan. The Jhelum River ends in a confluence with the Chenab River at Trimmu in District Jhang of Pakistan. Ravi River after its origin in Kangra District, Himachal Pradesh flows through the plains of Punjab, India and finally enters into Pakistan. It joins the Beas River at Trimab, some 65 km below Trimmu. The Beas River originate from beas Kund in Kullu, Himachal Pradesh, flows southwesterly before its confluence with Sutlej River at Hari-ke-Patan, Punjab, India. The Sutlej River originates in western Tibet, China in Mt. Kailash range and adjacent to the origin points of rivers Indus, Ganga and Brahmaputra. It enters in India from the eastern part of

Himachal Pradesh state at Shipki La at the Indo-China border and flows westerly through the hilly state of Himachal Pradesh. before entering into the plains of the Punjab State, India. Finally, the Sutlej River out flows into the plains of the Punjab Province of Pakistan till its confluence with joint waters of *Trimab* (i.e., Jhelum, Chenab and Ravi). The meeting point of the combined Sutlej, Beas, Ravi, Chenab and

Jhelum is called '*Panjnad*'. Below about 70 km to Panjnad, the combined waters of five rivers join the Indus River at Mithankot in west Punjab of Pakistan. The Indus River has two main tributaries, Kabul on the right bank and Panjnad on the left (Ali, 2013). The Panjnad is the flow resulting from the five main rivers (literally Punjab means 'five waters'). The Jhelum and Chenab rivers known as the western rivers, and the Ravi, Beas and Sutlej, known as the eastern rivers join the Indus River (Fig. 1.7).



Fig. 1. 7 – Indus River and Its Tributaries
(Source: wikipedia.org)

River Flow Line Diagram

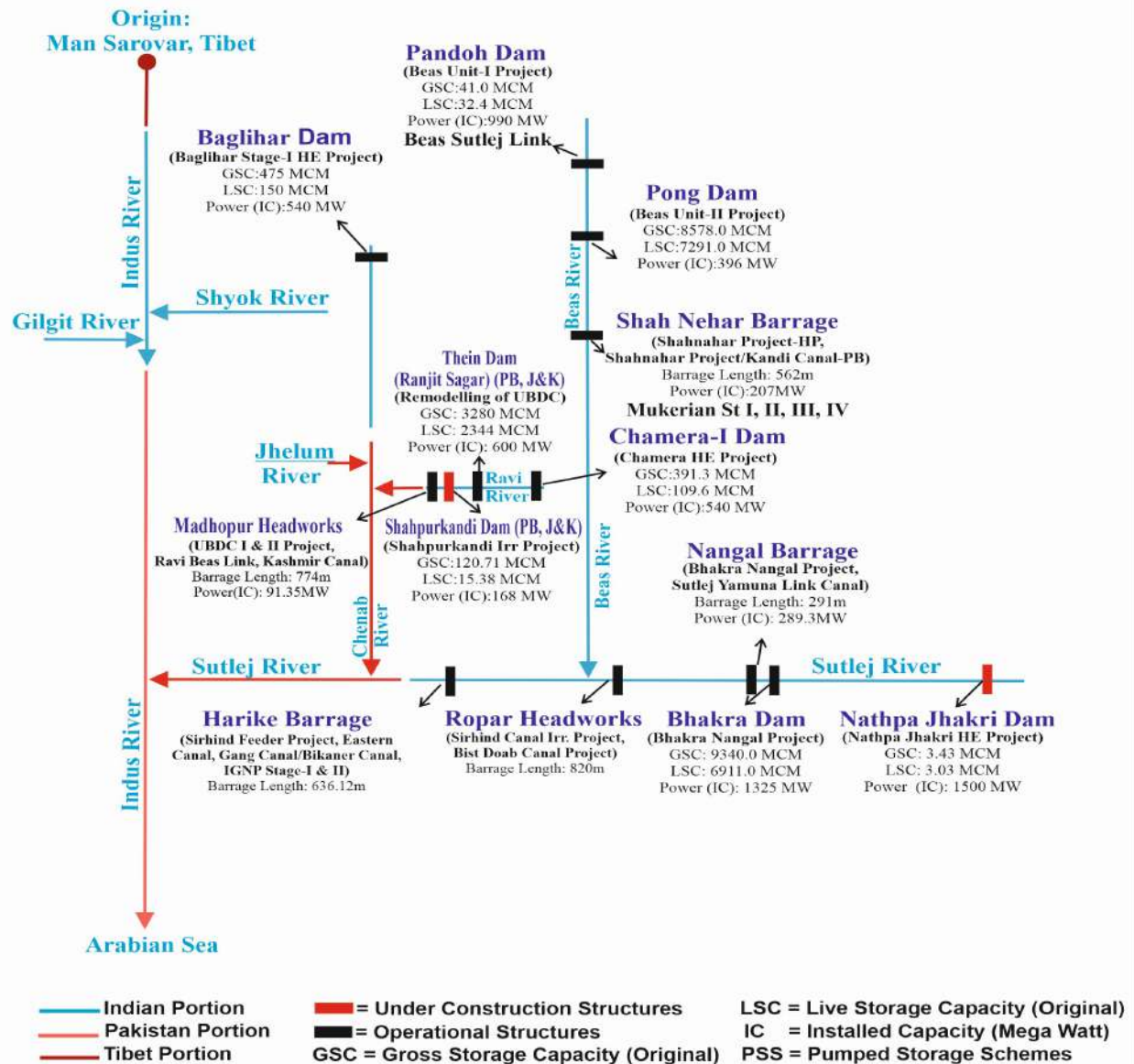


Fig. 1.8 – Indus River Flow Diagram

(Source: India-WRIS, 2012)

Climate: Climate is an important geographic factor regulating the water runoff of the Indus River Basin as climate in the basin is controlled by two giant wind-systems; (a) the western disturbance, and (b) the monsoon wind systems originating from the Arabian Sea during the summer season. The average temperature of the Indus basin is measured as 19.6° C (Ali, 2013). The Indus basin sprawls over a vast extent with a wide variability in climatic conditions ranging from the cold desert in the source region to tropical humid near its mouth. The Upper Indus River basin is a high mountainous region and mountains limit the intrusion of monsoon, the influence of which weakens northwestward. Most of the precipitation falls in winter and spring and originates from west. Monsoonal incursions bring occasional rains to Trans-Himalayan region. Climatic variables are strongly influenced by altitude. Northern valley floors are arid with annual precipitation ranging from 100 - 200 mm. Winter precipitation (October to March) is highly spatially correlated across the Upper Indus basin, north and south of the Himalayan divide (FAO – AQUASTAT, 2011b). The Upper basin has cold climatic conditions as it remains under the snow cover throughout the year and receives low rainfall <50mm, as the cold desert area of Ladakh lies in rain-shadow area. The average annual temperature of upper basin is 12.4° C indicating that this part is dominated mainly by the temperate climatic conditions throughout the year. Highest temperature recorded in the Upper basin in the month of August was 22.7° C whereas the monthly average temperature for the Upper basin dips down to 1.1° C while many meteorological stations in the Upper basin recording lowest temperature as low as -8° C to -10° C, particularly in Leh, Ladakh (Ali, 2013). The Upper Indus River Basin contains the greatest area of perennial glacial ice outside the polar region.

The climate in the Lower Indus River Basin or the Indus plains is arid to semi-arid. The cold season prevails during December to February with mean monthly temperature ranging from 14° C to 20° C. Mean monthly temperature during March to June varies from 40° C to 44° C. The upper plain area records temperature as high as 49° C during summers. Average annual rainfall on the Indus plains is about 230 mm. Thus, the major part of the basin lies in arid to semi-arid zones, but there are considerable temporal and spatial variations across the whole drainage area (Nepal and Shreshtha, 2015).

The Indus Water Treaty: Post-independence of India and Pakistan in 1947, a water dispute arose on the distribution and use of waters from the Indus River and its tributaries. After the protracted process of negotiations, a settlement under the Indus Water Treaty (IWT) was achieved in 1960. Accordingly, five prominent tributaries of the Indus River flowing from India to Pakistan were grouped as Western Rivers and Eastern Rivers. Under the IWT (1960), the following rules apply:

Western Rivers: Chenab and Jhelum Rivers were recognized as the western rivers. Pakistan shall receive all those waters of the western rivers for which India is under obligation to let flow, except for restricted uses, related to domestic use, non-consumptive use, agricultural use and generation of hydro-electric power of which the amount are set out in the Treaty. Total inflow from China to India in the Indus River Basin is 181.62 km³. It is estimated that flow generated within India is 50.86 km³, resulting in a flow from India to Pakistan of 232.48

km³, of which 170.27 km³ is reserved for Pakistan and 62.21 km³ are available for India (FAO – AQUASTAT, 2011b).

Eastern Rivers: Ravi, Beas and Sutlej are considered as the eastern rivers and all their waters originating in India shall be available for unrestricted use by India. Pakistan shall be under no obligation to let flow, and shall not permit any influence with, the waters (while flowing in Pakistan) of any tributaries which in its natural course joining the Sutlej main or Ravi main before these Rivers have finally cross to Pakistan. The average annual flow in India before crossing the border is estimated at 11.1 km³. All the waters, while flowing in Pakistan of any tributaries while in its natural course join the Sutlej main or Ravi main after these rivers have crossed into Pakistan shall be available for unrestricted use of Pakistan.

Groundwater Resources and Water Quality: The Indus River Basin represents an extensive groundwater aquifer, covering a gross command area of 16.2 million ha. In general, water quality in terms of Total Dissolved Solids (TDS) of the Indus River and its tributaries range between 60 ppm to 374 ppm, which is relatively safe for multiple uses (Bhutta, 1999; PWP, 2000; FAO-AQUASTAT, 2011b). TDS in the upper reaches range between 60 ppm during high flow and about 200 ppm during low flow. Water quality deteriorates downstream, but remains well within permissible limits. The Indus River Basin has its roots in irrigated agriculture since the time of old Indus Civilization and since then water related developments in the basin, particularly during the last one century or so have expanded exponentially. A large number of dams, barrages, hydroelectric projects and canal networks have come into existence. The total area equipped for irrigation in the entire Indus River Basin is estimated to be 26.3 million ha, of which India accounts for 6.7 million ha or 25.5% while Pakistan has a higher proportion of irrigated extent *i.e.*, nearly 19.08 million ha or 72.7% of total area.

Natural Diversity: The Indus River Basin has been bestowed with enormous diversity of mountain ranges, snowcapped peaks, large extent of glaciers, diverse forests, grasslands/ alpine pastures, high altitude wetlands, and a network of streams and rivers besides archeological sites of old civilizations and rich and diverse cultural heritage. Thus, the entire basin area is exceptionally rich and diverse naturally, biologically, ecologically and socio-culturally. The higher reaches are home to threatened flagship species *i.e.*, the Snow Leopard (*Panthera uncia*), its co-predator (Himalayan Wolf – *Canis himalayensis*), and prey (Ibex - *Capra ibex*, Bharal – *Pseudois nayaur*, Himalayan Tahr – *Hemitragus jemlahicus*, Himalayan Marmot - *Marmota himalayana*, Himalayan Pika - *Ochotona himalayana*). In some parts of the Indus River Basin, particularly in the middle and lower reaches, there is high abundance of Common Leopard (*Panthera pardus*). Other associated species are: Himalayan Brown Bear – *Ursus arctos isabellinus*, Asian Black Bear – *Ursus tibetanus*, Markhor – *Capra falconeri*, Himalayan Musk Deer – *Moschus leucogaster* and Himalayan Goral - *Naemorhedus goral*.

The Basin of Indus River harbors enormous diversity of birds including spectacular pheasants, reptiles, and amphibians while the river and its tributaries have a high diversity of freshwater fishes besides endangered aquatic mammals *viz.*, the Indus River Dolphin –

Platanista gangetica minor and two otter species: the Eurasian Otter – *Lutra lutra* and the Smooth Coated Otter – *Lutrogale perspicillata*.

People and Economy: The Indus River Basin and its tributaries is the most important supplier of freshwater resources for densely populated regions in India and Pakistan, and it forms the backbone of agriculture and food production and makes significant contribution towards hydropower generation and industrial development. Especially, the river is critical since rainfall is meager in the cold desert and lower Indus Valley regions. The Indus River Basin sustains a substantial human population (ca. 268 million) (Sharma *et al.*, 2019). The Indus River Basin is one of the regions in the world that is faced with major challenges for its water sector, due to population growth, rapid urbanization and industrialization, environmental degradation, unregulated utilization of the resources, inefficient water use and poverty, all aggravated by climate change (Laghari *et al.*, 2012).

1.6.2 The Beas River – Statement of Significance

The Beas River is one of the five tributaries of the Indus River those originate in India in the north-western Himalaya. The Beas River is a left bank tributary of the Indus River draining to Arabian Sea and also referred as one of the three eastern rivers under the Indus Water Treaty (1960). The 470 km long Beas River rises from the, Beas Kund Pir Panjal range and flows through the States of Himachal Pradesh and Punjab before its confluence with the other eastern river Sutlej. The Beas Basin is spread over parts of Kullu, Mandi, Hamirpur, Kangra and Chamba districts of Himachal Pradesh and its western most part falls in the Hoshiarpur and Gurdaspur districts of Punjab. The Beas River is the principal tributary of the Sutlej River in India. Mythologically, Beas River attains immense significance owing to the fact that ‘Veda Vyasa’ is the eponym of the Beas River, the author of Indian epic the ‘Mahabharata’; he said to have created it from its source lake the ‘Vyasa Kund’. Besides mythological, religious and cultural significance, the River Beas has immense value from the geomorphological, ecological, environmental and economic perspectives. The statement of significance of Beas River Basin based on diverse conservation values is presented in the Box 1.1. In spite of the noteworthy conservation values and fragile Himalayan mountain ecosystem, scarce and precious fresh water resources, the large scale alterations owing to the change in land use, extensification of agriculture, urbanisation along the river-course, establishment of sequential hydroelectric projects, physical barriers-dams and barrages, and diversion of river water to Sutlej River have severely impacted the overall ecology of the catchment, particularly the Beas Riverscape, associated faunal life and fishery of the basin. Unplanned rapid development of infrastructure, human disturbance, urbanisation and diversion of water has not only fragmented the Beas River and its tributaries, but has resulted into loss of longitudinal, vertical, lateral and temporal connectivity, reduced environmental flow, decline in water quality and overall degradation of river ecosystem.

The Beas River Ecosystem- Statement of Significance

Ecological Significance

Beas River is the second most important tributary of the Indus River System so far India is concerned. Beas River Basin is spread over 20,303 km² and represents 25% and 6.03% geographical area of Himachal Pradesh and Punjab, respectively. It is characterized by rugged topography with high ranges and peaks covered with glaciers massive ice and snowfields. The altitudinal variation in the basin ranges from 325 - 6,619 m amsl. The watershed of Beas River extends over the mountain ranges of the Greater Himalaya, the Lesser Himalaya, and Shivalik. The Beas River basin is flanked in the north by drainage of Ravi and Chenab Rivers while in the south by catchment of Sutlej River. The Beas River and its northern and eastern tributaries are glacial or snow fed perennial whereas the southern tributaries are seasonal. Along its course, the Beas River is fed by numerous important tributaries. Prominent tributaries in the upstream are: Parbati, Sainj, Tirthan, Solang, Manasu, Phojar and Hansa. The Uhl, Neugal, Juni, Gaj and Chakki are the critical tributaries in the downstream.

Beas River forms the second largest catchment area in the Himalayan State of Himachal Pradesh after Sutlej. Beas originates from two sources, '*Beas Kund* (4,060 m amsl)' on the south and '*Beas Rishi* (4,350 m amsl) on the right of the Rohtang Pass in district Kullu within the north-western Himalaya. The two streams meet at Palchan village, 10 km north of Manali to form river Beas. The river culminates at Hari-ke-Pattan (Harike) in the plains of Punjab; district Amritsar when it joins another tributary of the Indus i.e., the Sutlej River. Beas River drains nearly 25,900 km² area in two states viz., Himachal Pradesh and Punjab, having maximum run of 300 km in former and 170 km in the later. The catchment area of Beas River lies between latitudes 31° 8' 9" N to 32° 26' 22" N and longitudes 74° 56' 38" E to 77° 47' 48" E.

Owing to varied landforms, climatic conditions and a wide range in the altitudinal gradient, different mountain ranges within the basin are home to diverse forests viz., Tropical, Sub-tropical to Temperate and Sub-alpine forests and Alpine vegetation and are host to a variety of rare, endangered and threatened floral and faunal species. It represents two biogeographic zones: (i) The Himalaya, and (ii) The Semi-arid region of the Punjab plains. Two states along the course of Beas River collectively harboured forest cover of 17,283 km² or represented 2.42% forests cover of the country (FSI, 2019). In addition, two States also harboured 2,421 km² of Tree Cover in Trees Outside Forests (TOFs). Further, these States constitute 401.94 M m³ of the total growing stock of the country within the forests and TOFs. Forests in two states along the Beas River harboured 266.7 million tonnes of carbon stock or 3.74% of the total estimated 7124.0 million tonnes of carbon stock in different forests of the country which sequester carbon and also help in reduction of Greenhouse gas emissions. These two States in the Beas River Basin have 5,520 natural and manmade wetlands including three Ramsar sites (Pong Dam Lake, Harike Lake, and Beas Conservation Reserve), 10 Important Bird Areas (IBAs) and one World Heritage Site (GHNPCA) besides other important protected areas.

The Beas River Basin is home to several sensitive ecosystems viz., glaciers, snow-capped peaks, alpine meadows, high altitude wetlands, riparian forests, etc. The Great Himalayan National Park (GHNP) with two contiguous PAs (Tirthan and Sainj Wildlife Sanctuaries) and a buffer zone (Eco-sensitive zone) earlier referred as the Great Himalayan National Park Conservation Area (GHNPCA) sustains a unique biota comprised of several distinct altitude-sensitive ecosystems (Mehra and Mathur, 2001; Mathur, 2002). Subsequently, UNESCO in recognition of natural diversity and ecological and evolutionary processes occurring in the GHNPCA decided to inscribe a larger part of GHNPCA excluding the Eco-sensitive zone as the World Heritage Site (WHS) in 2014 (UNESCO, 2014). The WHS is home to numerous plants and animals endemic to the region. The GHNPCA displays distinct broadleaf and conifer forest types forming mosaics of habitats across steep valley side landscapes. It is a compact, natural and biodiversed protected area system that includes 25 forest types and an associated rich assemblage of faunal species. GHNPCA being an island of undisturbed environments not only allows a healthy ecosystem, but also promotes evolutionary processes to occur. It provides habitat for four globally threatened mammals, three globally threatened birds and a large number of medicinal plants, those are high in commercial demand.

The rare Western Tragopan along with Cheer, Kalij and Monal pheasants are found here. Among mammals the Himalayan brown bear, Himalayan black bear, musk deer, Himalayan tahr, Bharal or Blue sheep, Serow and Goral are some of the prominent and characteristic species of the high altitude forests. The snow leopard is also rarely seen in the interiors of the park. In the downstream area, the Pong Dam Wildlife Sanctuary and Harike Wildlife Sanctuary are two important wetlands and Important Bird Areas (IBAs); Harike wetland being a Ramsar site. Both wetlands are the major attraction for a wide-ranging of waterfowls and migratory birds. Harike wetland supports more than 400 avian species. In addition, Harike also harbours endangered aquatic mammalian as well as reptilian fauna like the Indus River dolphin, smooth-coated otter and seven species of rare freshwater turtles. Indus River dolphin, a rare aquatic mammal has been declared as the State aquatic animal of Punjab, and has been recognised as flagship species for the conservation of Beas River ecosystem. Beas River and its select tributaries originating from the Great Himalaya once harboured in abundance the indigenous *Mahseer* (*Tor putitora*) and snow trout (*Schizothorax richardsonii*). They exhibit spawning migration to the incoming streams and rivers and lay eggs in shallow pools amidst gravel and sand. Considering, the ecological significance of Beas River and for the purpose of protecting and conservation of wildlife, particularly the aquatic fauna and its environment, the Govt. of Punjab has declared a larger stretch of river from 52 head Talwara to Harike barrage as the Conservation Reserve. The tree vegetation all along the riverbanks mainly consists of species of *Alnus*, *Salix*, *Robinia* and Conifers.

Economic Significance

Once, the economy in the upstream of Beas was primarily dependent on forest resources in the catchment when diverse forests were exploited for timber and non-timber forest products. Gradually, in past 5-6 decades, agriculture expansion with a focus on cash crops i.e., (wheat and potato) cultivation occurred. Subsequently, these crops were replaced with apple

orchards in Kullu and Mandi districts. In Kangra district, the tributaries originating in the Dhauladhar range are feeders for *kuhls* that support irrigation for paddy and wheat cultivation. In general, the development of horticulture occupies an important place in the economy of the upper Beas River Basin. Agro-climatic conditions offer a great variety of production of temperate and sub-tropical crops especially apple, peach, apricot, chestnut, almond, cherry, goose-berry, olive, etc. Sequential reservoirs/ barrages, canal network and hydro-electric projects from upstream tributaries to downstream main stem of the Beas River have dramatically changed the scenario of agriculture expansion and production in the plains of Punjab State, and it has been a major contributor towards the Green Revolution and agricultural production in the country. Concurrently, efforts were made to improve the livestock and enhance production of milk and milk products and poultry. Himachal Pradesh, with five major rivers including four tributaries i.e., Chenab, Ravi, Beas, and Sutlej of the Indus river Basin flowing through the State, has about a quarter of India's total potential hydropower resources (RSET, 2019). Of the total identified hydropower potential of 27,436 MW in the State, Beas River Basin alone has potential (>5 MW projects) of 4,877.7 MW distributed among 51 hydropower projects throughout the basin. Out of these, 22 projects with total installed capacity 2,820.9 MW have already been commissioned while five projects of 947 MW capacities are under construction and 20 projects (total installed capacity 1028.9 MW) are at various stages of investigation and planning. Remaining four is yet to be allotted (RSET 2019). Availability of raw material, water and power has immensely helped in the growth and diversification of industries, particularly in the Punjab State. The Beas River Basin in two States (H.P. and Punjab) has several sites and places of high altitude and adventure tourism and religious significance. Prominent places of tourist attraction are: Rohtang Pass, Manali, Kullu, Mandi, Kangra, Jwala Devi, Amritsar, etc. The tourism industry by way of hotels/resorts, tour operators, travel agencies, etc. is fast expanding and brings substantial revenue to the government and income to private entrepreneurs and corporates. Beas River and its tributaries are critical and have enormous potential for food, irrigation, energy, tourism and economic development in India. The multifarious economy arising due to forests, river, agriculture, hydroelectric resources, development of industry and tourism sectors have definitely brought the much desired prosperity in the basin.

Cultural Significance

The Beas River Basin supports a substantial human population in five districts of Himachal Pradesh and two districts of Punjab; and harbours numerous ethnic groups. The attraction of the river has been so great that great sages namely, *Narad*, *Vashisht*, *Vishwamitra*, *Vyas*, *Prashar*, *Kanav* and *Parshuram* came here on different occasions and meditated on the banks of this sacred river. The Parbati River, the largest tributary of the Beas, has given birth to numerous religious and folk tales that has made the Parbati Valley alluring and sacred for many. The tale of Manikaran is popular lore with Lord *Shiva* and Goddess *Parbati* as the protagonists. Manikaran hold religious significance for Sikhs too, as *Guru Nanak* is believed to have visited this spot and yet another story rests in the folklore of the mountains. Historically, the Beas is known to have been the biggest hurdle in the way of Alexander's

invasion of India as river was the India's eastern most part up to which Alexander the Great's conquests in 326 BC were marked.

Mythological, cultural, religious, historical, natural, ecological, scientific and economic values provided by the river basin contribute in a significant way to the country's development and prosperity of the people in the region.

1.7 River Conservation Initiatives

Rivers in India are altered and depleted drastically in spite they are inextricably intertwined with culture and spiritual heritage. The current state of rivers cannot be held responsible entirely on the growth of human population or the development of the society over time. Irrigation development i.e., wells, canals, tanks, and dams and their efficient operations and maintenance from prehistoric time coupled with intensification of agriculture with the advent of technologies, deforestation and urbanisation in the past century or so are the primary factors responsible for the current plight of rivers. The Ganga and Indus basins in India that support the livelihood of nearly 370 million Indians are two of the world's ten most endangered river systems.

Despite increasing concerns about the urgent nationwide need to revitalize Indian Rivers to sustain ecosystem functions and provide livelihood security, efforts towards river conservation in past four decades or so have been *ad hoc*, fragmentary, slow or even lackadaisically. The first meaningful effort towards recognition and conservation significance of precious natural resources including rivers and other freshwater resources dates back to 1970s when the Government of India has enacted the Wildlife (Protection) Act (WPA), 1972 and established the separate Ministry of Environment and Forests in 1985. The WPA provided equal emphasis on all natural ecosystems i.e., terrestrial, aquatic, coastal and marine and extended legal support for protection and conservation not only to wildlife, but also to their habitats. The WPA also opened avenues for the establishment of protected areas i.e., (Biosphere Reserves, National Parks and Wildlife Sanctuaries) and as a result a large number of protected areas (PAs) were established those directly or indirectly focussed on conservation of diverse freshwater resources i.e., (glaciers, rivers, floodplains, lakes, swamps, estuaries, etc. The year 1976 is remembered as a landmark for the Indian Constitution, particularly from the perspective of environment because 42nd Amendment of the constitution. Specifically, the Article 48A of the amendment stipulated that the 'State shall endeavor to protect and improve the environment and to safeguard the forests and wildlife of the country'. Further, Article 51A (g) stipulated that it shall be duty of the every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife, and to have compassion for living creature. Immediately after the establishment, the new Union Ministry of Environment and Forests started paying attention to the priority agenda of river conservation and initiated the ambitious programme named as the 'Ganga Action Plan (GAP)'. The GAP was formally launched in January, 1996 with the objective of improving the water quality of River Ganga by preventing the pollution load. The MoEF established the National River Conservation Directorate which implemented the GAP Phase I and Phase II during 1986-2008 and prepared the National River Conservation Plan (NRCP)

so as to expand the programme and include other major rivers. A detailed report on the monitoring of water quality in pre and post-GAP (1996-2008) prepared by the IIT, Roorkee in 2009 revealed that the river water quality has shown discernible improvement over the pre-GAP period. The report also highlighted issues related to the maintenance of Sewage Treatment Plant (STP) and concluded that in spite of implementation of two phases of GAP and huge investments, efforts to decrease the pollution level in the river did not yield desired results. The report also stated that in the absence of implementation of GAP, there would have been further deterioration of water quality and enhanced pollution levels.

In 1985, concurrently the Government of India decided to setup the Ministry of Water Resources (MoWR) by bifurcating the erstwhile Union Ministry of Irrigation and Power in recognition of the necessity of planning for the development of country's water resources in a coordinated manner. The MoWR assumed a nodal role in regard to all matters concerning the water resources and the National Water Resources Council (NWRC) was constituted under the chairmanship of the Hon'ble Prime Minister to steer the agenda on water resources. For the first time, country's Water Policy was formulated and it was adopted by NWRC in September, 1987. Later, the NWRC first revised the National Water Policy in 2002 and thereafter, revisited and brought out comprehensive National Water Policy in 2012. The revised Water Policy of 2012 recognised water as a scarce resource, uneven distribution of water in space and time, occurrence of frequent floods and droughts, ever increasing demands, likely implications of climate change, rising inter-state and transboundary river disputes, essentiality of river corridors, and priority need for research and monitoring.

1.7.1 Conservation of Ganga River

In recognition of the conservation significance of the Ganga River in view of its ecological, cultural and socio-economic values, and also appreciating growing national concerns about environmental degradation of the river and its basin, the GoI declared the Ganga River as India's National River in 2008 and constituted the National Ganga River Basin Authority (NGRBA) on 20 February, 2009 under the Section 3(3) of the Environment (Protection) Act, 1986. The NGRBA has adopted a broader approach to the management and conservation of Ganga River following a basin-level multisectoral approach. The NGRBA not only provided regulatory and enforcement powers, but also established collaborative institutions with five concerned State Governments along the course of river and referred them as the State Ganga River Conservation Authority (SGRCA). The NGRBA entrusted the consortium of seven Indian Institute of Technology (IITs) with the task of preparing the Ganga River Basin Environment Management Plan (GRBEMP) and launched World Bank assisted National Ganga River Basin Project (NGRBP). The project adopted three pronged approach for rejuvenation of Ganga River by focussing on the river basin, multisectoral mandate so as to address both water quantity and quality (FRI, 2016). In addition, the MoEF&CC has been implementing two separate Central Sponsored Schemes (CSS): (i) the National Wetlands Conservation Programme (NWCP), and (ii) the National Lake Conservation Programme (NLCP). The NLCP scheme since June, 2001 focussed on conservation and management of polluted and degraded lakes in urban and semi-urban areas of the country through an integrated system approach. Further, the Union Cabinet approved National Water Mission

(NWM) in April, 2011 focussing on promotion of Citizen and State Actions for Water Conservation, Augmentation and Preservation at basin-level and Integrated Water Resources Management besides enhanced water uses efficiency. In July, 2014 immediately after the new government at the centre took charge felt that the Ganga River has a very special place in collective consciousness of the country and that earlier efforts of GAP, etc. have not yielded desired results for the improvement and conservation of the river and decided two significant decisions. Firstly, the renaming of the erstwhile MoWR as the Ministry of Water Resources, River Development and Ganga Rejuvenation (MoWR, RD & GR), and secondly, assigned the additional work related to NGRBA including other related matters of Ganga River. The Union Budget of 2014-15 announced the setting of an integrated Ganga Conservation Mission named as ‘National Mission for Clean Ganga (NMCG)’ or ‘*Namami Gange*’ while recognizing the multi-sectoral, multi-dimensional and multi-stakeholder nature of rejuvenation challenges in the context of Ganga River and entrusted the central key Ministries including: (a) MoWR, RD & GR, (b) MoEF&CC, (c) Ministry of Shipping - MoS, (d) Ministry of Transport – MoT, (e) Ministry of Urban Development - MoUD, (f) Ministry of Drinking Water and Sanitation – MoDW&S , and (g) Ministry of Rural Development – MoRD to work together so as to arrive at an action plan. The *Namami Gange* aimed for: (a) *Aviral Dhara* (uninterrupted flow), (b) *Nirmal Dhara* (clean water), (c) ecological rejuvenation by way of conservation of aquatic life and biodiversity, (d) promotion of tourism and shipping, and (e) knowledge management on Ganga. Based on modern scientific study and a more holistic understanding of rivers and their ecosystems the GoI has recognised the following as comprehensive definitions of a river (Misra, 2015; Isha Foundation, 2017):

A river is wholesome if it has the characteristic of ‘*Aviral Dhara*’ (continuous flow), ‘*nirmal dhara*’ (unpolluted flow), geologic entity, and ecologic entity, across the basin in all seasons (Misra, 2015). The MoWR, RD & GR and NMCG implemented a wide range of projects during past five years or so involving various ministries, state governments, departments and agencies. In the financial year 2015-16, the Ministry entrusted a major task to the Forest Research Institute (FRI), Dehra Dun on the preparation of Detailed Project Report (DPR) on Forestry Interventions for Rejuvenation of River Ganga. Accordingly, the FRI prepared the DPR which was one of its kinds. The DPR adopted a holistic riverscape approach with a focus on forestry interventions, aiming for improvement in quantity and quality of water. For past three years or so, the DPR is being implemented by five states located along the course of Ganga River.

Despite best intentions, concerted efforts, huge investments and steering at the highest level, the targets of clean Ganga by NMCG could not be achieved so far and much needs to be done. Meanwhile, the present Union Government under the Hon’ble Prime Minister Shri Narendra Modi was re-elected in May, 2019 and took an immediate step to launch a new Ministry named as the Ministry of Jal Shakti (MoJS) indicating a visible thrust on water. The MoJS is now the umbrella ministry in which all water- related ministries have been integrated. Thus, the MoWR, RD & GR and MoDW&S have been merged into the new ministry. The NRCD under the purview of MoEF&CC is also being brought under the MoJS. Parallel to various concerted efforts to restore the mighty Ganga River, the GoI has initiated

several different programmes to manage and conserve various major rivers of the country. Notable amongst them are as follows:

1.7.2 Yamuna Action Plan

In case of Yamuna River, a tributary (1,376 km) to Ganga River, the Yamuna Action Plan (YAP), a bilateral project between the GoI and Japan was initiated in 1993. It is one of the largest river restoration projects in India. The Government of Japan, through the Japan Bank of International Cooperation (JBIC), has provided financial aid of ¥ 17.7 billion to carry out the project. The project is being executed by the NRCD, MoEF&CC. The Phase I ended in 2003 and the Project Phase II began in 2004. The project aims to address the abatement of severe pollution of the river Yamuna by raising sewage treatment capacity, caused by rapid population growth, industrialization and urbanisation in towns of the river basin including New Delhi, the capital of India. The project is still going forward with an additional phase to clean pollution from the river. The water quality status of Yamuna River and effects of the YAP are provided by Central Pollution Control Board (CPCB) (2006) and Sharma and Kansal (2011). Accordingly, the sources contributing pollution are both point and non-point types. Based on the water quality, the entire Yamuna River has been segregated into 5 stretches i.e., the Himalayan stretch, Upper stretch, Delhi stretch, Mixed stretch and Diluted stretch. About 580 km long stretch between Wazirabad barrage and Chambal River confluence is critically polluted. The 22 km long Delhi stretch is polluted severely. The Nazafergarh drain of NCT-Delhi is the biggest polluter of Yamuna. CPCB is regularly monitoring water quality at nearly 20 locations along the main stem.

1.7.3 River Valley Project Development in the Indus River Basin

The North-Western region of the Indian sub-continent is the land of the Indus. India gets her name from this river. On the geographical division of the Indian subcontinent in August, 1947, two independent sovereign nations, India and Pakistan, came into existence. The new international boundary separating the two countries cut across the Indus System of rivers – the upper reaches of the main Indus River and left bank tributaries i.e., Jhelum, Chenab, Ravi, Beas and Sutlej came to lie in India while the lower reaches and right bank tributaries found their place in Pakistan. A vast part of the network of existing canals fell within the territory of Pakistan, but the installation which supplied water to these canals were situated in India. With partition and emergence of two independent nations, sharing of Indus water resulted into an international dispute. After about eight years of discussion and negotiations between two national governments, carried out under the auspices of the World Bank resulted in the Indus Water Treaty (1960). Accordingly, as already described in above section 1.6.1.3, India was awarded the exclusive use of waters of the three eastern rivers i.e., Ravi, Beas and Sutlej and a Master Plan was drawn to harness the water of these three rivers which came to India's share for assured irrigation, power generation and flood control. Mighty Bhakra-Nangal on Sutlej, Beas Projects (Pong, Pandoh) and Ravi through Thein (Ranjit Sagar) dam were planned and implemented soon after. Sequential projects on Sutlej and Beas form major part

of the plan and were named as Bhakra-Beas Management (BBM) joint venture of the then unified States of Punjab and Rajasthan.



River Sainj after water diversion to the Parvati HEP

a. Bhakra-Nangal Project on Sutlej

A proposal to construct a storage reservoir on the Sutlej was first time originated in November, 1908 before the partition. However, a detailed and comprehensive project for a high dam at Bhakra was prepared in 1919. During 1919-1951, the subject of harnessing water of Sutlej and construction of Bhakra dam remained active into consideration firstly, under the British India and subsequently after partition by the State Government of India and the Government of Punjab. During this period various consultations with different governments, US Bureau of Reclamation and US Irrigation Service, surveys and investigations, and planning for project proposal(s) took place. The full-fledged construction activity started only after April, 1952 and after untiring efforts of day and night for almost a decade, the Bhakra dam was ready and it was dedicated to the nation on 22 October, 1963. On reorganisation of the unified state of Punjab on 01 November, 1966, 'Bhakra Management Board (BMB)' was constituted under Sec 79 of Punjab Reorganisation Act, 1966 on 1 October, 1967 to manage the operation and maintenance of Bhakra-Nangal Projects.

b. Beas Project

The idea of storage dam across Beas River at Pong was first mooted in 1926. Like the Bhakra Project, the Beas Project at Pong also remained into active consideration up to 1959 and at different stages of surveys, investigations, consultations and planning. The agency of departmental construction, initiated at the Bhakra dam was adopted for the construction of Beas dam also. Punjab government constituted 'Beas Control Board (BCB)' in 1961 to

exercise efficient financial and technical control over all matters pertaining to the construction of the project. Consequent upon reorganisation of Punjab in 1966, the execution of the project was vested with GoI who reconstituted the Control Board and named it as 'Beas Construction Board (BCB)'. Subsequent to completion of Beas Project, the Beas Construction Board was transferred to Bhakra Management Board (BMB) in 1976. After merger of BCB with BMB, the BMB was renamed as Bhakra Beas Management Board on 15 May, 1976 and the world over, today it is popularly known as BBMB. The functions of the BBMB are to regulate the supply of Ravi, Beas and Sutlej water to the States of Punjab, Haryana, Rajasthan, Delhi and Chandigarh (UT) and to distribute power from Bhakra-Nangal and Beas Projects to the States of Punjab, Haryana, Rajasthan and Chandigarh (UT). BBMB has an installed capacity of 2,918.73 MW- the third largest installed hydropower capacity in India. Bhakra-Nangal and Beas Projects have been harbinger of Green and White Revolutions, rapid industrialization and urbanisation in the northern region, besides protecting the downstream areas from ferocious floods. The massive reservoirs have also promoted enhanced fish production, creation of wetlands providing shelter to migratory birds and development of tourism and recreational activities besides environmental protection and improvement, and various community services.

c. Ravi Project

The waters of the Ravi River are allocated to India under the IWT (1960). The river is under the jurisdiction of the riparian states of Punjab and Himachal Pradesh, and non-riparian states/UT of Haryana, Jammu & Kashmir and Rajasthan, but the management is presided by the Supreme Court of India and the Ravi Beas Tribunal, set up in 1986 for the purpose. Madhopur Headworks was the earliest project built on Ravi in 1902 prior to the partition. It is a run-of-the-river project without any water storage envisaged to divert flows through the Upper Bari Doab Canal to provide irrigation in command area of the then unified India. The hydro-power potential of Ravi has been assessed at 2,294 MW. Since 1980s, Baira Suil HEP of 198 MW capacity, the Chamera-I of 540 MW capacity commissioned in 1994, the Ranjit Sagar (Thein) multipurpose project (600 MW) completed in 1999 and the Chamera-II of 300MW capacity in the upstream of Chamera-I commissioned in 2004 are functioning. The post-independence, the Madhopur-Beas Link was built during 1955-57 linking Ravi River with Beas at Harike. The Rajasthan canal is a capacity of 18,500 Cs, off taking from Harike Headworks was constructed during 1958-1961, for supply of Ravi- Beas waters to Rajasthan.

1.7.4 Brahmaputra Board

On the lines of BBMB, the GoI constituted a statutory body named as the Brahmaputra Board in 1980 in order to regulate and develop inter-state Brahmaputra and Barak River Valley and utilization of water resources of Brahmaputra and Barak River and their tributaries for irrigation, hydropower, navigation and flood management. The jurisdiction of the Board covers all the states of the North-Eastern Region, Sikkim and part of West-Bengal falling in the Brahmaputra Basin.

1.7.5 Conservation of Narmada River

The Government of Madhya Pradesh has initiated a campaign to conserve the Narmada River. The campaign primarily focuses on creation of public awareness and their involvement besides promoting activities such as soil and water conservation, afforestation, pollution control and organic farming. As a part of the campaign, a *Yatra* or pilgrimage that run for 148 days during 2016-17 began and ended at Amarkantak, the origin of the Narmada River. The campaign also included planting 16 million trees along the riverbank.

1.7.6 Inter-Linking of Rivers

The Ministry of Jal Shakti has initiated the task of inter-linking of the rivers through the National Water Development Agency (NWDA). The NWDA has identified 30 links (16 under Peninsular Rivers and 14 under Himalayan Rivers) for the preparation of feasibility reports. So far, the feasibility reports of 16 links have already been prepared. DPRs for Ken-Betwa Link Damanganga-Pinjal Link and Par-Tapi-Narmada Link have also been completed

1.7.7 Rally for Rivers

Rally for Rivers (RfR) is a campaign launched by Isha Foundation in 2017, a non-profit, spiritual organisation found in 1992 by Sadhguru Jaggi Vasudev based at Coimbatore. RfR aims to instil awareness protecting rivers so as to tackle the water scarcity across rivers in India and brought out a document entitled 'Revitalization of Rivers in India Draft Policy Recommendation' and submitted to the Hon'ble PM of India on 03 October, 2017. The document recognised rivers as a 'national treasure' and envisaged that the protection of the rivers should encompass: (a) ensuring full ecological/environmental flows; and (b) preserving biological, chemical and physical characteristic of water that protects the gene pool (Isha Foundation, 2017). Rivers face challenges on two fronts – quality and quantity, which needs to be addressed simultaneously. RfR is of the opinion that revitalization of dying river is possible through riverside afforestation and proposed developing tree cover by planting trees for a minimum of 1 km – with along the entire river's length on either side of the river. The PMO formed an expert group to look into the policy recommendations made by RfR under the chairmanship of CEO, NITI Aayog. Six states i.e., Karnataka, Assam, Chhattisgarh, Punjab, Maharashtra, and Gujarat signed a MoU with Isha Foundation to plant trees along river banks.

1.7.8 NITI Aayog – Action to Revitalize India's Rivers

The Expert Group formed under the Chairmanship of CEO, NITI Aayog looked into the policy recommendation made by RfR and prepare programme for action which details how the recommendation to revitalized India's river will be implemented on the ground. The NITI Aayog has also come out with a detailed document on the India - Three Year Action Agenda (2017-18 to 2019-20) including a chapter on sustainable management of water resources. This document has been prepared on the basis of an extensive discussion with inputs from the Central Ministries and State Governments. The proposed key strategy includes: (a) to provide

irrigation to all farms (*Har Khet Ko Pani*) with improved on-farm water use efficiency ‘*Per Drop More Crop*’; (b) encourage the industry to utilize recycled/ treated water and ensure zero discharge of untreated effluents; (c) create additional water storage capacity to enhance utilization of surface water resources potential of 690 BCM; (d) ensure long term sustainability of the limited groundwater resources; (e) facilitate effective water governance; (f) develop benchmark for water footprints for the major crops; (g) establish and upgrade the existing National Hydrology Project and commence study on Integrated Water Resources Management (IWRM); (h) undertake the task of preparation of the feasibility reports and implementation works in respect of Inter-Linking of Rivers (LIR); and (i) complete the agenda on integrated Ganga Conservation Mission i.e., the ‘*Namami Gange*’ under the NGRBA (NITI Aayog, 2017). Further, the guidelines on IWRM by the Basin Planning and Management Organisation, Central Water Commission has defined the term ‘Integrated Water Resource Management’ as ‘a process which promotes the coordinated development of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems’ (MoWR, RD & GR, 2016). The NITI Aayog has also developed a Strategy for New India@75, and has focused on the current situation of water resources and the way forward for various dimensions of management of water resources in the country (NITI Aayog, 2018).

1.7.9 Initiative by National Afforestation and Ecodevelopment Board (NAEB)

In August, 1992, the GoI has set up the ‘National Afforestation and Ecodevelopment Board (NAEB)’ with the intention to promote afforestation, tree planting, ecological restoration and ecodevelopment activities in the country while laying special attention to the degraded forest areas and lands adjoining the forest areas, national parks, sanctuaries and other protected areas as well as the ecologically fragile areas like the Western Himalayas, Aravalli Hills, Western Ghats, etc. The NAEB has initiated a unique programme named as the Eco Task Force (ETF). ETF units were raised under the aegis of Ministry of Environment and Forests and Ministry of Defense in conjunction with states on priority tasks for challenging assignments in the ecologically fragile and sensitive areas. The objective behind starting ETFs was to solve the twin problems of eco- regeneration and rehabilitation of ex-servicemen. ETFs have in Jammu and Kashmir UT, Himachal Pradesh, Rajasthan and Uttarakhand have done commendable job by rehabilitating extensive degraded areas and overall ecological restoration. The NAEB has also taken an initiative on river restoration by way of forestry interventions. Present DPR is part of country-wide effort by the NAEB on major Indian Rivers.

1.7.10 River and Water Conservation as a National Movement

In the past decade or so, the GoI has realised the growing water crisis as the main impediment in the country’s development and in the process of nation building. Despite growing water crisis, India is not only committed to fulfill its international obligations towards biodiversity conservation, environmental management, climate change and mitigation, human rights, social justice, equity as well as peace, but at the same time country is fully geared for

planned accomplishments essential for nation building and meaningful contribution towards global agenda on sustainable development (Savita, 2019). In short, management of scarce and precious water resources and river conservation adopting a holistic approach have become a national movement.

1.7.11 Beas River Basin Management

Primarily, the Beas Project had two components: (a) Unit I – Beas-Sutlej Link Project, and (b) Unit II – Pong Dam on the Beas. The Unit I, the Beas-Sutlej Link is essentially an inter-basin transfer of water from Beas to Bhakra reservoir on Sutlej through a diversion dam at Pandoh and over 1,000 feet drop in Mandi District, Himachal Pradesh. In addition to the inter-basin transfer of water, the Unit I also included a power project known as Dehar Power House with an installed capacity of 990 MW. Dehar power house is run-of-the-river scheme also having buffer storage. The prestigious power house is the culmination of a long water conductor system comprising two tunnels i.e., 13.1 km long Pandoh-Baggi Tunnel and 12.35 km long Sundernagar-Sutlej Tunnel and open hydel channel i.e., 11.8 km long connecting the mighty Beas and Sutlej rivers. The Unit II is Pong Dam on the Beas with a gross storage of 6.95 MAF behind a 435-feet earth-core gravel shell dam. The power plant is located in stilling basin downside of six penstocks (each 5.025 m diameter) or at the base of the dam. The project generates a total of 396 MW power from its power station.

1.7.12 River Basin, Its Uniqueness and Problems

(a) Basin Uniqueness: Beas, being a principal river of the Indus River System is fed by snow and glacial-melt. It forms the second largest catchment area in the Himalayan Mountainous tract in the State of Himachal Pradesh and drains through the Great Himalaya, Middle Himalaya, and the Lower Himalaya before descending into Alluvial Plains of Punjab. Beas River exhibits varied landforms along vast range of altitudinal gradient and climatic conditions, and thus, harbours a wide range of forests, grasslands, alpine pastures and wetlands those are home to a variety of rare, endangered and threatened floral and faunal species. These diverse natural ecosystems not only provide enormous biodiversity values but significantly contribute for the maintenance of the ecological integrity, overall health and sustained environmental flows of the Beas River and its tributaries. The River Basin and the Beas Riverscape harbours a large number of glaciers, high-altitudinal lakes and extensive snow-capped peaks sustaining water flow in the river all through the year. The river harbours several large, contiguous and compact forest blocks along the altitudinal gradient those constitute some of the important protected areas (PAs). The unique faunal value of the high altitudinal region and recent re-discovery of the Indus River Dolphin in the lower most stretch of Beas River before its confluence with Sutlej at Harike has not only enhanced the biodiversity value of the river/Indus River System in India but also signifies the healthy river.

(b) Problems of the Basin: Weakness: The river, surrounding lands and its varied resources are excessively burdened due to high and competing demands of various sectors/ users,

human needs and greed, abuse and neglect. As a result, the river ecosystem exhibits numerous signs of degradation and deterioration. Moreover, the survival of several tributaries and the ecological integrity of the main river have been threatened. Rapid retreat of the prominent Parbati Glacier within the basin along with melting of several other smaller glaciers, enhanced landslides, intense sedimentation and erosion, diversion of substantial water to the Suttlej River, fragmentation and reduced connectivity and e-flows, increased pollution, and excessive use/ exploitation of forests, alpine pastures and important wetlands are some of the main issues of concern.

The actual and potential problems identified in achieving various project objectives are as follows:

- a. Fragility of the Himalayan environment owing to increased seismic activity and active landslides, wide spread soil and riverbank erosion, and enhanced sedimentation. Deforestation and rapid population growth in turn accelerates these processes. Despite the impregnable appearance, Himalayas are fragile and increase demand for fuelwood has rendered some slopes denuded (Bhandari, 1986). The immature and the complex geology of the Himalayas, heavy rainfall including the cloudbursts, flash floods accompanied by indiscriminate construction activities have led to the instability problems which have never been witnessed before (Pande *et al.*, 2002; Dikshit *et al.*, 2020).
- b. Harsh climatic conditions, erratic and changing patterns of snowfall, rainfall, and ambient temperature, unpredictable avalanches, retreat of glaciers, increase snowmelt and runoff; and prevailing uncertainties. The varied ability of mountain species to respond to temperature warms, glaciers retreat and the extreme weather becomes more common threat for some and is a threat to biodiversity in general. The cold temperatures have warmed up faster and the permafrost is also melting. The increased melting of the glaciers has led to the formation of GLOFs i.e. glacial lake outburst flood. In this case the water contained by a glacier melts and overflows resulting into much devastation (Ross *et al.*, 2020).
- c. Rugged terrain, steep slopes, inaccessible areas, shallow soil depth and low soil fertility. The Himalayan range being the highest mountains of the world pose a great deal of difficulties for the researchers. The altitudinal ranges are extraordinary. Tremendous pressure due to increased human and livestock populations have resulted in depletion of soil nutrients. Hill regions of Himalaya are moderately densely populated area with limited productive agriculture land and ever increasing demand for land based resources. The high rates of the soil erosion and nutrient loss have been



Encroachment of forest for horticulture is a great threat

reported from degraded forest land, grazing lands and sloping agricultural fields (Tiwari, 2000).

- d. Alteration in river course by linking river or diversion of water; sequential physical barriers by construction of dams, barrages, and establishments of HEPs. Large dams submerge the low lying areas and the wetlands. The agricultural land is also being destroyed and as a result it is affecting the earning of the farmers. These structures tend to obstruct fish migration and affect their population. The reservoir has higher amount of sediments and nutrients which have an ability to cultivate aquatic weeds. They choke the population of other aquatic organisms (Hussain *et al.*, 2019).
- e. Traditional resource dependence, enhanced biotic activities, and human disturbances on natural ecosystems; limited opportunities for alternate occupation and income generation; unsustainable harvest practices; illiteracy, lack of awareness, and poverty and vulnerable communities. Reckless cutting of the fuelwood leads to flooding which adversely impacts the life of many people. A widely shared willingness of the public to conserve biodiversity is lacking. There is also lack of familiarity in identification of basic native biodiversity. Wildfires and human settlements affect neighboring ecosystems through biotic processes, including wildlife subsidization, disease transfer, landcover conversion ultimately leading to habitat loss. Sustainable mountain development is must with a view of global conservation (Wang *et al.*, 2019).
- f. Widespread and extensive land use changes and faulty land use; expansion and intensification of agriculture and horticulture; and excessive use of fertilizers, pesticides, weedicides, etc. Abandoned cropland leads to creation of most of the wastelands where erosion takes place. There is also unsustainable use of resources with use of modern machinery and chemicals. Pollution of soil, depletion of ground water aquifers, algal blooms in local water bodies are a result of defective agricultural practices (Mondal and Zhang, 2018).
- g. Encroachment of forest lands, PAs, and other natural ecosystems; and all round rapid developmental activities (i.e., expanding highways, widening of road network, mushrooming of cities/ towns, irrigation and hydropower projects, transmission lines, etc.). Conversion of forests is a major landuse change in the recent times. Limited land and unemployment have been identified as the major causes of encroachment (Chauhan *et al.*, 2018). Intrusion into forest land leads to change in Normalized Differential Vegetation Index, forest vegetation types, forest composition and species richness.
- h. Forest fragmentation, enhanced patchiness, habitat loss and degradation of terrestrial and aquatic ecosystems by proliferation of invasive alien species and decline in productivity and lack of regeneration of native species. Fragmentation of the habitat has led to loss of the species at extremely high rate (Mullu, 2016). It also leads to creation of forest edges that differ from the interior forest in various physical and biological aspects. It leads to disruption of movement and dispersal patterns of forest species. Human interference has also changed the regional landscape by replacing native species by invasive ones. Such alteration in the landscape leads to deleterious impact of a significant drop in the number of species, caused by critically reduced survival rates for the organisms (Duenas *et al.*, 2018).

- i. Erosion of biodiversity value, smaller and isolated populations of threatened species and reduced distributional range of prominent faunal species. Development of infrastructures for transport and for energy production poses local impact on biodiversity. Reducing habitat heterogeneity at landscape level with expansion and intensification of agriculture as well as urbanization in some areas are the major causes of biodiversity loss and erosion worldwide (Hardman *et al.*, 2015).
- j. Enhanced pilgrimage, mass congregation, and unplanned and unregulated tourism activities and allied developmental activities and their impact on terrestrial and aquatic ecosystems including rivers, their flow and water quality. This change in the ecosystem also forces the wildlife to change their behavior. Cultural damage along with negative effect on economic and social climate of local people becomes common in case of unregulated tourism. The traditional pilgrimages to religious sites are evolving into large scale religious tourism in many protected areas. At present, the number of such religious sites has grown manifold due to economic development and access to better transport. A growing influx of visitors leading to infrastructural development of such sites has potential to immensely damage the natural ecological balance (Soni *et al.*, 2016; Badola *et al.*, 2018).
- k. Fragmentary approach of environmental impact assessment in case of sequential developmental projects and inadequate efforts for cumulative assessments. Failure in conducting appropriate environmental impact assessment can lead to the degradation of the environment. Absence of information on EIA makes it difficult to comment on the conservation (Gray and Edwards, 1999)
- l. Multiplicity of policies and laws, isolationist, conflicting or counterproductive strategies/ approaches adopted by different agencies/ sectors, lack of sectoral convergence, and lackadaisical law enforcement and implications of judiciary activism. Biodiversity loss is mainly driven by economic systems and the policies that fail to value the environmental resources. Awareness and understanding of ecology and the role disturbance plays in ecosystem dynamics, and the ability to communicate the information is essential in understanding ecosystem potentials and the consequences of management choices. For effective ecosystem management policy, resource managers and the public must understand the nature of ecological resiliency, stability and the role of natural disturbance on sustainability (Primmer *et al.*, 2015).
- m. Inadequate researches, databases, and baseline information, ineffective monitoring, lack of technological support, innovations and inadequate capacity. Ineffective monitoring leads to a faulty project design. The scientific method application to the study is of utmost importance. Absence of baseline data results in lack of knowledge on the current condition and makes it difficult to assess and predict the environmental changes.

1.8 The Present Task – Forestry Interventions for River Beas

On one hand, the foregoing description has highlighted the growing concern for conservation of rivers across the globe as well as the plight of rivers in India, while on the other hand accentuate on adoption of comprehensive and holistic approaches towards river conservation.

In recent times, efforts towards river restoration have emphasized on forestry interventions. Hence, the following section on one hand aims to draw attention about how forests perform multiple functions and provide various ecosystems services while on the other hand underline the emerging global perspective on strong linkages between forests and water.

1.8.1 Forests – Multiple Functions, Uses and Values

The world over, humanity is strongly intertwined with diverse forests as they provide various ecosystem services. Since time immemorial, human have been using timber, fuelwood, fodder, fibre, edible products, medicinal plants, etc. from forest and also living within or in vicinity for subsistence and livelihood. Forests provide habitat for wildlife and human have been taming many wild animals for his use or consuming their meat and other products. Forests are repository of biodiversity, form catchment of streams and rivers, and harbour a variety of wetlands. Thus, forests provide freshwater resources to the humanity. They have been the source of inspiration, recreation, adventure tourism and education, and forest groves have sacred and spiritual values. Forests help in the formation of soil and enrichment of soil minerals. Forests immensely help in sequestration of carbon and its storage. Thereby, they play an important in global carbon cycling and climate change mitigation. They also play vital role in protection from natural hazards *viz.*, avalanches, floods, cyclonic storms and tsunamis. Forests ameliorate local environment and influence all variables of microclimate.

Forests are crucial to the sustainable management of water ecosystems and resources, while water is essential for the sustainability of forest ecosystems. Forests, nature, water and people have an intricate relationship and they are interconnected. It is now well recognised that both quantity and quality of water are strongly influenced by forests. Forests absorb precipitation (rainfall and snowmelt) while slow runoff besides reducing soil erosion, improving water infiltration and recharge of groundwater and aquifers. Thus, forests have ‘sponge effect’. Forests regulate the carbon, oxygen and hydrological cycles. Riparian forests act as buffers to reduce the adverse impact of human activities on rivers. In a nutshell, forests not only provide multiple benefits to human society, but now seen as the source of multiple values. In spite, enormous benefits and values forests provide, they have been over exploited. Thus, most forests are in the state of degradation and deterioration and they are now unable to provide ecosystem services once they used to offer. Sustainable management of forests requires continuous efforts, financial resources, engagement and participation of forest dependent communities and political commitment.

1.8.2 Riparian Forest Buffers as ‘Biological Filters’ – Ecological Machinery for Self - Purification and Bio-remediation in River Ecosystems

The term ‘riparian’ refers to the biotic communities and the environment on the shores of streams, rivers, ponds, lakes and some other wetlands. The phrase riparian forest refers to the vegetation directly adjoining to the rivers and streams. The riparian forest extends laterally from the active channel to the uplands, thereby including active floodplains and the immediately adjacent terraces (Naiman *et al.*, 1998). Riparian forests are one of the biosphere’s most complex ecological systems, but also one the most important for

maintaining the vitality of the landscape and its rivers (Welsch, 1991; Lowrance *et al.*, 1985; Wenger, 1999). Riparian forests are highly variable in space and time. The riparian zone is the interface between the terrestrial and aquatic ecosystems and encompasses sharp gradients in environment and community processes. Plants of the riparian forests have numerous morphological, physiological and reproductive adaptations for life in variable environments. The dynamics of riparian forests vary longitudinally and laterally throughout a drainage network as function of valley morphology, physical processes, vegetative legacies, and life history strategies (Naiman *et al.*, 1998). Riparian zones are type of ecotones, or boundary between ecosystems. A riparian zone that is afforded some degree of protection is a 'riparian buffer zone'. The word 'buffer' is used because one of the functions of riparian area is to buffer the stream or river from the impact of human disturbances, such as farming, road construction, etc. Often, various terms *viz.*, 'buffer zone', riparian buffer or simply buffer are in extensive use. Riparian buffer zones are exceptionally rich in biodiversity and they perform a wide range of functions along with economic and social values to people. These functions include: (a) trapping/ removing sediment from runoff, (b) stabilizing streambanks and reducing channel erosion, (c) trapping/ removing phosphorus, nitrogen and other nutrients that can lead to eutrophication of aquatic ecosystems, (d) trapping / removing other contaminants, such as pesticides, (e) storing flood waters, thereby decreasing damage to property, (f) maintaining habitat for fish and other aquatic organisms by moderating water temperatures and providing woody debris, (g) providing habitat for terrestrial organism, (h) improving the aesthetics of stream corridors, and (i) offering recreational and educational opportunities (Malanson, 1993; Schueler, 1995; Wenger, 1999).

Riparian forests serve as 'natural buffers' and 'biological filters'. The key attribute of riparian forests in the context of a channel is the ability and efficiency of these inbuilt buffers to act as the ecological machinery for self-regulation, self-purification and self-support for the dynamic flow of river water and its quality (Ostroumov, 1998). The aquatic organisms *i.e.*, plants, periphyton – complex mixture of algae, cyano-bacteria, heterotrophic microbes and detritus *i.e.*, attached to submerged surfaces in the riparian zone along with aquatic animals *viz.*, bivalves, crustaceans, rotifers, some protistis, bryozoans, tunicates and other organisms serve as 'filter-feeders' or help in the mechanism of 'bio-remediation' of waste management (Ostroumov, 1998).

1.8.3 Forest Ecosystems – Fragmentation and Degradation

The history of human existence and civilization is strongly linked with forests and trees. All over the world, people depend on forests for various goods and services (Newton *et al.*, 2016). Over 1.6 billion people's livelihoods depend on forests, while forests are home to 300 million people around the world (UN, 2011). More than 60 million people are employed by forest-based industries. Thus, forests and forest resources have been used since time immemorial. As a result, there has been either extensive loss of forests or their degradation has occurred. Historically, forests were heavily grazed by livestock and burnt in the mountainous tracts, particularly in the river basins for promoting pastoralism and expansion of agriculture. In past two centuries or so, forests were heavily worked, cleared and extensive

plantations were raised to meet the growing demands of timber and other forests based industries. Forests were also severely impacted by the development of linear infrastructure such as road and rail network and other developmental activities like the establishment of multipurpose hydroelectric projects. In the process, a considerable chunk of forests were submerged. Since time immemorial, diverse use of forests by humanity has resulted into forest fragmentation and degradation. Forest fragmentation involves both the extents of forests and its spatial pattern. It reflects the degree to which large, compact and contiguous forested areas are being broken into smaller patches and pierced or interspersed with non-forest cover. The term “fragmentation” has been defined as simultaneous reduction of forest area, increase in forest edge, and subdivision of large forest areas into smaller non-contiguous fragments (Laurance, 2000).

There is a general consensus that fragmentation has a strong negative impact on biodiversity within forests (Sala *et al.*, 2000). The consequences of fragmentation include habitat loss for some floral and faunal species, habitat creation for others, decrease connectivity of the remaining vegetation, decreased patch size, increased distance between patches and an increase in edge at the expense of interior habitat (Reed *et al.*, 1996; Midha and Mathur, 2010). The long history of forest management besides high human disturbance, particularly in higher reaches or upstream forested tract along the streams and river courses has severely impaired not only the functioning of forest ecosystems by way of forest fragmentation and degradation, but also impacted soil erosion, e-flow and biota in terrestrial and aquatic ecosystems. Forest degradation on account of uncontrolled livestock grazing, recurrence of forest fires and invasion of alien species results into decline of capacity of forest ecosystems to provide important goods and services to people and nature.



NTFP Collections is a way of life in the upper catchments of the Beas

1.8.4 Forests and Water - Strong Linkages

The relationship between forests and water is complex that deserves to be accorded a high priority (Calder *et al.*, 2007). The intricate relationship between forests and water has been of interest for long to natural resource professionals and policy makers. It is a common knowledge that forests not only influence the hydrological cycle, but they also have an effect on water resources both quantitatively and qualitatively (FAO, 2013). Forested catchments serve as guarantors of high value surface and drinking water (Carina, 2008; Ekhuemelo *et al.*, 2016). Forests are crucial to sustainable management of water ecosystems and resources, while water is essential for the sustainability of forests ecosystems. The benefits of forests for the supply of water are multiple. Climate change is likely to have adverse impact on the availability and quality of water in several parts of the world as the climate change is not only altering the spatial and temporal patterns of precipitation i.e., snowfall and rainfall) and resultant intensities of flood and drought, but also the structure, composition and function of forests. Interactions between forest cover and water are complex with regard to different variables such as low flow, high flow, water yield and water quality. They depend on many parameters which often have a site-specific nature. The present scientific knowledge on forests and water interaction needs to be efficiently and effectively communicated to policy makers and society at large. Closer cooperation between the forests and water sector is a precondition for sustainable development as forests and water management have several broad socio-economic applications which deserve increased attention (Vose, 2019). There is an urgency to; develop an understanding of complex nature between forests and water and also to develop tools to estimate the value of water related ecosystem services provided by well-managed forests and to put in place financial mechanism for compensating the providers of such services. Vose (2019) based on long term experiments of forest watersheds has summarised five key lessons (Box 1.2).

Box 1.2

Forest and Water Linkages - Key Lessons for Watershed Management (Adopted from Vose, 2019)

- Forests provide the cleanest and most stable flows of surface water and groundwater recharge among all land uses.
- Flow amount (water yield) and timing can be altered by forest management; flows can increase or decrease depending upon post disturbance successional patterns.
- Stream nutrient concentrations in forested watersheds are generally low; however, sediments loading can increase when disturbance disrupts infiltration and results in erosion and sediments delivery.
- Riparian areas and forested wetlands are especially important for regulating flows and protecting water quality.
- The implementation of best management practices allows forests to be managed to avoid or minimize adverse effects of water resources.



High level temperate forest in the catchment; Tunda Bhuj, Parvati River catchment.

Often, interactions between forests and water are of a trans-boundary nature and that requires collaborations at the international level. Thus, forests and water interaction need to be recognised and considered in the broader landscape context an integrated approach should be applied at the local, national and international levels. Sustainable forest management is a key factor in water resources management in general and upland resources development in particular. Both intact natural forest and well managed forest generally produce high quality of water. The Sustainable Development Goals (SDGs) related to water (SDG 6) and land (SDG 15) explicitly acknowledge the linkages between forests and water (UNECE, 2018). In recognition of the crucial relationship between forests and water, there has been an increasing international action to address forest-water interactions since the 3rd World Water Forum and Shiga Declaration in 2002 and Five Year Action Plan emerged from the discussions and recommendations of the Forests and Water Agenda. The plan calls for the tangible integration in science, policy, economics and forest practices related to forests-water interactions (Forests and Water agenda, 2014).

1.8.5 From ‘Isolationist’ to ‘Holistic’ Approaches to River Conservation

The foregoing description has amply highlighted that there are strong and intricate linkages among forests, water, watershed, river, climate and people while these sectors have been seen in isolation for a long time and isolationist approaches were adopted for management. The isolationist, centralised, top-down, sectoral approaches to river conservation have not yielded

much desired success as the holistic, multi-disciplinary, multi-stakeholder, decentralised, bottom-up approaches to river basin or riverscape management were ignored. The vital aspects *viz.*, the complexity and dynamic nature of the rivers, connectivity, e-flow, ecological integrity, river health, biota, biodiversity conservation, and socio-economics of dependent people were overlooked from the perspective of inter-connectedness and entirety. The increasing national and international momentum and action now seeks to move from a sectoral to integrated and cross-sectoral approaches to environmental, economic and social planning at local, national and international levels in the context of river conservation and management of vital river resources. The holistic approach also advocates to promote effective and equitable collaborative arrangements and partnerships among governments, local communities, scientific organizations, private sector, civil society, forests and water managers and other stakeholders besides facilitating knowledge sharing, capacity development, science-based policy development and tangible improvements in forests and water management (FAO, 2013). In view of the emerging scenario and to fulfill the urgent requirements of national agenda and global commitments, the Government of India has also launched several new initiatives relevant to river rejuvenation and conservation as narrated in the above section 1.7. Amongst them, the Namami Gange programme initiated by the MoWR, RD & GR (Now Ministry of Jal Shakti) as a part of the National Mission on Clean Ganga (NMCG) focuses on the restoration of the National River i.e., the Ganga river and adopted a comprehensive, multi-sectoral, multi-dimensional and multi-stakeholder strategy including 'forestry interventions' as an important and vital component. The Forest Research Institute (FRI), Dehra Dun on behest of the MoWR, RD & GR has prepared a Detailed Project Report (DPR) on forestry interventions for rejuvenation of Ganga River in the year 2015. From the financial year 2016-17, the 5-year project on forestry interventions prepared by FRI is being implemented by five concerned states namely, Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal lying along the main river course. The NMCG has supported implementation of plantation activities in natural, agriculture and urban landscapes within the delineated Ganga riverscape besides other interventions as proposed in the DPR. The FRI, Dehra Dun in its report on implementation of DPR in 2018 has revealed that the above five states have planted 7,685.16 ha, 2,840.72 ha and 2,731.29 ha area in natural, agriculture, and urban landscapes, respectively during three years of project execution (FRI, 2018).

1.8.6 Current Task – DPR Preparation on Forestry Interventions for Rejuvenation of Beas River

Realising the current plight of all major Indian rivers, the Government of India, NITI Aayog prepared a programme for action which details how the recommendations made by Rally for Rivers (RfR) will be implemented on the ground. The programme for action was prepared by the Department of Rural Development and it was decided to launch a major mission on revitalization of rivers utilizing the existing schemes and programmes of the Government with community lead efforts. Accordingly, the NITI Aayog directed concerned Central Ministries i.e., MoRD, MoEF&CC, MoA, MoDWS, MoH&UA and MoPR and Chief Secretaries/Administrators of all States and UTs to initiate pilot projects for revitalization of

rivers by appropriate convergence of schemes and active involvement of various stakeholders. In response to this and following the pursuit of forestry interventions on Ganga River by NMCG, the MoEF&CC assigned a major task on the preparation of DPR(s) on forestry interventions for restoration of 13 major Indian rivers i.e., tributaries of Indus – Jhelum, Chenab, Ravi, Beas and Sutlej; Yamuna, Luni, Narmada, Godavari, Mahanadi, Krishna, Cauvery and Brahmaputra belonging to nine river systems to the Indian Council of Forestry Research and Education (ICFRE), Dehra Dun, an autonomous organisation under its control. The ICFRE is an umbrella organisation responsible for carrying out forestry research, education and extension activities in the country and an apex body in the national forestry research system. The Council has a pan India presence with its nine Regional Research Institutes and six Centre's located in different biogeographic zones of the country. Each regional institute of ICFRE has been mandated the task of research, education and extension in the States/UTs under their jurisdiction. The Himalayan Forest Research Institute (HFRI), Shimla, a regional institute has been entrusted the task to prepare DPR(s) of five tributaries of the Indus River. The present DPR specifically deals with the Beas River, a major tributary of the Indus River. The ICFRE has allowed HFRI a time frame of 12 months to prepare the DPR envisaging that proposed forestry interventions will immensely facilitate the major goals of accomplishing *Aviral Dhara* (uninterrupted flow), *Nirmal Dhara* (clean flow) and ecological regeneration of aquatic and terrestrial life/ biota.

1.8.7 The Himalayan Forest Research Institute (HFRI) – A Knowledge Management Centre

The Himalayan Forest Research Institute (HFRI), Shimla is one of the nine regional institutes under the umbrella of ICFRE. It was initially established as the High Level Conifer Regeneration Research Centre in 1977 specifically to carry out research on problems associated with natural regeneration of Silver Fir and Spruce. In 1998, the Government of India appreciating the environmental problems of Temperate Forests Ecosystems and high altitude ecology in the Himalayan States, particularly Himachal Pradesh and Jammu & Kashmir decided to develop this Centre to a full-fledged research institute at the time of reorganization of forestry research in ICFRE. The institute has been mandated to carry out forestry research, education and extension activities in the State of Himachal Pradesh and two Himalayan Union Territories – Jammu and Kashmir and Ladakh with a focus on eco-rehabilitation of cold desert, sub-tropical and temperate regions, regeneration of coniferous and broad-leaved forests, insect pest management, and popularization of agro-forestry. HFRI is well equipped with state of the art laboratories and other facilities in its own campus at Panthaghati, Shimla. The institute has established eight experimental field research stations, one model nursery and three Van Vigyan Kendras (VVKs) in different parts of Himachal Pradesh and Jammu and Kashmir and Ladakh UT. It has a team of multidisciplinary scientists working in five divisions and supported by technical staff. Since its establishment, HFRI has made significant contributions towards the development of suitable nursery techniques, propagation of native plant species and eco-restoration of mined areas and cold desert. Over the years, HFRI has developed as a knowledge management centre in the field of high altitude ecology. i.e., Himalayan and Trans-Himalayan regions and conservation of

diverse temperate forest ecosystems and privilege to have essential ingredients: (a) professionals and expertise, (b) state of the art laboratories and other physical infrastructure, and (c) processes and innovative technologies.

1.8.8 Project Development Phase and Preparation of DPR – The Approach

As directed by the MoEF&CC and ICFRE, the HFRI has followed the broad framework of DPR as adopted in the context of forestry interventions for rejuvenation of Ganga river. Long field based experience; existing scientific knowledge and multi-disciplinary expertise available at the institute have been optimally utilized for planning, assessment and development of suitable approaches and strategies in the case of Beas River. The Beas River originates from *Beas Kund* in the state Himachal Pradesh and flows in the plains of Punjab before its confluence with Sutlej River at *Harike Pattan*. In short, concerned two States namely Himachal Pradesh and Punjab were involved in the extensive consultative process, planning and assessment. The Project Launch Workshop and sequential Consultative Meetings organized in two States included policy and decision makers representatives of State Forest Department and various line agencies – Agriculture, Horticulture, Animal Husbandry, Mining, Irrigation, Hydroelectric Projects; state/national level scientific or specialized organizations – Soil and Water Conservation, Hydrology, Forestry, Wildlife, Environmental Management, Central Water Commission, Groundwater Board, Remote Sensing and GIS; Universities; Civil Society; and Non-Governmental Organizations besides conservationists and field practitioners. The well planned consultative process and feedback from various stakeholders have been the key step in the formulation of strategies and preparation of present DPR. Constant persuasion, guidance and support at all stages by the Hon'ble Union Minister for Environment, Forest and Climate Change, Hon'ble Forest Ministers of himchal Pradesh and Punjab, and senior officials of the MoEF&CC, ICFRE and SFDs were instrumental throughout the process of planning and finalisation of the DPR.

1.8.9 The Logical Framework Approach

Freshwater ecosystems, particularly rivers and its resources are used for a wide variety of purposes and by various agencies. Thus, people interact with river resources in different ways which impact the water environment. Managing a river basin or river ecosystem or a riverscape is a challenging task due to conflicting needs such as drinking water, industrial supply, irrigation, power generation, waste dumping, navigation, sand mining, fish harvest, water sports and recreation, and flood mitigation besides the development of the basin in terms of water resources, urbanisation and wetland protection (Bong and Putuhena, 2008; Puranik and Dhadwad, 2015). In view of the conflicting demands and in order to protect, conserve and utilize river resources sustainably, it is essential to take into consideration the diverse and complex relationship with other components of environment while planning whether it is for river basin development or river conservation. Hence, riverscape level planning and conservation requires integration of physical, biological and socio-economic sub-environments of river ecosystem adopting participatory approaches and active involvement of stakeholders.

Most developmental projects, irrespective of the sector focus on complex socio-ecological systems in which ecological, social and economic processes are closely intertwined. The developmental agencies rightly emphasize on ‘pathway to change’ or ‘impact chain’ or ‘Results-Based Management (RBM)’. The Theory of Change stress upon the ‘process’ through which change will occur and specifies the ways in which all the required outcomes and desired long-term change (impact) will be brought about. RBM as a broad management strategy aims at achieving improved performance and demonstrable results (UNDP, 2009).

In past, the holistic and results-based project approaches to planning and management of various developmental projects were ignored. Over the years, various international agencies working in the development sector have evolved various approaches *viz.*, Logical Framework Approach (LFA), Programme Logic Model (PLM) and Results-Based Management (RBM) those offer analytical tool for systematic and logical approach for designing projects with inbuilt mechanism for distinct performance review or evaluation so as to enhance the efficiency of such developmental projects and to ensure accomplishment of desired outcomes and goals (Framst, 1995; Cummings, 1997; Puranik and Dhadwad, 2015; Örtengren, 2016). The LFA was developed in late 1960s and its use became a requirement for the projects funded by USAID. The RBM is an evolution of a standardized Budgeting system i.e., (Results-Based Budgeting introduced within UN Agencies in the late 90s. Cummings (1997) has described role and use of LFA, PLM and RBM and pointed out their similarities and differences. The paper also noted that the approaches are perhaps not so much distinctive and suggested that practitioners could benefit from increasing cross-fertilization of ideas emerging from these resembling approaches.

LFA since its origin in 1960s has been under continuous development. Increasingly, LFA is employed in wide array of projects and sectors. LFA is an extensive, participatory and integral method that delivers a well-structured plan with clearly measurable objectives and well-defined, relevant activities and indicators (Örtengren, 2016). The approach facilitates the planning, monitoring and management of ‘change processes’ so that they can achieve positive and sustainable results. The LFA approach has proven to be a useful and effective tool when following the principles of RBM. The approach is an aid to the logical thinking and ensures that the basic premises are probed extensively and the interrelated key elements are analysed systematically. Considering the recognition of LFA as one of the most efficient tools for designing, implementation, monitoring and evaluating developmental projects, this approach has been used in the process of preparation of present DPR. According to the LFA methodology, the cyclic project planning process includes the nine steps: (a) the contextual analysis, (b) situation and problem analysis, (c) analysis of stockholders, (d) activity planning, (e) resources planning, (f) monitoring result, indicators and means of verifications, (g) risk analysis and management, and (h) analysis of assumptions. The logical framework or log frame developed in the process has being elaborated in Part II, Chapter 5 of this DPR. Envisaged shared vision in the present DPR is presented below:

Vision: Various conservation values of the Beas River are identified, recognized, conserved, restored, and maintained in order to ensure the ecosystem diversity, ecological integrity and

healthy river while allowing sustained flow of ecosystem services and other uses/ benefits essential for all life forms and the prosperity of the region.

The DPR envisages two Phases of 5-year each and have been named as the ‘Phase I - Project Implementation Phase’ and Phase II – Maintenance Phase’.

1.8.10 Aims and Objectives of the Project

The project aims to accomplish the broader goals of management of river ecosystem by ensuring connectivity i.e., longitudinal, horizontal, vertical and temporal, enhanced e-flows, biodiversity conservation, improved ecosystem services, and sustained livelihoods. On the lines of *Namami Gange programme*, the project intends to adopt multi-pronged approach for proposed forestry interventions so as to accomplish broad objectives of *Aviral Dhara*, *Nirmal Dhara*, and ecological rejuvenation. Following specific objectives were set forth for achieving the goals relevant to forestry interventions:

- (a) To review and assess the existing situation of Beas River Basin, past river management and implications, and lessons learned
- (b) To identify and involve stakeholders and build consensus for design and development of strategies and approaches
- (c) To assess ongoing forestry activities by the concerned States engaged in the river management programmes
- (d) To assess potential and possibilities for regeneration, improvement, and restoration of forest catchment
- (e) To examine the possibility of allied and other income generation activities
- (f) To assess the potential of cultivation of medicinal plants and restoration of conservation areas and identify appropriate species and suitable sites
- (g) To identify research and monitoring needs and develop a strategy for future research and monitoring
- (h) To formulate strategies, develop approaches and plan activities for project implementation

1.8.11 The Organization of DPR

The DPR for Beas River is presented in two volumes. Volume I deals with the main DPR while the Volume II provides summaries of two States located on the Beas River. Volume I further contains two parts i.e., Part I and Part II. The Part I describes the existing situation of Beas riverscape and incorporates four Chapters while the Part II deals with the proposed plan and includes three Chapters. The Chapter 1 – ‘Introduction’ highlights the intricacies and dynamic nature of river ecosystem and elaborates on vital aspects of connectivity, environmental flow, ecological integrity and river health. The Chapter narrates linkages among forests, river, other lands and human well-being, and also describes past management of river, and also dwells upon the evolving concepts and holistic approach of river basin management and the riverscape, present task on forestry intervention, logical framework

analysis, and the organisation of DPR. The Chapter 2 – ‘The Beas River and its Environment’ summarises the physical, biological and socio-economic sub-environments in the broader context of Beas River Basin, particularly the delineated riverscape along the course of Beas River. The Chapter 3 – ‘Approach and Methodologies’ describes the ‘Beas Riverscape’ delineated for the purpose of planning, assessment and preparation of present DPR. This Chapter also presents the approach adopted and its key components. The Chapter 4 – ‘Legislative, Policy and Institutional Context’ provides an insight on the existing policies and laws relevant to water, environment, forest management, biodiversity conservation, river management, etc. The Chapter 4 also provides details of various Central and State Government-level agencies and concerned scientific and specialized organizations that are directly responsible for the policy and decision making, over-seeing and management of activities of associated sectors. The Chapter on one hand examines critically the existing policies, conventions, treaties and laws pertaining to the themes of the DPR while on the other hand identify gaps, imperatives and future needs from the perspective of various users and those who either influence/impact or are responsible for the management of water resources. The Chapter 4 also provides an insight on potential partner organizations besides the State Forest Department those can either undertake activities relevant to forestry interventions or assist and facilitate various supporting activities. The Chapter 5 – ‘Forestry Interventions - The Objectives and Strategies’ in Part II, presents the goals and objectives of the proposed forestry interventions and describes the strategies formulated and adopted for plan implementation. The Chapter includes details on different landscapes deciphered within the riverscape for proposed interventions/ treatments and model wise treatment plans besides details on projected targets, model wise extent and cost, and theme plans. The Chapter 6 – ‘Implementation – Mechanism and Sustainability’ summarises partnership and institutional arrangements for programme implementation besides vital aspects of fund flow mechanism, risk assessment, monitoring and evaluation, and cost effectiveness. The Chapter 7 – ‘Project and Budget Schedule’ provides an overview on the project Budget, cost tables and schedule. The Chapter 8 – ‘Potential Benefits of Forestry Interventions’ attempts to highlights likely benefits due to execution of the project. The last Chapter is followed by references and annexure. As stated above the Volume II deals with the summaries of Himachal Pradesh and Punjab.



Rohtang: Surge in Domestic Tourism activity in the pristine catchment area



Alpine moist meadows environment– an important ecosystem

2.1 River Environment

The preceding Chapter 1 has highlighted that ‘a river is more than just the water inside it and water is only one component of the complex and dynamic river ecosystem’. Indeed, the environment of a river is the sum reflection of physical regimes (i.e., climate, topography, geology, and land cover); biological attributes (i.e., terrestrial and aquatic biodiversity; and the socio-economic condition in the surrounding lands of the river or even in its catchment. As a pre-requisite to the ecosystem based approach to river management, adequate appreciation and understanding of the overall environment of the river is required. The ecological characteristics of a river are responses to the source of flow and fluvial processes. The hydrological regimes or fluvial processes are vital driving forces of the river ecology. The climatic conditions i.e., spatial and temporal patterns of rainfall and snowfall) and glacier melt influence the environmental flow (e-flow) and to a great extent the four types of connectivity i.e., longitudinal, lateral, vertical and temporal) essential for the sustainability of river ecosystem. Connectivity ensures flow of energy and nutrients between and within aquatic and terrestrial environments. In addition to the climate, the geo-morphology that represents the configuration of the earth’s surface and distribution of land, water, etc. in turn dictates how water flows across the landscape or in other words, the hydrology. However, hydrology in turn affects geomorphology. The land cover controls surface interception of

rainfall as well as potential evapotranspiration. It land cover has also the dominant control on hydro chemical processes and water chemistry. Land cover also influences local variations in erosion rates and the type of sediment reaching stream channels. Geology controls groundwater storage capacity and transmissivity, and is likely to be the dominant influence of the base flow. Floods and high flows carve and shape the valleys, river channels and deposit sediments to create wide, flat floodplains, thereby changing the geomorphology. Living systems in the aquatic environment of river as well as terrestrial environment in surrounding lands comprises of a variety of plants, invertebrates and vertebrates. These organisms interact with the abiotic components of the ecosystem. The biotic components (diversity and productivity) are dependent on the driving variables (the climate).



Mantalai – a glacial lake at the origin of River Parvati (4100 m)

In view of the above inter-relationships and intricacies, a dynamic river from its origin to mouth reflects heterogeneity besides longitudinal changes, vertical interactions, lateral exchange processes, and temporal variations and resultant patterns in the overall environment of the river and its surrounding lands. This intricate and vibrant nature of a river calls for adopting a holistic approach to the scientific basis of its management and sustainability. In short, the environment of the river ecosystem comprises of the physical, biological and socio-economic sub-environments. Snelder and Biggs (2002) described the ‘River Environment Classification (REC)’, a new system for classifying river and environments that is based on climate, topography, geology and land cover factors which control spatial patterns in river ecosystems. The REC assumes that ecological patterns in a river are dependent on a range of

factors and associated landscape level processes. The REC recognized the hierarchy in the controlling factors at each level. It REC also assumes that the heterogeneity or ecological variations in a river are result of fluvial processes. Hence, the river environment classification takes into consideration the network of channels, in other words the stream order level. The REC identifies individual river sections/ stretches as independent classes. The classification given by Snelder and Biggs (2002) was employed to develop a multi-scale spatial framework for the management of rivers in New Zealand.

In appreciation of above described nature of rivers, increasingly most world countries including India have recognized the significance of adopting comprehensive river basin approach or riverscape specific interventions for rejuvenation of major rivers. Thus, the present chapter attempts to study, examine, and understand the nitty-gritty of three sub-environments in the context of Beas River Basin, and the Beas Riverscape in particular. The present synthesis is primarily based on the review of secondary information for the preparation of present DPR. Thus, synthesis on the environment of the river basin/ riverscape is mainly based on review and efforts have been made to summarize and highlight the vital aspects of three sub-environments from the perspective of DPR and rejuvenation of Beas River through forestry interventions. The following sections emphasize an insight on the biological environment from the perspective of forestry, wildlife, protected areas and biodiversity.

The entire Beas River Basin spreads over an extent of 22,262.10 km². Out of this, the delineated Beas riverscape includes an extent of 16,743.01 km² and represents 75.21% of the basin area (Table 2.1).

Table 2. 1 - Area Coverage under the Beas River Basin and the Beas Riverscape

Sr.No.	Consideration Unit	Area Covered (km ²)	Coverage Area (Indian States)
1.	Beas River Basin	22,262.10	Basin Area in two Indian States - Himachal Pradesh and Punjab
2.	Beas Riverscape	16,743.01	Entire catchment area of Beas River in Himachal Pradesh and select areas of concerned micro-watersheds in the case of main channel of Beas River in Punjab. 16 tributaries i.e., Patlikuhal, Sarbari, Parbati, Hurla, Sainj, Tirthan, Uhl, Suketi, Luni, Awa, Manuni, Baner, Banganga, Chakki, Gaj and Bein) and their catchments.

As stated earlier, the drainage area of the Beas River Basin lies in two States, namely Himachal Pradesh and Punjab located along the river course from its origin to confluence with the Sutlej River. The State-wise distribution of the riverscape area is presented in Table 2.2. The total catchment area of Beas River in Himachal Pradesh is 13,702.16 km² and this entire area has been included in the riverscape. A small sub-set (3,040.85 km²) of total catchment in Punjab was included as a part of the riverscape. Thus, the larger portion, being

81.84% of the riverscape, lies in Himachal Pradesh while 18.16% area of the riverscape falls in Punjab. Nearly 25% geographical area of the Himachal Pradesh represents in the riverscape while a small extent of 6.03% geographical area of Punjab State forms a smaller part of the riverscape.

Table 2. 2 – State-wise Distribution of the Riverscape Area

Sr. No	Consideration Unit	Geographical Area of the State (km ²)	Extent in the Riverscape (km ²)	Representative Area of the State (%)	Representative Area of the Riverscape (%)
1.	Himachal Pradesh	55,673.0	13,702.16	24.61	81.84
2.	Punjab	50,362.0	3,040.85	6.03	18.16
3.	Total (Two States/ Riverscape)	1,06,035.0	16,743.01	15.79	100.00

2.2 Beas – Headstreams, Main Stem, Tributaries and Confluence Points

The forgoing section has highlighted that a larger portion of the basin of the Beas River lies in the Himalayan State of Himachal Pradesh while the remaining smaller portion of the basin lies in Punjab state. Likewise, 81.84% extent of the delineated Beas Riverscape lies in Himachal Pradesh while the remaining 18.16% area of the riverscape is located in Punjab. More than 90% of the drainage system of Himachal Pradesh forms a part of the Indus River system while the remaining drainage area of the state constitutes a small part of drainage of Yamuna, Markanda and Ganga Rivers. Thus, the State has nine major catchment areas. These are the: Sutlej (36.6%), Beas (24.5%), Chenab (14.2%), Yamuna (10.6%), Ravi (9.9%), Indus (2.6%), Markanda (0.6%), Ganga (0.5%) and the Ghaggar (0.5%) (GoHP, 2012). Beas happens to be a principle tributary of Sutlej River in India.

RSET (2019) in its detailed report entitled ‘Cumulative Impact and Carrying Capacity Study of Beas Sub-Basin in Himachal Pradesh’ prepared for MoEF&CC has provided the general account on the Beas River, characteristics of the basin, hydro-meteorology, ecological aspects – terrestrial and aquatic ecosystems, environmental flows, and cumulative impact assessment. Substantial information from this study report has been liberally used to provide the background information on the river and its basin. Beas River originates from ‘*Beas Kund*’, near Rohtang Pass (3,978m) in the Pir Panjal Range. Beas Kund (3,505 m) and the Rohtang Pass are the major contributors of water in the Beas River. Water originating from both places meet at Palchan which is situated 10 km north of Manali where it is joined by *Solang Nallah*, one of the major tributary of Beas river (Ahluwalia *et al.*, 2015). River from its origin flows for a length of 470 km before joining the Sutlej River at *Harike Pattan*, south of Amritsar in Punjab. After the confluence of two source streams viz., *Beas Kund* and *Beas Rishi* at Palchan village, the river is known as Beas. The river after passing through Manali town traverses dense evergreen forested slopes and enters the town of Kullu. At Bhuntar, Beas River is joined by Parbati River on its left bank which is a major tributary. After this, the river flows through different terrain types cutting through the hills. The river flows in

north-south direction upto Larji and then turns west up to Pandoh diversion dam. It is fed by number of streams in this stretch up to Pandoh. In addition to Parbati River, major tributaries of Beas River in upstream of Pandoh are Sainj and Tirthan Rivers, and south-west Bakhli Khad joining from the east; Sanjoin, Manalsu, Fozal, and Sarbari from the west. After Pandoh, the river flows in northerly direction, and is joined by Uhl River on its right bank along its course. After this, river again turns westward up to Mandi where it takes northerly turn again to be joined by Rana Khad on its right bank. It then enters Kangra valley near Sandhol. In Kangra valley, Binwa, Neugal, Ban Ganga and Dehr are the major streams joining from the north and Kunah, Maseh, Son, Khairan Man from south direction. The northern and eastern tributaries of the Beas River receive water from the melting snow, and are perennial whereas the southern tributaries are seasonal. After leaving Himachal Pradesh, the river changes its way to southern-westerly direction and enters plains of Punjab at Talwara and joins the Sutlej River at Harike Pattan (RSET, 2019). The Beas River, its catchment and major tributaries in the basin are shown in Fig. 2.1.

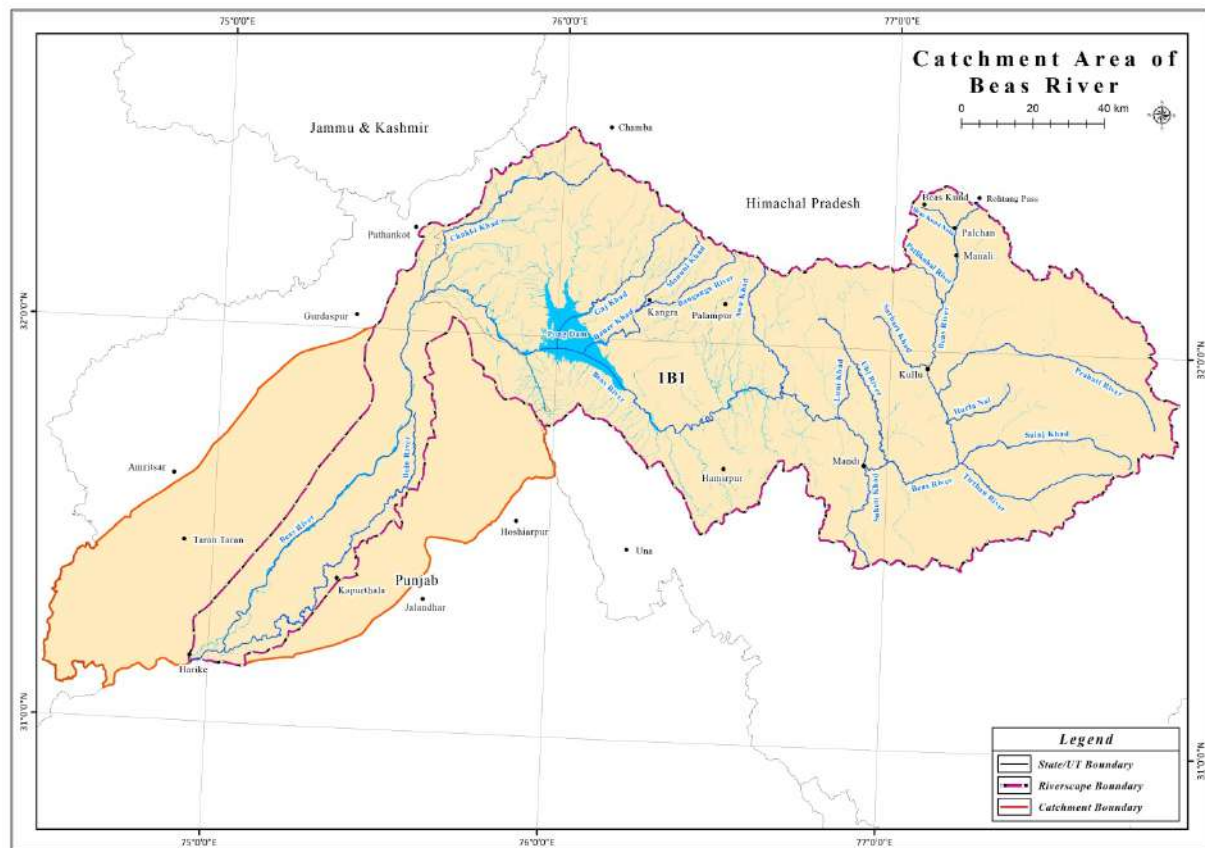


Fig. 2.1 – Beas Riverscape, its Catchments and Major Tributaries

The length of Beas Kund Nalla upto Palchan is 12.96 km. After confluence of two streams at Palchan, river is being referred as the Beas River. The length of Beas River in Himachal Pradesh is 307.2 km and its basin in the state administratively falls under five districts viz., Kullu, Mandi, Kangra, Hamirpur and Chamba. Most parts of Kullu and Mandi district form the upper reaches of Beas River Basin while Kangra and Hamirpur form the lower parts of

the basin. The Western most part of the river falls in the plains of Hoshiarpur and Gurdaspur districts of Punjab. The length of Beas River in Punjab is 149.7 km. Thus, the Beas River from its origin to confluence with Sutlej traverses a total distance of 469.83 km in two states. Major towns located within the basin area of Himachal Pradesh are Manali, Patlikuhl, Naggar, Kullu, Bhuntar, Bajaura, Nagwai Aut, Banjar, Mandi, Ner Chowk, Sunder Nagar, Padhar, Barot, Jogindernagar, Sujanpur Tirha, Nadaun, Kangra, Palampur, Jwalaji, Dehra, Nagrota, Bagwa, Shahpur, Nurpur, Yol and Dharamshala (RSET, 2019). Prominent towns located within Beas Basin area of Punjab are: Bainpur, Dhnoa, Bahadurpur Rajoa, Dera Baba Jaimal Singh ji, Goindwal Sahib, Gharka, and Naushera Pattan. Within Himachal Pradesh, the Beas River passes through four districts i.e., Kullu (from Palchan to Bajoura – 63 km), Mandi (from Bajoura to Sachuhi – 103 km), Hamirpur (Sachuhi to Kaloora – 54 km), and Kangra (from Kaloora to Dehra Gopipur – 35 km). In the present DPR, the main stem of the Beas River and its 16 tributaries have been taken into consideration. Details on length on main stem of Beas River and select 16 tributaries in Himachal Pradesh and Punjab states are presented in Table 2.2

Table 2.3 - Length of Beas Main River Stem and its Major Tributaries

Sr. No.	River Name	State	River Length (km)
Beas Main Stem			
1.	Beas Kund Nala	Himachal Pradesh	12.96
2.	Beas River	Himachal Pradesh	307.16
3.	Beas River	Punjab	149.71
Total Length			469.83
Major Tributaries			
4.	Patlikuhla Khad	Himachal Pradesh	16.49
5.	Sarbari Khad	Himachal Pradesh	26.63
6.	Prabati River	Himachal Pradesh	84.27
7.	Hurla Nala	Himachal Pradesh	26.18
8.	Sainj Khad	Himachal Pradesh	61.68
9.	Tirthan River	Himachal Pradesh	53.42
10.	Uhl River	Himachal Pradesh	63.34
11.	Suketi Khad	Himachal Pradesh	35.69
12.	Luni Khad	Himachal Pradesh	17.55
13.	Awa Khad	Himachal Pradesh	49.35
14.	Manuni Khad	Himachal Pradesh	30.37
15.	Baner Khad	Himachal Pradesh	30.96

16.	Banganga River	Himachal Pradesh	38.79
17.	Chakki Khad	Himachal Pradesh	69.49
18.	Chakki Khad	Punjab	49.26
19.	Gaj Khad	Himachal Pradesh	60.28
20.	Bein River	Punjab	148.91
21.	Total Length of Tributaries		862.66
22.	Total Length of Beas Main Stem and 16 Tributaries		1,332.49

Brief description of 16 tributaries from the origin of Beas River river to its confluence in the Sutlej River is presented below:

(a) Sarbari Khad

Sarbari Khad is a right bank tributary of Beas River. The total length of the Khad upto its confluence with Beas River at Dhalpur, Kullu is about 26.7 km. The total catchment area of the stream is 183 km², and flows through the middle of Kullu town.

(b) Patlikuhad Khad

It rises from the snow on the southern slopes of the Pir Panjal range and thereafter, it flows into the Beas River at Patlikuhl upstream of Kullu.

(c) Parbati River

Parbati River is the largest tributary of Beas River. It meets Beas River on its left bank near Shamshi in Kullu valley. The river originates from Parbati Glacier near Pin Parbati Pass (5,400) upstream of Manikaran on the foothills of the Great Himalayan Range in Kullu district. The glacier which feeds this river descends down from the steep southern slopes of the Greater Himalaya. The total length of the river from its origin to confluence with Beas River is about 82 km. The total catchment area of the river is about 1,729.5 km².

(d) Hurla Nallah

Hurla Nallah rises as a small channel from the snows in the depression of the north-western flank of Kullu valley. It joins the Beas River on its left bank near *Hurla* village at 1,020 m, close to Bajaura. The total length of the *Nallah* is about 33.3 km with catchment area of about 188.5 km². Numerous snow-fed streams join the River *Hurla Nallah*.

(e) Sainj River

About 13 km downstream of *Hurla Nallah*, Beas River is fed by Sainj River which traverses a distance of about 59.9 km to join Beas River on its left bank at Larji Dam. The catchment area of the river is 747 km². It rises from an unnamed glacier located at about 4,200 m at the water divide of the Beas and Sutlej Rivers in the lower ranges of the Great Himalaya to the east of Kullu. The Sainj valley is ‘V’ shaped and the river flows past a series of interlocking spurs. It has widened near the mouth of the river.

(f) Tirthan River

It is a tributary of the Sainj River and rises from an unnamed glacier at an elevation 4,378 m from the base of an offshoot of the Great Himalayan range to the south-east of Kullu in the Tirthan Wildlife Sanctuary. Thereafter, it follows a south-westerly course and travels a distance of 50.7 km to join Sainj River on its left bank at Larji. It is the biggest tributary of Sainj with a catchment area of about 679 km². Lower down the valley opens up and it is fairly wide near its confluence with the Beas River.

(g) Uhl River

Uhl River rises as two feeder channels in the area to the north of the Dhauladhar range in Himachal Pradesh. Thereafter, the two channels cross this gigantic mountain barrier and merge at the base of the southern slopes to form the main channel of the Uhl River in Kangra district. It flows for a considerable distance along the base of the Dhauladhar range. Later, it turns towards the south-east and joins the Beas before the Mandi Town.

(h) Awa River

It rises from the Dhauladhar range in the Kangra valley and flows in a south-westerly direction before joining the Beas River. It receives both snow-fed as well as rainfall water from smaller channels.

(i) Baner Khad

This tributary drains the central part of the Kangra valley and meets Beas River on its right bank near Mahora village. The *Baner Khad* rises as a small snow-fed channel on the Southern slopes of the Dhauladhar range near Palampur. The general direction of flow of the *Baner Khad* is towards south-west. The length of the tributary is 63 km with a catchment area of 749 km².

(j) Luni River

Luni rivulet rises from the southern slopes of Dhauladhar in the Kangra valley and merges with the Beas River in the central part of Kangra valley.

(k) Banganga River

It rises from the Southern slopes of the Dhauladhar ranges and joins the Beas River in the Kangra valley. The river is fed by snow melt waters and channels emanating from springs. Large fertile sediments have been formed all along the river near its mouth.

(l) Chakki River

The Chakki River rises as a small snow-fed and rain-fed stream from the southern slopes of the Dhauladhar range. It drains the south-western part of Himachal Pradesh. Later, the river enters into Punjab near Pathankot. It is the only tributary within the riverscape which flows in both these states. After traversing a distance of 118.75 km from its origin, it joins the Beas River in the territory of Punjab.

(m) Manuni River

It rises from the southern slopes of the Dhauladhar range and joins the Beas River. Steep slopes form the upper catchment of the *Manuni* River. There is a sharp fall in its gradient, thus large river terraces occur on the both sides of the river bed, which are used for extensive cultivation.

(n) Gaj Khad

Gaj Khad rises as a small stream from the snow clad southern slopes of the Dhauladhar range in Kangra district at an altitude of 4,400 m with a number of small streams joining it. It travels 64 km to join the Beas River a little upstream of the Pong Dam Lake (Maharana Pratap Sagar). The catchment area of the river is 1,246 km.

(o) Suketi River

This river is a tributary of the Beas River in the Kangra valley. It rises from the South facing slopes of Dhauladhar range. A number of small channels join the *Suketi* River in its upper reaches. The river has formed huge terraces, most of which are under cultivation. The upper catchment of the river consists of steep slopes.

(p) Bein River

Bein River is a rivulet in Punjab, India that flows into the confluence of the Beas and Satluj Rivers at *Harike Pattan*. It is believed that Guru Nanak attained enlightenment after taking a bath in the *Bein* River. It is also known as *Kali Bein*, literally meaning the black stream due to the black colour reflected by the minerals in its waters. The Punjabi word '*bein*' derives from the Sanskrit '*veni*' meaning a stream or a water body. *Beins* are a feature of the plains, and are marked by their zig-zagging course. The *Kali Bein* rises from *Terkiana* marshland in tehsil Mukerian of Hoshiarpur district. The water that oozes out in district Hoshiarpur, flows in it. *Odhra* rivulet and Mukerian Hydrel Channel are the main source of water for *Kali Bein* River. After flowing for 149 km, it merges at the confluence of the Beas and the Sutlej at *Harike Pattan*. The *Kali Bein* River is also called the Western Bein in Hoshiarpur and its course lies parallel to the Beas in the Hoshiarpur and Kapurthala districts. In the past, *Kali Bein* River was directly linked to the Beas River. With passage of time, the Beas River changed its course and moved away by a few hundred meters from its original place. The *Kali Bein* River flows through the districts of Hoshiarpur, Kapurthala and Jalandhar and there are several towns on its banks including Kapurthala and Sultanpur Lodhi.

2.3 The Physical Environment

The concept of environment is quite enormous in scope, ranges from the physical to biophysical and from the natural to the social environments. In a system analysis approach or ecosystem management, the focus is on interactions and inter-relationships between different parts of the environment. The term 'environment' simply means 'surroundings' (environs). Hence, the environment of an individual, object, element or system includes all entities with which it is surrounded, this means, the abiotic (non-living) and biotic (living) components of the environmental systems.



The fast flowing Sainj river as it prepares to exit the Great Himalayan National Park, Kullu

The physical environment in the context of a Himalayan River like Beas River is complex as its geological framework is formed due to consequences of the continental drift–tectonic movements and it has been immensely influenced by the geodynamic processes and evolution; glacial, fluvial and denudation processes; driving variables *viz.*, glaciers, snow cover, rainfall, temperature, etc.; and overall climatic conditions. Climate, geology and soils affect the availability of surface water and groundwater resources. Climatic largely determine the amount of available precipitation in the basin. Geology and soil factors determine the proportion of precipitation which runs off the land as surface water to that which infiltrates the soil and percolates through underline materials to become groundwater. Geology and soils also determine surface drainage characteristics, the vulnerability of aquifers to contamination, and the limits of groundwater development.

The Beas Riverscape represents two major physiographic divisions; (a) the Himalayan Mountainous Zone in the State of Himachal Pradesh, and (b) the Indo-Gangetic Plains in Punjab State. These two prominent physiographic and geomorphological divisions have a direct bearing on the characteristics of Beas River Basin, the riverscape and the river hydrology in particular. Noticeably, the physical environment of the Beas Riverscape is fascinating owing to the natural grandeur of Himalayan Mountains and vastness of the alluvial plains; incessantly evolving evolutionary and environmental processes; and expanding human imprint by way of developmental projects and intensification of agriculture. Thus, it is of paramount importance to first develop an insight on the physical environment in the context of Beas Riverscape, specifically with regard to above mentioned two prominent physiographic and geological formations that have experienced continuous change since their creation.

2.3.1 Himalayan Mountains in Himachal Pradesh

In case of Beas River, the Himalayan mountainous part of riverscape is represented in just one of the two States i.e., Himachal Pradesh. It covers an extent of 13,702.16 km² and represents 81.84% of the riverscape. This larger part of the riverscape is primarily constituted by the Himalayan Mountains, forming the Basin Beas River and its tributaries within the State of Himachal Pradesh.



Majestic Himalayan Mountains-Perennial source for Himalayan Rivers

The Beas River Basin is flanked by the basin of Ravi River in its north while on the south by the Sutlej River Basin, both also being the major rivers of the Indus River Basin. Owing to intricate mosaic of high mountains, steep snow-capped peaks, large valleys, unfathomable river gorges, complex geologic structure and landforms, alpine glaciers of stupendous size, topography deeply cut by erosion, and series of altitudinal zones that display different ecological associations of flora and fauna with harsh climatic conditions, Himalayan Mountains represent a unique geo-feature of the planet and characterize the Beas riverscape (Khawas, 2008). Geologically, Himalaya is the youngest folded mountain system, still undergoing the mountain-building process, and represent multifaceted sub-parallel structural units produced by the northward thrust of the Indian tectonic plate beneath the Central Asian plate (Saxena, 1970). The Himalaya is the representative of the recent-most epoch in the orogenic history of the earth causing uplift of Archaean to Mesozoic accumulations in the geosyncline (about 25-60 million years ago) (Wadia, 1961; Dewey and Bird, 1970; Powell and Conagan, 1973; Dewey *et al.*, 1989; Ni, 1989; Thakur, 2001). The upliftment of Himalaya is believed to have taken place in three main phases after upliftment of Karakoram and associated ranges during the Cretaceous period (Saxena, 1970; Reddy, 2015). The first and oldest phase of formation of the Inner Himalaya or the Great Himalaya was during

Oligocene period. The second phase led to formation of the Middle Himalaya or the Lesser (Lower) Himalaya during the Miocene period. The third and latest phase was formation of the Outer Himalayas or the Shivaliks (Sub-Himalaya) during the post Pliocene period. Thus, the Himalaya is not a single continuous chain or range of mountains, but a series of more or less parallel or converging ranges intersected by numerous valleys and extensive plateaus. According to Gansser's (1974) widely accepted classification, the Himalaya has been divided longitudinally into five tectonic zones on the basis of geological evolution. In addition to the above described three upliftments and resultant three parallel mountain ranges of the Himalaya, the Tethys (Tibetan) Himalaya and the Trans-Himalaya also exist in the northern part of the three ranges. Above mountain ranges in different tectonic zones are separated from each other by the principal Himalayan thrust faults (Thakur, 1981, 1984 and 1992; Valdiya, 1980 and 1988; Molnar, 1984 and 1986). The southernmost fault, the Main (or Himalayan) Frontal Thrust (HFT) separates the Shivaliks from the alluvial plains (the northern edge of the Indo-Gangetic Plain). The Main Boundary Thrust (MBT) separates the Lesser Himalaya from the Shivaliks. The Main Central Thrust (MCT) separates the Higher or Great Himalaya over those of the Lesser Himalaya. The South Tibetan Detachment (STD) marks the boundary between the Higher Himalaya and the overlying fossiliferous sequence of the Tethys Himalaya. The Indus-Tsangpo Thrust (ITT) separates the rocks of the Indus-Tsangpo Suture in the Trans Himalaya from the Tethys Himalayas (Powell and Conaghan, 1973; Thakur, 1981, 1984 and 2001).

The Himalayan arc extends from the Indus Trench below Nanga Parbat (8,125 m) in the west to the *Yarlung Tsangpo* – Brahmaputra gorge below Namche Barwa (7,756 m) in the east, a distance of about 2,500 km and a width of 200 km – 300 km (Ives and Messerli, 1989; Ives, 2004; Rao and Saxena, 1994; Khawas, 2008). Singh (1971) divided the Himalaya on the basis of geological and geo-morphological characteristics into the following three physiographic divisions viz., (a) Shivaliks, (b) *Himanchal*, and (c) *Himadri*, extending almost uninterrupted throughout its length.

- (a) **Shivaliks or Outer Himalaya (Sub-Himalaya):** The Shivalik range or the Sub-Himalaya forms the foothills of the Himalayan Range with an average height of 900 m - 1,200 m and width from 8 km - 80 km. This is essentially composed of Shivalik sediments derived from the erosion of the Himalaya. They are basically newer and river borne deposits brought down by the rivers coming from the Himalayas (Indus, Ganga, Brahmaputra and others) and represent the recent phase of the Himalayan orogeny. The system roughly has the appearance of hogback with steeply sloping southern and gently sloping northern face. The wide longitudinal valleys in between the lesser Himalaya and Shivaliks are called '*Duns*' in western and central Himalaya and '*Duars*' in eastern Himalaya. South of the foothills the *Terai* and *Duars* plains.
- (b) ***Himanchal* or Lesser Himalaya:** The *Himanchal* with an average height of 3,900 m - 4,500 m and width varying from 32 km to 80 km forms the central chain and composed mainly of highly compressed altered rocks from Algonkian or Pre-Cambrian to Eocene in age. These low grade sediments are thrust over the Shivaliks

along the MBT. Prominent ranges of the middle Himalaya include the *Nag Tibba*, the Dhauladhar, the *Pir Panjal* and *Mahabharat*.

Himadri or the Great Himalaya (High Himalaya): The Great or Inner Himalaya rises above 6,060 m and includes peaks like the Everest, K2, Kangchenjunga, Dhaulagiri, Nanga Parbat, etc. It forms the backbone of the Himalayan Orogeny and encompasses the areas with the highest topographical relief. Himadri Range is a granitic core flanked by metamorphosed sediments. Along with the Karakoram Range, Himadri has the credit of having the world's 14 highest peaks. As the highest zone, it consists of a huge line of snowy peaks with an average height exceeding 6,100 m. The width of this zone is about 24 km. To the north of Great Himalaya, stretch out several ranges such as Zaskar, Ladakh, and the Kailash (Saxena, 1970; Khawas, 2008).

Apart from the above tectonic/ longitudinal sub-divisions, the Himalaya also exhibits notable regional geographical characteristics. Eight regional divisions on the basis of regional heterogeneity have been described (Singh, 1971; Khawas, 2008). This includes: (a) Western Himalaya regional division - Kashmir Himalaya and Himachal Himalaya sub-divisions; (b) Central Himalaya regional division - Uttarakhand Himalaya and Nepal Himalaya subdivisions; and (c) Eastern Himalaya regional division – Sikkim, Darjeeling, Bhutan and Arunachal Himalaya sub-divisions. However, the biogeographic classification of India by Rodgers and Panwar (1988) divides the Himalayan Biogeographic Zone-2 in four biotic provinces *viz.*, 2A North-Western Himalaya, 2B Western Himalaya, 3B Central Himalaya, and 2D North-Eastern Himalaya and the vast region of the Trans-Himalaya as a separate Biogeographic Zone-1 having two biotic provinces *i.e.*, 1A-Ladakh Mountains and 1B-Tibetan Plateau. The Himalayan Mountains in Himachal Pradesh have representation of 1A-Trans-Himalaya, Ladakh Mountains, 2A-North-Western Himalaya, and 2B-Western Himalaya biotic provinces.

The Himachal Himalayan region corresponding to the Himachal Pradesh is situated between latitudes N 30°22'40'' to 33°12'40'' and longitudes E 75°45'55'' to 79°04'20''. The State is located in the northern part of India. It is bordered by Punjab in the west and Haryana in the southwest; China in the east and Uttarakhand in the southeast; and Jammu & Kashmir, and Ladakh UTs in the north. The Himachal Himalayan region owing to distinct ranges; variations in their evolutionary origin and wide altitudinal gradient; corresponding to geology, rock and soil types; and varied climatic conditions; largely influenced by glacial, glacio-fluvial and fluvial processes and sediments displays a wide range of geomorphic features, ecological characteristics and rich ethnic groups. The State forms the catchment of four major Himalayan Rivers *viz.*, Chenab, Ravi, Beas, and Sutlej feeding to the Indus River System. These main rivers are fed with numerous small first-and higher-order streams and rivers from both sides. Glaciers, snow-capped peaks, headstreams and their tributaries, lakes, waterfalls in the Himachal Himalayan region along with diverse forests in the Outer, Lesser, and Great Himalayas, and the Trans-Himalaya play a crucial role. In view of their importance to the basin and the riverscape, the following section attempts to provide an insight on them from the perspective of the physical environment. A large number of international, national

and state level Government organizations/ agencies have been carrying out long term researches on varied aspects of the Himalayan Mountains *viz.*, their formation and structure, geological characterization, tectonic movements, seismicity, glaciers, snow cover, glacial hazards, hydrology, surface and groundwater resources – springs and aquifers, erosion and sedimentation, environmental flow, water quality, pollution, climate change, irrigation and hydroelectric projects, vulnerability, etc. and have made significant contributions to the relevant literature. A voluminous body of literature highlighting past trends on above themes is available and optimally used to provide a brief synthesis and insight in the context of management of Beas riverscape and proposed forestry interventions for rejuvenation of important river like Beas.

a. Glaciers and Snow Cover

The dynamics of Himalayan rivers flow is greatly influenced by the seasonal and monsoonal precipitation by snow and glacial melt (Immerzeel *et al.*, 2000; Dutta *et al.*, 2012). All the rivers originating from higher Himalaya receive 30% to 50% of annual flow from snow and glacier melt run off (Agarwal *et al.*, 1983). Glaciers are vital to humanity as they not only control the global hydrological cycle, but also maintain the global sea level and perennial supply of fresh water to the rivers (Bahuguna *et al.*, 2014). Thus, the monitoring of glaciers and snow cover is important to assess the overall reservoir health (Bhambri and Bolch, 2009; Bhambri *et al.*, 2011). Five major perennial rivers i.e., Chenab, Ravi, Beas, Sutlej and Yamuna of northern India pass through Himachal Himalaya, which have either their origin in the glaciated terrains in the state or outside. Three rivers i.e., Chenab, Ravi and Beas originate from high mountains in Himachal Himalayas while two other rivers i.e., Sutlej and Yamuna have their origin outside the State/ country (GoHP, 2012). Glaciers are widely recognized as sensitive indicators for regional climate change (IPCC, 2007).



Glaciers: Glaciers are mass of snow, ice, water, and rock debris slowly moving down a gradient under the influence of gravity. Glaciers are formed due to the recrystallization and metamorphism of naturally fallen snow on land surface. It is permanent snow cover which gives rise to formation of glaciers. Glaciers are formed on the earth when rate of accumulation of snow is higher than rate of ablation and falling snow gets enough time and space to get metamorphosed to form ice. Nonetheless, the glacier ice must move down under the influence of gravity to be called as glacier (SAC, 2016). It is estimated that glaciers cover about 16.3 million km² of the globe and hold nearly 77% of world's fresh water resources (Srivastava, 2012). Presently, glaciers are distributed either in Polar Regions i.e., Arctic and Antarctica of the earth or in high mountainous regions. Majority of the glaciers exist in the Himalaya and they account for almost 70% of non-polar glaciers (Kaur *et al.*, 2009). The Indian Himalaya has nearly 9,600 glaciers, covering an extent of about 40,000 km², featuring as one of the major cryospheric components (Dyurgerov and Meier, 1997; Raina and Srivastava, 2008; Raina, 2009; Bhambri, 2011). Hence, the Himalaya are known as the 'third pole' of the world (Kulkarni and Karyakarte, 2014; Bandyopadhyay *et al.*, 2018). A sufficient area of the high mountain system lies higher than the snowline (isotherm 0° C) and in this area snow falls round the year. In these mountains, it is estimated that 10% to 20% of the total surface area, is covered by glaciers while an additional area ranging from 30% to 40% is overlying by seasonal snow cover.

The World Glacier Monitoring Service (WGMS) reported that measurements taken over the last century revealed a general shrinkage of mountain glaciers on a global scale and observed that the trend was most pronounced during the first half of the 20th century and that glaciers had started to grow again after about 1950. However, the WGMS claimed that glacial retreat has been accelerating again since 1980s at a rate beyond the range of pre-industrial variability (Haeberli and Hoelzle, 2001). A number of scientific studies have forecasted that up to a quarter of global mountain, glacial mass could disappear by 2050 (Kuhn, 1993; Oerlemans, 1994; IPCC, 1996). In general, the Himalayan glaciers have also been found in a state of retreat (Mayewski and Jeschke, 1979). The global warming is the main reason of deglaciation world over. In the context of Indian Himalaya, a large number of studies have been carried out on the aspects of inventory of glaciers and their distribution in different states/ basins, glaciers fluctuation and temporal changes, glacial retreat, glacial melt distribution, and role of glaciers in watershed hydrology (Campbell, 2005; Sharma *et al.*, 2013; Bahuguna *et al.*, 2007 and 2014; Bajracharya *et al.*, 2006; Bolch *et al.*, 2012; Kasturirangan *et al.*, 2013). Ravindra and Laluraj (2012) in the status report on cryosphere research in India have summarized the salient observations and challenges. Bahuguna *et al.*(2014) carried out a study on 2,018 glaciers representing climatically diverse terrains in different parts of the Himalayas in India and Nepal so as to map and monitor glaciers for planning of water resources and understanding the impact of climatic variations during the period of 2000-2011 and observed that out of this, 86.8% (1,752 glaciers) were observed having stable fronts (no change in the snout position and area of ablation zone), 12.3% (248 glaciers) exhibited retreat, and 0.9% (18 glaciers) revealed advancement of snout. They documented a net loss of 20.94 km² or 0.2% in overall area of 10,250.68 km² of the assessed 2,018 glaciers by them.

Various studies and estimates on glaciers in Himachal Pradesh have been prepared. One of the recent studies for Himachal Pradesh carried out in 2004 has documented that there were 2,554 glaciers in the State, covering an area of 4,160 km² (Fig. 2.2) (Campbell, 2005). The study also provided river basin-wise breakup on number of glaciers, their areal extent, and ice reserve in them. Accordingly, the highest number of glaciers, being 945 was reported in the Sutlej River Basin, followed by 681, 358, and 198 glaciers in Chenab, Beas, and Ravi River Basins, respectively. In addition, 372 glaciers were reported in sub-basins of other rivers flowing through the State. The study documented the distribution of glaciers area in different basins within Himachal Pradesh. Accordingly, the maximum glacier area (1,704.70 km²) or 40.97% glacier area of the State was represented by Chenab River Basin, followed by Sutlej River Basin having an aerial extent of 1,217.70 km² or little over 29% of the total glacier area within the State. The Ravi River Basin had glacier area to the extent of 235.21 km² or 5.6% of overall glacier area within the State.

Glaciers feeding the Beas River are mainly confined to the extreme northeastern and northwestern parts of the basin. Studies on glaciers, focusing on inventory and related aspects are relatively of past two-three decades. During these decades, with the advancement of modern RS and GIS based technologies, it has now become possible to quantify even a smaller glacier, assess their areal extent, and monitor spatio-temporal changes. Hence, available study reports depending upon the methodology and technology used provide different figures in the context of glaciers. A scientific report by the HP State Center on Climate Change (HPSCCC) under the Himachal Pradesh Council for Science, Technology and Environment (HIMCOSTE) described the extent of 51 glaciers in Beas River Basin covering an extent of 503.7 km² based on the LISS III satellite data for the year 2013 (Randhawa and Sharma, 2014). However, a report prepared by R.S Envirolink Technologies Private Limited on the 'cumulative impact and carrying capacity study of Beas River Sub Basin in Himachal Pradesh' for the MoEF&CC, GoI stated that the total number of glaciers in Beas Basin is 335 with an area of 698 km² (RSET, 2019). Campbell (2005) has documented 358 glaciers in Beas River Basin covering an aerial extent of 758.18 km² with ice reserve of 76.4 km³. Most available studies on glaciers so far are either one time effort or based on a short timeframe. Hence, it is difficult to obtain a comprehensive insight on glaciers, their distribution, status, and rate of retreat.

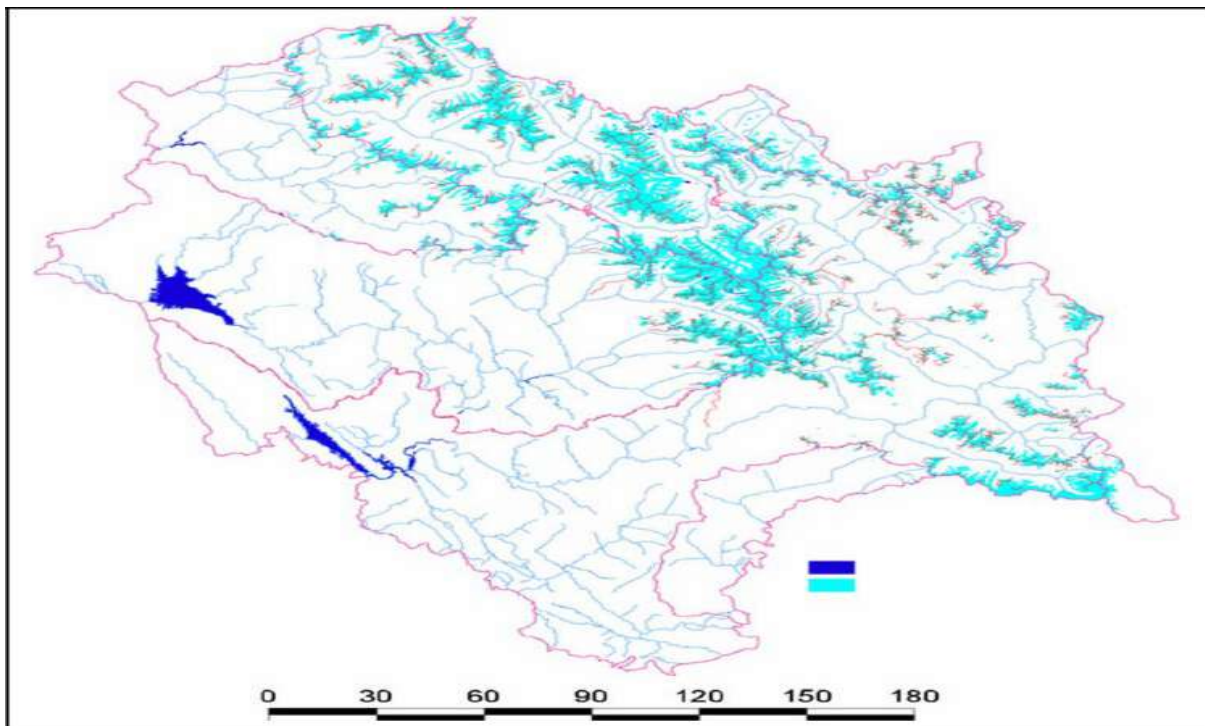


Fig. 2. 2 – Glaciers in Himachal Pradesh
(Source: Adopted from Campbell, 2005)

The Parbati glacier is one of the largest glaciers in the Parbati River Basin, a major tributary of Beas River Basin and fed by almost 36 glaciers, covering an aerial extent of 188 km². Melt water from these glaciers forms an important source of run-off in the Parbati River Basin. In term of economics, the Parbati River Basin is important because of significant hydropower potential and agriculture and horticulture based economy. A study by Kulkarni *et al.* (2005) reported that Parbati glacier has retreated 578 m between 1990 and 2001, almost 52 m per year. A study by Kumar *et al.* (2010) on snow and glacier melt contribution in the Beas River at Pandoh Dam in Himachal Pradesh described that the catchment of the Beas River Basin upstream of Pandoh Dam is 5,278 km², of which about 780 km² is under permanent snow and ice and the altitude in the area varied from 900 m to above 5000 m amsl. The average snow and glacier melt contribution to the annual flow of the Beas River at Pandoh Dam site was computed to be 35% for the period 1990-2004 (15 years). The variability of snow covered area was also assessed for the same period and the study showed that on average about 2,375 km² or 45% of the total drainage area of the Beas Basin above Pandoh Dam is covered by snow in March/ April and about 780 km² (15%) area remains covered by perennial snow and glaciers. This depletion of about 1,600 km² of snow covered area form the basin during the summer period provides a significant contribution to river flow due to occurrence of melting of seasonal snow, particularly when the demand for water is at peak during the summer season (Kumar *et al.*, 2010).

The review of information on glaciers in the context of Indian Himalaya, Himachal Pradesh and the Beas River Basin in particular has amply revealed that long term studies on glaciers, particularly on small size glaciers and potential risks due to effects of climate change are required on a priority basis.

Snow: Snow is a type of precipitation in the form of crystalline ice, consisting of a magnitude of snowflakes that fall from clouds. Snow is composed of small ice particles and it is a granular material. The process of precipitation is referred as snowfall. The density of snow when it is fresh is 30-50 kg/m³. However, when it becomes 'firn' then the density is higher in the range of 400-830 kg/m³. Snow becomes glacial ice when density is 830-910 kg/m³ (HPSCCC, 2019). Over 30% of the Earth's land surface is seasonally covered by snow (NIH, 2000). Snow and ice play an important interactive role in the Earth's radiation balance, because snow has a higher albedo than any other natural surface (Foster and Chang, 1993). The snow cover in the Himalayas occurs and exists depending on the terrain and the climatic conditions of the region. The snow cover has been categorized into three types: (a) temporary snow cover, (b) seasonal snow cover, and (c) permanent snow fields and glaciers. Snow cover that stays for a few days and then melts away has been termed as 'temporary snow cover' which usually occurs at lower altitude during winter and even sometimes at higher altitudes during summer. Snow cover that is formed over weeks or months by consecutive snowfalls and which melts away gradually during the following summer has been termed as the 'seasonal snowpack/ cover'. Above a certain altitude and in certain situation some amount of snow is carried over to the next winter season without melting during summer, and this turns into 'firn' and ultimately ice, adding to the permanent snow fields and glaciers (NIH, 2000). The seasonal snowpack contributes to the water resources during the lean summer months, and thus, very important for the flow of rivers during summer season. The Himalaya is the cradle of large number of streams and mighty rivers, which ensure all the year round availability of water even in summer or lean period due to the melting of seasonal snow pack.

Snow cover measurements are difficult and estimates are not reliable, cheap or easy because of hostile conditions. Conventional methods have limitations in the monitoring of snow covered areas in the Himalayan River basin because of inaccessibility. Remote Sensing has been used to provide information characterizing the snow cover of a basin and the information obtained through it has been integrated into snowmelt run off models. Snow by virtue of high reflectivity is one of the objects on the surface of earth which is readily detected or identified any visible or near infra-red remotely sensed image. Fresh snow has a very high reflectivity in the visible wave lengths. However, it decreases as the snow ages. During past two decades or so, remote sensing due to the availability of large number of satellites in the space at a time, improved sensors and high spatial resolution have opened up new avenues for efficient monitoring of snow cover in the large number of basins in the Himalaya (NIH, 2000). Monitoring of snow cover is vital for the purpose of understanding hydrological regimes and climatic patterns.

The Himachal Pradesh State Center on Climate Change (HPSCCC), Shimla and the Space Application Centre (SAC), ISRO, Ahmedabad assessed the spatial distribution of seasonal

snow cover in different river basins within Himachal Pradesh during 2017-18 and 2018-19 using satellite data and provided month-wise insight on temporal changes (HPSCCC, 2019). According to this short term study, the timing of snowfall had undergone a change, the onset of early snow in December and January had occurred more infrequently overtime and the period of snowfall had extended through the month of February and March. The year 2018-19 was an exceptional year of heavy snowfall. The increased snow cover was observed in almost all river basins including the Beas River Basin. Table 2.4 provides information on month-wise extent of snow cover in Beas River Basin and change in the aerial extent. Accordingly, the maximum extent of snow was recorded in the month of March, 2019. The values of percentage change revealed that there was substantial increase in snow cover in each month during 2018-19, except the month of December wherein there was reduced snow cover by 16.1% in comparison to the previous year i.e., 2017-18. In the absence of long term data sets, it was difficult to ascertain the exact pattern of variation in snow cover over a long period and whether there is any influence of altitudinal zones on the occurrence of snow.

Table 2. 4 – Monitoring of Area under Snow in Beas River Basin during 2017-18 and 2018-19

Sr.No.	Observation Month	Area Under Snow Cover (Monthly Average) km ² (2017-18)	Area Under Snow Cover (Monthly Average) (km ²) 2018-19	Area Under Snow Cover (% change)
1	October	703.6	1,452.6	106.4
2	November	1,483.5	2,264.7	52.6
3	December	2,577.2	2,160.0	-16.1
4	January	2,136.5	2,164.0	1.2
5	February	2,410.4	3,168.8	31.4
6	March	2,644.8	3,456.5	30.6

(Source: Adopted from HPSCCC, 2019)

Permafrost: In geology, permafrost refers to any ground material, including rock, soil, organic matter, etc. that remains at or below the freezing point of water 0° C for two or more years (Goudie, 2004; Vaughan *et al.*, 2013; Allen *et al.*, 2016). Most permafrost is located in high latitudes (Polar Regions), but also occurs at lower altitude as alpine permafrost at higher elevations. Permafrost accounts for nearly 0.02% of total water on the earth and the permafrost region covers 24% of exposed land in the Northern Hemisphere (Igor, 1993). Permafrost is described as an essential climatic variable by the World Meteorological Organization (WMO) (Mayewaski *et al.*, 1981; Owen and England, 1998; Schmid *et al.*, 2015) as thawing of permafrost as implications for the global climate. A global temperature rise of 1.5° C above current level would be enough to start the process of thawing of permafrost (Fiona, 2013). In the northern circumpolar region, permafrost contains 1,700 billion tons of organic material equaling the almost half of organic material in all soils (Tarnocai *et al.*, 2009). It is considered that the amount of the carbon sequestered in the pool of organic material in the permafrost soils was built up over thousands of years and it is four times the carbon that has been released to the atmosphere due to human activities in modern

time (Schuur *et al.*, 2011). Due to the close coupling between atmospheric and ground temperatures, permafrost is warming in many regions in response to global climate change. The resultant thawing of permafrost can have a wide spread impacts relating to destabilization of steep slopes, changes in sub-surface hydrology, and enhance sediment load in rivers (Fiona, 2013; Hobson, 2016; Allen *et al.*, 2016). Permafrost has significant consequences for ecological systems due to constraints imposed on the rooting zones and also limitations caused on den and burrow geometries for fauna requiring sub-surface habitats. Despite considerable significance, permafrost has not received desired attention in the Indian Himalayan Cryosphere (IHC) by the scientific community. Allen *et al.* (2016) based on a pilot Indo-Swiss collaborative research project entitled ‘Indian Himalaya Climate Adaptation Programme (IHCAP)’ under the Global Programme Climate Change (GPCC) have thrown new light on the rarely studied component i.e., permafrost in the IHC. The pilot study was carried out in Kullu District, Himachal Pradesh forming a significant part of the upper Beas Basin. Nearly, 9% (420 km²) of the land area in Kullu has been classified as permafrost terrain, extending down to as low as ~ 4,200 m amsl in isolated instances. Between ~ 4,200 m and 5,000 m amsl, permafrost underlies a surface area comparable in size to that overlaid by glacier ice. Hence, this identified permafrost was recognized as significant component of the local cryosphere. The findings of this pilot study have now provided a scientific basis for assessing the wide ranging potential impacts, hazards and risks associated with warming and thawing of frozen ground, with relevance for climate change adaptation studies across the entire Himalaya (Allen *et al.*, 2016, IHCAP, 2016). It can be now expected that the scientific community would come forward to undertake researches on permafrost in other river basins within Himachal Pradesh and other parts of the Indian Himalaya.

Aquifers and Springs: Aquifer is an underground layer of permeable rock or sand that collects, holds, and conducts water (Rosen, 2015). The materials act like underground sponges allowing water to flow very slowly through it. Water in the aquifer is called groundwater. Many aquifers are like reservoirs because they store water useful to human and aquatic ecosystems. Groundwater may naturally emerge from the aquifer as spring. When aquifer water table reaches the surface, groundwater can be released as surface water into streams, lakes or rivers. Wetlands may form where groundwater reaches ground level. Aquifers vary in size, from narrow to wide, and may have varying thickness. People drill wells or put submersible pumps into the aquifer to pump groundwater to the surface to use for drinking or irrigation. Aquifers are important source of water and most of the water pumped from aquifers used for irrigation. Springs are the places where aquifer water flows to the surface. A pool and often a stream are formed by springs. Springs are often forms along faults. Most aquifers do not support aquatic ecosystems as there is no light underground and hence photosynthesis by plants cannot occur. However, excess nitrates, particularly from agricultural lands where fertilizers or manure containing nitrates are used may seep into the aquifer as the water pollutant (Rosen, 2015).

Springs are the main source of water for millions of people and their livestock in the Indian Himalayan Region (IHR) as both rural and urban communities in Himalayan Mountains depend on springs for drinking, domestic and agricultural water needs. As per a rough

estimate, there are 5 million springs across India, out of which nearly 3 million are in the IHR alone (NITI Aayog, 2018). There is increasing evidence and growing concern that springs are drying up or their discharge is reducing throughout the Himalaya. Erratic rainfall, variable snowfall, seismic activity, ecological degradation due to change in land use and infrastructural development coupled with climate change are impacting mountain springs. Despite the key role played by mountain springs, particularly in the remote areas of the Himalaya, water production has declined in most springs indicating a dangerous sign that aquifers are depleting in mountainous Himalayan states where rural population is almost entirely dependent on springs for drinking water. Besides water quality has also deteriorated under changing land use, improper sanitation and pollutants from agricultural lands.

In Himachal Pradesh, the traditional groundwater resources *viz.*, springs, *Kuhls*, *Baories*, *Khaties*, ponds, etc., play a significant role. However, there is an imbalance between the supply and consumption of water, particularly by the poor and weaker section of the societies resulting into decline and deterioration of traditional sources of water. The Himachal Pradesh Council for Science Technology and Environment (HIMCOSTE) Himachal Pradesh has carried out a pilot survey in 169 Panchayats of seven districts in the state on traditional water resources. The survey revealed that there are 10,512 traditional sources of water in the state for rural habitations. The study also showed that only 30.4% sources are in good working condition and recharging properly throughout the year but a larger proportion (69.6%) of traditional water resources are not in proper working condition and likely to go dry in near future. According to the survey, Kullu district that forms the upper Beas River Basin had altogether 88 traditional water sources in 11 Panchayats. Out of this, nearly 51% of traditional water sources were found in bad condition (Bhardwaj, 2014).

In recent years, there has been upsurge of studies and initiatives to address spring management in India, realizing the seriousness of the emerging crisis around springs. Mostly community-centric initiatives have looked at distribution rather than regeneration, although they have helped in mitigating the rural water crisis to some extent. The concept of springshed management means the management of area of recharge of springs to down to the area of discharge. The concept is now getting increasingly well recognized in the form of pilots of varying scales across the Himalayan states within the country. Recently, the report of the NITI Aayog's Working Group on the 'Inventory and Revival of Springs in the Himalayas for Water Security' recommended launching a National Programme on Regeneration of Spring in the Himalayan Region (NITI Aayog, 2018). The Working Group made specific recommendations for systematic mapping of springs across the Himalayas, creation of web enabled database/portal, synergies between R&D Institutions/ Universities and community based NGOs to provide assistance for scientific assessments besides implementing plans for revival of springs, capacity development of young professionals and community based resource persons (Para-Hydrologists), policy interventions and addressing cross cutting issues. The Group also stressed for developing springshed management plans and protocols in addition to assessing hydrological and social impacts.

Glacial Hazards: Glacial Lake Outburst Floods (GLOFs), avalanches and flash floods in IHR have been recognized as primary hazards while rockfall/ debris fall have been considered as a secondary hazard. All lakes originating from present and past glaciers, in both continental ice sheets and mountain glaciers are described as glacial lakes (Fairbridge, 1968; Bhambri *et al.*, 2018). A glacial lake can form on the surface of the glacier itself (supraglacial), in front of a glacier (proglacial), and inside/ surrounding of glaciers (periglacial) or in relict cirques (tarn or cirque) and is also dammed by glacier moraine or ice. Glacial lakes are good source of fresh water. GLOFs are catastrophic discharges of water resulting primarily from melting glaciers. The accelerated retreat of glaciers in recent times has led to an enlargement of several glacial lakes. As the glaciers retreat, they leave a large void behind. The ponds occupy the depression earlier occupied by glacier ice. These dams are structurally weak and undergo constant changes due to slow failures slumping and run the risk of causing GLOFs. GLOF waves due to sudden release of huge amounts of lake water mixed with morainic material cause devastation downstream impacting communities, hydropower stations and other infrastructures. It has been observed that the occurrence of GLOF events in the Himalayan region has increased in the second half of the 20th century.

Bhambri *et al.* (2018) generated a glacial lake inventory of Himachal Pradesh using high resolution Resource sat 2 LISS IV satellite images and mapped a total of 958 glacial lakes ($>500 \text{ m}^2$) in Himachal Pradesh, covering an area of 9.6 km^2 . Out of these, 345 were classified as moraine-dammed lakes having a total area of 5.1 km^2 and represented 53.1% of total glacial lake area. Altitude-wise distribution of glacial lakes ranged from 3,001 m to 5,641 m amsl. In the context of Beas River Basin up to Pandoh, altogether 74 glacial lakes of different types covering an area of 0.88 km^2 were mapped. Out of this, the maximum numbers of lakes mapped were 51 formed due to erosion of glaciers and they were categorized as the ‘Other glacier erosion lakes’. These 51 lakes covered altogether 0.51 km^2 area and represented 68.9% of total glacier lakes mapped in the Beas River Basin Fig. 2.3 (Bhambri *et al.*, 2018). In recent past, a few number of events occurred in the Beas River Basin when glacier and snowmelt water coupled with sporadic heavy rainfall in a short span of time (e.g., cloud burst) created havoc and loss of human lives and properties downstream. From the perspective of flood damage, the Beas River and its tributaries viz., *Parbati*, *Uhl*, *Suketi Khad* and *Neugal Khad* are important as they are prone to flash floods. High magnitude floods have been recorded in Beas valley in 1902, 1945, 1993, and 1995. Flash flood occurred on 4-5 September, 1995 caused enormous damage in the Kullu valley. The cloud burst in the upper reaches of Sainj valley in Kullu district on 22 July, 2001 affected 40 families, two bridges and plenty of fertile lands were washed away. Some other areas in Kullu district were also affected due to excessive rains. Yet another cloud burst in Aani sub-division of Kullu district caused flash floods in the night of 21-22 August, 2001 resulted into loss of human life and damage to houses and crop fields besides loss of a large number of livestock. In a short span of just two years, on 16 July, 2003 another cloud burst in *Gharsa* valley, Kullu district occurred causing flash floods taking lives of 21 people and injuring an equal number of people besides 9 people were missing (GoHP, 2012).

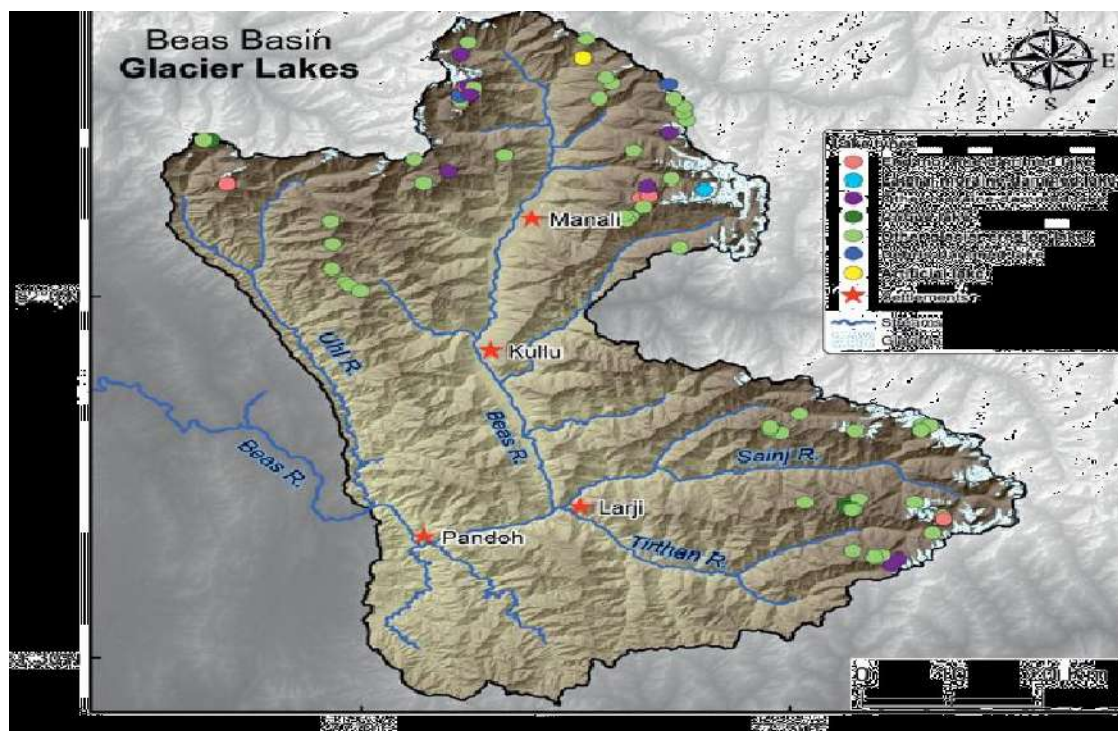


Fig. 2. 3 – Glacial Lakes in Beas River Basin
(Source: adopted from Bhamri *et al.*, 2018)

In addition to the hazards caused by GLOFs, cloud bursts and resultant floods and avalanches also occur in the Beas River Basin. An avalanche may be defined as ‘the sudden downward motion of snow mass which may contain rocks, soil, ice and trees’. In several ways, avalanches of snow resemble certain kinds of landslides but important differences are involved. The higher hills in the Kullu district in the upper Beas River Basin are particularly vulnerable to the hazards of avalanches. GLOFs and avalanches as natural hazards cast a wide shadow over human life as they cause floods, landslides, river bank erosion and results into erosion of valuable top soil (GoHP, 2000). A large avalanche not only releases enormous quantity of snow (ca. 2,30,000 m³ equivalent to 200 football fields covered with 10 feet or 3.5 m high snow), but the high speed of avalanche (~130 km/hr) trigger downward movement of rock mass, ice blocks and snow. GLOFs and avalanches occurred in recent pasts have severely impacted local terrestrial and aquatic ecology and also affected socio-economic situation in the area.

Vulnerability: Vulnerability is defined as the diminished capacity of an individual or group or an object to anticipate, cope with, resist and recover from the impact of a natural or man-made hazard. In relation to hazards and disasters, vulnerability is a concept that links the relationship that people have with their environment. The mountainous State of Himachal Pradesh is vulnerable to earthquakes, glacial lake outburst floods, cloud bursts, avalanches, landslides, hailstorms, and flash floods. Fragile and steep hills in the State are witnessing massive construction activities and development of infrastructure i.e., roads, bridges, dams, airports, etc. and concrete townships despite the State falls in the high Seismic Zone IV and V. Much of the Beas River Basin, particularly areas of Mandi, Hamirpur, Kangra and

Chamba Districts fall in the seismic Zone V. The State is prone to various hazards caused by landslides triggered due to different reasons including landslides. Landslides encompasses all varieties of down slope mass movements including different types of rock fall, topple, and debris flow. Kahlon *et al.* (2014) has provided a summarized comprehensive account on landside hazards in different districts of Himachal Pradesh. The findings of their study revealed that slope failure activities show an increasing trend of landslides. There is not only upward rise in annual and decadal frequency of landslides but the number of years with high occurrence during each decade have also enhanced. Even folk tales also corroborate the landslide activity in upper Beas River Valley in Kullu. The area under severe to very high risk due to landslide hazards in Kullu district was about 33.7% while 65.04% area of the district represented in the high risk category (GoI, 2003; Kahlon *et al.*, 2014). According to GoI (2003), nearly 97.42% of the total geographical area of the State is prone to landslide hazard. Over 14% and 70% area are liable to severe to very high and high risks of landslides, respectively. All the districts have over 90% area prone to landslide hazard except Una where it is about 80% of the total area. The annual distribution of landslide events for the period 1971-2009 displayed the steadily rising trend in landslide frequency and 919 events of landslides were recorded (Kahlon *et al.*, 2014). Definitely, there has been continual rise in landslide activities, post 1980 decade. Intense and torrential rains are the principal cause of slope failure and majority of landslides and nearly 76.5% landslides events occurred during the monsoon season. A study report prepared by incorporating inventory of past landslides using the data from Geological Survey of India and Building Material and Technology Promotion Council (BMPTC) revealed that 8% of the entire area of the State is under high hazard risk zone. The study when used the locations of major towns, major roadways, river network and past landslide locations and superimposed them over the landslide hazard risk map obtained from Analytical Hierarchical Process amply indicated that the landslide locations and towns are coinciding with the boundaries of the river network within the State (Fig. 2.4) (TARU, 2015).

Surroundings of major river courses including the Beas River and its tributaries in the State are undoubtedly under greater influence by concrete townships, national/state highways, expanded agriculture/ horticulture, and other developments. Thus, the river course within the riverscape is definitely in the high landslide hazard risk zone. Natural factors i.e., geological, topographical, and climatic coupled with human disturbances *viz.*, deforestation, expanding of road network, enhanced blasting for road cutting and construction of dams/ hydropower projects, housing, terracing, man-made annual forest fires, water intensive agricultural practices on steep slopes generally, result in landslides impacting the river environment. The intensity as well as frequency of landslides has increasing several folds over recent decades (TARU, 2015). The Sustainable Environment and Ecological Development Society (SEEDS) has prepared a vulnerability atlas for the State of Himachal Pradesh incorporating maps of various hazards i.e., earthquake, landslide, avalanche, wind, and forest fire and they clearly show that much larger part of the Beas River basin is prone to various hazards (SEEDS, 2009). The State of Environment Report, prepared by the Department of Environment Science and Technology, Government of Himachal Pradesh also provides a detailed account

on various natural disasters those have occurred within the State and their implications on the ecology, people, and the economy (GoHP, 2012).

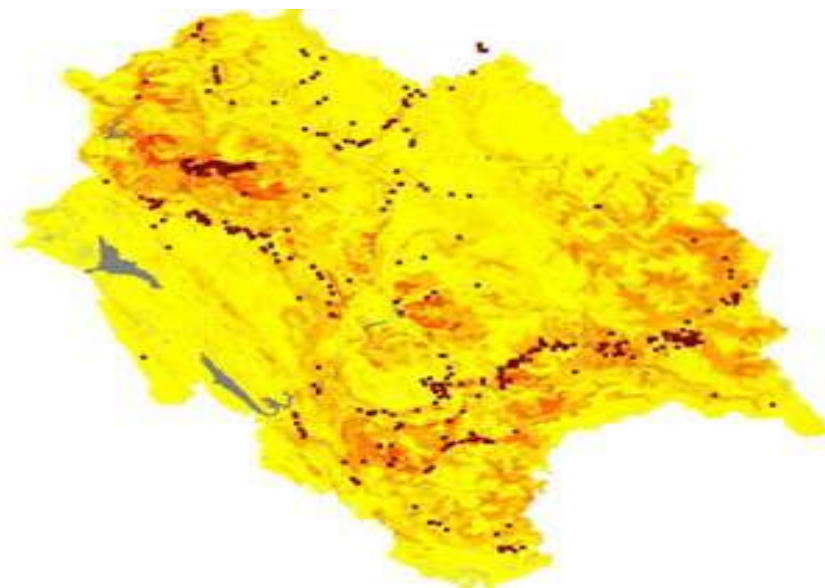


Fig. 2. 4 – Location of Past Landslides Coinciding with Major River Courses within Himachal Pradesh (Source: Adopted from TARU, 2015)

b. Hydrology – Surface and Groundwater Resources, Sedimentation, Environmental Flows and Water Quality

The Beas River has a typical Himalayan Basin comprising broadly of three parts: (a) the upper glacier-fed basin ($>4,000$ m), (b) the middle snow-fed basin ($2,000 - 4,000$ m), and (c) the lower rain-fed basin ($<2,000$ m). Annual variation in climatic conditions, particularly precipitation i.e., snowfall and rainfall has greater influence on the availability of surface water, runoff, and groundwater recharge. Himalaya has been recognized as the major source region of erosion (Wasson, 2003). Various dimensions of hydrological aspects in the context of Beas River from the perspective of surface and groundwater resources, its use for agriculture by way of irrigation, power generation, river fragmentation, linking of rivers, environmental flow, water quality, and pollution have been studied and quantified mostly by various national and state level government agencies (Rao and Ramasheshan, 1985; Kumar *et al.*, 2010 and 2017; Ahluwalia *et al.*, 2015; Lakhera *et al.*, 2016).

Annual Flows of the Beas River and Water Balance: The hydrological aspects in the case of Beas River could be appreciated by understanding the integrated operation of the Beas-Sutlej-Ravi River system as the Beas-Sutlej link, comprising a diversion dam at Pandoh across the Beas in the Kullu valley was created to transfer 4,727 million m^3 of water to Bhakra reservoir on the Sutlej River through tunnels and open channels (Rao and Ramasheshan, 1985). Likewise, water from the Ravi River is transferred by a diversion at Madhopur Headworks through the Madhopur-Beas Link (max. capacity: 283 cumecs) to the Beas River.

The interconnected surface water Budget system of the Beas River, the Sutlej, and the Ravi was shown diagrammatically by Lamba and Prem (1975) and adopted by Rao and Ramasheshan (1985). The same diagrammatic sketch showing the inflows of the three rivers and their interconnections has been incorporated in the present DPR for the purpose of clarity and better insight on three interlinked rivers (Fig. 2.5).

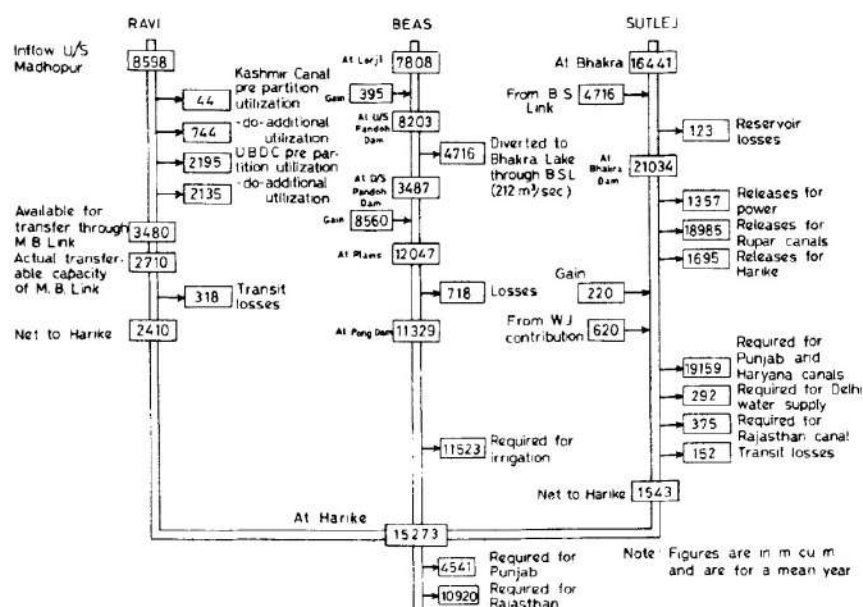


Fig. 2.5 – Interconnected Surface Water Budget System of Three Rivers, Beas, Sutlej and Ravi

(Source: Adopted from Lamba and Prem, 1975)

Flow Characteristics of the Beas River at Pandoh: Kumar *et al.* (2007) used the water balance approach to estimate the average contribution of snow and glacier melt of annual flow in Beas River at Pandoh Dam. The catchment of the Beas River Basin upstream of Pandoh dam is 5,278 km². About 45% of the basin area up to Pandoh is covered by snow during winter and about 15% remains covered by perpetual snow and glacier. The water Budget of the basin was computed for a period of 15-years (1990-2004). The 15-year data on rainfall input, volume of flow, and discharge of the Beas River at Pandoh were used in the study by Kumar *et al.* (2007). The discharge of the Beas River has two components: one derive from melting of snow and glacier and the other resulting from the rainfall in the catchment. The availability of flow from either snowmelt/ rainfall or base flow makes the river a perennial one. The discharge due to snowmelt varied annually due to variations in temperature and the amount of snowfall in the basin. Analyzing 15-year flow data, the average seasonal distribution of the annual flow volumes at Pandoh gauging station was computed and summarized by Kumar *et al.* (2007) and adopted here in Table 2.5. Accordingly, high discharges were measured in monsoon season i.e., July - September, mostly during July and August. The discharge during monsoon season contributed 55.1% of the annual flows. The minimum flow was observed during the winter season i.e., January – March and it contributed 7.2% of the annual flow.

Table 2. 5 - Average Seasonal Distribution of Annual Flows of the Beas River at Pandoh Dam

Sr. No.	Season	Months	Flow (km ³)	Percent (%)
1.	Winter	January-March	0.53	07.2
2.	Pre-monsoon	April-June	2.13	28.6
3.	Monsoon	July-September	4.09	55.1
4.	Post-monsoon	October- December	0.68	09.1
Total			7.42	100.0

(Source: Kumar *et al.*, 2007)

Kumar *et al.* (2007) also computed total volume of rainfall input by multiplying mean rainfall over the basin by the area of the basin and obtained the value of 78.8 km³. The annual rainfall during the study period varied significantly. Annual values of the snowmelt contribution to the total runoff generally varied from 30% to 47%, except in 1997 when it was only 11%. Table 2.6 shows rainfall and contribution by snow and glacier melt to flow in the Beas River based on 15-year data analyzed by Kumar *et al.* (2007). Vajja and Roy (2005) attempted to estimate snow-melt runoff on a 10 day average basis in Beas River Basin up to Pandoh Dam during May, 1998 - November, 1999 using a Snowmelt Runoff Model (SRM). The total discharge at the dam site was computed by a weighted sum of runoff components from all the elevations zones. The values of runoff coefficient indicating the percentage of rainfall converted to runoff during 12 month period ranged from 0.02 to 0.84. The lowest value was in the month of September while the maximum was recorded in the month of June. Likewise, the values of runoff coefficient of snow were also worked out and they ranged from 0.05 in the month of August to maximum value of 0.68 in June. Ahluwalia *et al.* (2015) estimated snow/ glacier melt contribution in the upper part of the Beas River Basin using conventional SNOWMOD modeling approach up to Manali town covering an area of 362 km² and assessed seasonal variation of runoff. They observed the minimum discharge (8%) during post monsoon months owing to negligible amounts of rainfall and negligible contribution from snow/ glacial melt runoff. The maximum discharge to the extent of 63% of total runoff was observed in the monsoon season. They concluded that variation in climatic condition is responsible for the variation in stream flow discharge. Later, Lakhera *et al.* (2016) carried out a study on water balance of the Beas River in the Basin up to Pong Dam for the period 1998-2014 using ArcGIS technique. The study revealed the annual basin yield of 7,672.46 MCM while the present water use including industrial water demand and projected water demand to be fulfilled from the Beas River was computed to the extent of 4,092.69 MCM. Thus, balance water available in the Beas River Basin was 3,579.76 MCM.

Table 2. 6 - Rainfall and Snow and Glacier-Melt Contribution to Flow in the Beas River at Pandoh Dam

Rainfall Volume (km ³)	Evapotranspiration Losses (km ³)	Total Runoff Volume (km ³)	Rainfall Contribution (km ³) (%)		Snow and Glacier Contribution (km ³) (%)	
77.8	5.5	111.4	72.3	64.9	39.1	35.1

(Source: Kumar *et al.*, 2007)

Water Use and River Fragmentation: Water of the Beas River and its tributaries have been extensively used for irrigation for a considerable time, particularly after the independence of the country when planning for projects linking Beas River with Sutlej and linking Ravi with

Beas River was initiated. Sequential irrigation and hydroelectric projects were implemented on three rivers. River Beas Basin in Himachal Pradesh has power potential of 4,877.70 MW (for > 5 MW projects) distributed among 51 hydro-electric projects spread throughout the basin (RSET, 2019). Accordingly, out of 51 HEPs, 22 projects with total installed capacity 2,820.9 MW were already commissioned, 5 projects with installed capacity of 947 MW were under construction, 20 projects with installed capacity 1,028.9 MW were at various stages of investigation, and 4 projects were yet to be allotted. Thus, 77.25% hydro potential of the Beas River Basin has already been established through operational (57.83%) and under construction projects (19.42%). The history of hydropower development in Beas River Basin goes way back to 1923 when Shanan Power Station (Uhl I-110 MW) was commissioned as first megawatt scale project of country and later Uhl II (60 MW) was commissioned during 1970-71. The largest project of the basin i.e., the Pandoh Dam, popularly known as Beas-Sutlej link project of 990 MW was commissioned in 1977. Another major project of the basin, Pong Dam (396 MW) was conceived way back in 1927. However, the construction work commenced in 1961 after approval of final design and was commissioned during 1978-83 period. In the recent past, Parbati-III HEP with installed capacity of 520 MW was commissioned in 2014. Yet another major project of 800 MW (Parbati-II HEP) is under construction. On the lines of Beas-Sutlej link, the Ravi-Beas link was also made operational. In addition to hydropower generation, much of the water of the Beas River Basin is being used for irrigation and expansion of agriculture in arid and semi-arid regions of Punjab and Rajasthan by way of canal network after the confluence of Beas River with the Sutlej River at Harike Pattan. The combined water of Beas-Sutlej-Ravi Rivers and huge investments made to harness water of these three important rivers for generation of hydropower and expanding irrigation potential have immensely helped the country in getting self-sufficiency in food production or making the programme of green revolution successful. In the process, the physical barriers created by way of dams, barrages and other manmade structures (canal network) and diversion of water by linking rivers through tunnels/open channels have not only fragmented the Beas River, but interrupted the flow of water, sediments, and upward and downward movement of aquatic faunal species besides the vital overall connectivity of the river. Undoubtedly, above developments in the context of Beas River have immensely helped country and the state/ region in particular by way of hydropower, agricultural, industrial, and economic development, but basin wide environmental losses in terms of river stability, soil fertility, water quality, ecological balance, flood events and health hazards have occurred. As a result of above developmental projects and enhanced human activities, the flow in the Beas River and its tributaries have drastically declined and the water quality has been severely impacted by way of pollution from crop fields, industries, waste and sewage disposal from towns/ cities located on the course of Beas River and its tributaries.

Ground Water Availability: The diverse physiographic, climatic, topographic and geological conditions in the Beas River Basin as well as in Himachal Pradesh have given rise to diversified ground water situation in different parts of the State. The rock formations ranging in age from Archean to Recent occupy the mountainous State and control the occurrence and movement of ground water depending upon aquifer composition, structure and deposition. Hilly and mountainous parts with steep slopes mainly constitute the runoff

areas and thus, have low ground water potential. However, in valleys and low lying areas, unconsolidated/semi-consolidated formations form potential aquifers. The Central Ground Water Board (CGWB) has assessed the ground water resources. Accordingly, for the year 2017, the Total Annual Ground Water Recharge of the State was 0.51bcm and the Annual Extractable Ground Water Resources was 0.46 bcm. The Current Annual Ground Water Extraction for all uses was 0.39 bcm and the Stage of Ground Water Extraction was 86%. Out of 8 assessment units, four have been categorized as ‘Over-exploited’, one as ‘Semi-critical’, and three as ‘Safe’. Further, there was no saline assessment unit in the State. In comparison to estimates of 2013, there was marginal reduction in the Total Annual Ground Water Recharge and the Annual Extractable Ground Water Resources. However, the Ground Water Draft had increased from 0.27 bcm to 0.39 bcm in 2017 (CGWB, 2019). The Northern Himalayan Regional Station of the Central Ground Water Board (CGWB) based at Dharamshala provides district-wise information on groundwater resources i.e., the distribution, utilization/ exploration, water quality and current status on a regular basis.

It is evident that the Annual Ground Water Recharge in the State is very low owing to hilly tract with steep slopes resulting into greater runoff while Districts viz., Hamirpur and Kangra in lesser Himalaya have some potential for ground water recharge. However, the intensity of annual ground water draft in these Districts is on increase.

Environmental Flow: Rivers in India have been significantly altered or influenced by human activities, particularly over the past century or so. As a result, the ecological integrity and the ecosystem services offered by them have been adversely affected by the alterations in availability of water throughout the year, its quality and flow regimes. Flow regime has been recognized as one of the most important drivers of river health. Increasingly, environmental flows are seen as a device to ensure healthy river ecosystems.

Environmental flows (EFs or e-flows) has been defined as a regime of flow in a stream or river that describes temporal and spatial variations in the quantity and quality of water required for freshwater and estuarine ecosystem to perform their natural ecological functions and allow them to offer goods and services they provide for supporting spiritual, cultural and livelihood activities that depend on these ecosystems (Brisbane Declaration, 2007). Flow has been recognized as master variable as it exerts significant impact on aquatic habitat, channel morphology, aquatic biota, river connectivity, and water quality (Joshi, 2017).

The *lotic* ecosystems harbour a large number of rare and threatened faunal species and several of them migrate upstream or downstream for spawning, nursery caring, feeding, and to complete other stages/ requirements of the life-cycle in any of the river systems. Most rivers in India harbour immense fish diversity of native species. Over the years, several exotic species have been introduced in the Indian rivers. In addition, streams and rivers also have amphibians, and large body aquatic reptiles (gharial, crocodile and turtle), and mammals (otter and dolphin). Hence, developing an understanding of the requirements of wide range of aquatic faunal species is a difficult task. Thus, often flow has been estimated targeting certain flagship or keystone species of a river or a particular stretch. In the context of Himalayan rivers, species such as snow trout (*Schizothorax richardsonii*), mahaseer (*Tor putitora*), hilsa

(*Tenualosa ilisha*), gharial (*Gavialis gangeticus*), mugger (*Crocodylus palustris*), otter (*Lutrogale perspicillata*), and dolphin (*Platanista gangetica*) have been considered important to work out the requirements of e-flow. Presently, there is a poor scientific insight on *in-situ* water conservation requirements of most Indian fishes and other threatened aquatic faunal species.

Around the world, there is an increasing desire, supported by national and regional policies and legislation to conserve or restore ecological health and functions of river for biodiversity and human use. Tharme (2003) and Acreman and Dunbar (2004) have provided a global perspective on the requirements of e-flow and reviewed the existing methods for assessment of e-flow on the basis of varied hydrological, hydraulic rating, habitat simulation and holistic approaches. More recently, the World Meteorological Organization (WMO) has provided a comprehensive guidance on environmental flows by integrating e-flow science with fluvial geomorphology to maintain ecosystem services (WMO, 2019).

In India, the issues of environmental flow (EF) have received considerable attention in past two decades or so as the most Indian Rivers are presently highly regulated owing to the fact that hundreds of multipurpose reservoirs/ barrages for water supply, irrigation, hydropower, development of fisheries, and diversion of water have been constructed. In the process, most rivers have been fragmented and cut off from the riparian lands or their floodplains (Kumar *et al.*, 2007; Kumar, 2009; Jain and Kumar, 2014, Soni *et al.*, 2014). Smakhtin and Anputhas (2006) have discussed the advantages and limitations of different e-flow assessment approaches and proposed recommendations for a longer-term e-flow research programme in India. Although, the study did not give prescriptions for e-flow estimation for the entire country, it can be seen as an important step towards the development of national e-flow tools and policies. In their report, continuous monthly time series were proposed as e-flow standards using a simple spatial interpolation procedure at a catchment scale, whereas the final e-flow demand was presented in two forms: as a flow duration curve and as a monthly flow time series. Despite the important presence of large reservoirs, it seems that limited efforts have been carried out to implement e-flows in Indian River Systems (Anuran and Jha, 2014, WMO, 2019).

Jain (2015) regarding assessment of EFs in India commented that there is lack of data on ecosystems and relationships between flows and ecosystem functioning as it requires involvement of multidisciplinary researches, extensive field level assessments, and long term data sets collected across large river basins. Piece meal and short term snapshot field sampling generally do not allow to document impact on biota in the altered flow systems. Further, studies and data on the assessment of ecosystem services are generally lacking and this theme also requires similar multidisciplinary efforts as of e-flow. He was of the opinion that all stakeholders are interested in understanding trade-off between ecosystem conservation and economic development. The framework proposed by Jain (2015) permits to define interim flows for hydro-electricpower projects (HEPs) in India until biological data are collected and analyzed to assess ecosystem response to flow alteration.

In the absence of clear insight on the complex nature of e-flow, long term researches, and field data, various studies, national/ state governments and concerned agencies, and even the

Hon'ble Courts/ National Green Tribunal (NGT) have given different recommendations for maintaining the minimum flow. Accordingly, the Central Water Commission (CWC) recommended different minimum flow criteria for the Himalayan and other rivers in the country. The CWC recommended that the minimum flow in the case of Himalayan Rivers must not be less than 2.5% of the 75% dependable annual flow, expressed in cubic meters per second (m^3/s) along with one flushing flow during the monsoon period, with a peak flow of not <250% of the 75% dependable annual flow. In case of other rivers, the CWC recommended the minimum flow in any 10-day period must not be less than the observed 10-day flow, with 99% exceedance. Where 10-day flow data are not available, this may be taken as 0.5% of the 75% dependable annual flow. In addition, one flushing flow would be required during the monsoon season with a peak flow of not less than 600% of the 75% dependable annual flows.

In view of the large number of HEPs in the State of Himachal Pradesh, the State Water Policy states that 'in projects for hydropower generation involving impounding of water, adequate water is required to be released around the year to meet the needs of downstream users'. Recently, the Department of MPP and Power, Government of Himachal Pradesh vide letter no. MPP-F(2)-16/2008, dated 29th January, 2009 frame the policy regarding ensuring minimum flow of water in hydroelectric power (HEPs) and decided that 'henceforth the hydroelectric project (HEPs) company in RoR Project shall ensure minimum flow of 15% water immediately downstream of the diversion structure of the project throughout the year. For the purpose of determination of minimum discharge, the average discharge in the lean months *i.e.*, from December to February shall be considered. This minimum discharge is required keeping in mind the serious concerns of the State Government on account of fragile ecology and environment and also to address issues concerning riparian rights, drinking water, health, aquatic life, wildlife, fisheries, silt and even to honor the sensitive religious issues like cremation and other religious rights on the banks. However, the companies are at liberty to install mini-hydel projects to harness such water for their captive utilities, systems and colonies subject to prior approval of the State Government (RSET, 2019).

Subsequently, the Directorate of Energy, GoHP had initiated the task of carrying out a study on the 'Cumulative Environment Impact Assessment (CEIA)' for Beas River Basin with an objective to assess the cumulative impact of HEPs in the basin. Later, the MoEF&CC, GoI decided to take overall such CEIA and carrying capacity studies being conducted by various Central/State Agencies in view of the Original Application No. 498 of 2015 (M.A. No. 628/2016) pending before the NGT, Principal Bench, New Delhi. In case of Beas River, the study was awarded to RS Envirolink Technologies Pvt. Ltd. (RSET), Gurgaon and the Expert Appraisal Committee (EAC) for River Valley and Hydroelectric Projects of MoEF&CC approved the ToR for the study. The firm initiated the study during February, 2016 and submitted the final report to the MoEF&CC in January, 2019 incorporating Minutes of the various Meetings of the EAC, its decisions and specific recommendations. The EAC while taking decisions in its various meetings took cognizance of the judgment dated 09 August, 2017 by the Hon'ble NGT and its directives to the MoEF&CC in the response to above cited Original Application. The firm finalized the report entitled 'Cumulative Impact and Carrying Capacity Study (CEIA and CCS) of Beas Sub-Basin in Himachal Pradesh' in consultation with the GoHP. Accordingly, the MoEF&CC adopted specific recommendations made on e-flow release for all the projects (operational, under construction, and projects being planned

or under investigation) with installed capacity of > 25 MW. As per the report, specific recommendations approved by the MoEF&CC for each of the project are reproduced in Table 2.7. Further, the MoEF&CC decided that for remaining projects with < 25 MW installed capacity, e-flow release recommendations shall be 20% in lean season, 30% in peak season, and 25% in other months irrespective of their stage of implementation. Calculations for e-flow release in lean season should be based on average of 4-6 leanest months discharge in 90% dependable year (DY). Calculations for e-flow release in peak season should base on average peak season discharge for 4 months in 90% DY i.e., June to September. Calculations for e-flow release for remaining 2-4 months i.e., non-peak and non-lean period should be based on average discharge of 90% DY in remaining months (RSET, 2019).

Table 2. 7 – Prescribed Environmental Flow Release for Hydroelectric Projects in the Beas Basin with Installed Capacity > 25 MW by the MoEF&CC on Basis of Cumulative Impact and Carrying Capacity Study

Name of Project	River (Affected Stretch)	Recommended E-flow as % of Average Discharge 90% DY			Recommended E-flow cumec		
		Lean Season (Dec-Mar)	Peak Season (June-Sept)	Other Months (Oct, Nov, Apr and May)	Lean Season (Dec-Mar)	Peak Season (June-Sept)	Other Months (Oct, Nov, Apr and May)
Beas Sutlej Link	Beas River (25 km)	20	15	15	14.25	64.72	25.74
Parbati-III	Sainj River (13.7 km)	20	15	15	1.51	8.46	2.83
Allain Duhangan	Allain (9.2 km)	20	15	15	0.42	2.43	0.85
	Duhangan (5 km)	20	15	20	0.15	0.96	0.4
Larji	Beas River (5.65 km)	20	15	15	11.42	64.06	21.45
Uhl-I	Uhl River (40 km)	20	15	15	0.44	2.37	1.11
Malana-II	Malana <i>Nallah</i> (5.2 km)	20	15	15	0.43	2.94	1.1
Sainj	Sainj River (9 km)	20	15	15	0.71	3.34	1.61
Malana-I	Malana <i>Nallah</i> (2.32 km)	20	15	15	0.49	3.32	1.24
Parbati-II	Parbati River (5.28 km)	20	15	15	2.99	16.3	3.79
	Jigrai <i>Nallah</i> (0.8 km)	20	30	25	0.2	1.16	0.54
	Jiva <i>Nallah</i> (8.2 km)	20	30	25	1.19	6.2	2.53
	Hurla Nalla (12 km)	20	30	25	0.57	3.12	1.28
Lambadug	Lambadug (6.3 km)	20	15	15	0.25	1.28	0.6
Uhl III*	Rana Khad	20	30	25	-	-	-
	Neri Khad	20	30	25	-	-	-
Nakhtan	Toss (4.4 km)	25	20	20	0.93	5.24	1.99

Name of Project	River (Affected Stretch)	Recommended E-flow as % of Average Discharge 90% DY			Recommended E-flow cumec		
		Lean Season (Dec-Mar)	Peak Season (June-Sept)	Other Months (Oct, Nov, Apr and May)	Lean Season (Dec-Mar)	Peak Season (June-Sept)	Other Months (Oct, Nov, Apr and May)
	Parbati (8.9 km)	25	20	20	1.42	7.84	2.94
Thana Plaun	Beas River (12.7 km)	20	15	15	5.05	46.62	11.64
Triveni Mahadev	Beas River (5.5 km)	20	15	15	5.62	54.05	14.49
	Binwa Khad (3.2 km)	20	15	15	0.93	4.6	1.5
Malana-III	Malana Nallah (3.35 km)	20	15	15	0.34	2.32	0.95
Dhauasidh	Beas River (37 km)	20	30	25	7.11	90.79	7.87

*Assessment for Uhl III could not be carried out in the absence of discharge data. This project needs to maintain 20%, 30%, 25% EF of the average values of their 90% DY discharge.

(Source: Adopted from RSET, 2019).

The Hon'ble NGT in its judgment order dated 09 August, 2017 has clearly directed that all rivers in the country shall maintain minimum 15% to 20% e-flow of their average lean season flow and directed that whichever State is unable to adhere to this average percentage can approach to the MoEF&CC with justification. The MoEF&CC will dispose the representation by the State in consultation with the Union Ministry of Water Resources. Hence, it is evident from the forgoing description that the Government of India has lately recognized the merit of maintaining e-flow throughout the year in the country's rivers so as to balance between the essential ecological requirements of the river ecosystem and the demands of various developmental sectors. This way, the goal of healthy river with multiple objectives relevant to the maintenance of uninterrupted flow, clean water, aquatic biota, ground water recharge, and sediment movement besides supporting livelihoods and allowing the river to be used for other multiple values and benefits can be achieved.

Erosion Processes: It is evident that for a very long time, the geological processes have been persistently changing the face of the Earth, but extremely recent second type of process of change, if considered at the geological time scale is caused due to permanent activities by human (Gupta *et al.*, 2012). However, as recognized by the International Geosphere Biosphere Programme (IGBP), anthropogenic pressure is seen as the cause of several other facets of global change. These include major changes in vegetation cover across the Earth's surface, wide ranging disturbance of that surface by land use activities, infra-structural development, mineral exploitation, and modification of the hydrological cycle caused by water resource exploitation (Walling, 2008). The accelerating pace of notable change brought

by human activities since 1900 or over just the past 100 years or so has been emphasized, and it is evident in the form of increase in the world's population by six folds, expansion of the world's croplands by double and increase in the extent of pasture by about 75%, and the decrease in the area of the globe covered by the tropical forests by about 25%. Likewise, almost all of the world's major reservoirs were constructed during the past 60-70 years (Walling, 2008). These human induced changes coupled with ongoing climate change are exerting a significant influence on global erosion rates and the sediment loads of the world's rivers. Erosion rates are sensitive to change in vegetation cover and land use activities. The potential changes in erosion and sediment transport have wide ranging implications – 'on-site' and 'off-site' effects. On one hand, the on-site effects are reflected in the form of reduced soil productivity, food insecurity, and even water crises. On the other hand, the off-site effects of changes in sediment load/transfer from the global perspective could be in terms of land-ocean sediment transfer and global biogeochemical cycles including of carbon besides scouring of river channels and erosion of delta shorelines. Potential changes in erosion and sediment load would result in accelerated rates of sediments in reservoirs, river channels and water conveyance systems causing problems for water resource development as well as adverse impacts on aquatic habitats and river ecosystems in particular.

The Beas River, being a Himalayan River originating in the High/Great Himalayas and traversing through the Lesser Himalaya and Outer (Shivalik) Himalaya before entering into the Punjab plains and merging with Sutlej River is immensely influenced by different source regions of erosion in the mountainous tract those are topographically and lithological distinct Table 2.8. Following major erosion source regions are relevant in the Beas River Basin Wasson (2003).

Table 2. 8 - Major Erosion Source Regions, Features and Processes in the Context of Beas River

Source Region	Major Features	Major Erosion processes
High Himalaya	Crystalline rocks, steep slopes; high relief; little forest; extensive grazing	Landslides, glaciation, channel erosion, sheet and rill erosion, GLOFs and Landslide Lake-burst Floods (LLFs)
Lesser Himalaya	Sedimentary and meta sedimentary rocks; steep slopes; moderate to high relief; forested in part; cultivation, grazing and forestry	Landslides, sheet and rill erosion, channel erosion, and LLFs
Shivaliks	Sedimentary rocks, often partly lithified; steep slopes, moderate to low relief; forested in part; cultivation and grazing and forestry	Landslides, sheet and rill erosion and channel erosion
Plain	Unconsolidated alluvium and aeolian deposits; very gentle slopes and very low relief except along incise drivers; cultivation and grazing	Sheet and rill erosion, channel erosion and wind erosion

(Source: Adopted and modified from Wasson, 2003; FRI, 2016)

The upper and middle parts of the Beas River Basin, entirely located in the Himalayan region, represented by above three erosion source regions are under the enhanced influence of human activities in past 100 years or so. These regions are afflicted with a serious problem of soil erosion as nearly 27.2% area of the basin within the mountainous tract is located above 3,000 m while 33.7% area of the basin is lies between >1,200 m and <3,000 m amsl. The rocky hill slopes form a straight inclination of 30°-40°. In the upper catchment area the slopes are steep ranging between 35° and 40° and even more than 40°. Therefore, the main channel of Beas River and its tributaries traversing through the above erosion prone regions transport a heavy load of sediment. Assessment of erosion susceptibility and status is vital pre-requisite from the perspective of river rejuvenation. Unfortunately, like major rivers of Himalaya (e.g., Indus, Ganga and Brahmaputra), there is poor insight exist on the erosion status in the Beas River Basin. In spite of significant ramifications of erosion, limited efforts have been made to generate information on this important aspect. Prasad *et al.* (2016) assessed the mountain hazard susceptibility and livelihood security in the upper catchment area of Beas River, Kullu Valley and concluded that a significant part of Kullu Valley is subject to soil erosion and land slide. The escalation of risk and vulnerability has come about through land use intensification in the area. Singh and Singh (2018) carried out a study on soil erosion susceptibility of the Suketi watershed in the Lesser Himalaya that lies on the left bank of the Beas River to determine the critical and priority areas for soil and water conservation involving geospatial techniques.

Sediment Transport: Most rivers exhibit unique fluvial processes as they operate in three zones *viz.*, (a) source area in the high mountains, (b) vast alluvial plains, and (c) deltaic plains. These three zones are more pronounced in the Himalayan River systems as they represent three specific process-dominated zones; (i) the upper source zone, (ii) the middle transfer zone, and (iii) the lower accumulation zone (Schumm, 1977; Sinha, 2004, FRI, 2016). Sedimentation is a process whereby soil particles are eroded and transported. Broadly, two types of fluvial sediment transportation *viz.*, the suspended load, and the bed load have been described. In the case of suspended load, particles such as clay and silt with varying amount of sand during high energy flows continuously entrain in the water column while in the case of bed load sand grains, gravel or even larger particles move along or near the channel bed by various mechanisms such as traction and saltation. In case of traction, particles are in constant contact with channel bed while moving and includes sliding and rolling while saltation describes where particles skip along the channel bed. Suspended load is vital for the deposition process in the natural floodplain and maintenance of deltaic and estuarine environments. Bed load transport is crucial for instream habitat complexity and maintenance as well as deltaic accretion (formation).

The intense erosion process is undergoing in the Himalayan Mountains since their formation and Himalayan rivers have been removing and transporting large amount of sediments to the Arabian Sea (the Indus River), the Bay of Bengal (Ganga and Brahmaputra), and the Andaman Sea (the Irrawaddy River) as these mighty rivers have

been forming large deltas. A large number of studies have been carried out relevant to sediment transfer, sediment Budget, deltaic accretion, and formation of deep sea fan (Milliman and Meade, 1983; Milliman and Syvitski, 1992; Milliman and Meybeck, 1995; Abbas and Subramanian, 1984; Subramanian, 1996; Wasson, 2003).

Marine sediments represent the longest and most complete archives of continental environmental evolution, and they have been used to reconstruct past patterns, rates of erosion and changing environments at the time of deposition. These in turn can be used to assess the influence that climate or tectonics have over continental environments (Clift and Giosan, 2013). The drainages of the Indus, Ganga and Brahmaputra River Basin have experienced major variations in climate since the Last Glacial Maximum (LGM) that has affected the volumes and compositions of the sediments reaching the ocean since that time.

Sediment Budget: According to Clift and Giosan (2013), the sediment flux to the Arabian Sea from the Indus River has experienced significant variability after the LGM. They estimated that 4,050-5,675 km³ of sediment has been deposited in the incised valley, sub-aerial delta, shelf clinoforms and the upper Indus canyon. About half of the stored sediments falls off-shore on the shelf and in the canyon.

Over the past few decades, most of the large rivers draining through East, Southern and Southeast (ESSE) Asian regions have been dammed and regulated in order to meet water and energy requirements of rapidly growing economies and to sustain burgeoning human population. Gupta *et al.* (2012) estimated that currently Indian peninsular rivers collectively transport about 83 Mt of sediments annually. The Ganga-Brahmaputra and the Indus Rivers contribute 850 Mt and 13 Mt of sediments, respectively to the oceans. Their estimate suggested that presently the large rivers of ESSE Asian countries i.e., China, Taiwan, Vietnam, Myanmar, Thailand, India, Pakistan and Bangladesh collectively depositing ~2,150 Mt of sediment annually to the oceans. Further, they documented that ESSE Asian countries host about 250 mega dams and several tens of thousands of large and small reservoirs and observed that despite the increase in the annual flux of inland sediment due to enhanced human activities, the annual flux of sediment reaching to the world's coast has been drastically reduced because of the retention within mega dams and other reservoirs. Thus, existing, ongoing and planned dam construction activities across ESSE Asia may further reduce the annual sediment fluxes (Gupta *et al.*, 2012). The sediment load of the Indus River dramatically reduced between 1930 and 2003 by > 90%. Gupta *et al.* (2012) reported that storage of event-driven flood water results in the sequestering of huge amount of sediments behind the mega dams. The present day fluvial sediment fluxes may further decline with the closure of several additional under-construction mega dams in the ESSE Asian region. They also postulated that a continuous annual supply of huge sediments load from the large Asian rivers helped in forming and evolving some of the world's largest deltas. However, in recent times many of these deltas are shrinking, due to considerable decrease in sediment supply from the river, continuous subsidence, increased coastal erosion and sea level rise. Substantial reduction in annual sediment fluxes to coastal seas will have a direct influence on oceanic primary productivity, rock cycle or geochemical

cycle, and the overall coastal environment, influencing a variety of natural processes leading to greater socio-economic environmental and ecological consequences.

The Beas River along its course from the origin to confluence with Sutlej River has two dams (the river diversion dam at Pandoh and the mega dam at Pong). Shukla *et al.* (2017) have assessed sedimentation in Pong reservoir on the Beas River and Bhakra reservoir on Sutlej in Himachal Pradesh using geospatial technique and reported that the volume of sediment deposited during 1974-2009 (35 years) is 632 Mm³ in Pong reservoir, whereas it was determined as 802.34 Mm³ for Bhakra reservoir in the span of 46 years (1963-2009). Further, they computed the higher sedimentation rate, being 18.08 Mm³/year in the case of Pong reservoir, while for the Bhakra reservoir, it was 17.46 Mm³/year. In both cases, sedimentation rates were comparable with the conventional method of hydrographic survey analysis. The findings of study by Shukla *et al.* (2017) revealed that sedimentation rate in Beas (Pong) and Sutlej (Bhakra) were almost in similar range in spite of one would expect a much higher sedimentation rate in case of Sutlej River owing to its longer length, larger catchment, higher proportion of fragile Trans-Himalayan/cold desert and Great Himalayan regions, and pronounced human disturbance by way of sequential reservoirs/ HEPs, extensive road works, wider network of transmission lines, and intensification of agriculture/horticulture all through the river course once it enters in India from China. However, the finding has to be considered in view of the fact that in last four to five decades, sequential reservoirs/HEPs have been constructed in the upstream of Sutlej River, and a large number of watershed-wise catchment treatment plans have been implemented. Hence, it can be hypothesized that sequential HEPs upstream and concerted effort of implementation of CAT plans might have been able to check/reduce sedimentation in Sutlej River to some extent.

Water Quality: In India, most rivers are being revered and worshiped. In spite of cultural and religious significance, majority of rivers have drastically declined in their quantity and quality of water with the passage of time and enhanced human imprint owing to burgeoning population, urbanization, and industrialization (Sharma and Walia, 2016; Kumar *et al.*, 2017; Solanki and Khera, 2019). The Beas River is no exception and the entire course of its main channel and its tributaries are under great influence of densely populated human habitations, townships, tourism destinations, and expanding agriculture and horticulture. Thus, the Beas River and its tributaries are heavily burdened by waste and untreated disposal of sewage and effluents from townships, and pollutants from agricultural landscapes. The issue of water quality has become much more severe in recent years rather than the issues of quantity and access of water. Thus, the assessment of the status of water quality of natural water bodies and rivers is of utmost importance from the perspective of drinking water, other uses and public health. The State Pollution Control Board (SPCB) is the primary agency responsible for monitoring the water quality in a State as the monitoring is a pre-requisite to ascertain the impact on water quality and planning of type and extent of pollution control measures required to mitigate the situation.

The chemical and physical properties of water define the aquatic environment while assessment of biological properties of the lotic system allows detection of changes in water quality that other methods might miss or under estimate. Planktons (phytoplankton and zooplankton), benthic macro-invertebrates, and fish are the most commonly used variables in assessing the biological integrity of any river ecosystem. The river water quality assessments are best analyzed when they are based upon a comprehensive picture of physical, chemical, and biological assessments. Over the years, various national and international agencies have provided the guidelines for the standards of water quality from the perspective of inland surface water, ground water resources, and drinking water as a number of agencies are involved in water quality monitoring (Kumar *et al.*, 2017; CPCB, 2007). The Government of India, MoEF&CC Government of India has provided the guidelines for standards of inland surface water under the Environmental (Protection) Rules, 1986 (MoEF, 1993). The Bureau of Indian Standard (BIS) has also provided guidelines for drinking water (BIS, 2012). However, in order to optimize and rationalize the monitoring programme, the Central Pollution Control Board (CPCB) and MoEF&CC, Government of India, an apex body in the field of water quality management in India has issued 'Water Quality Protocol' of surface water which is being followed by the SPCBs (CPCB, 2007). The tolerance limits for inland surface waters provided by the CPCB under five categories is provided in Table 2.9 and water quality standards prescribed for drinking water are presented in Table 2.10.

Table 2. 9 - Tolerance Limits of Inland Surface Water

Sr. No.	Parameter and Unit	Class-A	Class-B	Class-C	Class-D	Class-E
1	Colour (Hazen Units)	10	300	300	-	-
2	Odour	Unobjectionable	-	-	-	-
3	Taste	Tasteless	-	-	-	-
4	pH (maximum) (min:6.5)	8.5	8.5	8.5	8.5	8.5
5	Conductivity ($\mu\text{S}/\text{cm}$)	-	-	-	1,000	2,250
6	DO (mg/L) (minimum)	6	5	4	4	-
7	BOD (3 days at 27°C) (mg/L)	2	3	3	-	-
8	Total Coliforms (MPN/100 mL)	50	500	5,000	-	-
9	TDS (mg/L)	500	-	1,500	-	2,100
10	Oil and Grease (mg/L)	-	-	0.1	0.1	-
11	Mineral Oil (mg/L)	0.01	-	-	-	-
12	Free Carbon Dioxide (mg/L CO ₂)	-	-	-	6	-
13	Free Ammonia (mg/L as N)	-	-	-	1.2	-
14	Cyanide (mg/L as CN)	0.05	0.05	0.05	-	-

Sr. No.	Parameter and Unit	Class-A	Class-B	Class-C	Class-D	Class-E
15	Phenol (mg/L C ₆ H ₅ OH)	0.002	0.005	0.005	-	-
16	Total Hardness (mg/L as CaCO ₃)	300	-	-	-	-
17	Chloride (mg/L as Cl)	250	-	600	-	600
18	Sulphate (mg/L as SO ₄)	400	-	400	-	1,000
19	Nitrate (mg/L as NO ₃)	20	-	50	-	-
20	Fluoride (mg/L as F)	1.5	1.5	1.5	-	-
21	Calcium (mg/L as Ca)	80	-	-	-	-
22	Magnesium (mg/L Mg)	24.4	-	-	-	-
23	Copper (mg/L as Cu)	1.5	-	1.5	-	-
24	Iron (mg/L as Fe)	0.3	-	50	-	-
25	Manganese (mg/L as Mn)	0.5	-	-	-	-
26	Zinc (mg/L as Zn)	15	-	15	-	-
27	Boron (mg/L as B)	-	-	-	-	2
28	Barium (mg/L as Ba)	1	-	-	-	-
29	Silver (mg/L as Ag)	0.05	-	-	-	-
30	Arsenic (mg/L as As)	0.05	0.2	0.2	-	-
31	Mercury (mg/L as Hg)	0.001	-	-	-	-
32	Lead (mg/L as Pb)	0.1	-	0.1	-	-
33	Cadmium (mg/L as Cd)	0.01	-	0.01	-	-
34	Chromium (VI) (mg/L as Cr)	0.05	0.05	0.05	-	-

Sr. No.	Parameter and Unit	Class-A	Class-B	Class-C	Class-D	Class-E
35	Selenium (mg/L as Se)	0.01	-	0.05	-	-
36	Anionic Detergents (mg/L MBAS)	0.2	1	1	-	-

Class-A : Drinking water source without conventional treatment but after disinfection

Class-B : Outdoor bathing

Class-C : Drinking water source with conventional treatment followed by disinfection

Class-D : Fish culture and wildlife propagation

Class-E : Irrigation, industrial cooling and controlled waste disposal

(Source: CPCB, 2007)

Table 2. 10 - Drinking Water Quality Standards

Sr. No.	Parameters Desirable	Acceptable Limit*	Permissible Limit**
1	Color (Hz)	5.0	25
2	Odour	Unobjectionable	-
3	Taste	Agreeable	-
4	Turbidity (ntu)	5	10
5	pH	5-8.5	No relaxation
6	Total Coliforms (MPN/100 ml)	0	-
7	TDS (mg/l)	500	2,000
8	Total hardness (mg/l) as CaCO ₃	300	600
9	Total alkalinity (mg/l)	200	600
10	Chlorides (mg/l)	250	1,000
11	Sulphates (mg/l)	200	400
12	Flourides (mg/l)	1.0	1.5
13	Nitrate (mg/l)	45	100
14	Calcium (mg/l)	75	200
15	Magnesium (mg/l)	30	100
16	Manganese (mg/l)	0.05	0.5
17	Copper (mg/l)	0.05	1.5
18	Zn (mg/l)	5.0	15.0
19	Iron (mg/l)	0.30	1.0
20	Lead (mg/l)	0.05	No relaxation
21	Cadmium (mg/l)	0.01	No relaxation
22	Chromium (mg/l)	0.05	0.05
23	Phenolic compounds as phenol (mg/l)	0.001	0.001
24	Anionic detergents as MBAS (mg/l)	0.001	0.002
25	Arsenic as As (mg/l)	0.05	0.05
26	Selenium as Se (mg/l)	0.01	0.01
27	Mercury total as Hg (mg/l)	0.001	0.001

Sr. No.	Parameters Desirable	Acceptable Limit*	Permissible Limit**
28	Cyanide (mg/l)	0.05	0.05
29	Mineral oil (mg/l)	0.01	0.3
30	Polynuclear aromatic hydrocarbons (PAH) (µg/l)	0.02	0.02

*The values indicated under the column ‘Acceptable’ are the limits up to which water is generally acceptable to the consumers.

**Values in excess of those mentioned under ‘Acceptable’ render the water not acceptable, but still may be tolerated in the absence of alternative and better source, but up to the limits indicated under column “Cause for Rejection” above which the supply will have to be rejected.

**(Source: CPCB, 2007)

The CPCB under the National Programme of Indian Natural Aquatic Resources (MINARS) sponsors the water quality monitoring of major rivers in the country. As per the prescribed protocol, samples are being collected quarterly in the months of January, April, July and October each year. The SPCB, Himachal Pradesh has been monitoring water quality at 13 different points along the course of Beas River. The status of water quality in different stretches of the river differed from ‘A’ category or ‘B’ category and at few locations of ‘C’ category owing to the presence of much higher levels of ‘Total Coliforms’ (TC) (GoHP, 2012). According to the HPPCB, the Beas River at downstream of the towns – Manali, Kullu, Mandi and Dehra showed the contamination of water mainly due to sewage contributing to higher levels of Total Coliforms. According to the primary water quality criteria, the designated best use category of fresh water means drinking water source without conventional treatment, but after disinfection. The ‘B’ category fresh water can be best used for outdoor bathing while the ‘C’ category fresh water means drinking water source with conventional treatment, followed by disinfection (GoHP, 2012).

Further, as a part of the MoEF&CC, GoI’s sponsored ‘Cumulative Impact Assessment and Carrying Capacity Study (CIA & CCS)’ of Beas Basin, the RSET Pvt. Ltd. undertook water quality assessment at 59 sampling locations covering different hydroelectric project (HEP) areas across the entire basin in the State of Himachal Pradesh and collected water samples during various seasons i.e., winter, pre-monsoon and monsoon and monthly samples from May, 2016 to December, 2016 so as to cover different sampling locations on the main channel as well as various tributaries. The results of all the water quality parameters analyzed for water samples collected from different sampling locations were described sub-basin wise (RSET, 2019). The analysis of most of the physico-chemical parameters in general revealed that there was hardly any significant variation in majority of the parameters as most of them were within prescribed standards. The absence of heavy metals was mainly attributed to the absence of heavy industries in the basin except for medium and small enterprises in towns like Kullu, Mandi and Kangra comprising mainly of Agro and Food Processing, mechanical and engineering, woolen and wood based industries, and prominent exportable items viz., fabric and ayurvedic medicines. Main economic activities were tourism, horticulture, agriculture and other related activities. Being hilly and mountainous region, industries have not developed in the basin. The heavy metals in Beas River and its tributaries were either ‘Not Detectable’ or ‘Below Detectable Limits’. RSET (2019) has provided the overall assessment of important attributes of water quality at the Basin level in the comprehensive report prepared for the MoEF&CC. The study also used the concept of ‘Water Quality Index (WQI)’ in order to assess the overall physico-chemical water quality of Beas River and its tributaries. The concept of WQI was developed by the Washington State Department of

Ecology, Environmental Assessment Programme. The values of WQI were computed using the formula provided by Thukral *et al.* (2005). The WQI used is a unit less number ranging from 1 to 100. A higher number is indicative of better water quality. For temperature, pH, Coliforms and dissolved oxygen, the index expresses result relative to levels required to maintain beneficial uses. Water quality index is a 100-point scale that summarizes results from a total of 9 different parameters listed below.

pH	Temperature Change (°C)	Total Phosphates (mg/L)
Dissolved Oxygen (DO) Saturation (%)	Total Coliforms (MPN/100mL)	Nitrates (mg/L)
Turbidity NTU	Biochemical Oxygen Demand (BOD) (mg/L)	Total Suspended Solids (TSS) m/L

The water quality can be designated as ‘Excellent’, ‘Good’, ‘Medium’, etc. as per the range of WQI defined in the tabular statement below.

Water Quality Index	
Range	Quality
90 – 100	Excellent
70 - < 90	Good
50 - < 70	Medium
25 - < 50	Bad
0 - < 25	Very bad

In case of study by RSET (2019) on the Beas River Basin, the values of WQI varied from 64.94 to 93.49. The analyses showed that WQI at majority of sampling sites in different sub-basins during all seasons ranged from Good to Excellent indicating that water quality was largely in the ‘Good’ or ‘Excellent’ categories. Only at few of the sampling sites in Parbati lower basin, Sharni and Sarsadi HEP areas were in the Medium category. It was also seen that BOD values were higher than the normal range and Total Coliforms were also on the higher side presumably due to discharge of untreated domestic sewage directly into the Beas River from prominent towns *viz.*, Manali, Kullu and Mandi along the main channel. Similarly, biological water quality was also estimated (RSET, 2019).

In addition to the above comprehensive study sponsored by the MoEF&CC, several other studies have been carried out in different stretches of Beas River or its tributaries and varying periods so as to assess the water quality (Mishra and Nadda, 2014; Sharma and Walia, 2016). Mishra and Nadda (2014) assessed the trends in the water quality of Beas River from Manali to Larji as this river stretch expose to the flow of sewage, garbage and muck resulting from the various project activities, thereby, making the river vulnerable to pollution. They concluded that pollution of river has ultimately affected the livelihood of local population in this region. In view of this, they continued water monitoring for the said stretch at 15 various locations on quarterly basis between January, 2010 and January, 2012. The study showed that the total coliform and faecal coliform levels during the assessment period were considerably high indicating that the river received either untreated or partially treated sewage. Sharma and Walia (2016) based on water quality assessment from six sampling stations i.e., Beas Kund, Shamshi, Pandoh Dam, Dharampur, Nadaun, and Pong Dam along Beas in summer season

reported that cadmium and iron were found to be higher than the acceptable limit prescribed by the Bureau of Indian Standards for drinking water in India. They observed higher mean pH value of 8.55 at Nadaun with Coliforms being present in all the sampling stations. Awasthi and Tamot (2010) assessed the water quality of three tributaries i.e., Poon, Awa and Mole of Beas drainage system in upper reaches of Palampur. They observed that water of three tributaries was suitable for drinking purpose. Mishra and Nadda (2014) highlighted that recent trends in enhanced human activities have impacted the water quality of important river like Beas to a great extent. Main reasons for deterioration of water quality can be attributed to the expanding unregulated tourism and urbanization with complete disregard of the environmental, cultural and religious significance of the river. The municipalities of Manali, Kullu, Bhuntar and other townships could not check pollution in the Beas River inspite of their best efforts.

Following the directions of the National Green Tribunal (NGT), the State Pollution Control Board had issued notices to close down 34 hotels operating along Beas River in Kullu–Manali area. The HP State Pollution Control Board has recently submitted a comprehensive report on the action plan for prevention and control of pollution in Beas River and rejuvenation of Beas River from Kullu to Dehra-Gopipur in compliance to the Hon'ble NGT order dated 20 September, 2018 and 19 December, 2018 in response to Original Application Nos. 673 of 2018 (HPPCB, 2019).



Alluvial plains of Punjab

2.3.2 Alluvial Plains

The Beas River after traversing a distance of about 270 km in Himachal Pradesh descends into the alluvial plains in Punjab. The Punjab Plain is a part of the vast Indo-Gangetic Plain (IGP) formed due to flexing of Indian lithosphere during continent to continent collision of Indian Plate against the Asian Plate. The collision formed the Himalayan Mountain chain where the Indian Plate is still under-thrusting the Asian Plate (Molnar and Tapponier, 1977; Seeber *et al.*, 1981; Ni and Barazangi, 1984; Molnar, 1984; DeCellers and Giles, 1996; Wesnousky *et al.*, 1999; Srivastava *et al.*, 2014). The collision created the Indo-Gangetic peripheral foreland basin, formed on the flexed Indian Plate lithosphere in early Miocene, which expanded in middle Miocene where the sediments from the Himalaya started depositing mainly through fluvial processes (Singh, 1987 and 1996). The rocks of Shivalik

succession i.e., middle Miocene to early Pleistocene are the uplifted sediments of the northern margin of the Indo-Gangetic foreland basin, thrust along the Himalayan Frontal Thrust (HFT). The thrusting events in the Himalaya, making the Shivalik Hills, caused southward shift of the present Indo-Gangetic foreland basin (Ghosh and Singh, 1988). The tectonic activity is continuing in the Himalaya and its manifestations are recognizable in the quaternary alluvial deposits of the Indo-Gangetic Plain (Srivastava *et al.*, 2014).

The Indo-Gangetic Plain is drained essentially by two major river systems, namely the Indus River System, which drains into the Arabian Sea and the Ganga River System which drains into the Bay of Bengal. The Indo-Gangetic Plain has been divided into: (a) Punjab-Rajasthan Plain, (b) Ganga Plain, (c) Bengal Plain, and (d) Brahmaputra Plain (Singh, 1987; Singh and Ghosh, 1994). The Punjab-Rajasthan Plain comprises the Indus Plain in the west and the Punjab-Haryana Plain in the east. The Punjab-Haryana Plain occupies a unique position, located in the water divide area of two river systems (the Indus River system and the Ganga River system).

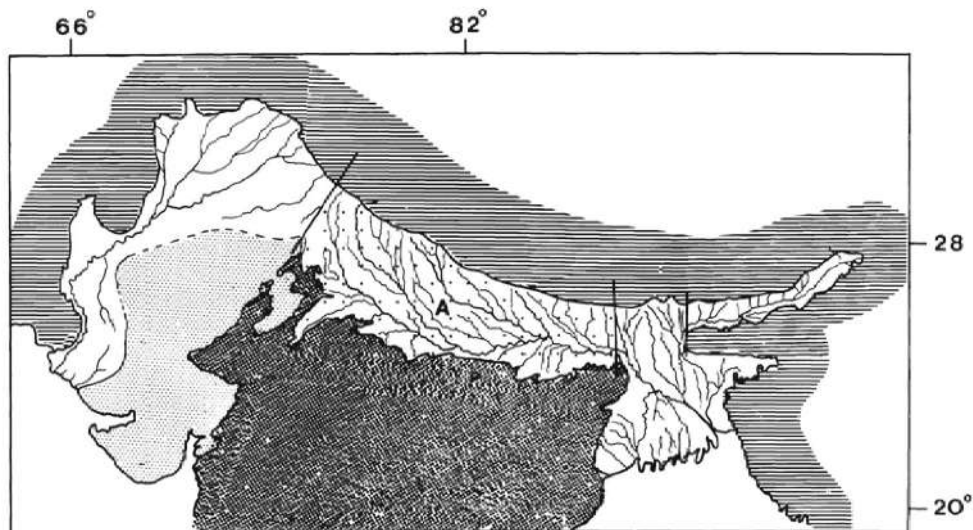


**Fig. 2. 6 – Map Showing the Ganga Plain (A) within the Indo-Gangetic Plain
(Source: Singh, 1996)**

The Punjab-Haryana Plain is a vast alluvial plain, bounded by Shivalik Hills in the north and the Aravalli-Delhi Massif in the south, formed by essentially fluvial processes. Several distinct regional geomorphic surfaces have been identified on the basis of their location, type of sediment, slope and pattern of drainage (Fig 2.7). These surfaces were formed during changing climatic conditions in late Quaternary period. However, they have been partly modified later and still undergoing changes in the present time (Srivastava *et al.*, 2014).

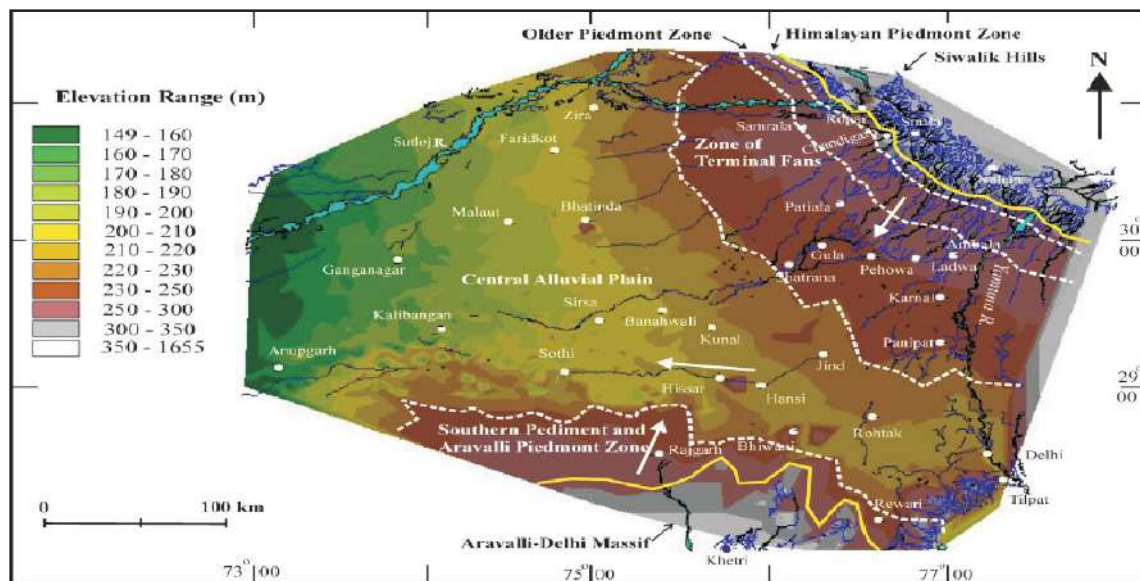


Fig. 2. 7 - Geomorphological Map of Punjab-Haryana Plain
(Source: Srivastava *et al.*, 2014)

The various geomorphic surfaces identified in the Punjab-Haryana Plain are:

- (a) **Himalayan Piedmont Zone** - This zone is located at the base of Shivalik hills and primarily confined to the altitudinal gradient between 300 - 350 m and makes a 10-15 km wide belt along the Shivalik hills.
- (b) **Older Piedmont Zone** - This is nearly 20 km wide belt south of the Himalayan Piedmont Zone. The surface is often covered with muddy to sandy sediments, but shows gravel and core sand below. This zone generally extends between 270 - 300 m and displays several ephemeral streams.
- (c) **Zone of Terminal Fans** - This is a 80-km wide belt south of the Older Piedmont Zone and is the most prominent feature of the Punjab-Haryana Plain. It has been formed by amalgamation of terminal fans, extending from 200 - 270 m. Most of the channels disappear in the distant part of this zone.
- (d) **Central Alluvial Plain** - This is a low-lying area south of the Zone of Terminal Fans, developed between 180 m in southwest to 228 m in the north east. The zone is characterized by a flat surface having a narrow zone of westward gentle slope occupied by the dry alluvial low area.
- (e) **Southern Peditain** - This small zone is confined between the Aravalli Piedmont Zone and the Central Alluvial Plain and made up of sediments derived from the Aravalli Mountain front and consists of brownish mud and silt, with granules of pedogenic calcrete.
- (f) **Aravalli Piedmont Zone** - A narrow belt along the Aravalli-Delhi Massif comprising of brownish coloured clays, silts and sand.

The Indo-Gangetic Plains (IGP) ranks as one of the most extensive fluvial plains of the world, the deposits of this tract represents the last chapter of the Earth history as they came into existence due to the collision of Indian and Asian plates during middle Miocene (Pal *et*

al., 2009). Like the greater part of the IGP, the Punjab-Haryana Plain regions are also environmentally sensitive, socially significant, and economically strategic domain of India wherein the landscape, hydrology and fertility are of utmost importance from the point of view of high human density, agricultural production, and granary of the country. The Plains of Punjab are immensely benefitted by the hydrological regime and sedimentation by prominent rivers like, Beas, Sutlej, Ravi and Ghaggar. The Plains of Punjab are critical as this important zone of the country is strongly connected to the tectonics, climate of Himalaya and anthropogenic factors those are liable to adversely affect the hydrology, soil fertility, food production, and settlement pattern (Saini, 2008). The State of Punjab representing 1.57% geographical area of the country, contributes >50% of the grain in the central grain pool (GoI, 2013). In particular, the State contributes about 55% of wheat and 42% of rice to the central pool. >83% of land in Punjab under agriculture as compare to the nation average of 40.38%. The cropping intensity has increased from 133% in 1971 to 190% in 2009. Nearly 98% of cropped area is under irrigation that uses about 84% of the State's water resources. The Punjab plains are over stressed due to over exploitation of land, surface water and ground water resources. As a result, the region is threatened by excessive development of ground water resources, drying up of aquifers, decreased water supply, and deterioration of water quality due to pollution, stabilization, desertification, and ultimate decline in food production

a. Alluvial Stratigraphy

Rivers entering sedimentary basins distribute their sediment and water in major sediment fans which have been recognized in stratigraphic records around the world (DeCelles and Cavazza, 1999; Leier *et al.*, 2005; Hartley *et al.*, 2010; Weissmann *et al.*, 2010). The development of alluvial stratigraphy is controlled by river avulsion, sedimentation rate, and the stacking pattern of fluvial channel-belt sand bodies (Leeder, 1978; Allen, 1978; Bridge and Leeder, 1979). This alluvial stratigraphy, in turn, determines the characteristics and productivity of groundwater aquifers in terms of (a); the percentage of sand-rich aquifer bodies in the subsurface, (b) the geometry and dimensions of the aquifer bodies, (c) their hydraulic conductivity and specific yield, and (d) their connectivity (Larue and Hovadik, 2006; Renard and Allard, 2013). Understanding the stratigraphic architecture of large alluvial aquifer systems is particularly critical because these systems are major repositories for groundwater and are a primary source of fresh water in large parts of the world.

Traditionally, geological studies focused mainly the rock succession. However, studies of vast alluvial plains were ignored (Singh, 1996). The extreme flatness of the vast region and geomorphologically monotonous character also did not attract the geomorphologist to undertake detailed investigations of alluvial plains or flood plains. Some systematic geomorphic studies were carried out on the vast Indo-Gangetic Plain, particularly the Ganga Plain (Geddes, 1960; Mukerji, 1963; Singh, 1996). The vast alluvial plain of Indo-Gangetic plains(IGP)was classified into Older Alluvium (Bhangar) and Newer Alluvium (Khadar), each with different sediments (Pascoe, 1973). The Older Alluvium makes the higher interfluvial areas while the Newer Alluvium forms deposits of major river channels and their

valleys. Khadar land lies next to a river while Bhangar land has greater elevation and lies away from the river. Bhangar soils are poor in fertility as they are above flood levels whereas Khadar soils are fertile as they are found at relatively below the flood level. The former soils are full of kanker (Lime Module) while latter soils are composed of fine silt and clay. The area lying below the mountains is referred as Kandi. The Himalayan Rivers divide the plains into doabs i.e., the region between two rivers or it is land lying between two converging or confluent rivers. The Punjab Plains owing to flowing of multiple river from Himalaya and several confluent rivers/ tributaries created varied *doabs*. Hence, they were named differently. The *Bist Doab* refers to the land between the Beas and the Sutlej Rivers. The *Bari Doab* lies between the Ravi and the Beas Rivers and the *Rechna Doab* lies between the Chenab and the Ravi Rivers. The *Bist Doab* tract of Punjab is an agriculturally important region as it lies between two important rivers i.e., Beas and Sutlej on two sides and the Shivalik range on the third side (Singh, 1987). Since alluvial plains of the Ganges symbolizes the life line of one of the world's largest population. Consequently a number of studies have been carried out on the morphology, hydrology including flooding history and sediment transport behavior of the river system. The alluvial stratigraphy of the large valleys and interfluvies in the plains has provided insight about the sediments pattern (Sinha, 2004). However, the insight on alluvial stratigraphy in the context of Punjab-Haryana Plains is relatively poorer. The scarcity and the lack of integrated geomorphologic, stratigraphic, sedimentological, mineralogical, and geochemical approaches have precluded a comprehensive insight (Sinha *et al.*, 2005). It was quite evident in the case of Punjab Plains.

River System, Fluvial Processes and Channel Dynamics: The behavior of Beas River drainages has structural control as river flows through structurally lower and weaker zones of bedrocks such as along syncline, soft rocks, rock fractures, and along faults that can be easily eroded (Kumar, 2005). Hard rocks and mountain ranges offer greater resistance for the river flow. The Beas River follows geological structure in upper section but cut across them in the lower sections, mainly because that the river in the upper section, is a consequent stream that follows different structural zones of weakness whereas it is antecedent to structure of lower valley section. The drainage system of lower section followed the depression formed between Dhauladhar in north and Shivaliks in south and Jalori ridge in south east. The Beas Valley in lower section is almost parallel to Dhauladhar range.

The geomorphic asymmetry in the upper and lower sections of the Beas Valley is quite evident (Kumar, 2005, Bhatt *et al.*, 2008). In the upper portion, the Beas River divides the valley into two unequal parts. The western side or right bank tributaries are relatively smaller than the eastern side or the section of the left bank tributaries. The *Sarbari Nallah*, the longest right bank tributary is about 25 km long whereas the Parbati River, the longest left bank tributary is about 78 km long. Likewise, other prominent left bank tributaries i.e., *Sainj*, *Thirthan*, and *Hurla* are about 63 km, 54 km and 32 km long. The larger drainage section in the eastern side developed on relatively older Great Himalayan Range and Jalori ridge while the smaller drainage sections of western bank was developed on Dhauladhar Range. Since, the Greater Himalayan Range in geological time was uplifted earlier than the Dhauladhar, the eastern bank tributaries i.e., *Parbati*, *Sainj*, *Thirthan* and *Hurla* are older than the western

bank tributaries. On the lines of upper portion/valley, the lower section of the valley is also asymmetrical (Kumar, 2005, Bhatt *et al.*, 2008). However, in the lower section, the longer tributaries i.e., *Uhl*, *Banganga*, *Neugal*, and *Rana Khad* are those joining the main channel on right bank while prominent southern bank tributaries namely *Kunh*, *Bakhil*, *Man Khad*, *Suketi*, and *Juni Khad* are relatively shorter in length. Thus, the Beas channel divides the lower Beas Valley also into two unequal parts. The northern part tributaries originate on the southern slope of Dhauladhar, while southern bank tributaries originate on the northern slope of Lesser Himalaya and Shivalik hills. In this case also, since Dhauladhar range was uplifted earlier than the Shivalik Hills and Lesser Himalayan Range, consequently the tributaries of Dhauladhar Range are older than the southern bank tributaries flowing from Shivalik Hills and Southern Lesser Himalayan Range. It is evident that the differences in age of mountain range formations have manifested the length of tributaries. The upper Beas valley is narrow while the lower valley is much wider.

The Beas River shows formation of meanders in front of Lesser Himalaya once it enters the Shivalik formations (Kumar, 2005). As the Lesser Mountains was uplifted earlier than the Shivaliks, at the time of meander formation the region had gentle sloping. Downstream of *Beas- Binno* confluence in Kangra District, the meandering river channel is replaced by the braided channel. The meandering channel pattern once again appears downstream of *Beas-Neugal* confluence (Kumar, 2005). Broad braided channel segments are the conspicuous feature of the lower Beas Valley. Similar trends in channel segments along some tributaries of Beas River can be observed.



Bear River entering Punjab

2.3.3 Beas-Sutlej Confluence

As the Beas River meets Sutlej River for its confluence upstream of the Harike Barrage in alluvial plains of Punjab, the river does not form a delta. Hence, the process of channel dynamics in the form of braiding is not conspicuous as in other prominent Himalayan Rivers i.e., Indus, Ganga, and Brahmaputra those make world's largest deltas.

2.3.4 Climate

The climatic conditions in the Beas Riverscape spread over the mountainous Himalayan State of Himachal Pradesh and alluvial plains in Punjab are influenced significantly by various driving variables *viz.*, solar radiation, precipitation i.e., snowfall and rainfall, temperature, humidity, and wind. The notable altitudinal variation from plains to the high mountains of the Great Himalaya in the riverscape plays significant role in maneuvering varied climatic conditions. The extent of snowfall and spatio-temporal pattern of rainfall have a direct bearing on the hydrological regime of the Beas River and its tributaries. The influx of solar radiation and diurnal temperatures, particularly in the Himalayan stretch of the riverscape also has an important role to play in the process of formation of glaciers ablation, and glacier and snow-melt, plant transpiration, and evaporation of surface water from open water bodies i.e., lakes, rivers, and reservoirs. Wind direction and velocity also influence the humidity, evaporation and transpiration. Cumulatively, above stated climatic attributes of the mountainous stretch and the Punjab plains have profound implications on weather, micro-climate, hydrology, water flow, diversity and productivity of forests, grasslands and maintenance of wetlands, cropping pattern, and agricultural productivity besides several aspects of livelihood.

The entire stretch of the Beas riverscape from its origin to confluence with Sutlej experiences tropical monsoonal climatic environment with the onset of southwest monsoon occurring in late summer season i.e., around the second fortnight of June month. Monsoon usually lasts for four months from July 1st to September 30. The longest delayed monsoon withdrawal in Himachal Pradesh in the past 37 years was on October 11. The climate in Himachal Pradesh is also influenced by northeast rains and the occasional western disturbances. The State thus experiences three marked seasons *viz*; (a) summer season (April-June), (b) rainy Season (July to September), and (c) winter season (October-March). Overall, Himachal Pradesh is known for its salubrious climate. Precipitation declines from west to east and south to north with the average annual rainfall of 1,100 mm. District-wise rainfall relevant to the riverscape within Himachal Pradesh is presented in Table 2.11.

Table 2. 11 - District-wise Trends of Rainfall within Beas Riverscape

Sr. No.	District	Year			
		1990	2000	2014	2017
1	Kullu	1,155.4	1,088.0	409.3	504.1
2	Mandi	2,268.6	1,397.6	1,050.8	1,061.9
3	Hamirpur	1,819.8	1,320.7	1,078.9	1,019.0

Sr. No.	District	Year			
		1990	2000	2014	2017
4	Kangra	2,490.0	1,353.4	1,058.2	1,595.9
5	Chamba	1,532.2	1,414.2	469.4	1,051.8

(Source: GoHP, 2000 and IMD website)

It is evident from the Table 2.11 that values of rainfall in five districts in different years have varied remarkably. On occasions, Dharamshala in Kangra District has received high rainfall to the extent of more than 3,000 mm. the maximum value being 3, 400 mm of rainfall has been recorded in the case of Dharamshala, and it is being considered as the second wettest place in India. Nearly, 70% of total rainfall is received within the three month period i.e., from July to September). Generally, hills up to 1,500 m altitude do not receive snowfall. On an average, snowfall in hills above 3,000 m elevation gets about 3 m depth which usually lasts for four months from December to March. Above 4, 500 m, there is almost perpetual snow. The amount of rainfall and snowfall varies with altitude. The rainiest months are July and August. The months of December and January record minimum rainfall (GoHP, 2000).

The average temperature in Himachal Pradesh, particularly in summer months varies from 22° C to 37° C while the average temperature during winter season varies from 0° C to 15° C. The higher reaches also record temperature below 0° C. The Great Himalayan and the Lesser Himalayan ranges of the riverscape usually witness the temperature below 15° C while the Outer Himalayan or Shivalik Hills record temperature above 15° C.

The Relative Humidity (RH) is usually high in the rainy months of July to September with values ranging between 76 % and 95%. The upper Beas Valley generally records high values of RH even during the months of December and January owing to the presence of dense forests.

Based on regional variations in rainfall, temperature, and humidity, the State of Himachal Pradesh has been divided into five climatic zones (GoHP, 2000 and 2012). These are: (a) Sub-Tropical Zone (<900 m), (b) Warm Temperate Zone (>900 m to <1,800 m), (c) Cold Temperate Zone (>1,800 m to <2,400 m), (d) Cold High Mountain Zone (>2,400 m to <4,000 m), and (e) Snowy Frigid Zone (>4,000 m) (GoHP, 2000).

The climatic conditions in alluvial plains of Punjab mainly vary from semi-arid to dry sub-humid while experiencing the tropical monsoonal climate. Owing to much lower altitudinal areas in Punjab Plains, except in the northeastern part of the State that is bordering with the Outer Himalaya or Kandi area of Shivaliks, generally, temperatures are higher. Broadly, the region of alluvial plains of the riverscape experiences four seasons: (a) monsoon i.e., July to September, (b) post-rainy season i.e., October to November, (c) winter i.e., December to February, and (d) summer (March to June). The maximum temperature rises up to 48° C in month of May-June while winter months are generally colder experiencing lower temperature reaching to 0° C. Frost is common in winter season. Generally, temperature starts rising slowly from the month of February and increases rapidly February to June with hottest days in June. In July, when monsoon sets in, the temperature subsides and keeps falling till

January. The sunshine is abundant except for a brief period in December and January. The amount of rainfall in plains varies from 250 mm to 1,100 mm; the maximum is near the Shivalik Range and the minimum in the southwestern extreme of the plains. Over 70% of the rainfall is received during the period of July to September. Some time, the monsoon begins to retreat in the middle of September. Broadly, the climatic conditions in the alluvial plains part of the riverscape can be divided into two categories: (a) Less Hot and Humid Northeast Zone – This zone is spread over Gurdaspur and Hoshiarpur Districts. The region is not very hot and for eight months of the year monthly temperature remains below 20° C. Being located in the Shivalik Ranges, this climatic zone enjoys more than 800 mm of average annual rainfall; and (b) Hot and Semi-Dry Central Zone - This zone is spread over Amritsar, Kapurthala, Moga, Ludhiana, Fatehpur Sahib, Sangrur and Patiala Districts. Annual average temperature of this zone is higher than that of the Less Hot and Humid Northeast Zone. In the months of December and January, ground frost and mist are the common phenomenon. This region receives average annual rainfall of 400 - 800 mm and the amount of average rainfall received gradually increases as one moves towards the northern parts. Effects of global warming and climate change are evident. Villagers, farmers, fishermen and populace in general do realize changes in rainfall and snowfall pattern in terms of total amount of rainfall/ snowfall, number of rainy days, delayed onset of monsoon, longer dry spells, early withdrawal of monsoon, etc. Hence, the close scrutiny of climatic variables generally provides an insight on large scale variation in monthly values, mean values and even annual average values of precipitation. These changes are obviously bringing changes in cropping pattern, shift in distributional range of a particular crop/horticulture species, frequent drought or floods, etc. Greater variability and extremities in climatic attributes is of serious concern in context of Himachal Pradesh as well as alluvial plains region in Punjab from the perspective of maintenance of surface and ground water resources, river ecosystems, other natural ecosystems, agro-ecosystems, and sustainable livelihoods.

2.4 Biological Environment

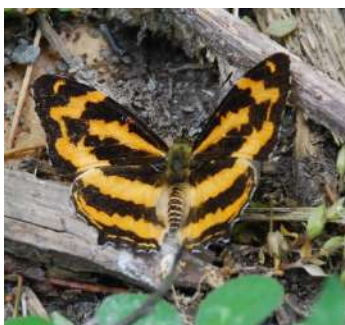
Man is an integral part of a natural ecosystem whether it is forest, grassland, wetland or marine ecosystem. Since time immemorial, nature and humanity have always had an intricate and symbiotic relationship as natural ecosystems are the planet's life support system not only for human well-being but also for all other forms of life viz., plants, animals, and micro-organisms. Natural ecosystems provide varied goods and services to humankind. Enhanced human imprint, particularly in the last century and increase in human disturbance by way of conversion of natural ecosystems, livestock grazing, forest fires, over harvests of natural resources, introduction of invasive and alien species, and incompatible land use in surrounds of delicate ecosystems has caused habitat fragmentation, decline of biodiversity, reduced ecosystem services, and even impairment of natural functioning of complex and dynamic ecosystems. It has been lately realized that the maintenance of 'natural capital' is essential for the human well-being and to accomplish varied goals of sustainable development. Decline in fresh water ecosystems and looming water crisis in a considerable part of the world has

attained the significance as one of the global challenges that is strongly linked with other challenges faced by the humanity.

The biological environment in the context of a lotic system like river or the riverscape includes terrestrial, aquatic, coastal and deltaic ecosystems all along the main channel and its tributaries and their catchment. The biological environment from the point of view of the Beas Riverscape is thereby, constituted by diverse forests, alpine pastures, grasslands, and wetlands in the Himachal Himalaya and the Punjab plains. The following section attempts to provide an insight on the biological environment based on a synthesis of widely scattered information on varied aspects of natural ecosystems and associated flora and fauna.



Common Map



Jester



Chocolate Pansy

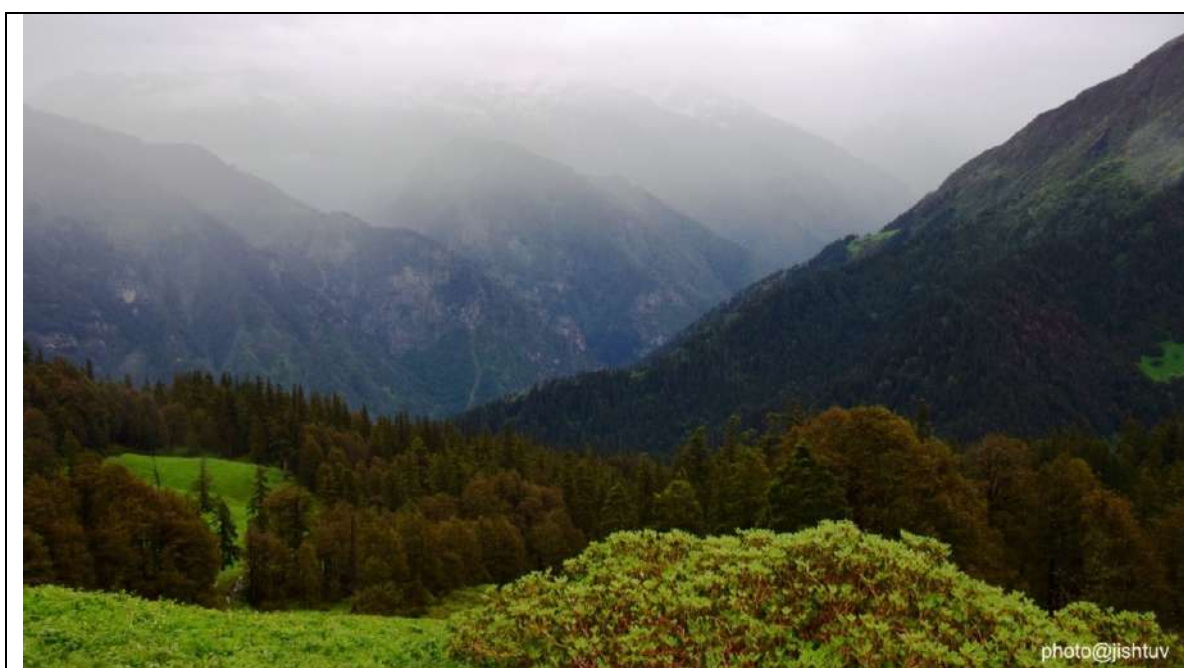
2.4.1 Biogeographic Representation

The Beas Riverscape along two Indian States represents two biogeographic zones: (i) 2-Himalaya, and (ii) 4-Semi Arid. These two biogeographic zones are further represented by three biotic provinces, namely (a) 2A- Northwestern Himalaya, (b) 2B- Western Himalaya, and (c) 4A-Punjab Plains (Rodgers and Panwar, 1988). These two biogeographic zones and three biotic provinces cover a wide range of natural ecosystems and associated rare, endangered and threatened floral and faunal species. The biogeographic zone – 2, Himalaya with two biotic provinces are represented in the mountainous State of Himachal Pradesh while the Punjab State falls in one biogeographic province of a single zone i.e., 4 A-The Punjab Plains of the Semi-Arid zone.

2A-Northwestern Himalaya Biotic Province: The Himalayan Mountain Ranges covering an area of about 2,36,300 km² in India spread across five States i.e., Uttarakhand, Himachal Pradesh, Sikkim, West Bengal, and Arunachal Pradesh and one Union Territory i.e., Jammu and Kashmir. The value of Himalayan Mountains in terms of their natural resources, particularly the fresh water resources is much greater than the extent of the area implies. A significant portion of the country's population besides human populations in Nepal, Bhutan, Bangladesh, Myanmar, China, and Pakistan depend on water for various uses. The small State of Himachal Pradesh embodies the full range of Himalayan ecosystem from the arid cold desert of the Trans-Himalaya (Zone 1) across the main Himalayan Range (Zone 2) to the semi-arid foothills (Zone 4). The State has representation of two biotic provinces (2A-North

Western Himalaya and 2B-Western Himalaya). These two provinces are divided by the Sutlej River which acts as a barrier for species like the Himalayan Ibex (Rodgers and Panwar, 1988).

The 2A-Northwestern Himalayan biotic province characterized by high snowcapped peaks, steep slopes, unconsolidated soils, intense rainfall and represented by the Great Himalaya, Lesser or Middle Himalaya, and the Outer Himalaya or Shivaliks. Varied landforms, notable altitudinal gradient, and harsh climatic conditions make the environment in this zone of extreme fragility. The area of this biotic province harbours a considerable chunk of glaciers, snow covered areas, diverse forests, alpine pastures, high altitude wetlands, and rivers and tributaries besides spectacular Pir Panjal and Dhauladhar Himalayan ranges. In spite of rugged terrain, one can find wide spread human habitations, high densities of livestock, expanding agriculture/ horticulture, and growing mountain tourism and adventure activities on steep slopes. The natural environment in this biotic province has greatly suffered under ever mounting human pressure and developmental activities i.e., linking of rivers and diversion of water, hydroelectric projects, widening of road network, and ever increasing tourism and hospitality industry. Despite human pressure and impact of developmental activities, the biotic province harbours a large number of endangered faunal taxa viz., snow leopard, bears, wolves, tahr, bharal, musk deer, etc. The biotic province is represented by a wide range of galliforms and other avifauna. The biotic province harbours broad leaved forests, temperate forests, sub-alpine and alpine vegetation dominated by conifers, oaks, spruce, fir, rhododendron, etc. The biotic province is rich in lichens, bryophytes, orchids, bamboos, grasses, medicinal herbs, and shrubs. The Beas Riverscape in this biotic province includes a large contiguous and compact area, referred as the Great Himalayan National Park Conservation Area which has been designated as the World Heritage Site (WHS) by the UNESCO besides the biotic province also harbours several smaller protected areas.



Great Himalayan National Park (UNESCO HERITAGE SITE)

2B-Western Himalaya Biotic Province: This biotic province covers Himalayan region from the Sutlej to the Gandak River in Nepal. In general, the Western Himalaya biotic province is drier and experience harsher winters. The biotic province includes the eastern part of Himachal Pradesh and the larger part in Uttarakhand i.e., Garhwal and Kumaon Himalaya). The Nanda Devi, Garhwal Himalaya is the prominent peak in this province. Important PAs in this province are: (a) Himachal Pradesh – Shimla Catchment WLS, Chail WLS, Shri Naina Devi Conservation Reserve, Churhdhar WLS, Rupin Bhaba WLS, and Rakchham Chitkul WLS, (b) Uttarakhand - Nanda Devi National Park, Valley of Flowers National Park, Kedarnath Musk Deer Sanctuary, Govind Pashu Vihar National Park, Gangotri National Park, and Askot WLS. Thus, the biotic province is represented by some of the best known large, contiguous and compact PAs harbouring significant portion of diverse forests and numerous rare and threatened species of plants, mammals, avifauna and other taxonomic groups.

4A-Punjab Plains Biotic Province: According to Rodgers and Panwar (1988), the entire state of Punjab lies in a single biotic province i.e., 4A-The Punjab Plains of the Semi-Arid Biogeographic Zone. Climatically, much of the Punjab should be in the Arid Desert Biogeographic Zone (<400 mm rainfall), but the great extent of irrigation by Himalayan Rivers i.e., Ravi, Beas and Sutlej) has removed virtually all true desert elements. Thus, the State is placed in the Semi-Arid Indus drainage area. The entire biotic province can be recognized in three regions viz., (a) the north Shivalik Hill system, the Indus Alluvial Plains, and a fragmented region of wetlands-natural and artificial. The Shivaliks have a dry deciduous forest cover, but much has been severely eroded and reforestation has largely used exotic tree species. The Shivalik forests still has faunal elements like the sambar, wild pig, barking deer, etc in good numbers. The alluvial plains have fragmented relic populations of Nilgai which together with wild pig cause considerable crop damage. A few smaller and isolated populations of Black buck and Chinkara also occur. The wetlands have an important migratory waterfowl avifauna. The Harike Barrage at the confluence of Beas and Sutlej forms an important wetland site, and is one of the Ramsar Sites.

2.4.2 Diverse Forests

Forests cover nearly 6% of the planet, but they harbour up to 90% of the world's terrestrial biodiversity. Forests and trees make vital contributions to both people and the planet, bolstering livelihoods, providing clean air and water, conserving biodiversity and responding to climate change (FAO, 2018). According to FAO, the world's total forests area is just over 4 billion hectares, with forests covering 31% of total land area and legally established protected areas covering an estimated 13% of the world's forests. The Global Forest Resources Assessment (GFRA), coordinated by FAO revealed that the world's forest area decreased from 31.6% of the global land area to 30.6% between 1990 and 2015, but the pace of loss has slowed down in recent years. The livelihoods and food security of many of the world's rural poor depend on world's diverse and vibrant forests and trees. Evidence shows that around 40% of the extreme rural people–250 million people–live in forests. Nearly,

three-quarters of the globe's accessible fresh water comes from forested watersheds and about 40% of the world's 230 major watersheds have lost more than half of their original tree cover. While the importance of forests and trees to a healthy, prosperous planet is universally recognized, the depth of those roots is much greater than imagined. The quantitative evidence now suggests that forests and trees also make significant contributions to the sustainable development goals through the informal sector, agro-forestry, opportunity to empower women, sustainable water management, tourism, sustainable cities, climate change adaptation and tackling land degradation and biodiversity loss (FAO, 2018). Forests also influence the nature's capacity to cope with natural hazards.



Forests make significant contributions to the Sustainable Development Goals (SDGs)



Riverine forest along the River Sainj near Neoli, Kullu

Diverse forests (tropical, sub-tropical, temperate and sub-alpine) in the Himalayan State of Himachal Pradesh and tropical dry deciduous mixed forests and scrub forests in the alluvial plains of Punjab within the Beas Riverscape are treasure for enormous diversity of plants and animals; and several rare, endangered and threatened species besides they provide provisioning i.e., timber, fodder, fuelwood, NTFPs), regulating, cultural and supportive ecosystem services. A large number of governmental and non-governmental organizations have contributed to create a large body of information on these forests - diversity, species composition, extent and distribution, status, temporal changes, use, management, diversion for non-forest use, and conservation initiatives to manage them. The Forest Working Plans prepared or revised by the State Forest Departments from time to time for various Forest Divisions within the State provide an insight on the historical perspective and silvicultural management practices during past 100 years or so.

Recognizing the vast diversity of forests along the altitudinal gradient from lower altitude in alluvial plains of Punjab to higher altitude in the Himalayan State of Himachal Pradesh within the riverscape, it is felt appropriate to provide details on the diversity of forests in two broad parts of the riverscape. An insight on forest diversity in the Himalayan State of Himachal Pradesh, and Alluvial Plains of Punjab is provided below one by one on the basis of a synthesis of the existing information.

a. Forests in Himachal Pradesh

The mountainous Himalayan part of the riverscape within Himachal Pradesh exhibits a wide variety of natural vegetation owing to the wide altitudinal gradient, and varied soils, habitats aspect, and climatic conditions. Broadly, on the basis of altitudinal zones, four vegetation zones can be deciphered viz., (a) Lower Montane Zone in the Outer Himalaya or Shivaliks (<1,000 m); (b) Middle Montane Zone in the Lesser Himalaya (>1,000 m to <2,000 m); (c) Temperate Zone in the Greater Himalaya (>2,000 m to <3,000 m); and (d) Sub-Alpine and Alpine Zones in the Great Himalaya (>3,000 m). Major forest types in the Himalayan part of the riverscape as per the revised classification of forest types by Champion and Seth (1968) represent seven Major Groups, and four Sub-Groups, and 23 Forest Types (Table 2.12). Brief description on species composition of each of the forest type represented in the riverscape has been taken from the cumulative impact and carrying capacity study of Beas Sub-Basin by RSET (2019) and provided below.

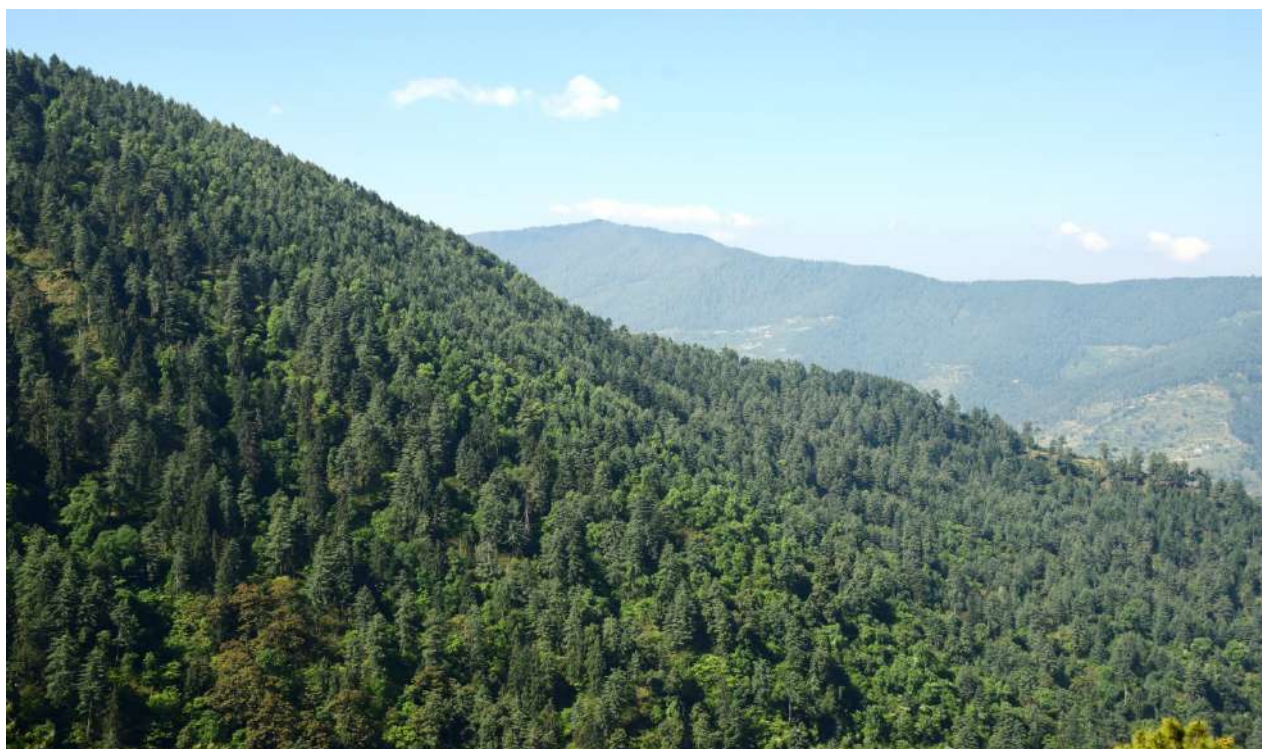
Table 2. 12 – Forest Types Represented in the Himalayan Part of Beas Riverscape

Major Group	Type Group	Sub - Group	Forest Types
Dry Tropical	5- Tropical Dry Deciduous Forests	5-B: Northern Dry Mixed Deciduous Forests	5B/C2 Northern Dry Mixed Deciduous Forests
Montane Sub-	9-Sub- Tropical Pine		9/C1a: Himalayan Sub-Tropical Pine

Major Group	Type Group	Sub - Group	Forest Types
Tropical Forests	Forests		Forests
			9/C1b: Upper or Himalayan Chir Pine Forests
			9/ C1/DS1: Himalayan Sub Tropical Scrub
			9/C1/DS2: Sub tropical <i>Euphorbia</i> Scrub
Sub- Tropical Dry Evergreen Forests	10-Sub- Tropical Dry Evergreen Forests		10/C1a <i>Olea cuspidata</i> Scrub Forests
Montane Temperate Forests	12-Himalayan Moist Temperate Forests	12-C1: Lower Western Himalayan Temperate Forests	12/C1a: Ban Oak Forests (<i>Quercus oblongata</i>)
			12/C1b: Moru Oak Forest (<i>Q. floribunda</i>)
			12/C1b: (a, b) DS1/Oak Scrub
			12/C1c: Moist Deodar Forests
			12/C1d: Western Mix Coniferous Forests
			12/C1e: Moist Temperate Deciduous Forests
			12/C1f: Low-level Blue Pine Forests (<i>Pinus wallichiana</i>)
		C2: Upper West Himalayan Temperate Forests	12/C2a: Kharsu Oak Forest (<i>Quercus semecarpifolia</i>)
			12/C2b: Himalayan Upper Oak-Fir Forests
			12/DS1: Montane Bamboo Brakes

Major Group	Type Group	Sub - Group	Forest Types
			12/DS3: Himalayan Temperate pastures
			12/C1/DS2: Himalayan Temperate Secondary Scrubs
Sub- Alpine Forests	14-Sub- Alpine Forests	14-C: West Himalayan Sub-Alpine birch/fir Forest (<i>Betula/Abies</i>)	14/C1a: West Himalayan Sub -Alpine fir forest
			14C1b: West Himalayan Sub-Alpine Birch/fir Forests
Alpine Scrubs	15-Moist Alpine Scrubs		15C1: Birch-Rhododendron Scrub Forests
			15/C3: Alpine Pastures
Dry Alpine Scrubs	16-Dry Alpine Scrubs		16C1: Dry Alpine Scrubs

(Source: RSET, 2019)



Himalayan Moist Temperate Forest in the Tirthan valley

(A) Group 5 - Tropical Dry Deciduous Forests

This Group is represented by one Sub-Group and one Forest Type.

(a) Sub-Group 5B - Northern Tropical Dry Deciduous Forest

This is a dry deciduous forest in which the upper canopy is light but probably fairly even and continuous in the climax form. The canopy is formed of mainly deciduous trees. The undergrowth is thin represented mainly by shrubs including some xerophytic evergreen species.

(i) 5B/ C2 - Northern Dry Mixed Deciduous Forest

This is an open, dry deciduous forest in which the top canopy is thin, but probably complete. Most trees have low spreading crowns and leafless during the hot weather. The main tree species are *Acacia catechu*, *Aegle marmelos*, *Anogeissus latifolia*, *Ehretia acuminata*, *Flacourtia indica*, *Holarrhena pubescens*, *Mitragyna parvifolia* and *Desmodium oojeinense*. The lower storey consists of trees like *Butea monosperma*, *Cassia fistula*, *Diospyros montana*, *Mallotus philippensis*, *Hymenodictyon suaveolens*, *Nyctanthes arbor-tristis*, *Phyllanthus emblica*, etc. The common shrubs are: *Justicia adhatoda*, *Bauhinia vahlii*, *Carissa opaca*, *Dendrocalamus strictus*, *Leptodermis lanceolata*, *Murraya koenigii*, *M. paniculata* and *Woodfordia fruticosa*. This type of forest can be observed throughout the dry areas in Joginder Nagar, Dharamshala, Mandi and Sainj areas. The common grasses which colonize the riverine soil include *Heteropogon contortus*, *Chrysopogon serrulatus*, *Themeda anathera*, *Arundinella nepalensis*, *Polypogon fugax*, *Cymbopogon martini*, *Imperata cylindrica*, *Neyraudia arundinacea*, *Saccharum* spp., etc.

(B) Group 9 - Sub-Tropical Pine Forest

This is a forest dominated by chir pine in the top canopy. Broad-leaved, especially evergreen oaks increase with increasing altitude and leaving the pine on the warmer and drier ridges. Towards the lower limit of this forest there is an increase in the trees of the dry deciduous type. Climbers and bamboos are usually absent. The important forest types that form a part of this forest are described below.

(i) 9/C1a - Himalayan Sub-Tropical Pine Forest

This is a more or less pure forest of chir pine forest with a scattered lower canopy of deciduous trees and a low scrub growth of xerophytic shrubs. The top canopy of the forest is dominated by *Pinus roxburghii* either singly or with a scattered group of deciduous tree storey. The main tree associates of the second story include *Acacia catechu*, *Dalbergia sissoo*, *Mallotus philippensis*, *Emblica officinalis*, *Pyrus pashia* and *Syzygium cumini*. The common shrubs are: *Berberis lycium*, *Carissa spinosa*, *Colebrookea oppositifolia*, *Dodonaea viscosa*, *Murraya koenigii*, *Myrsine affricana*, *Rubus ellipticus*, and *Woodfordia fruticosa*. This type of forest can be observed throughout the low hill areas in Joginder Nagar, Mandi and Kangara area. Herbaceous vegetation is represented by dry habitat loving grasses like *Chrysopogon fulvus*, *Cymbopogon* spp., *Dichanthium annulatum* and *Themeda anathera*.

(ii) 9C/1B Upper or Himalayan Chir Pine Forest

This is a high forest in which the top storey is dominated by chir pine (*Pinus roxburghii*) and scattered deciduous species restricted to the middle storey. This forest type is found in the lower Himalayas between 1,200 - 1,800 m which towards upper limits give way to temperate forests. The main broad-leaved tree species found in the middle storey are *Engelhardtia spicata*, *Lyonia ovalifolia*, *Myrica esculenta*, *Pyrus pashia*, *Quercus leucotrichophora*, *Sapindus mukorossi* and *Rhododendron arboreum*. The common shrubs in the forest are *Berberis lycium*, *Colebrookea oppositifolia*, *Indigofera heterantha*, *Leptodermis lanceolata*, *Prinsepia utilis*, *Rubus ellipticus*, etc. This type of forest can be observed in the sub-basins of Sainj, Parvati, Malana, Uhl and Beas.

(iii) 9/C1/DS1 - Himalayan Sub-Tropical Scrub

This type of low scrub is usually found over considerable areas in the Shivalik chir zone, extending up to the Himalayan chir forest and passes down into the lower mixed deciduous forests. The dominant species vary place to place and often one or two of them are predominating. Both edaphic and biotic factors are involved in determining the species. *Justicia adhatoda*, *Berberis lycium*, *Leptodermis lanceolata*, *Murraya koenigii*, *M. paniculata*, *Rosa moschata*, *Zanthoxylum armatum*, *Colebrookea oppositifolia*, *Carissa opaca*, *Dodonaea viscosa*, *Rubus ellipticus*, *Woodfordia fruticosa*, etc. are the important shrubs found in these forests. These types of forests are observed in Uhl and Beas sub-basin areas.

(iv) 9/C1/DS2 - Sub-Tropical *Euphorbia* Scrub

This type of forest occurs below the height of chir forests especially on rocky southern aspects. *Euphorbia royleana* is found abundantly throughout the dry rocky ridges either in pure form or mixed with other shrubs like *Justicia adhatoda*, *Dodonaea viscosa*, *Maytenus senegalensis*, *Woodfordia fruticosa*, etc. Their distribution is mainly related to edaphic factors especially on dry rocky ridges. But, due to some biotic pressure like lopping and grazing, their population is becoming denser and purer in the entire lower catchment. This type of Scrub forest is observed in Tirthan and Sainj sub-basins.

(C) Group 12 - Himalayan Moist Temperate Forest

These are rich and diverse forests comprised of conifers and broad-leaved species found in the moist temperate regions of the Himalaya. The top canopy is comprised of conifers or broad-leaved species or their mixture. These forests extend along the whole length of the Himalaya above the sub-tropical forests and towards higher elevations they give way to sub-alpine forests. The altitudinal range is from 1,500 - 3,300 m depending on the latitude, aspect and configuration of the ground. These forests maybe of the following types:

(i) 12/C1a - Ban Oak Forest (*Quercus oblongata*)

Dominated by ban oak (*Quercus oblongata*), this forest is found on relatively moister sites. The trees form a close canopy when they are not affected by biotic pressure. These forests are found in the lower part of the temperate belt, between 1,800 - 2,300 m, but it often reaches as low elevation as 1,200 m where it occupies the moister ravines and other favourable sites.

The main associates are: *Carpinus viminea*, *Ilex dipyrena*, *Cornus macrophylla*, *C. capitata*, *Neolitsea pallens*, *Lyonia ovalifolia*, *Myrica esculenta*, *Machilus duthiei*, *Persea odoratissima*, *Pyrus pashia*, *Symplocos paniculata*, *Rhododendron arboreum*, etc. Climbers are few such as *Clematis montana*, *Hedera nepalensis*, *Parthenocissus semicordata*, *Smilax aspera*, etc. Shrubs are *Berberis lycium*, *Indigofera heterantha*, *Leptodermis lanceolata*, *Rosa moschata*, *Rubus ellipticus*, *Myrsine africana*, *Viburnum cotinifolium*, etc. This type of *Cornus oblonga* forest can be observed in Sainj, Uhl and Beas sub-basin areas.

(ii) Moru Oak (*Quercus floribunda*) Forests

These forests are dominated by Moru oak (*Quercus floribunda*) and occur in a narrow belt above the ban oak forests between 2,000 - 2,500 m asml. Usually, the height of trees is between 20 m and 30m, though taller trees having long boles may also be found in the first storey. There is a relatively greater admixture of secondary species in the top canopy and well marked evergreen second storey. The main associated species *Acer caesium*, *Q. oblongata*, *Cornus macrophylla*, *Buxus wallichiana*, *Ilex dipyrena*, *Neolitsea pallens*, *Lyonia ovalifolia* and *Rhododendron arboreum*. The associated shrubs are *Berberis aristata*, *B. lycium*, *Deutzia corymbosa*, *Rosa macrophylla*, *Rubus niveus*, *Drepanostachyum falcatum*, *Viburnum cotinifolium*, *Cornus oblonga*. The herbaceous growth consists of *Anemone vitifolia*, *Agrimonia pilosa*, *Potentilla fulgens*, *Geranium wallichianum*, *Geranium nepalense*, *Viola canescens*, *V. pilosa*, *Reinwardita indica*, *Valeriana hardwickii*, *V. jatamansi*, etc. This type of forest is observed in the upper reaches of Parbati, Malana, Beas, and Uhl sub-basin.

(iii) 12/C1c - Moist Deodar Forests

This is more or less pure forest of deodar (*Cedrus deodara*) with a little proportion of other species. These forests are found in the temperate areas, between 1,700 - 2,500 m asml. The canopy is fairly complete though not very dense. The main associated species *Pinus wallichiana*, *Picea smithiana*, *Cornus macrophylla*, *Taxus wallichiana*, *Quercus oblongata* and *Rhododendron arboreum*. Climbers and epiphytes are few, the prominent climbers being *Clematis montana*, *Hedera nepalensis*, *Jasminum officinale*, *Parthenocissus semicordata*, *Rubia cordifolia*, *Berberis lycium*, *Deutzia staminea*, *Indigofera heterantha*, *Desmodium elegans*, *Lonicera quinquelocularis* and *Rosa macrophylla*. These types of forests are found in Kullu, Mandi and Kangra districts.

(iv) 12/C1d - Western Mixed Coniferous Forest

This is a mixed coniferous forest of the temperate areas comprised of fir, spruce, deodar and blue pine. These forests are found above the deodar forests between 2,400 - 3,000 m, asml. Varying admixture of evergreen and deciduous broad-leaved trees may occur mixed in this forest. The main species in the first storey include *Abies pindrow*, *Cedrus deodara*, *Picea smithiana* and *Pinus wallichiana* and the other associated species are *Acer acuminatum*, *A. caesium*, *Cornus macrophylla*, *Corylus jacquemonti*, *Euonymus pendulus*, *Juglans regia*, *Rhododendron arboreum* and *Taxus wallichiana*. Shrubs are dominated by small bamboo thickets with other tall spreading shrubs. *Berberis aristata*, *B. lycium*, *Cotoneaster microphyllus*, *Deutzia corymbosa*, *Ribes himalense*, *Sorbaria tomentosa*, *Drepanostachyum*

falcatum, *T. spathiflora*, *Viburnum grandiflorum*, etc. are common shrubs in the understorey. Such type of forests are found in Kullu, Mandi and Kangra Districts.

(v) 12/C1e - Moist Temperate Deciduous Forest

This is a deciduous forest in which individual trees may attain 20-30 m height. Usually, trees have large girths. This type of forest is found between 1,800 - 2,700 m asml bluepine. The main tree species are *Abies pindrow*, *Acer caesium*, *Aesculus indica*, *Carpinus viminea*, *Fraxinus micrantha*, *Juglans regia*, *Prunus cornuta*, *Cornus macrophylla*, *Corylus Jacquemontii*, *Lyonia ovalifolia*, *Rhus wallichii*, *R. punjabensis*, *Rhododendron arboreum* and *Taxus wallichiana*. Shrubs are *Berberis* spp., *Cotoneaster microphyllus*, *Deutzia corymbosa*, *Jasminum humile*, *Ribes* spp., *Sarcococca pruniformis*, *Sorbaria tomentosa*, *Drepanostachyum falcatum*, *Thamnocalamus spathiflorus*, *Spiraea canescens* and *Viburnum cotinifolium*. This type of forests occurs in Mandi Kullu Districts. Herbaceous growth belongs to species of *Aconitum*, *Fragaria*, *Geranium*, *Impatiens*, *Lilium*, *Paeonia*, *Polygonatum*, etc.

(vi) 12/C1f - Low Level Blue Pine Forest (*Pinus wallichiana*)

This forest is dominated by blue pine (*Pinus wallichiana*), but there are other species found mixed with it. Blue pine is a primary colonizer though other species may come up after sometime in vacant areas. This type of forest is found in the temperate areas especially in riverine soil though it is not as widely distributed as the moist deodar forest. The other tree species found in the forests are: *Acer cappadocicum*, *Cedrus deodara*, *Viburnum mullahaa* and *Rhododendron arboreum*. Undergrowth is represented by species of *Berberis*, *Cotoneaster*, *Isodon*, *Sarcococca*, etc. These types of forests are found in Kullu and Mandi Districts between 2000-3200m, asml.

(vii) 12/C1/DS2 - Himalayan Temperate Secondary Scrub

An irregular or dense scrub cover with a few predominating and scattered residual trees of the Oak-deodar forest occur on excessively grazed and lopped areas of the temperate forest. *Berberis lycium*, *Rubus biflorus*, *Indigofera heterantha*, *Desmodium elegans*, *Sorbaria tomentosa*, *Elsholtzia flava*, *Prinsepia utilis*, etc. are the important secondary nature of scrub communities which occur especially on the southern aspect. This type of scrub forest occurs between 1800-2600m, asml in Kullu and Mandi Districts.

(viii) 12/C2a - Kharsu Oak (*Quercus semecarpifolia*)

Kharsu oak (*Quercus semecarpifolia*) forms a dense pure forests. The main associated tree species are *Abies pindrow*, *Acer acuminatum*, *Pinus wallichiana*, *Prunus cornuta*, *Betula utilis*, *Prunus cornuta* and *Sorbus foliolosa*. Shrubs include *Cotoneaster bacillaris*, *Ribes glaciale*, *Rosa macrophylla*, *Rhododendron campanulatum*, *Viburnum grandiflorum*, etc. Such forests occurs in Kullu and Mandi Districts between 2800-3200m, asml.

(ix) 12/C2b - West Himalayan Upper Oak-Fir Forests

This type of forests occurs above the mixed coniferous forest along the higher ranges, between 2,600 - 3,400 m asml. The main tree species found are: *Abies pindrow* and *Pinus wallichiana* while their other associated species are *Acer acuminatum*, *Prunus cornuta*, etc. Undergrowth constitutes spreading shrubs like *Rosa macrophylla*, *R. sericea*, *Rubus foliosus*, *Thamnocalamus spathiflorus*, *Viburnum grandiflorum*, etc. Herbs belong to species of *Ainsliaea*, *Fragaria*, *Galium*, *Valeriana*, etc. This type of forest is found in Kullu and Mandi Districts between 2800-3400m, asml

(x) 12/DS1 - Montane Bamboo Brakes

Dense bamboo brakes occur throughout the moist temperate forests. Small bamboos species like *Drepanostachyum falcatum* and *Thamnocalamus spathiflorus* form dense and impenetrable brakes as an undergrowth in higher oak, *Rhododendron* and coniferous forests. This type of bamboo brakes is observed as an underwood in Sainj, Uhl sub-basin areas Parbati Lower sub-basins.

(xii) 12/DS3 - Himalayan Temperate Pastures

These Himalayan grasslands occur on ridges and slopes especially where moist or wet conditions are present. The common grasses in the mixed coniferous forest zone are mainly species of *Agrostis*, *Calamagrostis*, *Danthonia*, *Festuca*, *Poa* and *Dactylis*

(xiii) 12/IS1 - Alder Forests

These forests occur along the banks of the large streams and sometimes extending up to ravines and moist unstable hill slopes. The altitudinal range is wide from 1,500 3,000m asml. The top storey is dominated by *Alnus nitida*, *Celtis tetrandra*, *Populus ciliata* and *Ulmus wallichiana*. The undergrowth is thin and varies place to place depending upon site conditions. This type of subsidiary Alder forest is observed in upper Beas, Malana (Kullu Valley), and Sainj sub-basin.

(C) Group 14 - Sub-Alpine Forests

These forests are a typically dense growth of small crooked trees or large shrubs with patches of coniferous over wood. These forests are the top most tree forests of the Himalaya forming the tree line at altitude of more than 2,900 m and extending over 3,500 m. The forests of this group include the following types:

(i) 14/C1 - West Himalayan Sub-Alpine Birch-Fir Forests

This is an irregular forest consisting mainly of fir, birch and rhododendron. This type of forest is found above 3,000 m. The underwood is fairly dense. They may further be of the following sub-types:

(ii) 14/C1a - West Himalayan Sub-Alpine High Level Fir Forests

The main species found in the first storey are *Abies spectabilis* and *Pinus wallichiana*. Second storey is composed of *Betula utilis*, *Prunus cornuta*, *Rhododendron campanulatum* and *Taxus wallichiana*. Undergrowth is composed of *Berberis* spp., *Cotoneaster acuminatus*, *Deutzia corymbosa*, *Ribes* spp., and *Viburnum grandiflorum*. Among herbs *Anemone*

obtusiloba, *Geranium* spp., *Osmunda claytoniana*, *Trillidium govanianum*, etc., are common. This type of forest is found in Kullu and Mandi Districts between 3000-3600m asml.

(iii) 14/C1b - West Himalayan Birch/ Fir Forests

The main species found in this forest are *Betula utilis*, *Abies spectabilis* and *Pinus wallichiana*. Second storey is composed of *Rhododendron campanulatum*, *Sorbus foliolosa*, *Syringa emodi*, *Prunus cornuta*, *Acer acuminatum*, etc. Under storey is composed of *Cotoneaster acuminatus*, *Lonicera* spp., *Ribes glaciale*, *Rosa sericea*, *Rubus foliosus*, *Smilax vaginata*, *Spiraea bella*, etc.

(E) Group 15 - Moist Alpine Scrubs

This type of forest consists of the alpine zone vegetation found just below the snowline and usually above the tree line in the moister tracts. Arctic climatic conditions are experienced in this tract of vegetation. The vegetation of this group consists of the following forest types:

(i) 15/C1 --Rhododendron Scrub Forest

This is low evergreen forests, mainly dominated by *Rhododendron, campanulatum*. The other associated species include *Rhododendron anthopogom*, *R. lepidotum*, *Lonicera* spp., *Salix* spp., *Rosa* spp., *Berberis* spp., etc.

(ii) 15/C3 - Alpine Meadows

These are found above 3300m, asml. The important herbs are species of *Aconitum*, *Anemone*, *Fritillaria*, *Gentiana*, *Festuca*, *Iris*, *Kobresia*, *Carex*, *Bromus*, *Potentilla*, *Caltha*, *Rheum*, *Primula*, *Ranunculus*, *Valeriana*, *Dactylorhiza*, etc.

(F) Group 16- Dry Alpine Scrubs

This is the alpine vegetation of the cold and dry tracts of the Trans-Himalaya and the inner dry valleys of the main Himalayan ranges.

(i) 16/C1 - Dry Alpine Scrubs

This is an alpine xerophytic formation in which dwarf shrubs predominate. This type of forest is found at high elevations in the cold desert. The main species are *Caragana versicolor*, *Juniperus communis*, *J. indica*, *Potentilla fruticosa*, *Lonicera* and *Rosa* spp. This type of vegetation is observed in Upper Beas sub-basin, Upper Parbati, and Uhl sub-basin areas.

Forest Resources and Taxonomic Researches: The vast area of the Beas Riverscape and adjacent areas in the north-western Himalaya has been a center of botanical explorations and floristic studies for past more than two centuries. The Flora of Himachal Pradesh by Chowdhery and Wadhwa (1984) highlights botanical explorations and studies during the (a) early historical period: 1821–1900; (b) middle period: 1900-1950; and (c) recent period: 1951 onwards. Apart from the flora and botanical surveys undertaken by the scientists from the Northern Circle, Botanical Survey of India, Dehra Dun, a large number of plant scientists have made significant contribution by way of providing an insight on plant diversity, vegetation dynamics, medicinal plants, orchids, resource dependence, ethnobotany, rare and threatened plants, vegetation in protected areas, and ecology (Samant and Dhar, 1997; Samant *et al.*, 1998; Dhaliwal and Sharma, 1999; Mathur and Mehra, 1999; Singh and Rawat,

2000; Samant *et al.*, 2007a,b and c; Rana *et al.*, 2008; Pant and Samant, 2008; Rana and Samant, 2009; Lal and Samant, 2010; Rana and Samant, 2010; Kaur *et al.*, 2011; Rana and Samant, 2011a and b; Thakur *et al.*, 2011; Marpa and Samant, 2012; Rana *et al.*, 2012; Pant and Samant, 2012; Kumar *et al.*, 2013; Sharma and Samant, 2013; Jyoti *et al.*, 2014; Sharma and Samant, 2014a and b; Kumar and Kumar, 2014; Sharma *et al.*, 2015; Bodh *et al.*, 2017 and 2018; Sharma *et al.*, 2017; Lal and Samant, 2017; Devi *et al.*, 2018; Paul *et al.*, 2018; Kumari *et al.*, 2018; Devi *et al.*, 2019a and b; Paul *et al.*, 2019a and b; Bodh *et al.*, 2019; Kundra *et al.*, 2019). Much of the available information is widely scattered and either it is specific to the entire State of Himachal Pradesh or the entire Beas River Basin within Himachal Pradesh. A large number of papers describe plant diversity and related aspects specific to a particular zone/district/forest division/protected area. The best comprehensive insight on the biological environment of the Himalayan part of the riverscape has been provided by RSET, (2019). The following section attempts to highlight various aspects of plant diversity in the context of Beas Riverscape based on review of secondary information.

Plant Diversity: RSET (2019) listed 1,581 flowering plants (Angiosperms) representing 162 families and 765 genera in the Himalayan part of the Beas River Basin based on the available literature (Table 2.13). This included representation of 133 families of dicots and 29 families of monocots. In addition, 14 species of Gymnosperms, 113 Pteridophytes, and 19 species of Bryophytes were also reported.

Table 2. 13 - Plant Diversity in Beas River Basin

Sr. No.	Taxonomic Group	Families	Genera	Species	Total Number of Species
1	Angiosperms				1,727
A	Dicots	133	600	1,263	
B	Monocots	29	165	318	
Total		162	765	1,581	
2	Gymnosperms	3	7	14	
3	Pteridophytes	18	36	113	
4	Bryophytes	11	12	19	

(Source: RSET, 2019)

The Poaceae family was the most dominant family with 153 species, followed by Asteraceae with 122 plant species. The family Fabaceae with 119 species was at the third rank. The family Cyperaceae was represented by 40 species while Orchidaceae had representation of 22 species. Among gymnosperms, *Juniperus* spp., was the most dominant genus represented by 6 species. The family Pinaceae was represented by (*Pinus roxburghii* and *P. wallichiana*, *Picea smithiana*, *Abies pindrow*, *A. spectabilis*, *Cedrus deodara* and *Taxus wallichiana*. Amongst the Pteridophytes, families like Pteridaceae, Dryopteridaceae and Polypodiaceae were the largest and the genera *Polystichum* was the most common. RSET (2019) reported 19 species of bryophytes belonging to 11 families from the Beas Basin. Most dominant families being: Marchantiaceae, Bryaceae, and Anthocerotaceae.

The Himalayan part of the Beas River Basin owing to wide altitudinal range harbours not only rich diversity of plant species but also represented by 14 rare, endangered and threatened

(RET) plant species based on BSI Red Data Book (Nayar and Sastry, 1987, 1988 and 1990) (Table 2.14). Further, 64 species endemic to the Beas River Basin were listed by RSET (2019).

Table 2. 14 – RET Species Reported from Beas River Basin and their Conservation Status based upon BSI Red Data Book

Sr. No.	Family	Scientific Name	Conservation Status
1	Aceraceae	<i>Acer caesium</i>	VU
2	Asteraceae	<i>Saussurea costus</i>	EN
3	Amoryllidaceae	<i>Allium stracheyi</i>	VU
4	Cyperaceae	<i>Carex munroi</i>	I
5	Liliaceae	<i>Eremurus himalaicus</i>	R
6	Orchidaceae	<i>Cypripedium cordigerum</i>	R
7	Ranunculaceae	<i>Aconitum ferox</i>	VU
8	Valerianaceae	<i>Nardostachys jatamansi</i>	VU
9	Plantaginaceae	<i>Picrorhiza kurroa</i>	VU
10	Dioscoreaceae	<i>Dioscorea deltoidea</i>	VU
11	Brassicaceae	<i>Erysimum thomsonii</i>	Rare
12	Fabaceae	<i>Hedysarum astragaloides</i>	Rare
13	Fabaceae	<i>Hedysarum microcalyx</i>	VU
14	Campanulaceae	<i>Campanula wattiana</i>	Rare

EN=Endangered; VU=Vulnerable; R=Rare; I=Indeterminate

(Source: Nayar and Sastry, 1987, 1988 &1990; RSET, 2019)

The Himalayan part of the Beas Riverscape includes a large, compact and contiguous block of diverse forests across a wide altitudinal gradient in the Great Himalayan National Park Conservation Area (GHNPCA) in Kullu district. The conservation area includes the Great Himalayan National Park (GHNP), Tirthan Wildlife Sanctuary, Sainj Wildlife Sanctuary, and Eco-development Zone comprising of reserved forests, protected forests and unclassified forests. Singh and Rawat (1999) carried out systematic floristic surveys across different constituent areas of the GHNPCA during 1995-1999 and reported altogether 832 plant species belonging to 128 families and 427 genera of higher plants. Habit wise distribution included 69 tree, 113 shrub, 493 herb, 96 grass, 27 fern, and 8 climber species. This represented nearly 26% flora of Himachal Pradesh. Further, an ethnobotanical survey undertaken by Singh and Rawat (1999) revealed that local people use more than 250 plant species for various purposes. They observed that the Himalayan temperate forests characterized by both conifers and broad leaved species between 1,500 m and 3,600 m dominate the landscape and reported two species of bamboo that occur in GHNPCA (Mathur and Mehra, 1999). It was also recorded that opportunistic plants viz., species of *Rumex*, *Polygonum*, *Impatiens*, *Girardiana*, etc. dominated ground cover in disturbed areas. 192 species of lichens belonging to 15 genera and 31 families were reported by Upreti (1999) from GHNPCA. High diversity of 40 saxicolous (rock inhabiting) species was reported while 149 species of lichens were corticolous (bark inhabiting) species. *Quercus semecarpifolia* trees harbour more than 30 species of lichens.

Oak Forests: Troup (1921) has highlighted the importance of oaks (*Quercus* spp.) as dominant as well as climax tree species of the moist temperate forest. Out of 35 species of *Quercus* extensively distributed between 1,000 m and 3,500 m elevations in the Indian Himalaya, three species of ever green Oak viz., *Quercus oblongata* (ban), *Q. floribunda* (tilonj/moru), and *Q. semecarpifolia* (kharsu) were reported from GHNP. These three broad leaved species occurred in large extensive pure patches. According to Singh and Rawat (2012), these three species of oak provide several ecosystem services (e.g., fodder, soil and water conservation, habitat for native flora and fauna, etc.). Owing to multiple benefits three oak species offer, they significantly contribute to the life support system of the mountain people. According to Singh (1981), Oak forests are strongly associated with natural springs and wildlife besides they are a major source of fuel wood and fodder. In general, oak forests are under heavy demand and being exploited by way of logging, lopping, grazing, and even removal of leaf and wood litter from the forest floor. The degradation of oak forests is wide spread. Oak forests are being increasingly replaced by pine forests (Singh *et al.*, 1984). Maintenance and restoration of oak forests from the perspective of springshed management is critical.

Temperate Grasslands and Alpine Meadows: Temperate grasslands and alpine pastures are important grazing resources for wild fauna as well as livestock, including sheeps, and goats. The inhabitants practice trans-humance migration particularly for sheeps and goats. The village pastures (*Ghasnis*) are grass dominated areas in village surround, mostly on the warmer southern slopes. The migratory sheep and goat moves upward and downward through different forests along the altitudinal gradient every year during migration to and from alpine areas. Pastoralists along with their migratory sheep and goat use pastures (*Thatches*) or grass openings in the mid temperate (2,000 m to <2,800 m), upper temperate (2,800 m to <3,300 m), and sub-alpine (3,300 m to 3,600 m) forests. Generally, alpine pastures occur above the natural tree line (Mathur and Mehra, 1999). Rawat (1998) has described five types of grasslands across the Himalaya. These are: (a) warm temperate grasslands, (b) cool temperate grassy slopes, (c) sub-alpine meadows, (d) alpine meadows, and (e) steppe formations of the Trans-Himalaya. In the present case, the first four types of grasslands are found in Beas River Basin.

Livestock rearing, particularly sheep and goat is an aged old practice and occupation of local people and shepherd communities in the mountainous State of Himachal Pradesh. They as have been using specific grazing routes and grazing resources year after year as grazing rights and other concessions (Misri, 1998; Mehra and Mathur, 2001; Singh *et al.*, 2006). Nevertheless, grazing resources have been severely impacted and drastically reduced owing to their large scale conversion for the expansion of agriculture and other developmental activities. In several instances, alpine pastures are either overburdened or neglected. Efforts are required to maintain and restore grassy slopes on southern aspects and to conserve alpine pastures as they offer habitat for wild ungulates, grazing resources for migratory livestock, and habitat and for a wide range of medicinal plants besides they help in checking runoff and allow infiltration of water.

Medicinal and Aromatic Plants and Ethnobotany: The natives living in the remote high altitude areas of Himachal Pradesh have been utilizing the forest resources in the form of medicine, fuel, fodder, timber, agricultural tools, fiber, religious purposes, gums, resins, and for various other purposes since time immemorial (Samant and Dhar, 1997; Bodh *et al.*, 2019). The entire region of the mountainous tract within the riverscape from lower to higher altitude areas offer a wide range of medicinal and aromatic plants of significant economic importance. A large number of authors have contributed information on the diversity, distribution, status, ethnobotany, etc. RSET (2019) has documented a list of 355 medicinal plants. Samant *et al.* (2007) have identified 643 species of medicinal plants in Himachal Pradesh, northwestern Himalaya and reported about the use of different plant parts for the treatment of various ailments. The number of various medicinal plants species varies with increasing altitude. Dominant genera of medicinal plants included *Artemisia*, *Saussurea*, *Euphorbia*, *Polygonum*, *Aconitum*, *Prunus* and *Nepeta*. The representative species of each altitudinal zone are given in Table 2.15.

Table 2. 15 – Representative Medicinal Plants of Different Altitudinal Zones in Himachal Pradesh

Altitudinal Zones	Representative Species
Tropical and Sub-tropical <1,800 m	<i>Justicia adhatoda</i> , <i>Achyranthes aspera</i> , <i>Mangifera indica</i> , <i>Apium graveolens</i> , <i>Rauvolfia serpentina</i> , <i>Acorus calamus</i> , <i>Calotropis gigantea</i> , <i>Asparagus adscendens</i> , <i>A. racemosus</i> , <i>Azadirachta indica</i> , <i>Artemisia absinthium</i> , <i>A. japonica</i> , <i>Tagetes minuta</i> , <i>Berberis asiatica</i> , <i>Rorippa indica</i> , <i>Bauhinia variegata</i> , <i>B. vahlii</i> , <i>Caesalpinia decapetata</i> , <i>Cassia fistula</i> , <i>Terminalia alata</i> , <i>T. arjuna</i> , <i>T. chebula</i> , <i>Cyperus rotundus</i> , <i>Dioscorea bulbifera</i> , <i>Emblica officinalis</i> , <i>Swertia angustifolia</i> , <i>Hypericum perforatum</i> , <i>Curculigo orchoides</i> , <i>Ajuga integrifolia</i> , <i>Mentha arvensis</i> , <i>M. piperata</i> , <i>Ocimum canum</i> , <i>O. sanctum</i> , <i>Salvia plebeia</i> , <i>S. lanata</i> , <i>Cinnamomum tamala</i> , <i>Aloe barbadensis</i> , <i>Woodfordia fruticosa</i> , <i>Tinospora cordifolia</i> , <i>Syzygium cumini</i> , <i>Crepidium acuminatum</i> , <i>Ziziphus mauritiana</i> , <i>Prinsepia utilis</i> , <i>Rubia cordifolia</i> , <i>Zanthoxylum armatum</i> , <i>Sapindus mukorossi</i> , <i>Bergenia ligulata</i> , <i>Bacopa monnieri</i> , <i>Withania somnifera</i> , <i>Atropa belladonna</i> , <i>Urtica parviflora</i> , <i>Hedychium spicatum</i> and <i>Elaeagnus</i> spp.
Temperate 1,801 - 2,800 m	<i>Ferula jaeschkeana</i> , <i>Heracleum candicans</i> , <i>Asparagus filicinus</i> , <i>Ainsliaea aptera</i> , <i>Berberis aristata</i> , <i>Betula alnoides</i> , <i>Sagina saginoides</i> , <i>Corylus Jacquemontii</i> , <i>Rosularia rosulata</i> , <i>Gentiana kurroo</i> , <i>Skimmia laureola</i> , <i>Geranium nepalense</i> , <i>Elsholtzia fruticosa</i> , <i>Rhododendron arboreum</i> , <i>Malva verticillata</i> , <i>Oxalis corniculata</i> , <i>Phytolacca acinosa</i> , <i>Polygala sibirica</i> and <i>Taxus wallichiana</i> .
Sub-alpine 2,801 - 3,800 m	<i>Allium humile</i> , <i>Bunium persicum</i> , <i>Malaxis muscifera</i> , <i>Carum carvi</i> , <i>Geranium wallichianum</i> , <i>Angelica glauca</i> , <i>Archangelica himalaica</i> , <i>Bupleurum falcatum</i> , <i>Heracleum lanatum</i> , <i>Arisaema flavum</i> , <i>Saussurea auriculata</i> , <i>S. costus</i> , <i>Tanacetum gracile</i> , <i>T. tenuifolium</i> , <i>T. tomentosum</i> , <i>Impatiens glandulifera</i> , <i>Arnebia benthamii</i> , <i>Eritrichium canum</i> , <i>Rhododendron campanulatum</i> , <i>Ribes orientale</i> , <i>Polygonatum multiflorum</i> , <i>P. verticillatum</i> , <i>Plantago depressa</i> , <i>Aconitum ferox</i> , <i>A. leave</i> , <i>A. heterophyllum</i> , <i>A. falconeri</i> , <i>Pedicularis pectinata</i> ,

Altitudinal Zones	Representative Species
	<i>Polygonatum verticillatum</i> , <i>Dactylorhiza hatagirea</i> and <i>Picrorhiza kurroa</i> .
Alpine >3,800 m	<i>Cortia depressa</i> , <i>Selinum wallichianum</i> , <i>Heracleum wallichii</i> , <i>Inula royleana</i> , <i>Saussurea graminifolia</i> , <i>S. obvallata</i> , <i>S. simpsoniana</i> , <i>S. gossypiphora</i> , <i>Arnebia euchroma</i> , <i>Corydalis meifolia</i> , <i>C. govaniana</i> , <i>Iris kumaonensis</i> , <i>Fritillaria roylei</i> , <i>Polygonum affine</i> , <i>Rhododendron anthopogon</i> , <i>Rheum australe</i> , <i>R. moorcroftianum</i> , <i>R. webbianum</i> , <i>Dactylorhiza hatagirea</i> , <i>Picrorhiza kurroa</i> , <i>Aconitum heterophyllum</i> , <i>A. rotundifolium</i> , <i>A. violaceum</i> , <i>A. spicatum</i> , <i>Delphinium cashmerianum</i> , <i>D. vestitum</i> and <i>Nardostachys jatamansi</i> .

(Source: Samant *et al.*, 2007)

Rana and Samant (2011b) described 270 medicinal plant species belonging to 84 families and 197 genera in Manali Wildlife Sanctuary. Out of this, 162 medicinal plants species were native and 98 were endemic to the Himalayan region. Thirty seven (37) species were identified as threatened. *Dactylorhiza hatagirea*, *Aconitum heterophyllum*, *Arnebia benthamii*, *Lilium polyphyllum*, *Swertia chirayita*, *Podophyllum hexandrum*, *Jurinea macrocephala*, *Taxus wallichiana*, etc., were highly preferred species and continuous extraction from the wild for trade has enhanced pressure which may cause extinction of these species in the near future. Sharma and Samant (2014b) assessed the diversity of medicinal plants in Parbati Valley, Kullu district and documented 402 species of medicinal plants belonging to 98 families and 266 genera. Out of this, 207 species were natives, 04 species endemic, and 44 near endemic. Devi *et al.* (2019b) studied the diversity, distribution pattern and indigenous uses of medicinal plants in Kanawar Wildlife Sanctuary and documented 390 medicinal plant species.



***Lilium polyphyllum* – a threatened medicinal plant**

Forests and other natural vegetation in the high altitude areas offer a wide variety of wild edible plants. A large number of studies on diversity, distribution and indigenous uses of wild edible plants have been carried out (Samant *et al.*, 1998; Dhaliwal and Sharma, 1999; Samant *et al.*, 2001; Rana, 2007; Chauhan *et al.*, 2016; Singh *et al.*, 2016; Bodh *et al.*, 2019 etc. Bodh



Burans (*Rhododendron arboreum*) – An important NTFP

et al. (2019) studied wild edibles of Shikari Devi Wildlife Sanctuary in Mandi District and observed that local communities utilize different parts of the plants. Different wild edible plants are consumed either in the crude or processed form. They identified total 71 species (Angiosperms – 68; Gymnosperms – 01; Fungi – 02) of wild edibles belonging to 38 families and 55 genera. Maximum richness of wild edible plants *i.e.*, 69 species were recorded between 1,800 m and 2,800 m elevations. The notable wild edible plants documented were *Rhus chinensis*, *Pistacia chinensis* subsp. *integerrima*, *Lactuca longifolia*, *Berberis lycium*, *Viburnum mullaha*, *Cornus capitata*, *Dioscorea deltoidea*, *Elaeagnus parviflora*, *Rhododendron arboreum*, *Elsholtzia fruticosa*, *Ficus nerifolia*, *Myrica esculenta*, *Prinsepia utilis*, *Rubus niveus*, etc. Some important plants recorded at an altitude zone of >2,800 m were; *Cotonoeaster microphyllus*, *Smilacina purpurea*, *Lonicera quinquelocularis*, *Morchella esculenta*, *M. conica*, etc. Thus, dependence of local communities on forest resources, particularly medicinal and aromatic plants and wild edible plants for subsistence and sustainable livelihoods is much greater than what is usually perceived. Often, local people use faulty methods to collect and harvest plant resources for their consumption ignoring the concerns for regeneration or even disturbances caused to the habitat itself.

Sacred Natural Sites: Nature worship is an integral part of the human society. Historically, the tradition of nature worship in most continents is evident in the culture, religion and social norms. Nature worship can be in different forms by assigning the divinity to any place or natural elements (e.g., stone, rock, mountain, river, jungle, etc.). Sacred groves are one form of nature worship and can be defined as undisturbed patches of vegetation on the outskirts of villages or town or in the plains or a part of forested areas that are dedicated to local folk deities or ancestral spirits. They are fine example of *in-situ* conservation and usually vary in size between 5 ha and 500 ha (Gadgil and Vartak, 1975; Gokhale *et al.*, 1998; CIIED, 2014; Amirthalingam, 2016). The existence of sacred grove depends upon the social tradition and taboos incorporating spiritual and ecological values which prevent their destruction. Sacred groves serve as invaluable gene-pool and are repositories of biodiversity, particularly rare and endemic plants and animals. Several sacred groves constitute pristine vegetation and serve as a seed source for dispersal by birds and other animals. Often, they are important refuge of rare and endangered medicinal plants. In India, the sacred groves are still in the process of being documented. According to Amirthalingam (2016), 13,217 sacred groves those are intact had been documented from the different parts of the country by various authors. He has reported 329 sacred groves in Himachal Pradesh. However, CIIED (2014) has reported 5,000 sacred groves in Himachal Pradesh alone out of total 13,270. The ENVIS Centre on Himalayas and the GB Pant National Institute of Himalayan Environment and Sustainable Development have made efforts to document 378 sacred groves from Kullu, Mandi, Solan, Sirmour, Shimla, and Kinnaur. Mostly, the sacred groves are dedicated to *Bakhu Nag Devta*, *Ringa Rishi Devta* and *Devi*. From the foregoing description, it is evident that there is an ambiguity with regard to the exact number of sacred groves within the State of Himachal Pradesh and their distribution in different districts. An insight on their current status is highly desirable.

The local myths and legends associated with the sacred grove have gone a long way in preserving the forests from destruction. Sacred groves in Himachal Pradesh are generally

dedicated to a particular deity and referred as ‘Dev Van’ or ‘Devta ka Jungle’ where no one is allowed to cut trees or even carry dried leaves outside the areas. A temperate region, the sacred groves have pure patches of *Cedrus deodara* and occasionally having few associated species viz., *Pinus wallichiana*, *Quercus semecarpifolia*, *Juniperus* spp., etc. The high density of plants in sacred groves immensely helps in soil and water conservation. The sacred groves have also been recognized as an important repository of medicinal plants (Chanda and Ramachandra, 2019). Dense forests provide habitat for wide ranging wild animal species viz., common leopard (*Panthera pardus*), barking deer (*Muntiacus muntjak*), goral (*Naemorhedus goral*), black bear (*Ursus thibetanus*), hare, wolf (*Canis lupus*), jackal (*Canis aureus*) and several other animals including pheasants. Further, there are more than 10,000 temples in the State and many of them have their own groves. Hence, the State can be called as ‘Land of Deities’ and ‘Sacred Groves’.

Sacred groves portray a fine example of community based nature conservation without any extramural support. However, most sacred groves are typical representation of islands of native vegetation amidst the human dominated heterogeneous landscape. Moreover, most groves are under various human induced pressures. Changing social structure also plays an important role in gradual decline of some sacred groves. There is an urgency to strengthen the existing community based conservation efforts so as to aware people about the importance of sacred groves in the larger landscape and to initiate actions to restore degraded groves.

b. Forests and Grasslands in Beas River Plains

Natural vegetation i.e., forests and tall grasslands in the alluvial plains in the State of Punjab are largely confined to small and scattered managed forests and protected areas. These remnant forests and protected areas are located mainly in district Pathankot, Gurdaspur and Hoshiarpur. The part of Alluvial Plains is represented by the following two forest types:

(i) 5B/C1 – Northern Dry Deciduous Forests

In this type of forest, the vegetation tends to be xerophytic in nature and species like *Acacia nilotica*, *A. catechu*, *Leucaena leucocephala*, *Tamarindus indica* and *Anogeissus latifolia* are preponderous. The associated shrubs are: *Carissa opaca*, *Murraya koenigii*, *Trema orientalis*, *Justicia adhatoda*, *Zizyphus* spp., etc. In the north-eastern parts of the state, *Dendrocalamus strictus* is found mixed with *Anogeissus latifolia*, *Lannea coromandelica*, *Terminalia alata*, *Sapium insigne*, etc. Seral stages of Khair-Sissoo (*Acacia catechu* and *Dalbergia sissoo*) forests are found along the streams or riparian areas.

(ii) 5B/C2 - Dry Deciduous Forests

The majority of areas in the Kandi tract fall under this type. The main species are *Acacia catechu* and *Dalbergia sissoo* along with *Bombax ceiba*, *Emblica officinalis*, *Lannea coromandelica*, *Toona ciliata*, *Azadirachta indica*, *Diospyros montana*, *Cassia fistula*, *Acacia nilotica*, *Hymenodictyon suaveolens*, *Ehretia laevis*, *Ficus racemosa*, etc.

2.4.3 Forest Cover and Change

For a vast country like India having enormous diversity of forests in different biogeographic zones and States/ UTs, the Forest Survey of India (FSI) has been undertaking the biennial assessment of forests and tree resources of the country since 1987. The FSI provides after every biennial assessment, the India State of Forest Report (ISFR). The sixteenth such report was provided in the year 2019. The forest cover assessment is wall to wall mapping exercise based on remote sensing supported by intensive ground verification and field data from National Forest Inventory. The term 'Forest Cover' refers to all land more than 1 ha in area with a tree canopy more than 10% irrespective of land use, ownership and legal status. On the other hand, the term Recorded Forest Area (RFA)' refers to all the geographic areas recorded as 'forests' in the government records. The RFAs are largely consists of Reserved Forests (RFs), Protected Forests (PFs), and Un-demarcated Forests (UDFs) or Unclassified Forests constituted as per the provision of Indian Forest Act, 1927. The FSI categories forests in five categories based on canopy classes. These are: (a) VDF - Very Dense Forest i.e., lands with tree canopy density of >70% (b) MDF - Moderately Dense Forest i.e., lands with tree canopy density of 40% - <70%); (c) OF – Open Forest i.e., lands with tree canopy density of 10% - <40%); (d) SF – Scrub Forest i.e., degraded forest lands with canopy density <10%); (e) Non-Forests (lands not included in any of the previous four categories) (FSI, 2017). Changes in forest cover between the two consecutive assessment periods allow appreciation of the actual change on the ground during the intervening period. The real changes on the ground can be on account of diversion of forest lands for non-forestry uses, plantation activities, harvesting of short rotation plantations, silviculture based fellings, shifting cultivation, clearances in encroached areas and conservation measures (FRI, 2016). In addition to the vital information on forest cover that provides an insight on the aerial extent of country's forests, the FSI also provides crucial information on growing stock which is the measure of substance of its tree wealth. In recent years, FSI has also started providing valuable information on the Tree Outside Forests (TOFs). TOFs are the tree resources outside RFAs. The inventory of TOFs is carried out in both rural and urban areas of the randomly selected 60 Districts. Further, FSI has started estimating the carbon stock in the Indian Forests based on the methodology of 'Good Practices Guidance (GPG)' provided by the Inter-governmental Panel on Climate Change (IPCC). More recently, FSI has also started collecting information on Bamboo Resource of India. An insight on forest cover, TOFs, growing stock, carbon stock, spatial pattern of forest cover and fragmentation and forest changes in two states representative within the Beas Riverscape is provided below based on the information published by FSI in its biennial ISFR (FSI,2019).

(a) Forest Cover

According to the ISFR–2019 (FSI, 2019), India had a Recorded Forest Area (RFA) of 7,67,419 km² representing 23.34% of the country's geographical area. This RFA included 56.66%, 28.52%, and 14.82% proportion under the legally defined Reserved Forests (RFs), Protected Forests (PFs), and Unclassed Forests (UFs), respectively (Table 2.16). The values of RFAs in the States of Himachal Pradesh and Punjab along the course of the Beas River

were 37,033 km² and 3,084 km², respectively. The mountainous state has nearly 67% area as the recorded forest area while the agriculture dominated State of Punjab had a meager recorded forest area of just 6.12% of its geographical area. The proportion of reserved forest in both the states was substantially low as bulk RFA was in the legal category of protected forest. The State of Himachal Pradesh with its nearly 67% RFA contributes 4.82% of the country's RFA while the Punjab state contributes a minuscule proportion of country's RFA. The factual information provided in Table 2.16 amply revealed that the hilly State of Himachal Pradesh wherein the Beas River not only originates, but also have catchment of some of its major tributaries still has considerable RFA. However, the bulk RFA is under the relatively lower category of PFs. The situation of forests in terms of overall RFA as well as their lower legal categories (PFs and UFs) in the Punjab alluvial plains is dismaying in proportion to the larger size of this state. The factual insight about the current forest cover in two States and the historical information on the considerable loss of forests in these two states in the past century or so warrants intensive forestry interventions in the riverscape by way of plantations as well as strict protection to the existing limited extent of forests.

Table 2. 16 - Recorded Forest Areas (RFAs) in India and Two Indian States Represented in the Beas Riverscape

Sr. No.	India/ State	Geogra- phical Area km ²	Reserved Forests km ²	Protected Forests km ²	Unclass- ed Forests km ²	Forests Recorded Area km ²	Country/ States' Geograp- hical Area (%)	% of India's Forests Area (%)
1	All India	32,87,469	4,34,853	2,18,924	1,13,642	7,67,419	23.34	23.34
2	Himachal Pradesh	55,673	1,898	33,130	2,005	37,033	66.52	4.82
3	Punjab	50,362	44	1,137	1,903	3,084	6.12	0.40
4	Total of Two States	1,06,035	1,942	34,267	3,908	40,117	37.83	5.22

(Source: FSI, 2019)

Further, the close scrutiny of information on forest cover on canopy density provided by the FSI in its ISFR – 2019 in two concerned States provided almost similar impression (Table 2.17). Notably, out of total forest areal extent of 16,937 km² in two States, a small area (3,118 km²) or 18.4% was under the category of Very Dense Forests (with >70% canopy density) while as much as much 37.2% forests were under the category were under Open Forests. The Moderately Dense Forests (MDFs) with >40% and <70% canopy density constituted 44.3% of total forests in two States. The lowest proportion of VDFs in both the States and a meager extent of just 8 km² of VDFs in Punjab justify improvement of forests by way of protection, massive plantation and interventions like assisted natural regeneration and gap planting (Table 2.17).

Table 2. 17 - Forest Cover in India and Two Indian States Represented in the Beas Riverscape

Sr. No.	India/ State	Geograp- hical Area km ²	VDF	MDF	OF	Total Forest	Percent Geograp- hical area (%)	Tree Cover	Total Forest and Tree Cover	Scrubs
			km ²	km ²	km ²	km ²		km ²	km ²	km ²
1	India	3,287,469	98,158	3,08,318	3,01,797	7,08,273	21.54	95,027	8,03,300	45,297
2	Himachal Pradesh	55,673	3,110	6,705	5,285	15,100	27.12	829	15,929	250
3	Punjab	50,362	8	806	1,023	1,837	3..65	1,592	3,429	33
	Total of Two States	1,06,035	3,118	7,511	6,308	16,937	15.97	2,421	19,358	283

(Source: FSI, 2019)

Tree Outside Forests (TOFs)

Tree cover in small tree patches i.e., <1 ha in extent outside the recorded forest area and usually those lie in village woodlots, orchards, homesteads, urban areas, industrial plantations, and compact blocks along roads, canals, railway lines, etc. and as well as scattered trees is of immense value as it provides multiple benefits. Owing to mapping limitations, isolated small tree patches (<1 ha) are excluded from ‘forest cover’, however, their contribution is captured in the form of tree cover. The entire country as per the ISFR-2019 had tree cover outside RFAs to the extent of 95,027 km² while two States along the Beas River course together had 2,421 km² tree cover outside RFAs (Table 2.17). The Punjab State which was deficient in the actual forest cover had greater areal extent of 1,592 km² than the mountainous State of Himachal Pradesh having 829 km² of tree cover.

(b) Growing Stock

The ISFR-2019 by FSI (2019) provided the insight on the growing stock in the RFA. The growing stock for the whole country was computed to the extent of 4,273.47 million m³ while the growing stock in TOFs was 1,642.29 million m³ (Table 2.18). Collectively, diverse forests in two States had the growing stock in RFAs to the tune of 358.19 million m³ and this constituted 8.38% growing stock of the country in RFA. Two States (Himachal Pradesh and Punjab) contributed just 2.66% growing stock of the country in TOFs. Incidentally, both States included in the riverscape were poor contributors to the growing stock in RFA as well as TOFs of the country.

Table 2. 18 - Growing Stock in India and Two Indian States Represented in the Beas Riverscape

Sr. No.	India/ State	Geographical Area km ²	Forest Recorded Area km ²	% of India's Forest Area (%)	Country/ States' Geographical Area (%)	Growing Stock in RFA M m ³	Growing stock in TOF M m ³
1	India	3,287,469	7,64,566	23.26	23.26	4,218.3	1,603.9
2	Himachal Pradesh	55,673	37,948	4.96	68.16	315.5	23.2
3	Punjab	50,362	3,084	0.40	6.12	12.9	20.0
4	Total of Two States	1,06,035	41,032	5.36	38.69	327.4	43.2

(Source: ISFR, 2017)

Above revelations with regard to the extent of RFA, legal categories of forests, forest cover, representation of canopy density classes, and contribution to the growing stock of RFA and TOFs of the country by two concerned States noticeably explained that the overall situation of forests in two catchment States is notably not very sound. These observations provide ample clues that there is enormous scope not only to enhance the forest extent in two States along the river course, but also to improve the quality of forests and the resultant contribution to the growing stock.

(c) Spatial Pattern of Forest Cover and Fragmentation in Different Patch Size

Most of the world's forests have been exploited and used by human for multiple benefits since time immemorial. In country like India, a substantial rural population, particularly forest dwellers and people living in forest fringe villages have been traditionally dependent on forest resources for their subsistence and livelihoods. In addition, the country's forests have long history of management. Further, substantial chunk of forests was cleared for expansion of agriculture and in a larger part of the north-east India shifting cultivation is being practiced. Forest lands are being diverted for non-forest uses and various developmental projects. These multiples uses, long history of management, and changes in land use owing to developmental works have resulted into fragmentation of natural as well as man-made forests. Laurance (2000) has defined fragmentation as simultaneous reduction of forest area, increase in forest edge and sub-division of large forest area into smaller non-contiguous fragments or forest patches. The process of forest fragmentation has produced a mosaic of natural and managed ecosystems in the human dominated landscapes (Roy *et al.*, 2013; Midha and Mathur, 2010).

The fast growing discipline of Landscape Ecology aims to study and assess the spatial patterns or landscape structure, composition, and dynamics as a result of developmental activities, change in land use and implications of fragmentation. Forest fragmentation not

only disrupts the contiguity, but also results into the loss of biodiversity and associated ecosystem processes and services. The emerging tools and procedures as a part of the advancement in the discipline of landscape ecology examines spatial patterns by way of patch characterization (patch number, size, shape, edge, interspersions, etc.) and also evaluate the condition of the matrix. Recognizing the need to appreciate the changes in and around forests and impact of forest fragmentation, the FSI from the year 2015 started the assessment of number and size of patches with regard to the forest cover of the whole country as well as for each of the State/ UT and different forest types. Thus, valuable information on spatial patterns, patch characteristics and fragmentation is available for the entire country as well as all States/UTs for biennial assessments on forest cover and patch characteristics. Availing this information from ISFR-2017 and ISFR-2019, the following section attempts to compare the situation with regard to patch characterization in the entire country as well as two concerned States located along the course of river Beas Table 2.19 (FSI, 2017 and 2018).

According to ISFR-2017, it was revealed that > 40% of the forest cover for the entire country was contained in nine larger patches, each having area greater than 10,000 km². 65 patches, each having an area above 1,000 km² covered more than 65% of the forest cover of the country. The largest patch was located in the northeastern State and covered an area of 1,58,439 km². As many as 7,27,380 forest patches or 97.4% of total patches recorded in the country were less than 1 km² in size and these patches constituted just 7.64% of the forest cover of the country (FSI, 2017). While comparing the most recent situation on forest cover and patch characterization as of 2017 at the national level with the previous biennial assessment (ISFR-2015) provided startling revelations. These revelations based on comparison were: (a) the forest cover in the country showed slight increase from 7,01,673 km² to 7,08,273 km² in two year intervening period, (b) total number of patches decreased from 9,53,244 to 7,46,386 showing loss of 2,06,858 forest patches in just two years or 21.7% loss in number of forest patches, (c) the maximum loss of patches, being 2,08,484 was in the smallest patch size range (≥ 0.01 - ≤ 1.0 km²), and (d) the second lower patch size range (> 1.0 - ≤ 10 km²) category showed increase of 1,487 patches in the year 2017 (Table 2.19). These revelations evidently reflected that on one hand the country showed increase in the overall forest cover while in a short span of just two years lost a large number (2,08,484 or 21.7%) of smaller patches (< 1 km²) indicating significant loss of forest and a very high rate of forest fragmentation. Indeed, it is a worrisome situation and calls for widespread forestry interventions to safeguard from the deteriorating situation.

On the above lines of national level assessment of forest cover and patch characterization, information for the mountainous State Himachal Pradesh which makes the primary catchment of the Beas River is also available for two consecutive biennial assessments by FSI. As per the ISFR-2017, the State had 15,100 km² area under the forest cover and it was represented by 22,729 patches under various patch size classes. > 97% patches were in the lowest patch size range (≥ 0.01 - ≤ 1.0 km²) category indicating that bulk forest patches were of very small size (< 1 km²) prone to gradual disappearance, fragmentation, and degradation owing to the severe human pressure and disturbances. These small size patches constituted just 10.45% of forest cover of the State. There were just four large patches (> 1000 - ≤ 5000 km² extent) covering 5,109 km² area and constituting 33.83% of the total forest cover of the State. Ninety three

patches ($>10 \text{ km}^2$ in size) constituted nearly 60% forest cover of the State (Table 2.19). On a comparison with the data of ISFR-2015, important observations made were: (a) the State registered a slight increase in the forest cover from $14,696 \text{ km}^2$ to $15,100 \text{ km}^2$ i.e., a gain of 434 km^2 area under the forest cover, (b) the number of forest patches in the State increased from 18,692 to 22,729 indicating gain of 4,037 patches or 21.5% increase in overall number of patches reflecting rapid fragmentation, and (c) the bulk gain by 4,444 patches was in two lowest patch size range categories i.e., up to $<10 \text{ km}^2$ in 2-year period was quite significant showing the high pace of fragmentation (FSI, 2015 and 2017). This type of further division of smaller patches indicates their vulnerability and reduced ecosystem services they can offer.

Likewise, two consecutive biennial assessments on forest cover and patch characterization in the case of Punjab State also offered startling observations based on ISFR-2015 and ISFR-2017. In 2017, the State had a forest cover of $1,837 \text{ km}^2$ represented by 6,185 patches. There was just one large patch in the patch size range of $>500 - \leq 1000 \text{ km}^2$ constituting 30% of the total forest cover of the state (Table 2.19). As many as 98.39% patches were $<1 \text{ km}^2$ and they constituted nearly 25% of the total forest cover in the State. There were just seven patches $>10 \text{ km}^2$ those constituted 63.37% of the total forest cover. While comparing the situation of forest cover and patch characterization based on ISFR-2015, notable observations were: (a) an increase in number of forest patches from 5,161 to 6,185 with majority increase in the lowest patch size category ($<1 \text{ km}^2$), (b) the contribution by singular largest patch to overall forest cover of the State decreased from 556 km^2 to 551 km^2 in two years of intervening period. The contribution of this patch to State forest cover decreased from 31.29% to 30% (FSI, 2015 and 2017). In one way, the situation of Punjab resembled to great extent with the overall country and the State of Himachal Pradesh as they all showed the bulk proportion of patches in the smallest forest patch range class and greater pace of fragmentation of smaller patches.

Table 2. 19 - Patch Size Classes in India and Two Indian States Represented in the Beas Riverscape

Forest Cover Informatics in Different Patch Size Class							
All India							
Sr. No.	Patch Size Range (km^2)	ISFR – 2017			ISFR – 2019		
		No. of Patches	Area (km^2)	(%)	No. of Patches	Area (km^2)	(%)
1	$>0.01 - \leq 1.0$	9,35,864	50,494	7.20	7,27,380	54,082	7.64
2	$>1.0 - \leq 10$	14,957	40,583	5.78	16,444	43,639	6.16
3	$>10 - \leq 100$	2,056	57,675	8.22	2,183	58,052	8.20
4	$>100 - \leq 500$	240	48,476	6.91	257	51,298	7.24
5	$>500 - \leq 1000$	58	40,109	5.72	57	39,628	5.59
6	$>1000 - \leq 5000$	45	92,041	13.12	42	85,407	12.06
7	$>5000 - \leq 10000$	15	62,718	13.21	14	90,028	12.71
8	>10000	9	2,79,577	39.84	9	2,86,139	40.40
9	Total	9,53,244	7,01,673	100	7,46,386	7,08,273	100

Himachal Pradesh							
1	>0.01 - ≤1.0	18,041	1390	9.46	22,082	1,578	10.45
2	>1.0 - ≤10	551	1459	9.93	554	1,482	9.82
3	>10 - ≤100	84	2843	19.35	76	2,276	15.07
4	>100 - ≤500	9	2133	14.51	9	1,635	10.83
5	>500 - ≤1000	4	3013	20.50	4	3,020	20.0
6	>1000 - ≤5000	3	3858	26.25	4	5,109	33.83
7	Total	18,692	14696	100	22,729	15,100	100
Punjab							
1	>0.01 - ≤1.0	5065	385	21.74	6,086	451	24.55
2	>1.0 - ≤10	89	212	11.97	92	222	12.08
3	>10 - ≤100	3	65	3.67	3	65	3.54
4	>100 - ≤500	3	553	31.23	3	548	29.83
5	>500 - ≤1000	1	556	31.29	1	551	30.00
6	Total	5,161	1,771	100	6,185	1,837	100

(Source: FSI, 2015 and 2017)

(d) Forest Changes in Two States

The spatio-temporal changes in forest cover between two consecutive assessment periods reflect the change on the ground during the intervening period and provide an insight on the forest dynamics in human dominated landscapes. A comparison of total forest cover and forest canopy density classes in two consecutive assessment periods (2017 and 2019) in the case of entire country and two concerned States relevant to the Beas Riverscape provided noteworthy observations (Table 2.20). Accordingly, the country as well as two States registered slight increase in respective forest cover in 2019 than the previous biennial assessment. The extent of Very Dense Forests (VDFs) increased in two-year period from 98,158 km² to 99,278 km² in the case of entire country. Likewise, the mountainous State of Himachal Pradesh showed a slight increase in the extent of VDFs from 3,110 km² to 3,113 km². However, forest in the case of Punjab, there was no change in the extent of VDF between two consecutive assessments of 2017 and 2019. In case of MDFs, the country as a whole showed slight increase (from 3,08,318 km² to 3,08,472 km²) while Punjab State recorded slight decline in MDFs over two-year intervening period. The extent of MDF increased in Himachal Pradesh. The extent of Open Forests was enhanced in the case of whole country as well as the State of Punjab while in contrast; Himachal Pradesh State registered a slight decline in the extent of open forest in 2019 in comparison to the previous biennial assessment (Table 2.20).

Table 2. 20 – Comparison in Forest Cover and Canopy Density Classes in India and Two States Between two Consecutive Assessments of 2017 and 2019

Sr. No.	India/ State	Geo-graphical Area km ²	2017 Assessment				2019 Assessment			
			Total Forest Cover km ²	VDF km ²	MDF km ²	OF km ²	Total Forest Cover km ²	VDF km ²	MDF km ²	OF km ²
1	All India	3,287,263	7,08,273	98,158	3,08,318	3,01,797	7,12,249	99,278	3,08,472	3,04,499
2	Himachal Pradesh	55,673	15,100	3,110	6,705	5,285	15,434	3,113	7,126	5,195

Sr. No.	India/ State	Geo-graphical Area km ²	2017 Assessment				2019 Assessment			
			Total Forest Cover km ²	VDF km ²	MDF km ²	OF km ²	Total Forest Cover km ²	VDF km ²	MDF km ²	OF km ²
3	Punjab	50,362	1,837	8	806	1,023	1,849	8	801	1,040
4	Total of Two States	1,06,035	16,937	3,118	7,511	6,308	17,283	3,121	7,927	6,235

(Source: FSI, 2017 and 2019)

(e) Changes in Forest Cover

As stated earlier, FSI has been carrying out biennial assessment on forest cover for the entire country and each of the State/UT since 1987. Thus, in past 16 consecutive assessments until 2019, valuable insight on changes in forest cover has been obtained. The same has been summarized in Table 2.21 for the entire country and two States relevant to the Beas Riverscape. Accordingly, in general, the country has shown the continuous gain in the extent of forest cover from 1987 to 2019, except in 1991 assessment. The forest cover increased from 6,40,819 km² in 1987 to 7,12,249 km² in the intervening period of 32 years. Hence, there was an overall gain in forest cover to the extent of 10.02%. Like India, two concerned States also showed gradual increase in forest cover since 1987 except an aberration between 2001 and 2005 in the case of Punjab State when the forest cover decreased from 2,432 km² to 1,558 km² (Table 2.21).

Table 2. 21 – Comparison of Forest Cover in India and Two States between 1987 and 2019

Sr. No	India/ State	Geo-graphical Area km ²	Change in Total Forest Cover Since 1987 km ²							
			Assessment Years							
			1987	1991	1995	2001	2005	2011	2017	2019
1	India	3,287,263	6,40,819	6,39,879	6,38,879	6,75,538	6,77,088	6,92,027	7,08,273	7,12,249
2	Himachal Pradesh	55,673	12,480	12,480	12,502	14,360	14,369	14,669	15,100	15,434
3	Punjab	50,362	943	1,343	1,342	2,432	1,558	1,764	1,837	1,849
4	Total of Two States	1,06,035	13,823	13,823	13,844	16,792	15,927	16,433	16,937	17,283

(Source: FSI, 2017 and 2019)

Undoubtedly, the country as well as two concerned States showed gradual increase in forest cover in past 32 years. However, such increase in forest cover has to be seen with caution in connotation with the valuable insight on various forest canopy density classes, growing stock, spatial patterns of forest cover, patch characterization, and the pace of fragmentation, particularly loss of smaller forest patches at a very fast pace. The forgoing description on changes in forest cover, the condition of the growing stock and the alarming rate of forest

fragmentation warrants extensive as well as intensive forestry interventions so as to ensure healthy forests, efficient catchments, and sustainability of river ecosystems.

2.4.4 Carbon Stock in Forests

Climate change has emerged as the leading environmental issue of the present century and has become a global concern. Climate change and its implications not only pose enormous challenges for natural ecosystems, but also likely to severely influence the quality of human life. Among natural ecosystems, forests have important role to play in climate change mitigation as forests and climate change are intricately connected. On the one hand, forests regulates the climate, rain, groundwater, and soil while on the other hand climate influences the spatio-temporal patterns of forests, their diversity, associated floral and faunal life, productivity, and even the ecosystem services they offer to humankind. Forests are both, the source as well as sink of carbon. Forests sequester the carbon as well as store more carbon than any other terrestrial ecosystem. Carbon sequestration by forests has been recognized as a major contributor towards the climate change mitigation. The ‘Good Practices Guidance (GPG)’ developed by the Intergovernmental Panel on Climate Change (IPCC) is the universally accepted source book for concepts, definitions, various pools, methods, default values, various required equations, etc. for preparing account of Forest Carbon Stock (FCS). The total carbon which is stocked in the forests has been divided into five pools by GPG (FSI, 2019). The living portion of carbon in biomass is in two pools viz., the Above Ground Biomass (ABG) and the Below Ground Biomass (BGG) and they are major stores of significant amount of carbon. The Dead Organic Matter (DOM) is also categorized into two pools viz., the ‘Dead Wood’ and ‘Litter’. The fifth pool is Soil Organic Carbon (SOC). Since, FSI has a huge repository of past data on forest growing stock as well as continue to carry out biennial assessment of forest cover in the country, State/ UTs, and forest types; FSI is in a position to provide an insight on carbon stock in India’s forests and changes. The ISFR – 2019 has provided updated valuable information on State-wise carbon stock in different carbon pools. This valued information provided by FSI (2019) is used below to summarize the current situation of carbon stock in different pools into two States relevant to the Beas Riverscape.

The forest carbon stock for the country has been estimated to be 7,124 MT (FSI, 2019). An increase of 40 MT of carbon stock has been recorded in comparison to the estimates of previous assessment. The carbon stock in SOC as per the ISFR-2019 was 4,003 MT which was the largest pool (56.19%), followed by AGB (31.66%), BGB (9.82%), Litter (1.78%) and Dead Wood (0.49%) (Table 2.22). The forest carbon stock in Himachal Pradesh as per the ISFR-2019 was 175.7 MT, and it constituted 3.54% of the country’s total forest carbon stock. AGB was the largest pool in the mountainous State, followed by SOC, BGB, Litter and Dead Wood. The values of per hectare stock in different pools ranged from 71.30 t ha⁻¹ (SOM) to 1.66 t ha⁻¹ (Dead Wood). The forest carbon stock in the Punjab State recorded in 2019 was 133.4 MT. The AGB contributed 35.29 MT while the SOC contributed 82.98 MT of carbon. The value of per hectare stock was higher in Himachal Pradesh, being 163.51 than Punjab which registered the value of 72.18 per hectare stock (Table 2.13) (FSI, 2019).

Table 2. 22 – Forest Carbon Stock in Different Carbon Pools (values in '000 t) in India and Two States along the Course of Beas River (values in parentheses are of per ha of a stock in tonnes)

State	Forest Cover (km ²)	AGB	BGB	Dead Wood	Litter	SOM	Total
All India	7,12,249	22,56,533 (31.68)	7,00,824 (9.84)	35,842 (0.50)	1,27,9.2 (1.80)	40,03,575 (56.21)	71,24,676 (100.03)
Himachal Pradesh	15,434	1,10,045 (71.30)	30,745 (19.92)	2,559 (1.66)	2,711 (1.76)	1,06,300 (68.87)	2,52,360 (163.51)
Punjab	1,849	3,529 (19.09)	1,367 (7.40)	25 (0.14)	125 (0.67)	8,298 (44.89)	13,344 (72.18)

(Source: FSI, 2019)

2.4.5 Wetlands

Wetlands have been recognized as one of the world's most important environmental assets, existing in all continents and latitudes (IUCN, 2017). Wetlands are important features in the landscape and are the most productive ecosystems in the world, comparable to rain forests and coral reefs (HIMCOSTE, 2018). Wetlands provide a wide array of useful and appreciated ecosystem services. Wetlands are essential to human wellbeing and climate mitigation and adaptation as they are the Earth's greatest natural carbon stores (Ramsar, 2018). Wetlands have been recognized as the 'biological supermarkets' as they offer immense food that attracts wide range of faunal species for completion of their life cycle (Randhawa, 2014). They are home to a variety of biota and provide significant economic, social and cultural benefits, Wetlands provide water for human consumption and agriculture and numerous benefits for people, wildlife and aquatic species. Important functions of wetlands include protecting and improving water quality, providing fish and wildlife habitats, storing flood water, maintaining surface water flow, and protect shores. They are ecologically sensitive and adaptive systems.



High altitude wetlands in the alpine zone

Wetlands are the ecosystems infused with aquatic, semi-aquatic as well as terrestrial characteristics. As the name suggests, they are characterized by the presence of water, unique soils and vegetation (hydrophytes) adapted to wet conditions. Wetlands cover about 6% of the total land surface. Cowardin *et al.* (1979) provided first widely used classification on wetland systems based on their hydrological, ecological and geological characteristics and categorized them into lacustrine i.e., lakes, riverine i.e., along rivers and streams, palustrine i.e., marshes, swamps and bogs, marine i.e., coastal wetlands, and estuarine (including deltas, tidal marshes, and mangrove swamps). Varied definitions of wetlands exist. Broadly, wetlands are land areas saturated with water, either permanently or seasonally, and thus characterize a distinct ecosystem. Wetlands can be natural or man-made. The Convention on Wetlands or the Ramsar Convention defined wetlands as ‘areas of marsh, fen, peatland or water, whether natural, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceeds 6 meters’ (Ramsar Convention, 1971). These include estuaries, deltas, bogs, streams, ponds, reservoirs, etc.

India, with its varying topography and climatic regimes, supports diverse and unique wetland habitats (Prasad *et al.*, 2002). The available estimates about the areal extent of wetlands in India vary widely from a lower of 1% to a highest of 5% of geographical area, but do support nearly fifth of the known biodiversity (SAC, 2011; Bassi *et al.*, 2014). In India, various attempts have been made to prepare the inventory of wetlands and assess the areal extent

(Woistencroft *et al.*, 1989; WWF and AWB, 1993; Garg *et al.*, 1998). However, these earlier assessments were marred by problem of inadequate understanding of the definition and characteristics of wetlands (Gopal and Sah, 1995). The National Wetland Atlas prepared by the Space Application Centre (SAC), ISRO is the latest scientific inventory on wetlands of the entire country, identified and mapped on 1:50,000 scale (SAC, 2011). A total of 2,01,503 wetlands were mapped in the country. In addition, 5,55,557 wetlands with area <2.25 ha which is smaller than minimum measurable unit were identified as point features (Bassi *et al.*, 2014). Thus, India has about 7,57,060 wetlands covering total area of 15.3 million ha, accounting for nearly 4.7% of the country's geographical area.

The mountainous State of Himachal Pradesh encompasses a wide variety of wetlands, spread in various ecological zones which are the source of livelihood besides having enormous values of biodiversity, aesthetic, recreational and tourism. Altogether, 641 inland wetlands (natural-67; man-made-170; wetlands <2.25 ha-471) covering an area of 984.96 km² (Table 2.23).

Table 2. 23 - Diversity of Wetlands in Two States - Himachal Pradesh and Punjab Relevant to the Beas Riverscape

Sr. No.	Wetland Category	Himachal Pradesh			Punjab		
		Number of Wetlands	Wetland Area (ha)	% of Wetland Area	Number of Wetlands	Wetland Area (ha)	% of Wetland Area
A	Inland Wetlands – Natural						
1	Lakes/ Ponds	8	52	0.05	200	1,934	2.24
2	Oxbow Lakes/ Cut-off Meanders	-	-	-	11	373	0.43
3	High Altitude Wetlands	42	387	0.39	-	-	-
4	Riverine Wetlands				9	306	0.35
5	Waterlogged	10	47	0.05	43	2,032	2.36
6	River/ Stream	67	55,558	56.41	1.51	59,864	69.38
B	Inland Wetlands – Man-made						
7	Reservoir/ Barrages	13	41,817	42.46	31	11,858	12.74
8	Tanks/ Ponds	27	134	0.14	878	3,526	4.09
9	Waterlogged	3	30	0.03	58	1,341	1.55
C	Total Inland Wetlands	170	98,025	99.25	1,381	81,234	94.15
D	Wetlands (<2.25 ha)	471	471	0.48	5,049	5,049	5.85
E	Grand Total	641	98,496	100	6,430	86,383	100

(Source: SAC, 2010a and b)

It is evident from Table 2.23 that amongst diverse natural and man-made wetlands in the Himalayan State, wetlands in the categories of rivers, streams, reservoirs, barrages, and high altitude wetlands were prominent covering nearly 99.26% of the total wetland area in the

State. Obviously, four prominent rivers i.e., Chenab, Ravi, Beas and Sutlej) and their tributaries those originate/ flow through the State contributed the maximum number as well as area amongst various natural wetlands. The reservoirs/ barrages created on different rivers or their tributaries constituted the second largest category of wetlands i.e., man-made. In addition, the other prominent category was of high altitude wetlands. The 'high altitude wetlands – (HAW), is a generic term to describe 'areas of swamp and peat-land or water bodies located at an altitude higher than 3,000 m whether they are natural or artificial, permanent or temporary with water that is static, brackish or saline' (Panigrahy *et al.*, 2012). The high altitude wetlands represented 0.39% area of all wetlands in the State. Prominent high altitude lakes are Chandertal lake (4,000 m), Brighu lake (4,200 m), Surajtal lake (4,833 m), Nako lake (3,635 m), Manimahesh lake (4,190 m), Seruvalsar or Sirolsar lake (3,100 m), Ghadasaru lake (3,470 m), Mahakali lake (4,080m), Lamadal lake (3,960 m), etc. The wetland category of rivers/ streams represented the maximum area of wetlands in the State, being 56.41% while reservoirs/ barrages covered 42.46% area of total wetlands. There are few barrages made on Beas and Sutlej Rivers. The barrage on Beas River at Marhi, situated at 3,255 m is the highest barrage in the state. The barrage at Sundernagar situated at 845 m on Beas and converted to river Sutlej. Among reservoirs, the Pandoh reservoir and the Pong Dam Lake (Maharana Pratap Sagar) are important reservoirs on the Beas River while the Govind Sagar is the prominent reservoir and wetland on the river Sutlej River. Chamera reservoir is on the Ravi River. The Pong Dam Lake Wildlife Sanctuary is one of the Ramsar Sites. Prashar Lake is an important wetland site at an altitude of 2,730 m in Mandi District. In addition, the Wetland Atlas for Himachal Pradesh also mapped 471 wetlands <2.25 ha in size as point feature (Table 2.23).

The Punjab State also harbours a wide variety of natural and man-made wetlands. Amongst diverse wetlands mapped in Punjab, the wetland category of river/stream was the most prominent, covering 59,864 ha area that represented 69.38% of the total wetland area mapped in the State (Table 2.23). The second largest category of wetlands in terms of areal extent was reservoirs/ barrages covering 11,858 ha area, representing 13.74% area of the total wetland area recorded in the State. The State is rich in natural lakes/ponds as well as man-made tanks/ponds. The State also recorded ox-bow lakes/ cut-off meanders as rivers once descended in the alluvial plains of Punjab showed change in their course and thus ox-bow lakes were created. Smaller wetlands, mainly tanks <2.25 ha in size represented 5.85% area of the overall wetland extent in the State. Most of the wetlands in Punjab are located on major rivers and they are the main source of water for irrigation and hydro-power generation and have large canal network. These wetlands attract large number of migratory birds. The prominent wetlands of the State are Harike Lake, Kanjli wetland, Nangal Lake, Ranjit Sagar wetland and Ropar wetland. Harike lake wetland falls in three districts viz., Amritsar, Kapurthala, and Ferozepur, constructed at the confluence of Beas-Sutlej Rivers. Kanjli wetland in Kapurthala district was created in 1870.

In the context of Beas Riverscape, the Brighu Lake, Prashar Lake, Rewalsar Lake, Pandoh dam and Pong Dam lake are prominent wetlands in Himachal Pradesh of greater ecological, cultural and recreational importance. Brief description in case of these prominent wetlands is provided below:

Bhrigu Lake: Bhrigu Lake is named after *Maharishi Bhrigu* and is located at an elevation of around 4,300 m in Kullu District. The lake is located to the east of Rohtang Pass and is around 6 km from Gulaba and is close to the town of Manali.

Prashar Lake: Prashar Lake lies 49 km north of Mandi at an altitude of 2,730 m. There is a round, floating island inside the lake. It is composed of plant matter in various stages of decomposition, and is held aloft by the oxygen in its plants' roots. The floating land moves in all directions in the lake. The floating land covers 7% of area of lake whereas water is with 93%.

Rewalsar Lake: Rewalsar Lake is a mid-altitude lake located at 1,360 m on a mountain spur in the Mandi District. The lake is shaped like a square with the shoreline of about 735 m. It is held as a sacred spot.

Pandoh Dam Lake: The 76 m high Pandoh Dam is an embankment dam on the Beas River. The dam was commissioned in 1977 and its primary purpose is hydroelectric power generation. Dam is a part of a run-of-the-river power scheme; it diverts the waters of the Beas River to the Sutlej River. Pandoh Lake was created by the dam commissioned in 1977.

Pong Dam Lake: : Pong Reservoir or Pong Dam Lake also known as Maharana Pratap Sagar was created in 1975 by building the highest earth fill dam in India on the Beas River. It is one of the largest man-made wetland of northern India. The lake is a well-known wildlife sanctuary and one of the 27 international Ramsar wetland sites declared in India by the Ramsar Convention. The reservoir is 42 km long and 19 km wide with live storage capacity of 7,290 million m³. The area of water body varies from 125 km² at minimum water level in summer season to about 220 km² at the maximum water level in the rainy season and also leaving behind the maximum draw down area of about 80 km². The reservoir covers an area of 24,529 ha and the wetlands portion is 15,662 ha. Geomorphologically, the wetland is located in a typical inter-mountain valley filled with a thick pile of fluvial deposits. This man-made wetland has created the five main types of avian habitats in the reservoir area viz., (a) mud flats and mud spits along the receding shoreline, (b) open deep water, (c) dry sand banks with little or no vegetation, (d) waterside vegetation and swamps below the outfall from the dam, and (e) shallow water at the reservoir margin. Mud flats exposed during the lean period constitute the broad peripheral belt along the water body. There is some submerged aquatic vegetation in the reservoir. Owing to the pronounced seasonal changes in water level, the shoreline does not support extensive areas of emergent vegetation. The surrounding hill sites have some mixed deciduous and pine (*Pinus roxburghii*) forests (Pandey, 1993). Streams that join the waterbody from the northern side are straight and some of them are structurally controlled with a little meandering. However, the streamlets joining the wetland in the southern side are ephemeral and locally called *choes*. Soils are primarily alluvial and sandy loam.

The lake is an important wintering ground for waterfowl. The Pong wetland is the first major wetland which potentially offers a transitory resting reserve for migratory birds coming from the Trans-Himalayan zone in the winter season. Pong wetland earned the distinction being designated as the Ramsar Site in the year 2002 as it fulfilled the Ramsar Site criteria A1- (Globally Threatened Species – site regularly holds significant numbers of a globally

threatened species, or other species of global conservation concern); A4 – (Congregations – A4i: site known or thought to hold, on a regular basis, >1% of a biogeographic population a congregatory water bird species); A4iii: site known or thought to hold, on a regular basis > 20,000 water birds or > 10,000 pairs of seabirds of one or more species). Dhauladhar Mountains are feeder of water supply to Pong Lake.

The Pong wetland is a part of Central Asian Indian Flyway and one of the Important Bird Areas (IBAs) (Islam and Rahmani, 2004; HPFD, 2018). Gaston (1985) observed a total of 103 species in the area but later Pandey (1989) reported > 220 species from the Pong Dam Lake Wildlife Sanctuary. Subsequently, Pandey (1993) documented changes in water bird diversity due to the construction of Pong Dam reservoir and compared with the bird diversity earlier reported by Whistler (1926). Randhawa (2014) documented that the environs of the Pong wetland support more than 415 bird species belonging to > 60 families. den Besten (2004) reported that the creation of the reservoir in 1975 caused marked changes in river flow and land use patterns, thereby dramatically altering the diversity of wintering birds and indicated now 515 avian species from the Kangra district as compare to 395 species recorded in the early 1920s for the Punjab plains (Whistler, 1926). Fernandes and den Besten (2013) documented some interesting breeding records for Pong sanctuary. The Hamirpur Wildlife Division, Himachal Pradesh Forest Department carried out a systematic baseline study on population trend of migratory birds in pong wetland during 2017-18 and reported 119 species of migratory birds. Bar-headed goose (*Anser indicus*) is the main attraction as the species congregates in the wetland in the highest number as compared to any other wetland in the country. The Wetlands International (2002) estimated the global population of Bar-headed goose to be between 52,000 to 60,000. The HPFD (2018) reported count of 55,536 individuals of Bar-headed goose in Pong wetland in March, 2018 in the third round of monitoring during the year 2017-18. However, in order to depict the population of each species, average count based on assessment three times over a period of four months was considered appropriate. Accordingly, the average count of Bar-headed goose in 2017-18 was 35,538 (HPFD, 2018). During the study, water birds representing 23 families were recorded. The family Anatidae (includes ducks, swans and geese) was represented by the highest number of species, being 18, followed by Laridae (includes skimmer, tern and gulls) and Scolopacidae (includes shanks, sandpipers, stint, godwit, dunlin and ruff) with 12 species each, and Motacillidae with 10 species and so on. Besides, waterfowls and other birds, key fauna of the Pong Dam lake sanctuary include Golden Jackal (*Canis aureus*), Himalayan Yellow-throated Marten (*Martes flavigula*), Wild pig (*Sus scrofa*) and Nilgai (*Boselaphus tragocamelus*).

Islam and Rahmani (2004) reported fisheries, grazing, incidental poaching, water pollution by pesticides and solid waste, and tourism as major threats to the avifauna diversity and ecological integrity of the wetland. The development and utilization of resources along the Beas River and the Pong wetland continue unabated cause major concerns for the wetland.

In context of the lower part of the Beas Riverscape i.e., the Punjab Alluvium, the Harike Lake Bird Sanctuary is one of the prominent wetlands, the Important Bird Area, and the Ramsar site. Harike Lake is a shallow water storage reservoir created by the construction of a barrage

at Harike in 1952, at the confluence of the Beas River with the Sutlej River. The sanctuary area lies in three districts viz., Amritsar, Kapurthala and Firozpur of Punjab State and covers 8.6 km² area. As per Islam and Rahmani (2004), the lake covers an area of about 14.8 km² in the open water and reported that about 33 islands are scattered throughout the lake. The lake is surrounded by agricultural land, and is main source of water for the Indira Gandhi canal (formerly Rajasthan canal providing water to a larger western arid part of the Rajasthan State). The artificial water body is heavily infested with water hyacinth that forms floating islets throughout the lake. Thick stands of *Typha* spp. are found at the margins. The embankments have been planted with *Dalbergia sissoo*, *Acacia nilotica*, *Zizyphus* spp., *Ficus* spp., and *Prosopis* spp. The lake is an important staging and wintering area for migratory waterfowl. A study conducted by the Bombay Natural History Society (1980-85) recorded 167 species of resident and migratory birds. The updated list by Harvey (2002) included 358 species, including some very old records such as the Little Bustard (*Tetrax tetrax*) that was not seen in India for the past five decades or more. The open water zone is very important for Near Threatened Darter (*Anhinga melanogaster*). Because of congregation of this threatened species and other birds, Harike as the Ramsar site qualifies A4i criteria, i.e., the site is known to or thought to hold, on a regular basis, >1% of a biogeographic population of a congregatory water bird species. Sinha (1997) reported 16 mammalian species from this IBA site including the Smooth coated Indian Otter (*Lutrogale perspicillata*), fresh water turtles and a large number of species.



Migratory birds visiting wetland

The forgoing description on wetlands in two States along the course of Beas River have amply revealed that most wetlands are small (<2.25 ha) or in the categories of natural inland wetlands – rivers/ streams or the wetlands created due to man-made reservoirs/ barrages. Like

most wetlands in India and elsewhere, wetlands in above two States and within the Beas Riverscape are facing enormous human pressure as they are surrounded by densely populated townships or other urban areas. Most high altitude wetlands in Himachal Pradesh are fragile and threatened by geological processes, climate change and ever increasing tourism pressure. The man-made wetlands created due to reservoirs/ barrages face challenges owing to high rate of sedimentation, pollutants from surroundings agricultural lands and waste from towns and cities besides issues of excessive fishing, livestock grazing in drawdown areas once water has receded, unchecked increase in tourism activities.

2.4.6 Terrestrial and Aquatic Weeds

Weeds are unwanted plants in a particular situation or a plant in the wrong place. Weeds have been considered enemies of the farmers since the dawn of agriculture. The struggle of the farmers against them to save their precious crop has been continuing. The weeds cause drastic losses in the productivity and resultant loss of economy. Over the past 4-5 decades, the concept of invasive alien species and threats by them has received special attention all over the world. An alien species are non-native or exotic organisms that occur outside their natural adapted ranges and dispersal potential. However, some of the alien species become invasive when they are introduced deliberately or unintentionally outside their natural habitats into new areas where they express the capability to establish, invade and out-compete native species (Raghubanshi *et al.*, 2005). Invasive Alien Species (IAS) have devastating impacts on native biota, causing decline or even extinction of native species, and negatively affecting ecosystems as they reproduce rapidly, out-compete native species for food, water and space, and has been recognized as one of the main causes for global biodiversity loss. Invasive species are the second largest threat to biodiversity after habitat loss. Invasive species impact native ecosystems by way of habitat modification, out-compete native species, predation of native species, herbivory on native plants, bring pathogens, and hybridize with natives, leading to loss of genetic diversity. About 40% of the species in the Indian flora are alien, of which 25% are invasive. Proliferation of invasive alien species is caused due to higher level of disturbances i.e., livestock grazing, forest/grassland fires, lopping, excessive openings, etc.

The mountainous State of Himachal Pradesh has been gifted with plenty of land that cannot be put under frequent cultivation. Such lands are under orchards, pastures, grasslands, forests and wasteland ecosystem. Since, most of these lands do not receive frequent cultivation and intensive care of the owners, the obnoxious invasive alien species or weeds like *Ageratina adenophora*, *Ageratum houstonianum*, *Bidens pilosa*, *Parthenium hysterophorus*, *Lantana camara*, *Chromolaena odorata* and *Urtica dioica* have invaded most of these areas (Angiras, 2014). These invasive species are difficult to control and have spread like a wild fire in almost the entire State because of the favorable climatic conditions; ability to propagate by seeds, stems and roots; faster dissemination by wind, water, birds, other animals, machinery, transport systems, and even human (Angiras, 2014 and Rana *et al.*, 2015; Badiyala *et al.*, 2015). Angiras (2014) have provided a detailed account on diversity and management of

invasive species under non-cropland hill ecosystem. Rana *et al.* (2015) have also provided an insight on major weeds in the non-cropped lands of Himachal Pradesh while Badiyala *et al.* (2015) have given a descriptive account of major weeds of cropped lands of Himachal Pradesh. Varshney *et al.* (2008) have provided an insight on the current status of aquatic weeds and their management in India. Accordingly, *Eichhornia crassipes*, *Ipomoea aquatica*, *Typha domingensis*, etc. are prominent aquatic weeds and are of primary concern. Lot of work has been done to control and manage weeds in agricultural areas and there has been considerable success in checking the menace. However, most control measures require either manual uprooting or use of chemicals/ weedicides those can be practiced by farmers in smaller crop fields but such methods cannot be recommended for natural ecosystems and protected areas as chemicals/weedicides may have adverse impact on wide range of biota as well as influence quality of freshwater resources, particularly, wetlands and river ecosystems. It is always desirable to prevent invasion of alien species as either appropriate control measures are not available or they are expensive, cumbersome, and even risky as they may allow invasion of other species. Sporadic efforts have been made to control and manage terrestrial weeds in forests, grasslands, and wetlands with little success. Much needs to be done in the field of management of invasive alien species and it calls for well-coordinated, concerted, and long term efforts to mitigate menace of invasive species.

2.4.7 Wildlife

The diversity of geological formations, landforms, forests, grasslands, alpine pastures, wetlands, etc., play important role for the diverse habitats of the wildlife. The role played by the vast altitudinal range and extremities of climatic conditions in maintaining such diversity was also understood. Varied physical and biological systems influenced by long history of management and human influence also offer an array of faunal species representing different natural ecosystems in the terrestrial and aquatic environments. The following section attempts to provide an insight on the diversity of wild fauna in varied ecosystems.

a. Terrestrial Ecosystem

In context of the Beas Riverscape, Himalayan Mountains in Himachal Pradesh and vast lands in Punjab Plains are two relevant geological formations and they are home to a wide range of rich and unique wild fauna including mammals, birds, reptiles, amphibians, fishes, and exceptionally diverse invertebrates. Prominent mammalian species of the Beas Riverscape are: snow leopard (*Panthera uncia*), Himalayan brown bear (*Ursus arctos*), Himalayan black bear (*Ursus thibetanus*), Common leopard (*Panthera pardus*), Indian wolf (*Canis lupus*), Himalayan tahr (*Hemitragus jemlahicus*), Blue sheep (bharal) (*Pseudois nayur*), Serow (*Naemorhedus sumantraensis*), Himalayan musk deer (*Moschus chrysogaster*), Goral (*Naemorhedus goral*), Sambar (*Rusa unicolor*), Barking deer (*Muntiacus muntjac*), Wild pig (*Sus scrofa*), etc.

The two States in the Beas Riverscape harbour nearly 60% of the country's avifauna. Voluminous literature in the form of published and unpublished documents represented by

faunal check lists, peer reviewed papers, and survey/ research reports are available focusing different regions, taxonomic groups and taxa. Considering the importance and relevance to the DPR, diversity of terrestrial and aquatic fauna is described below for each of the physiographic region under consideration i.e., in Himachal Pradesh and the Punjab Plains.

(a) Himachal Pradesh

The fauna of the Himachal Pradesh constitutes a different assemblage sandwiched between the tropical forests of the alluvial Punjab Plains and the Palaearctic steppe of the Tibetan Plateau (Gaston *et al.*, 1983). The State of Himachal Pradesh has representation of the northwestern and western Himalayan biotic provinces. The mountainous region as a whole is geologically young, tectonically active and environmentally very sensitive. The steep slopes, unconsolidated soil and ill planned developmental activities make it all the more fragile. The exploitation level of natural resources in the State is especially high where rapid conversion of protective ecosystems into productive and urban-industrial ecosystems has become major cause of environmental concern. As a result, a large number of faunal species have become rare and many of them are endangered in the State. In spite of high human pressure and disturbances, the State harbours considerable faunal diversity associated with wide range of ecosystems i.e., forests, grasslands, alpine pastures, and wetlands including rivers; protected areas; agro-ecosystems; and even the urban environment.

Himachal Pradesh has a rich assemblage of 74 species of mammals (excluding Chiropterans) belonging to eight Orders and 21 Families/sub-families. Out of these, 17 species were unconfirmed although they were most likely to occur (HPFD, 2005). RSET (2019) has compiled information on mammals in the Beas River Basin exclusively for the mountainous part of Himachal Pradesh based on secondary sources including published papers; Forest Working Plan and Wildlife Management Plans and reported 40 mammalian species in the mountainous part of the Beas River Basin. The conservation status of the mammalian species was reported on the basis of their listings by different agencies viz., the IUCN Red List of Threatened Species (2015) and different Schedules notified under the Wildlife (Protection) Act, 1972. Accordingly, nine species of mammals belonged to the Schedule-I of WPA, 1972; 14 species were Schedule-II and rest of the species were either included under the Schedule-III, IV or V. Six species have restricted distribution inhabiting higher elevations of the basin. According to the IUCN Red List (2015), 11 species are listed under different threat categories of which two species are under Endangered category viz., *Panthera uncia* and *Moschus chrysogaster*, 4 are under Vulnerable category viz., *Panthera pardus*, *Capricornis sumatraensis*, *Rusa unicolor* and *Ursus thibetanus* while 5 species are listed as Near Threatened category. Rest of the 29 species of mammals reported from the basin is under Least Concern (LC) category. Among these threatened species, Snow Leopard, Musk Deer, Serow, and Himalayan tahr are confined to upper reaches of the basin.

Among the prominent carnivores, Common leopard (*Panthera pardus*), Snow leopard (*Panthera uncia*), Leopard cat (*Felis bengalensis*), Fishing cat (*Felis viverrina*), Jungle cat

(*Felis chaus*) and the Eurasian Lynx (*Lynx lynx*); viverids (civets), Small Indian civet (*Viverricula indica*), Common palm civet (*Paradoxus hermaphroditus*) and Himalayan palm civet (*Paguma larvata*); Herpestids, Common mongoose (*Herpestes edwardsi*) and Small Indian mongoose (*Herpestes auropunctatus*); Hyaenid, Striped Hyaena (*Hyaena hyaena*); Canids (dogs), Himalayan wolf (*Canis himalayensis*), Jackal (*Canis aureus*), Red fox (*Vulpes vulpes*), Indian fox (*Vulpes bengalensis*) and Dhole or Indian wild dog (*Cuon alpinus*); Ursids, Asiatic black bear (*Ursus thibetanus*) and Himalayan Brown bear (*Ursus arctos isabellinus*); Mustelids, Eurasian otter (*Lutra lutra*), Smooth-coated otter (*Lutra perspicillata*), Small-clawed otter (*Anonyx cinerea*), Beech or Stone marten (*Martes foina*), Himalayan yellow-throated marten (*Martes flavigula*), Himalayan weasel (*Mustela sibirica*), Stoat or Ermine (*Mustela erminea*), Pale weasel (*Mustela altaica*) and Yellow-bellied weasel (*Mustela kathiah*); and Wild Ungulates, Tibetan Argali (*Ovis ammon*), Bharal or Blue Sheep (*Pseudois nayaur*), Asiatic Ibex (*Capra ibex*), Himalayan Thar (*Hemitragus jemlahicus*), Serow (*Nemorhaedus sumatraensis*) and Goral (*Nemorhaedus goral*). The other mammals are Sambar, fairly common in most of the densely forested habitats in the lower and middle altitude zones; Muntjac or Barking deer (*Muntiacus muntjac*) is commonly encountered below 2,700 m in most parts of the State. Habitat degradation, habitat loss and poaching are the major threats to these species. Himalayan Musk deer (*Moschus chrysogaster*) is distributed in isolated pockets all along the southern side of the Greater Himalaya between 2,800 – 3600m. This species has been persecuted for centuries for its ‘musk’. The Indian wild pig (*Sus scrofa*) is reported to be fairly common <2,700 m in most parts of the State. Rhesus macaque (*Macaca mulatta*) and Common langur (*Presbytis entellus*) occur throughout the State in a variety of habitats upto 3,000 m. The species is recognized as a problem species in some parts of the State, common langur occurs in forested areas and may occur even in sub-alpine zone upto 3,700 m. Rhesus macaque – human conflict is a serious problem in Himachal Pradesh and the Forest Department has undertaken a state-wide program to capture and sterilize monkeys so as to control the population. However, there appears to be little success as monkeys are fed at almost all religious places.

Common leopard occurs throughout the State up to 4,000 m in a wide variety of habitats. In many parts of the State, this is a ‘problem species’ as increased incidence of livestock loss and human attacks are frequently reported. Leopard cat occurs in forested habitats and sometimes near cultivated areas or human habitations. Presence of water characterizes its habitat and is usually encountered in the lower elevations in the State (1,500 - 3,000 m). Bharal or Blue Sheep is a commonly encountered species in the Trans-Himalaya and some alpine regions of the Greater Himalaya between 3,500 - 5,500 m. In Beas River Basin, it occurs in catchment of Parbati and GHNP. Asiatic ibex is distributed most of Lahaul and Spiti and upper catchments of Beas and Parbati between 3,500 - 5,500 m. Himalayan tahr is distributed in isolated pockets along a narrow strip (2,200 - 4,400 m) in GHNP, Kanawar WLS, etc. Serow occurs in low densities along a narrow strip (2,000 m to ‘treeline’) in the Greater Himalaya in GHNP and other high altitude regions of Beas River Basin, Goral is commonly encountered in a variety of habitats throughout the State < 4,000 m. It is found in most of the PAs. Black bear occurs in forested habitats (1,200 m to 3,300 m) throughout the State. This is largely due to its ability to use plantations, orchards, scrub lands, cultivated

areas and even villages to move between forested areas which results in conflict with people. Black bear is reported to be present in and around several Protected Areas. Himalayan brown bear is also reported to be present in and around several PAs. Black bear is seriously threatened due to poaching for its gall bladder and skin. Brown bear is threatened due to retaliatory killings by shepherds to avoid livestock loss due to predation by brown bear. Populations of black and brown bears are under severe threat.

Jackal (*Canis aureus*) commonly occurs <1,500 m throughout the State including degraded areas and near human habitations. Red Fox (*Vulpes vulpes*) occurs in the sub-alpine and alpine regions of the Greater Himalaya and the Trans-Himalayan region (3,000 - 5,000 m). Indian Fox (*Vulpes bengalensis*) is reported to occur only in the lower areas of the State, particularly areas adjoining Punjab. The Dhole or Indian wild dog (*Cuon alpinus*) is likely to be present in the Trans-Himalayan region, but its presence is yet to be confirmed. The Eurasian Otter (*Lutra lutra*) occurs in the major river systems (<3,000 m) of the State, but there is no information on the conservation status of this species. The Stone or Beech Marten (*Martes foina*) usually inhabit the temperate and sub-alpine zones (1,500 - 3,600 m) and are threatened due to poaching for fur and to reduce predation on poultry. The Himalayan Yellow-throated Marten (*Martes flavigula*) occurs between 1,200 - 3,200 m in the temperate and sub-alpine zones and also in the Shivaliks (600 - 1,200 m). It predaes on small herbivores, birds including pheasants and sometimes ungulates such as musk deer, tahr and goral. This species is relatively more easily sighted when compared with the Stone or Beech Marten. Weasels (*Mustela* spp.) occur in a variety of habitats between 1,500 - 4,500 m. Himalayan weasel is rare in occurrence.

The **Avifauna** includes 657 bird species from 18 Orders and 88 Families. This is 51% of the bird species reported from India and includes 53 threatened species i.e., Critically Endangered-4, Endangered-5, Vulnerable-19, Near Threatened-24 and Data Deficient-1 as per the IUCN (HPFD, 2017). Pheasants along with other Galliformes (such as partridges and quails) represent a unique group of birds marked by relatively large body size and attractive plumage patterns. In Asia, , the wild populations of pheasants seem to have suffered constant removal from sport hunting by rulers, and for meat and the beautiful plumage to fulfil economic and social needs of local people. Burgeoning human population leading to large scale conversion of wildlife habitats (including those of pheasants) into human habitations and indiscriminate removal of wild populations have created a situation, wherein the once abundant and widely distributed pheasant species are now found in isolated pockets, survived by small population size.

In the State, 7 species of pheasants and over 12 species of Galliformes occur. Of these pheasants, the Western tragopan (*Tragopan melanocephalus*) and Cheer pheasant (*Catreus wallichii*) are among the most vulnerable bird



Western Tragopan

species (according to IUCN Red Data List). These birds are patchily distributed with a small surviving populations. Pheasants are representative of the forest ecosystem, with strong association with ground vegetation i.e., shrub and herb layers. They are among the most popular wildlife in the State and Western tragopan, ‘the king of all birds’ is the State Bird. Other pheasants are: Kalij (*Lophura leucomelana*), Red Jungle fowl (*Gallus gallus murghi*) and the Indian Peafowl (*Pavo cristatus*). Given the ‘**Flagship**’ stature of this group, it would be logical to assume that conservation initiatives for these species would also help survival of other forest wildlife. However, scientific support for several of these species is grossly inadequate to be able to effect efficient conservation/management actions for the wildlife in the State.

The Herpetofauna comprises of amphibians that include frogs, toads, newts, salamanders, etc. and reptiles which include snakes, lizards, turtles, terrapins, tortoises, etc. Sharma and Sidhu have reported diversity of amphibians and reptiles of Himachal Pradesh and listed 16 species of amphibians 55 species of reptiles. RSET (2019) compiled an inventory of herpetofauna in the crenon and rhithrone zones of the Beas River in Himachal Pradesh from the Forest Working Plans, Wildlife Management Plans and published literature by Singh *et al.* (2015) and reported total 59 species including 51 species of reptiles and 8 species of amphibians. The reptilian fauna was represented by 12 families. The IUCN Red List (2017) has kept the Indian rock python (*Python molurus*), Spottedpond turtle (*Geoclemys hamiltonii*) and Gangetic soft-shell turtle (*Nilssonia gangetica*) under vulnerable category. Eleven species were under the Least Concern category and rest of the species is yet to be evaluated for their status. Altogether, seven species of turtles viz., Spotted pond turtle (*Geoclemys hamiltonii*), Indian black turtle (*Melanochelys trijuga*), Gangetic soft-shell turtle (*Nilssonia gangetica*), Brown roofed turtle (*Pangshura smithii*), Indian tent turtle (*Pangshura tentoria*), Indian flap-shelled turtle (*Lissemys punctata*), and North Indian flapshell turtle (*Lissemys punctata andersoni*) were included in the list of reptilians. Eight species of amphibians reported by RSET (2019) belonged to 4 families, which comprises of toads and frogs.

The **Invertebrates diversity** in the context of Beas River and two concerned States is relatively poor except survey and taxonomic records maintained by the ZSI. Moreover, the existing information is fragmentary, old or specific to select stretches or regions of the States. Chandra (2012) has provided broad base information on insect fauna of States and UTs in India. The phylum Arthropoda alone constitute about 80% of the total number of faunal species described so far globally. Insects accounts for about 66% species in 39 orders. The insect order Coleoptera represents about 38% of the insect species (Zhang, 2011). According to Chandra (2012), Himachal Pradesh is represented by 2,356 species of insects constituting 3.7% of insect diversity while Punjab harbours 1,116 species of insects representing 1.75% of known insect diversity in the country. In Himachal Pradesh, the order Lepidoptera (butterflies and moths) is represented by 570 species while in the case of Punjab, 340 species of butterflies and moths have been described. RSET (2019) has attempted to describe the diversity of butterflies in the mountainous landscape and forest cover of Himachal Pradesh based upon the data compiled from secondary sources, Forest Working Plans, Management Plans of Protected areas, and published literature (Uniyal and Mathur, 1998; Uniyal, 2007; Bhardwaj and Uniyal, 2009; Chandel *et al.*, 2014). Accordingly, a total of 150 species of

butterflies sub-basin wise were listed and they were grouped under seven families. Species richness in different sub-basins ranged from 76 - 137. Majority of the species were common in distribution in all sub-basins while a few of them were restricted to upper reaches (Red Apollo – *Parnassius charltonius*, Common Blue Apollo - *Parnassius hardwickei*, Painted Lady- *Vanessa cardui*, Mountain Argus - *Erebia shallada*) and lower reaches (Spangle- *Papilio protenor*, Tawny Mime-*Chilasa agestor*, Psyche - *Leptosia nina nina*, Common Jezebel - *Delias eucharis*, Pale Hedge Blue - *Udara dilecta*, Purple Hedge Blue - *Heliophorus epicles*, Common Baron – *Euthalia aconthea*, Common Jester - *Symbrenthia hippochus*, Common Bush Brown - *Mycalesis perseus*, Dark Blue Tiger - *Tirumala septentrionis*, etc). Likewise, other taxa in Beas River Basin, the richness of butterflies decreased along the elevational gradient. Thus, the sub-basins in the lower reaches harboured relatively high butterfly richness.

Flagship Species – Snow Leopard: The higher reaches (>3,600 m) or above the tree line in Lahaul and Spiti, Kinnaur, Chamba and Kullu Districts form the habitat of the iconic, elusive and culturally treasured cat, a flagship species of the Himalayan Mountains i.e., the Snow leopard (*Panthera uncia*) or also known as the ‘Ghosts of the Mountain’. The rare and elusive snow leopard is unique to high mountains. These high mountainous regions are also home to unique high altitude fauna that includes Himalayan tahr (*Hemitragus jemlahicus*), Bharal (*Pseudois nayur*), Argali (*Ovis ammon*), and Ibex (*Capra sibirica*). Nearly 27,000 km² area in the higher reaches is the potential snow leopard landscape in Himachal Pradesh. The National Conservation Foundation (NCF) in collaboration with the Himachal Pradesh Forest Department has been carrying out a collaborative project since 2016 to estimate the population of snow leopard and its wild prey population(s) using camera traps and field level assessments based on direct sightings and indirect evidences. The NCF in its preliminary findings based on camera trapping studies has identified seven landscapes within the larger project area having the confirmed presence of snow leopard. These are Bhaga, Chandra, Miyar-Thirot, Tabo, Upper Spiti and Pin Valley landscapes in Lahaul and Spiti District, and Kinnaur landscape in Kinnaur District. Based on preliminary analysis, a minimum population of 44 snow leopards across the seven landscape sites was estimated (NCF, 2019). Thus, it is evident that snow leopard occur in very low densities in the Trans-Himalayan region. The Upper Spiti landscape recorded the highest number of snow leopard, followed by Upper Kinnaur and Pin Valley landscapes. The northeastern part of the Great Himalayan National Park and upper reaches of Parbati sub-watershed and upper Beas valley are also potential sites. Poaching for skin and retaliatory killing to reduce livestock loss are the two major concerns for the conservation of endangered snow leopard.



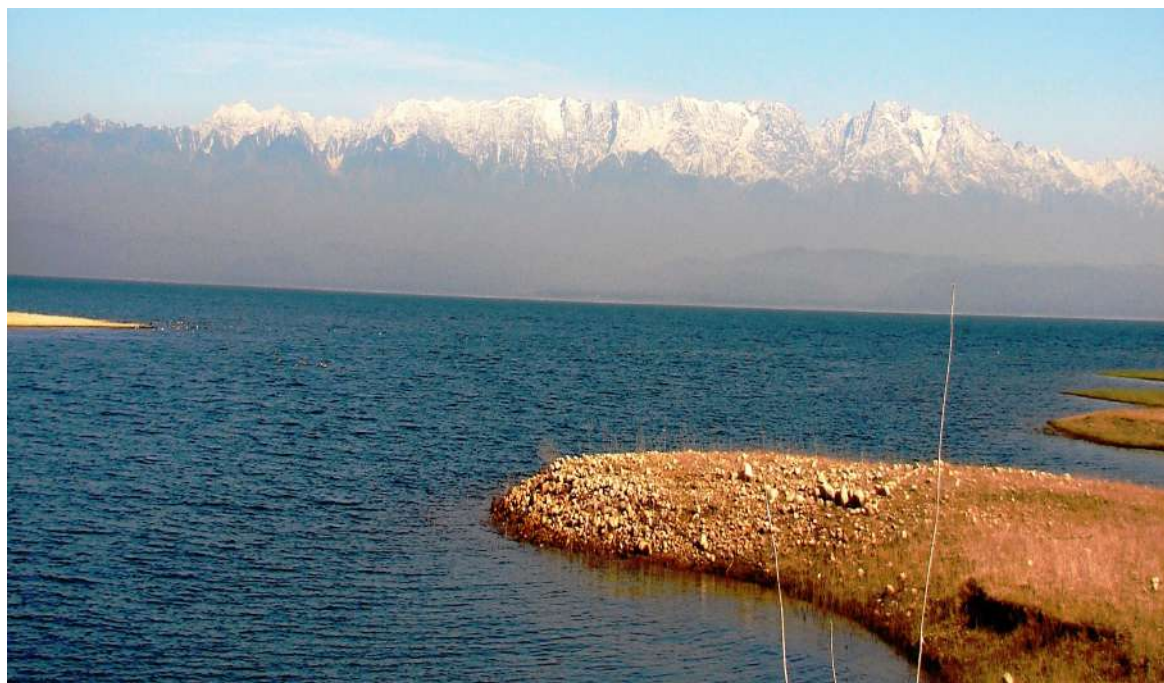
High Altitude Transition Zone in the Great Himalayan National Park

(b) Alluvial Plains in Punjab

Punjab has made an unparalleled progress in agriculture sector since the advent of Green Revolution in the mid sixties as a result the State is densely populated and intensively cultivated. Nearly 84% of the State's geographical area is under agriculture with a cropping intensity of 183%. Only a meager area i.e., 5.7% of the geographical area is under forest that too mainly confined to northeastern part of Shivalik hills. Owing to the expansion of agriculture and conversion/ reclamation of natural areas i.e., forests, grasslands and wetlands), and creation of several large dams and barrages have resulted into the great loss of natural diversity. In the context of Beas Riverscape, there are hardly any known or substantial forest and grassland areas left in the alluvial plains of the Punjab State. However, nine large man-made wetlands have been formed. Several natural wetlands also exist. Thus, from the perspective of wildlife, aquatic ecosystems and associated aquatic fauna, the State attains higher importance. The forgoing section on wetlands and associated avifauna has already provided much desired insight on resident and migratory birds. Forests i.e., dry tropical riverine and dry mixed deciduous forests) are found around wetlands. An insight on Harike Ramsar Wetland Site has already been provided and its avifauna. Once, Punjab Plains use to have abundant populations of antelope (blackbuck and nilgai). Populations of antelopes have also suffered. The threatened fauna of Punjab includes the Indus River dolphin (*Platanista gangetica minor*), White-backed vulture (*Gyps bengalensis*), Sarus crane (*Grus antigone*), Indian rock python (*Python molurus*) and Indian Roofed turtle (*Pangshura tecta*).

b. Aquatic Ecosystem

The Beas River, its numerous tributaries and diverse wetlands in Himachal Pradesh and Punjab constitute rich and unique aquatic ecosystems. They are home to a wide variety of aquatic plants, fishes, reptiles (crocodilians), amphibians, and aquatic mammals (e.g., otter and the Indus River dolphin). **Fish Fauna** represents nearly half of all known vertebrate species, and are an important resource worldwide especially as food. Nearly, 22,000 species of fishes have been recorded in the world of which about 11% are found in Indian waters (Jagtap, 2013). Out of the 2,200 species so far listed, 73 (3.32%) belong to the cold freshwater regime, 544 (24.73%) to the warm freshwaters domain, 143 (6.50%) to the brackish waters, and 1,440 (65.45%) to the marine ecosystem. Roughly, 40 families of freshwater (warm freshwater species) fishes out of 450 families recorded globally are represented in India. About 25 of these families contain commercially important species (Jagtap, 2013). According to Hilborn *et al.* (2003), 544 endemic species in warm water have been reported. Cyprinidae is one of the largest families and is well represented in India species ranging from few millimeters in length (minnows) to more than a meter (major carps). Cyprinidae accounts for nearly 24.12% freshwater fishes in India. Owing to substantial variation in altitude from 210 m (at Harike) to 6,500 m and a vast network of rivers/ streams along with a large number of natural and man-made wetlands, the two States (Himachal Pradesh and Punjab) relevant to the Beas River Basin constitute important zone for fish fauna.



Maharana Pratap Sagar Wetland: also known as Pong Reservoir or Pong Dam Lake



Birds at the Pong & Grazing pressures in the alpine zone

Different workers have either provided insight on the diversity and status of fish fauna state-wise or specific to different stretches/ river zones based on biotic status *viz.*, (a) the crenon zone - area near the source of river with lower oxygen level and colder temperatures, (b) the rhithron zone – the upstream area of the river characterized by faster and turbulent flowing speeds, cooler temperatures and higher oxygen level, and (c) the potamon zone – the downstream area of the river having slower water flowing speeds, warmer temperatures with lower oxygen level. Seghal (1974) has provided an account on fisheries survey of Himachal Pradesh and some adjacent areas with reference to trout, mahseer and allied species while Tilak and Hussain have provided a checklist of fishes of Himachal Pradesh. Later, Sharma and Tandon (1990) also provided an account of fish and fisheries of Himachal Pradesh. Johal *et al.* (2002) described the fish diversity in the streams of lower Middle Western Himalaya. Dhanze and Dhanze (2004) provided an updated insight on fish diversity of Himachal Pradesh. However, in the case of river Beas, Mozah and Mishra (2007) have presented the findings based on the investigations carried out in the potamon zone (downstream area in plains of Punjab) of Beas River Basin and gave complete picture of the environment i.e., water abstraction, pollution source and load, ecology i.e., soil texture, riverbed quality, water quality and organization various biotic forms, fish diversity, fisheries resources and its economics. They highlighted that the Beas Basin has been well developed, prosperous and its resources utilized judiciously from time immemorial, but the resource utilization witnessed a sea change after the country's independence in order to fulfill the greater need of overall development and to meet the aspirations of burgeoning population. According to them, the rhithron (upstream area) zone of Beas River within Himalayan region has been maneuvered mainly for power generation by creation of two dams (Pandoh and Pong), and diversion of its

water to river Sutlej through Beas-Sutlej link tunnel/canal while the potamon (downstream area) within plains has been exploited for intensive irrigated agriculture by carving of canals (Shah Nehar canal and Mukerian hydel). Mozah and Mishra observed that the fishery present within Beas was formed by 54 species out of which 31 were economically important. The upper stretch running along the foothills of Shivaliks Himalayas hold cold water (*Schizothorax richardsonni*) to eurythermal carps while the lower stretch had *Notopterus chitala* and *Mystus aor*. Kumar and Khana (2014) assessed ichthyofaunal diversity in upper stretches of river Beas and reported that six fish species belonging to three orders and three families. *Schizothorax richardsonni* was the most dominant species, followed by *Oncorhynchus mykiss*. Sharma (2019) reported ichthyofaunal diversity of Beas River system in the northwestern Himalaya. The State of Himachal Pradesh has maximum stretch of about 57% (256 km) of the Beas River and due to vast variation of altitude of the river (300 m to 4,000 m), the fish diversity is overwhelming and comprised of 63 fish species belonging to 44 genera, 14 families and 07 orders. She also assessed the distribution and conservation status of the ichthyofauna. The Beas River harbours both cold water as well as warm water fishes. The cold water fishes, viz., species of *Tor*, *Schizothorax*, *Barilius*, *Bangana*, *Garra*, *Schistura*, *Triplophysa* were the indigenous fishes important in terms of food, sport and ornamental value.

According to Jagtap (2013), the rivers/ streams of Himachal Pradesh falls under two categories viz., general waters and trout waters with estimated length of 600 km and 2,400 km, respectively and reported 61 species of fishes belonging to 13 families. The major fishes available in various rivers/ streams were Trout, Mahseer, *Nemacheilus* spp., *Barilus* spp., *Schizothoracides*, *Crossocheilus* spp., *Glyptothorax* spp., etc.

Sugunan (1995) provided detailed account of fish fauna and fisheries of four reservoirs viz., Gobind Sagar on Sutlej; Pong and Pandoh on Beas, and Chamara on Ravi River. The paper offered details on physio-chemical limnology, water quality, primary productivity and plankton, benthic invertebrates, fish fauna and fisheries, fish yield, major fisheries, biology of fishes, fisheries management and marketing. The study reported that the Gobind Sagar Reservoir was designed to hold 9,621 million m³ of water when it is full. However, due to silt accumulation, the capacity has declined 7,118 million m³. Commissioning of Beas-Sutlej Link (BSL) project in 1978 added a new dimension to hydrographic cycle of the waterbody. The Beas contributes 4,477 million m³ water annually and the blending of the cold water of Beas with warmer Sutlej water in the reservoir leads to unique pattern in the thermal and oxygen regimes and other processes which influence the life and production cycle of organisms. Ichthyofauna of the Gobind Sagar Reservoir comprises 51 species belonging to 9 families, including the brown trout (*Salmo trutta*), snow trout (*Schizothorax* spp.), and several other species of hill stream fishes. Prior to the construction of dam, the cold water of the upper reaches of the river Sutlej used to sustain 30 species of fish. In 1961-62, the reservoir was stocked by *Catla catla*, *Labeo rohita*, and *Cirrhinus mrigala*. The emergence of silver carp in 1979 marked the beginning of a radical change in the catch structure and the fish has established an overriding dominance over all other species. The fish catch in the reservoir from 1970-71 to 1992-93 ranged from 160 t to 964 t per year with an average catch value of 556.9 t per annum. The fish yield ranged from 16 kg/ha to 96.4 kg/ha during 1970-1993. In

contrast, the Pong is a shallow reservoir with lower organic production than Gobind Sagar and the fish catch was originally dominated by carnivores. On account of systematic stocking over a number of years with seed of mirror carp and Indian major carps, the catch structure of the reservoir was completely altered and carps eventually accounted for 61.6% of the total landings. The fish yield also increase significantly from 6.5 kg/ha in 1976-77 to 53.1 kg/ha during 1987-88. The values of fish catch in Pong from 1976-77 to 1989-90 ranged from 98 t to 797 t in different years with average value of 484.8 t per annum.

Dua and Parkash (2009) studied the distribution and abundance of fish populations in Harike wetland, a Ramsar site and reported 61 fish species belonging to 35 genera and 17 families. Maximum number of species (27) was recorded for family Cyprinidae. Study compared fish fauna in Harike with Beas and Sutlej rivers and observed that these two rivers provide less diverse habitats than the Harike wetland. Hence, Harike is very rich wetland in term of fish species diversity. Kaur *et al.* (2017) assessed the fish composition and biodiversity indices at Harike and reported 37 fish species belonging to 14 families and 25 genera. They also reported that Harike wetland fed by the Sutlej River is excessively eutrophic and the portion fed by Beas River water is mildly eutrophic, but eutrophication has not yet been seen in the middle portion of the reservoir and the downstream areas. Further, they concluded that despite of different natural and anthropogenic disturbances, the wetland continuous to support a good number of fish species which needs to be conserved.

Moza and Mishra (2007) based on detailed study on ecology and fishery of Beas River concluded that diversion of water resources than pollutional influx affected ecology and fish productivity of Beas River. Fishing by ‘*chatti jal*’ and rope loop type takes away juvenile fishery bruders from the system affects the natural recruitment. The study recommended: (a) massive afforestation programm along foothills of Shivalik Himalaya so as to check soil erosion, (b) establishment of sewage treatment plants along *Kali/West Bein* to diminish organic load, and (c) removal of water *hyacinth* from *Kali Bein*.

The Herpetofauna is confined to the Harike wetland where, seven species of turtles *viz.*, Brown roofed turtle (*Pangshura smithii*), Indian roofed turtle (*Pangshura tecta*), Crowned river turtle (*Hardella thurjii*), Spotted pond turtle (*Geoclemys hamiltonii*), Indian flap-shelled turtle (*Lissemys punctata*), Indian soft-shell turtle (*Nilssonina gangetica*), Narrow-headed soft-shell turtle (*Chitra indica*), four species of snakes, and six taxa of amphibians have been reported (PSCST, 2008). In spite of the fact that natural ecosystems, particularly rivers and other wetlands are under serious threat of human pressure and developmental activities, there was hardly any evidence to ascertain the current status of these threatened species, except the taxonomic surveys or explorations.

Aquatic Mammals and the Flagship Species – The Indus River Dolphin

From the perspective of ecological integrity, health of Beas River, and conservation of Beas riverscape, the Indus River Dolphin (*Platanista gangetica minor*), acquires a great significance. Freshwater dolphins are distributed within nine river systems with brackish lagoons in Asia, and most of them have been categorized as endangered or critically endangered (Mohan and Kelkar, 2015). The Indus River dolphins were found in the Indus and its tributaries from the foothills of the Himalaya to the limits of tidal zone in undivided

India (now India and Pakistan) a linear range of around 3,500 km (Braulik 2006; and Anderson, 1879). Braulik *et al.* (2015) reported that the historical range has been fragmented by barrages into seventeen river fragments, including 15 fragments in Pakistan and two in India. According to them, the Indus River Dolphin now occur in 5 sub-populations in the Indus main stream, separated by sequential barrages. The Indus River dolphin has been recently rediscovered in the Beas River and it constitutes the sixth sub-population of this sub-species that occurs in India (Khan, 2013 and 2015). Khan also reported that a study was undertaken between April, 2011 and May, 2013 in approximately 70 km long stretch of Beas River, upstream of Harike barrage or before the confluence of Beas River with Sutlej to estimate the abundance and distribution pattern as a key step towards its conservation (Fig 2.8). Based on seven vessel-based collinear line transects of 10 km each every month, Khan (2015) reported 33 sightings during the study and found that the studied isolated sub-population occur in very low abundance of 0.047 dolphins/km. The distribution of the dolphins was found significantly different in different flow seasons. The dolphins were found migrating upstream during high flows as the increased water level creates new suitable habitat patches; where as low flows restrict them to the only remaining habitats downstream. Occurrence of dolphins, even in low density (1.44 ± 0.27 individuals/ km²) in this isolated small stretch of Beas River was considered as a good sign and recommendations were made to the Government of Punjab for providing highest protection to this small, isolated, only surviving sub-population in the Indian waters in the tributary (Beas) of Indus River (Khan, 2013 and 2015). Compared to the abundance (encounter rate = 6.23 dolphins/ km) of the main population surviving between Guddu and Sukkur barrages in Pakistan, the studied isolated population was found in very low abundance (0.047 dolphins/ km). The recorded encounter rate of the Indus River dolphin in a short stretch of Beas River was much less than those recorded for the closely related the Ganges River dolphin (0.52-1.36 dolphins/ km) in Ganga-Brahmaputra River system (Bashir *et al.*, 2010; Sinha *et al.*, 2000; Khan, 2016).

Government of Punjab has not only recognized the importance of this critically endangered sub-species, but has also realized the susceptibility of the small, isolated sub-population of the Indus river dolphin to random demographic stochasticity, environmental catastrophes, inbreeding depression, and loss of genetic diversity that all can contribute to increased extinction risk. Thus, the Government of Punjab recently announced the Indus River dolphin as the State aquatic animal and created the 'Beas River Conservation Reserve' in 2017 vide legal notification dated 29 August, 2017 under Section 36-A of the Wildlife (Protection) Act, 1972. The reserve area includes 'Beas River with all its water channels from 52 Head Talwara to Harike Barrage including all Government areas in Beas River'. The river stretch downstream Pong Dam or exactly from 52 Head Talwara to Harike Barrage is about 150 km long. The DCB Bank, a new generation private sector bank and WWF-India have come forward to conserve the endangered river dolphin in the Beas River Conservation Reserve, working closely with the Department of Forests and Wildlife Preservation, Government of Punjab by implementing initiatives around strengthening multi-stakeholder leadership, education, awareness and community-led dolphin conservation.

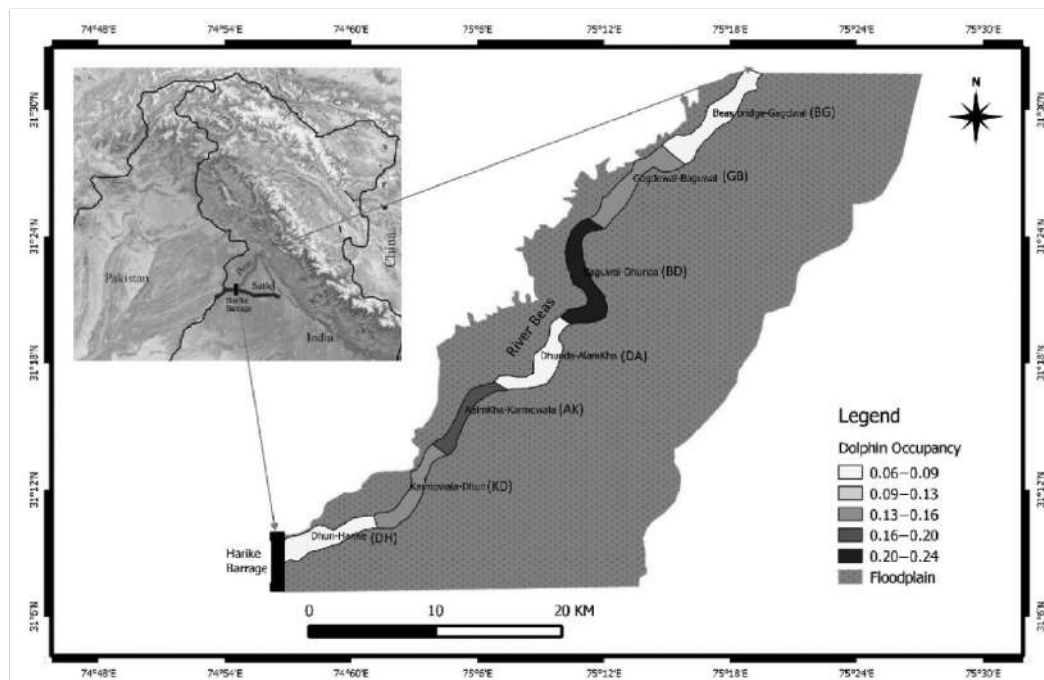


Fig. 2. 8 – The Select Stretch of Beas River Showing Study and Proportion of Dolphin Sightings (i.e., Dolphin Occupancy) in Each Section

(Source: Khan, 2016)

Yet another aquatic mammalian species i.e., the otters have been recognized as an emblematic or flagship species for conservation of fluvial ecosystems or as the ambassadors of the aquatic bodies (Norris and Michalski, 2009; Khan, 2015; Gupta *et al.*, 2016). The amphibious lifestyle of otters allows them to disperse over wide areas of riverine landscapes and use diverse habitats. They influence the ecological processes of the river flood plain. These mammalian carnivores belonging to the family Mustelidae exist at the apex of the aquatic food chain and have been recognized as indicators of healthy aquatic ecosystems. Historically, three species of otters viz., the Smooth-coated otter (*Lutrogale perspicillata*), Oriental small-clawed otter (*Aonyx cinereus*), and Eurasian (*Lutra lutra*) were widely distributed in the Indian Himalayan region (Hussain, 1999; Hussain and de Silva, 2008; Hussain *et al.*, 2008; Khan *et al.*, 2014; Mishra *et al.*, 2006; Khan, 2015). However, they have been severely impacted by wide scale human disturbances and large scale changes in land use of their natural habitat. Despite all species of otters face growing threats, few studies have been undertaken to assess the distribution, population dynamics, habitat use and overall current status of these threatened species.

The alluvial plains of Punjab with a wide network of river systems has water-stressed semi-arid environment. Once, the distribution of the Smooth-coated otter (*Lutrogale perspicillata*), locally called *Ludhar* in Punjab was widespread (Singh, 1991). Currently, like other regions of the country and other species of otters, the population of smooth-coated otter is severely fragmented. In absence of much desired baseline information on this threatened species, the gross neglect and the mis-management of its habitat, the WWF-India in 2010 decided to initiate the work towards documentation of the distribution of the species in Punjab and to undertake state-wide field surveys on population assessments along stretches of

Beas River, Sutlej River, Ravi River and Harike wetland in Punjab. Accordingly, Khan (2015) reported the findings of the population assessment carried out during 2010-12 on the basis of direct and indirect signs besides the question air survey and interviews of locals. He confirmed the occurrence of smooth-coated otters along select stretches of Beas, Sutlej and Ravi Rivers and Harike wetland in Punjab. During field surveys, eight otter sightings were made in and around the Harike Wildlife Sanctuary and the maximum group size recorded was of seven individuals (2 adults and 5 young once) (Khan, 2015). Further, the study confirmed the occurrence of otters in the upper reaches of river Sutlej between Nangal barrage and Ropar barrage whereas the upstream of Beas River till Dhunda Pattan found divide of otters presence. The homogenous distribution of otters along the course of Ravi River in Punjab was confirmed. The species definitely requires urgent measures for its protection and conservation in human dominated landscapes of Punjab.

Further, the Government of Punjab alarmed by decline of seven freshwater turtle species in the State has decided to enforce wildlife laws for effective protection of nesting sites of seven turtle species in Harike Wildlife Sanctuary and Beas River Conservation Reserve. The government has planned to involve ex-poachers and people from the riparian community in the turtle watch program as tour guides so as to pave a way for the transformation of the local community besides involving them in protection of turtle nesting sites and safe release of hatchlings into the river. The Department of Forest and Wildlife Preservation, Punjab has

selected two field sites viz., Khitan in Harike WLS and Gagrewal in Beas River Conservation Reserve for protecting the nesting sites of seven species of freshwater turtles and has planned for collecting vital information on the nesting female population, frequency of breeding, hatching success rate, etc. The Department has also reintroduced the Gharial (*Gavialis gangeticus*), the fish eating crocodile that is critically endangered. The last documented record of gharial in



Gharial in Beas Conservation Reserve

Punjab was of 1930s and after that no one has reported this species in waters of Punjab. Hence, the Department decided to reintroduce the species in waters of the Beas River in phased manner. So far, 47 gharials have been released into the Beas River in three phase's viz., (i) 10 individuals on 25th December, 2017, (ii) 15 gharials on 31st January, 2018, and (iii) 22 individuals (18 females and 4 males) on 14th March, 2018. The release was 79 km upstream of Harike barrage and about 4 km downstream of the Beas River bridge. The gharial reintroduction project is considered a successful effort aiming at restoring a species verging on the brink of extinction.

2.4.8 Conservation Initiatives and Challenges

The forests, grasslands, and wetlands in Himachal Pradesh and Punjab are now under great stress due to the impact of modern civilization, economic development and growth in human and livestock population. Both States were part of the larger Punjab prior to the country's independence, partition and bifurcation of two sovereign countries in 1947. Later, the State of Punjab, India was reorganized to carve out the present three Indian States i.e., Punjab, Haryana, and Himachal Pradesh. They have longer historical perspective of management of their natural resources prior to the independence of the country as well as their subsequent reorganization(s). Further, both States on account of their physical, biological, and socio-cultural sub-environments exhibit uniqueness and varied peculiarities and challenges for conservation of natural resources.

In Himachal Pradesh, nearly 90% of the population lives in rural areas. Most of the villages are situated on steep slopes and are either adjacent to or enclosed by forests. Thus, forests are deeply integrated with the livelihood of the local people. They depend on forests for timber, construction of the houses, firewood, agriculture implements, fodders and a variety of other products and services, including certain medicinal herbs. A larger proportion of the rural population is still use fuelwood for cooking and heating. Almost 90% of the forests of the State apart from protected areas and forest areas taken up for regenerations and plantations are open to grazing. Cultivation of green fodder in the agriculture fields is virtually non-existent. Much of the human population in higher reaches keeps substantial population of sheep and goat, and they still practice transhumance seasonal migration to sub-alpine forests and alpine pastures every year from May to September. Local people have recorded rights for constructional timber. Annually substantial quantity from the forest annually goes in Timber Distribution (TD) Rights. The menace of encroachment of the forest areas particularly in the undemarcated protected forests is alarming as these adjoin private forests. The fate of village common lands vested in the government is similar. The forests fires are of a recurring nature and cause lot of damage to forests and wildlife. The increasing demand of land for agriculture, lead to the clearance of the forest tracts, especially in the years after independence under Grow 'More Food' campaign and later, when the big landed estates were abolished and the scheme for 'Allotment of Land to the Landless' was launched in the mid 1970s also resulted in substantial loss of forests. Expansion of horticulture and large requirement of wood based packing crates for fruits during 1970-1990 brought extra burden on forests. Further, the mountainous stretches were maneuvered mainly for power generation by creation of sequential hydro-electric projects (HEPs).

Likewise, the pressure on forests and other natural ecosystems in Punjab State after the independence of the country was not different than Himachal Pradesh as it increased several folds because of policies favoring the expansion of agriculture, increased food production, construction of large dams and vast network of canals besides rapid development of agro-based industrial and food processing units. In 1966, at the time of trifurcation of the erstwhile Punjab State into three parts, the State had only 3.72% (1,875 km²) area under forest cover which has now increased to 6.12% (3,084 km²) of its geographical area in 2017 (FSI, 2017; TERI, 2015). However, the bulk of the forests are still under the lower categories of protected

forests – 36.8% and unclassed forests–61.7%. In contrast, the extent of reserved forests is grossly meager of just 1.43%.

As such, both the above States have initiated much earlier a wide range of conservation programmes and initiated measures to protect the forests along other natural ecosystems so as to safeguard the interests of varied terrestrial and aquatic wildlife. However, like most world countries and other parts within the country, the awakening towards the protection of environment and conservation of natural ecosystems and wildlife in particular started late in 1960s. Since 1960s, the Government of India has enacted different laws pertaining to the environment, forests, wildlife, and forest dwellers; formulated numerous national level policies and launched countrywide programmes, projects, and schemes besides several other initiatives so as to protect the environment and conserve the country's natural heritage. Likewise, the State governments also initiated several priority actions for conservation of scarce natural resources of their respective State

The Wildlife (Protection) Act, 1972 enacted by the GoI was the first unified piece of legislation of the country for the protection of wildlife and their habitats by setting aside protected areas for conservation of diverse flora and fauna in their natural environment. The establishment of Protected Areas (PAs) was recognized as the foremost step towards protection and conservation of natural ecosystems, and their associated flora and fauna alongside genetic resources so they can continue to provide varied ecosystem services to humanity. Rodgers and Panwar (1988) not only provided the biogeographic basis for appreciating the country's unique and spectacular wildlife resources in different biogeographic zones and biotic provinces but also carried out a comprehensive review of PAs at that time so as to identify gaps and make recommendations for the planning and establishment of protected area network in the country.

The Beas River in Himachal Pradesh and Punjab have altogether 55 PAs including 05 National Parks, 40 Wildlife Sanctuaries, 07 Conservation Reserve, and 03 Community Reserves, 8,787.88 km² area representing 8.28% and 0.26% geographical area of these States and the country as a whole, respectively (Table 2.24). The forgoing description has described that two States are represented by three biogeographic zones and five biotic provinces. The State is represented by four biotic provinces and harbours 35 protected areas including all Biosphere Reserve 05 National Parks, 32 Wildlife Sanctuaries, and 03 conservation reserves covering 8,406.55 km² representing 15.09% geographical area of the State. Thus, Himachal Pradesh has three times more per cent area of its geographical area covered under PAs than the national average of just about 5%. However, in contrast, the State of Punjab with 20 PAs i.e., 13 Wildlife Sanctuaries, 04 conservation reserves, and 03 community reserves) covered a meager area of 381.33 km² and just represented 0.75% geographical area under PA network (Table 2.24). Comparing the status of PAs in different biotic provinces in two States, it was observed that State of Himachal Pradesh has nearly 41.22% area of the Trans-Himalaya biogeographic zone and 22.2% area of the Himalaya bio-geographic zone. The State had representation of 17.23% area of the country's Northwest Himalaya biotic province. Punjab represented a very small proportion (0.31%) of the Punjab plain biotic province. The average

size of PAs in Himachal Pradesh was 240.18 km² while the average size of the PA in Punjab was just 19.0 km².

Out of above PA network in two States, the Beas Riverscape included 03 National Parks and 10 Wildlife Sanctuaries within Himachal Pradesh. Three National Parks viz., the Great Himalayan National Park (GHNP), Inderkilla National Park, and Khirganga National Park and three Wildlife Sanctuaries (Kanawar, Sainj, and Tirthan) in the Great Himalaya in Kullu district collectively formed an important compact and contiguous PA complex covering 15,942.29 km² area and harbour a wide range of diverse forests from conifers to alpine pastures and several associated threatened floral and faunal species. This PA complex is not only rich in biodiversity but forms an important catchment tract for major tributaries viz., Parbati, Sainj, and Tirthan Rivers and *Jiwa Nallah*. Other PAs of Himachal Pradesh included in the Beas Riverscape were: *Manali*, *Nargu*, *Khokhan*, *Kais*, *Dhauladhar*, *Shikari Devi*, and the Pong Dam Lake, Wildlife Sanctuaries. The Pong Dam Lake Wildlife Sanctuary, a large man-made wetland and the Ramsar site is one of the prominent PAs of the Himachal Pradesh and also priority conservation site from the perspective of Beas Riverscape. Further, in the Punjab Plains, Harike Lake Wildlife Sanctuary at the confluence of Beas River with Sutlej River as a Ramsar site and recently created Beas River Conservation Reserve, also a Ramsar site and the only habitat for the Indus River Dolphin in India obviously are of highest conservation priority and require utmost attention and care in managing these unique and environmentally sensitive PA sites.

Table 2. 24 – Protected Area Network in Himachal Pradesh and Punjab Showing Biogeographic Representation

Biozone Number	Province Name	Province Area (km ²)	Name of PA	PA Area falling in province(km ²)	Total Area and % of PAs falling in Province
A. Himachal Pradesh					
01A	Ladakh Mountains	6,502	Pin Valley NP	675.00	675.00 (10.386%)
01B	Tibetan Plateau	7,325	Chandratal WLS	38.56	2,258.68 (30.84%)
			Kibber WLS	2,220.12	
02A	Northwest Himalaya	27,785	Great Himalayan NP	754.40	4,787.46 (17.23%)
			Inderkilla NP	104.00	
			Khirganga NP	710.00	
			Bandli WLS	32.11	
			Gangul Siyabehi WLS	108.40	
			Kais WLS	12.61	
			Kalatop-Khajjiar WLS	17.17	
			Kanawar WLS	107.29	
			Khokhan WLS	14.94	
			Kugati WLS	405.49	
			Lippa Asrang WLS	31.00	
			Manali WLS	29.00	
			Nargu WLS	132.37	
			Pong Dam Lake WLS	207.59	
			Rupi Bhabha WLS	503.00	

Biozone Number	Province Name	Province Area (km ²)	Name of PA	PA Area falling in province(km ²)	Total Area and % of PAs falling in Province
			Sainj WLS	90.00	
			Sechu Tuan Nala WLS	390.29	
			Shikari Devi WLS	29.94	
			Thirthan WLS	61.00	
			Tundah WLS	64.00	
02B	Western Himalaya	14,061	Chail WLS	16.00	685.41 (4.87%)
			Churdhar WLS	55.52	
			Darlaghat CR	0.67	
			Daranghati WLS	171.50	
			Majathal WLS	30.86	
			Renuka ji WLS	4.00	
			Rakchham Chitkul (Sangla Valley) WLS	304.00	
			Shilli Conservation Reserve	1.49	
			Shimla Catchment WLS	10.00	
			Shri Naina Devi Conservation Reserve	17.01	
			Simbalbara NP	27.88	
			Talra WLS	46.48	
A. Punjab					
04A	Punjab Plains	1,20,903	Abohar WLS	186.50	381.33 (0.31%)
			Beas River Conservation Reserve	Not Available	
			Bir Aishvan WLS	2.64	
			Bir Bhadson WLS	10.23	
			Bir Bunerheri WLS	6.62	
			Bir Dosanjh	5.18	
			Bir Gurdialpura WLS	6.20	
			Bir Mehaswala WLS	1.23	
			Bir Motibagh WLS	6.54	
			Harike Lake WLS	86.00	
			Jhajjhar Bacholi WLS	1.16	
			Kathlaur KushlianWLS	7.58	
			Keshopur Chham Community Reserve	3.40	
			Lalwan Community Reserve	12.67	
			Nangal WLS	2.90	
			Rakh Sarai Amanat Khan Conservation Reserve	4.95	
			Ranjit Sagar Conservation Reserve	18.65	

Biozone Number	Province Name	Province Area (km ²)	Name of PA	PA Area falling in province(km ²)	Total Area and % of PAs falling in Province
			Ropar Wetland Conservation Reserve	2.11	
			Siswan Community Reserve	12.95	
			Takhni – Rehampur WLS	3.82	

(Source: National Wildlife Database, WII, 2019)

A brief description of key features of PAs included within the Beas Riverscape is provided below.

(i) Great Himalayan National Park Conservation Area (GHNPCA)

A larger area including the Great Himalayan National Park (GHNP) in Kullu District along with the Sainj and Tirthan Sanctuaries and the buffer area (named as the Eco-development Zone) to GHNP was coined as the Great Himalayan National Park Conservation Area (GHNPCA) at the time of multi-disciplinary research studies were undertaken by the Wildlife Institute of India under the IDA funded Forestry Research, Education and Extension Project (FREEP) (WII, 1999; Mehra and Mathur, 1999). After an exhaustive exercise of rationalization of PA boundaries initiated by the Wildlife Wing, HPFD and duly approved by the MoEF&CC, Government of India, the State has also notified Khirganga National Park adjacent to GHNP. Thus, the contiguous and compact forest patch today covers 1615.40 km².

Great Himalayan National Park (GHNP) is the most important Protected Area in the Beas sub-basin. The park was initially notified in 1984. The final notification of the park was issued in 1999. It is comprised of the catchments of Jiwa, Sainj and Tirthan rivers. It is bounded by Rupi Bhaba, Sainj and Kanawar WLS and Pin Valley National Park. The GHNP represents the 2A North-west Himalaya Biogeographic Zone. The Khirganga NP was established on July 28, 2010 covering an area of 710 km².

GHNP is most important component of GHNPCA. Great Himalayn NP harbours forests of Oak (*Quercus oblongata*) Brown Oak (*Quercus semecarpifolia*), Blue Pine (*Pinus wallichiana*), West Himalayan Silver Fir (*Abies pindrow*), West Himalayan Spruce (*Picea smithiana*) and Himalayan Cedar (*Cedrus deodara*). The broad-leaf forests contain Horse Chestnut (*Aesculus indica*), *Rhododendron arboreum*, *Quercus oblongata*, *Q. floribunda* at the lower altitudes and pure patches of Birch (*Betula utilis*) at higher altitudes. Yew (*Taxus wallichiana*) form an important medicinal tree of the understory. A rich variety of shrubs and patches of ringal bamboos (*Drepanostachyum falcatum* and *Thamnocalamus spathiflorus*) are found as a dense understory. The shrubs of (*Rhododendron campanulatum*) forms the characteristic Krummholz patch in the sub-alpine zone, which is an important habitat of musk deer. Other shrubs that occur extensively at about 3,700 m are *Juniperus communis*, *J. indica*, along with species of *Lonicera*, *Berberis*, *Cotoneaster*, *Viburnum* and *Rosa* occur extensively at about 3,700 m. There are a number of man-made forest clearings/grasslands locally known as *thach* used as grazing and camping ground for the migratory livestock (predominantly

sheep and goat). The alpine flora occurring above 3,500 m is characterized by species with medicinal and economical values (RSET, 2019). They include: *Aconitum chasmanthum*, *A. violaceum*, *Fritillaria roylei*, *Jurinea macrocephala*, *Rheum australe*, *Bergenia ciliata*, *Picrorhiza kurroa*, *Nardostachys jatamansi*, *Saussurea graminifolia*, etc. A total of 832 plant species belonging to 427 genera and 128 families of higher plants were reported from GHNPCA (Singh and Rawat, 1999). Thirty-one mammalian species have been recorded in the area (Vinod and Sathyakumar, 1999; Mehra and Mathur, 1999). Main mammal species found are: Serow (*Capricornis sumatraensis*), Himalayan Tahr (*Hemitragus jemlahicus*), Goral (*Nemorhaedus goral*), Blue Sheep (*Pseudois nayaur*), Himalayan Black Bear (*Selenarctos thibetanus*), Himalayan Brown Bear (*Ursus arctos*), Himalayan Red Fox (*Vulpes vulpes*), and Musk Deer (*Moschus chrysogaster*). The GHNPCA is home to 209 bird species, which include the endangered Western tragopan and four other pheasant species (Ramesh *et al.*, 1999). GHNPCA was inscribed as the World Heritage Site by the UNESCO in 2014 in recognition of its outstanding significance for biodiversity conservation.

(ii) Inderkilla National Park

Final notification of ESZ of Inderkilla NP was issued on 17 January, 2018. Inderkilla NP is comprised of the catchments of *Hamta Nallah*, *Jobrie Nallah* and *Allain Nallah*. It comprises the habitat of Snow leopard (*Panthera uncia*), Himalayan Brown Bear (*Ursus arctos*), Himalayan Tahr (*Hemitragus jemlahicus*), Black Bear (*Ursus thibetanus*), Himalayan Ibex (*Capra ibex*), Musk Deer (*Moschus chrysogaster*), Himalayan Griffon (*Gyps himalayensis*) and several important floral species viz., Rakhal (*Taxus wallichiana*), Bhojpatara (*Betula utilis*), Maple (*Acer caesium*, *A. pictum*, *A. sterculiaceum*), Shingli Mingli (*Dioscorea deltoidea*), Patish (*Aconitum* spp.), Dhoop (*Jurinea macrocephala*), Artemisia (*Artemisia* spp.), Salam Panja (*Dactylorhiza hatageria*), Jatamansi (*Valeriana jatamansi*), Karu (*Picrorhiza kurroa*) Banaksha (*Viola* spp.) etc. are the important rare, endangered, threatened flora and fauna of the National Park. The proposed *Jobrie* HEP is located within the National Park boundary. The operational *Allain Duhangan* HEP also located within ESZ of the NP.

(iii) Manali WLS

Manali WLS is comprised of catchment of *Manalsu Nallah* upstream of *Kaland* village which is a right bank tributary of Beas River joining at Manali town. The sanctuary harbours rich floral and faunal diversity. Biological significance of the area is characterized by forests of Deodar (*Cedrus deodara*), Fir (*Abies pindrow*), Spruce (*Picea smithiana*) and Kail (*Pinus wallichiana*) among conifers and a variety of broad leaved species represented by species of *Prunus*, *Acer*, *Juglans*, *Buxus*, *Rhododendron*, *Celtis*, *Betula*, *Ulmus*, *Aesculus*, *Alnus*, *Quercus* spp. etc. The proposed *Manalsu* HEP is located within the sanctuary.

(iv) Kanawar WLS

Kanawar WLS comprises of upper catchments of *Dolang* and *Hurla Nallahs*. Dolang Nala drains into Parbati River on its left bank while Hurla Nala drains into Beas River. The Head Race Tunnel of Parbati-II HEP passes through Kanawar WLS.

(v) Khokhan WLS and Nargu WLS

Nargu and Khokhan Sanctuaries comprise of part catchments of Uhl River and *Sarbari Khad*. Biodiversity significance of these PAs is characterized by avifauna like Western Tragopan (*Tragopan melanocephalus*) Himalayan Monal (*Lophophorus impejanus*), Chukor (*Alectorischukar*), Koklas (*Pucrasia macrolopha*) and Kalij (*Lophophorus leucomelanus*) while among mammals Musk Deer (*Moschus chrysogaster*), Barking deer, Leopard, Leopard Cat, Jungle Cat, Himalayan Yellow-throated Marten, Black Bear, Brown Bear, Porcupine are the important faunal elements inhabiting the two sanctuaries. They have dense forests of Deodar, Fir, Spruce, Kail and Rhododendron.

(vi) Kais WLS

It is small sanctuary comprising the catchment of *Kais Nallah* located on the left bank of Beas River. Important faunal elements of the sanctuary are Himalyan Monal (*Lophophorus impejanus*), Kalij (*Lophophorus leucomelanus*), Chukor (*Alectoris chukar*) and Grey Partridge (*Perdix perdix*) among birds and Black Bear, Goral, Leopard Cat and Himalayan Yellow-throated Marten. The forests are comprised of Ban Oak (*Quercus oblongata*) forest, Moist deodar forest, Western mixed coniferous forest, Moist temperate and Kharsu (*Quercus semecarpifolia*) oak forests.

(vii) Dhauladhar WLS

Large part of Dhauladhar WLS falls in Ravi River catchment and only southern part of the sanctuary falls in upper catchment of Uhl River, a tributary of Beas River. Biological significance of the sanctuary is comprised of mammals like Himalyan Tahr, Himalyan Ibex, Musk Deer, Serow and Brown Bear. The area is rich in avifaunal diversity comprised of species like Rock Bunting, Wren, Western tragopan, Himalyan Monal, Kalij and Koklas Pheasants. The area is rich in butterflies also. Two proposed HEPs viz., *Bhujling* and *Makori* HEPs fall within Dhauladhar WLS (RSET, 2019).

(viii) Shikari Devi WLS

Notified in June, 2013, it encompasses an area of 213.51 sq. kms in Mandi district under Kullu (WL) Division. The Northern part of the sanctuary is comprised of upper catchment of Deola Nala draining into Beas River while its southern part drains into the Sutlej River. Besides good forests and vast alpine meadows, the area is rich in faunal elements, especially the avifaunal diversity.

(ix) Pong Dam Lake WLS

It is comprised of reservoir formed by Pong dam; having area of 307 sq. km. Pong Dam Lake WLS is famous for its rich bird diversity, especially the winter migrants. The avifaunal diversity of Pong Dam Lake sanctuary has already been provided in the section on wetlands.

Besides protected areas, the riverscape includes one World Heritage Site (GHNPCA), two Ramsar sites (Pong Dam Lake and Harike Lake), and 10 Important Bird Areas (IBAs). The Bird Life International is the world's largest nature conservation partnership. It identifies Important Bird Areas (IBAs) worldwide for conservation action. The Bombay Natural History Society (BNHS) is the Bird Life partner for India and is responsible for coordinating the IBA programme in the country. Altogether, 467 IBAs have been identified so far in the country (Birdlife International, 2017). India's IBAs are host to 75 species of globally threatened birds. In Himachal Pradesh, 27 IBAs have been included and they represent two national parks, 24 sanctuaries and only one of them is non-protected area (Islam and Rahmani, 2004). The Beas Riverscape part in Himachal Pradesh has nine IBAs while the part of alluvial plains in Punjab has only one IBA i.e., the Harike Lake Bird Sanctuary. In addition, the Punjab State also has two more IBAs viz., Kanjali Lake and Ropar Lake.

The above description has revealed that most of the PAs within the two States and the Beas Riverscape are small and widely scattered as islands in amidst the human dominated landscape. Most PAs owing to small size and irregular shapes have a peculiar situation of PA-People interface that results into human wildlife conflict. The common leopard (*Panthera pardus*), wild pig (*Sus scrofa*) and Rhesus Macaque (*Macaca mulatta*) are in conflict with people in the larger part of Himachal Pradesh. Most PAs also suffer on account of the non-compatible land use around them or various activities of infrastructure development in their proximity. Most PAs, particularly sanctuaries, conservation reserves and community reserves are burdened by traditional resource dependent communities. Majority of PAs face enormous problems on account of wide-spread invasive alien species resulting into loss of vital habitat for wild fauna. PAs area greatly influenced by activities of multi-agencies involved in developmental works. The wider concept of landscape approach to conservation is essential so as to link different PAs by appropriate corridors provided by reserved and categories of forests.

Despite varied demands of burgeoning human population and multitude of pressures, two States have succeeded in establishing a large number of PAs, consolidated their boundaries and ensured adequate protection ultimately helping in recovery or maintenance of several threatened species. Nevertheless, PA managers always face enormous pressure and they try to address them in available limited resources and capacity. One of the milestones in the conservation history for the Himalayan States was the launch of Project Snow Leopard in 2009 that gave a boost to the conservation of elusive species, its prey and habitat. Since then, substantial research and monitoring work on the species has been undertaken in Himachal Pradesh as well as other Himalayan States. The enactment of Forest (Conservation) Act, 1980 that envisage prior approval of the GoI for diversion of forest lands for non-forestry purposes was a timely welcome step as its enforcement has greatly reduced diversion of forest lands by the State Governments. The National Wildlife Action Plan, 1984 and subsequent revisions

provided not only direction but also the desired thrust for the conservation movement. The National Forest Policy, 1988 was undoubtedly a distinct departure from the previous forest policy of 1952 as the new policy laid emphasis on environmental stability, participatory approaches of forest management, and recognizing needs of forest dwellers and others. The States decided to forego the substantial revenue from forest operations as they shifted emphasis to the conservation of scarce and fast depleting natural resources, particularly biodiversity. The timely provision of yet another legislative act i.e., the Environmental (Protection) Act, 1986 by the Central Government has immensely helped the country after its enactment in improvement of human environment, particularly in the urban areas by ensuring effective measures for air, water and noise pollution and even the waste management besides the prevention of hazards to living creature and human property. The EPA, 1986 also facilitated the identification and establishment of Eco Sensitive Zones around majority PAs in the country. In subsequent decades, the enactment of Biological Diversity Act in 2002 has not only helped in fulfillment of country's obligations and commitments under the United Nations Convention on Biological Diversity but also in recognition of role of local communities in documenting and managing biodiversity of their respective areas as the biodiversity registers and contribution through the Biodiversity Management Committees (BMCs) at the grassroots level. Further, in past decades or so, India has signed international conventions related to conservation of biodiversity, combat of desertification, conservation and wise use of wetlands, climate change mitigation and adaptation, control of illegal trade of endangered species, their products and derivatives, and protection and conservation of migratory species. The country has been able to avail the optimum benefit of the UNESCO's global programme on Biosphere Reserves and World Heritage Sites. Most States have taken advantage of such programmes and established biosphere reserves and a wide range of WHS in natural as well as cultural categories.

Thus, from the above description it is evident that the GoI has enacted various legislative acts, formulated policies, strategies and action plans and to safeguard the interests of forests, wetlands including rivers, wildlife, and the environment. On the one hand, the country aims to emerge as the fastest growing economic nation while on the other hand committed to contribute meaningfully for the global agenda on climate change mitigation and sustainable development. Definitely, the country face enormous challenges to strike the balance between the conservation and development and much needs to be done to conserve the 'natural capital' which is central to the goals of growing economy and sustainable development.

2.5 Geospatial Analysis of the Beas Riverscape and Modeling for Prioritization of Sites for Forestry Interventions

The preceding Chapters have justified the rationale for adopting the concept of 'riverscape' for the purpose of present DPR on forestry interventions for rejuvenation of Beas River, the approach to delineate the Beas Riverscape, its geospatial analysis and criteria for modeling to prioritize sites for proposed forestry interventions within the delineated riverscape. Further, the preceding section has described the physical and biological sub-environments of the Beas

Riverscape so as to comprehend the existing situation of the physical conditions and biological diversity within the riverscape and at the same time to appreciate the factors responsible for the current state of environment and degradation of natural resources, particularly the river ecosystem, the analysis of river environment also helped in understanding the past trends and in recognizing the major challenges, issues, threats and constraints relevant to conservation of Beas River ecosystem. The following section presents the findings based on geospatial analysis of the Beas Riverscape and priority sites identified for forestry interventions on the basis of multi-criteria modeling performed for the purpose.

(i) Altitude and Digital Elevation Model (DEM)

Altitude, particularly in the Himalayan Mountains plays a decisive role in the physical characteristics, biological diversity and its distribution, socio-economic uses and consumption patterns. In particular, higher altitudes greatly influence river flow, rate of sedimentation, vegetation, wild animal use and even human settlements and their uses. Advanced Land Observing Satellite based Digital Elevation Model (ALOS-DEM) data was downloaded from <http://www.asf.alaska.edu/> and was used to derive the elevation classes in the Beas Riverscape (Fig. 2.9). The different elevation classes were regrouped and a total of 12 elevation classes were been derived (Fig. 2.10). The riverscape from south-west to north-east direction depicts large altitudinal variation from 127 m to 6,488 m amsl. The distribution of areas under different elevation classes within the riverscape is presented in Table 2.25 and it revealed that nearly 50% area of the riverscape lies at altitude >1,000 m. The maximum extent of 2,801.96 km² or 16.74% area of the riverscape represented the lowest category of the elevation class i.e., <250 m. About 11.27% of the riverscape belong to the higher altitude >4,000 m (Table 2.25 and Fig 2.11). The entire area of alluvial plains in Punjab falls under the lowest altitudinal class of <250 m. Thus, substantial area of about 13,942 km² or 83% area of the riverscape lies in the Himalayan State of Himachal Pradesh that harbours diverse forests from sub-tropical broad leaved moist or mixed deciduous forests to upper temperate forests. However, most of these forests are under severe influence of biotic pressure. They need efforts towards protection, enhanced regeneration and gap plantations. Degraded forests or areas presently devoid of vegetation owing to past activities or in sides in close proximity to hydro-electric projects (HEPs), townships, riverine habitats or roadsides have ample opportunities for suitable forestry interventions. Areas above 3,000 m representing nearly 20% area of the riverscape have little opportunities for forestry interventions except in lower parts of this elevation class due to steep slopes with poor soil conditions, snow-covered and avalanche prone areas exhibiting cold desert like conditions. Nevertheless, there is opportunity for limited plantations of select species, improvement of alpine pastures or cultivation of medicinal plants in the lower elevations of this DEM class.

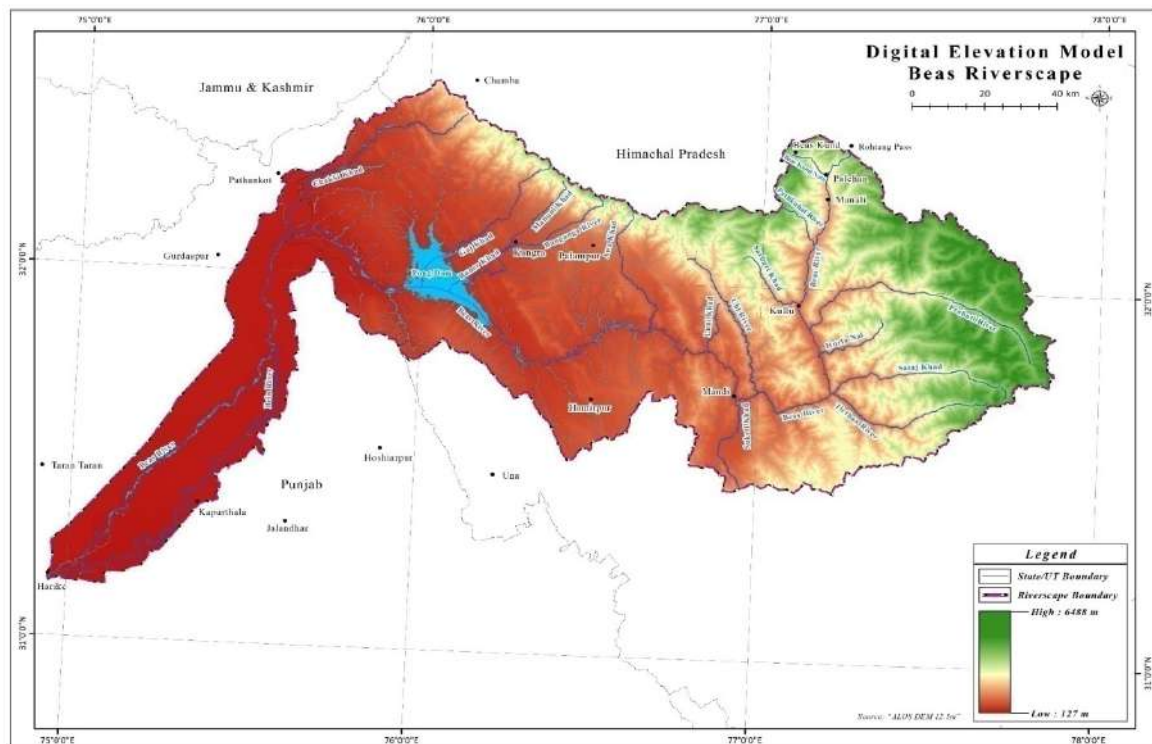


Fig. 2. 9 – Digital Elevation Model of Beas Riverscape

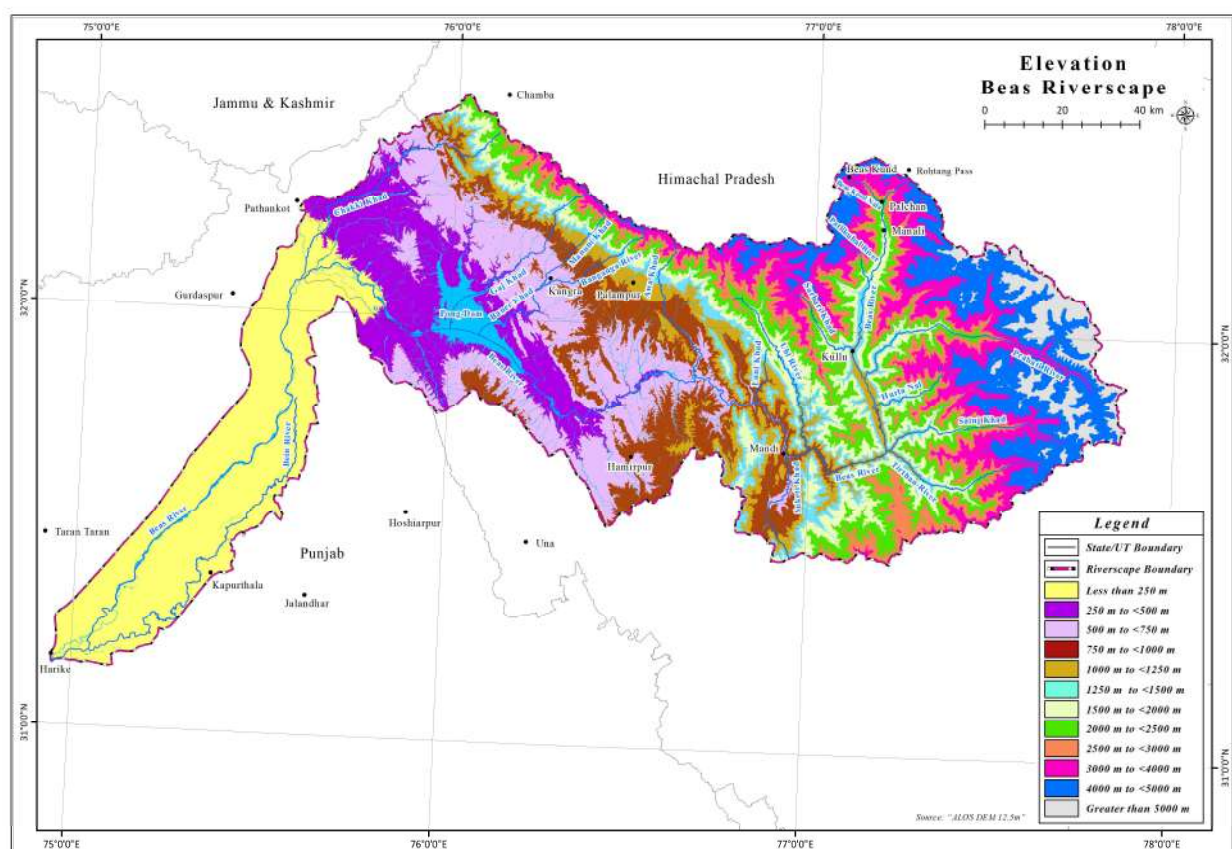


Fig. 2. 10 – Altitudinal Variation in Beas Riverscape

Table 2. 25 - Distribution of Area of Beas Riverscape under Different Elevational Classes

Sr.No.	Elevation Classes	Area (in km ²)	Representation of the Class (%)
1	<250 m	2801.96	16.74
2	250 m to <500 m	1,874.72	11.20
3	500 m to < 750 m	2,176.48	13.00
4	750 m to <1000 m	1,574.83	09.41
5	1,000 m to <1,250 m	906.86	05.42
6	1,250m to <1,500 m	680.64	04.07
7	1,500 m to <2,000 m	1,140.02	06.81
8	2,000 m to <2,500 m	1,195.49	07.14
9	2,500 m to <3,000 m	1,093.24	06.53
10	3,000 m to <4,000 m	1,410.88	08.43
11	4,000 m to <5,000m	1,413.40	08.44
12	≥5,000 m	474.49	02.83
	Total	16,743.01	100

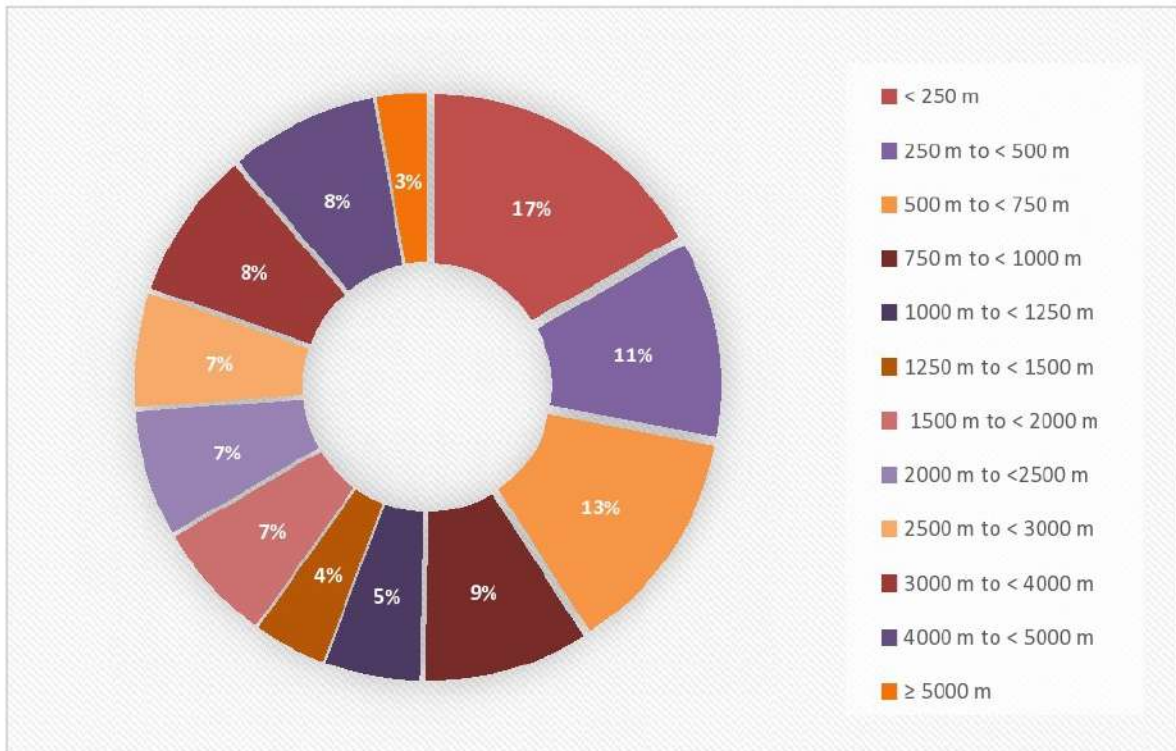


Fig. 2. 11 - Distribution of Altitude in different Elevation Classes

(ii) Slope

Slope matters in the context of Himalayan Mountains as it is considered vital while suggesting suitability of areas for forestry interventions, particularly plantations and soil moisture conservation works. Varied classification characterizing different slope classes exist. A total of 10 classes of slope have been derived in the riverscape and appropriately named (Table 2.26). The higher degree of slopes ($>30^\circ$) usually cause a lot of soil erosion and are prone to landslides, greater runoff, etc. Thus, areas with slopes $>30^\circ$ to 45° require safeguards from erosion while raising plantations of multiple values i.e., fuelwood, fodder, small timber, etc. These types of forest resources are in heavy demand in upper reaches due to increased pressure of tourism activities, presence of paramilitary forces, transhumance pastorals, and widespread human settlements. The distribution of areas under different slope classes is presented in Table 2.26. Nearly one-fourth area of the riverscape lies in slope category $>30^\circ$. About 10% area of the riverscape has slopes $>40^\circ$. About 17% area of the riverscape lies in slope class $<2.5^\circ$ or nearly level slope category. A reasonable area of about 39.3% of the riverscape that lies southwest direction has lower categories of slope $<10^\circ$ (Fig. 2.12 and Fig. 2.13).

Table 2. 26 - Distribution of Area of Beas Riverscape under Different Slope Categories

Sr. No.	Slope Class	Slope Category	Area (km ²)	Percentage of Total Area (%)
1	$< 2.5^0$	Nearly Level	2,816.99	16.82
2	2.5^0 to $<5^0$	Gently Undulating	1,860.77	11.11
3	5^0 to $<10^0$	Gently Rolling	1,919.15	11.46
4	10^0 to $<15^0$	Moderately Rolling	1,525.37	09.11
5	15^0 to $<20^0$	Strong Rolling	1,520.86	09.08
6	20^0 to $<25^0$	Moderately Steep	1,390.87	08.31
7	25^0 to $<30^0$	Steep	1,505.56	08.99
8	30^0 to $<35^0$	Very Steep	1,428.67	08.53
9	35^0 to $<40^0$	Extremely Steep	1,196.52	07.15
10	$\geq 40^0$	Escarpement	1,578.25	09.43
Total			16,743.01	100.00

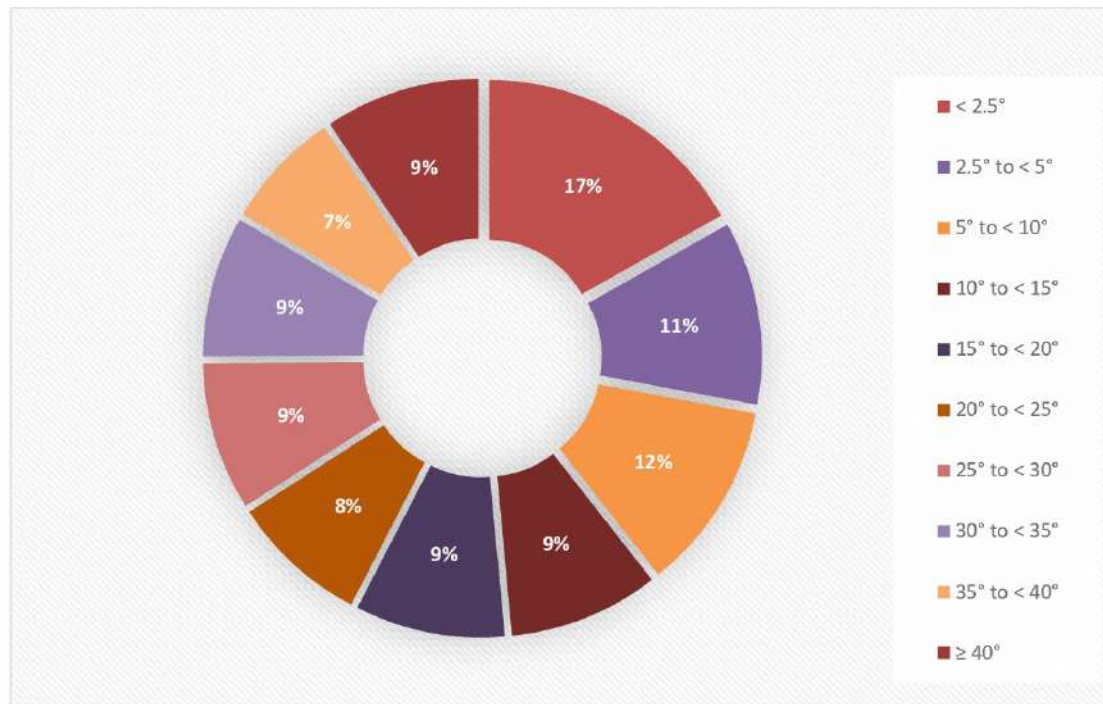


Fig. 2. 12 - Distribution of Beas Riverscape Area under Different Slope Categories

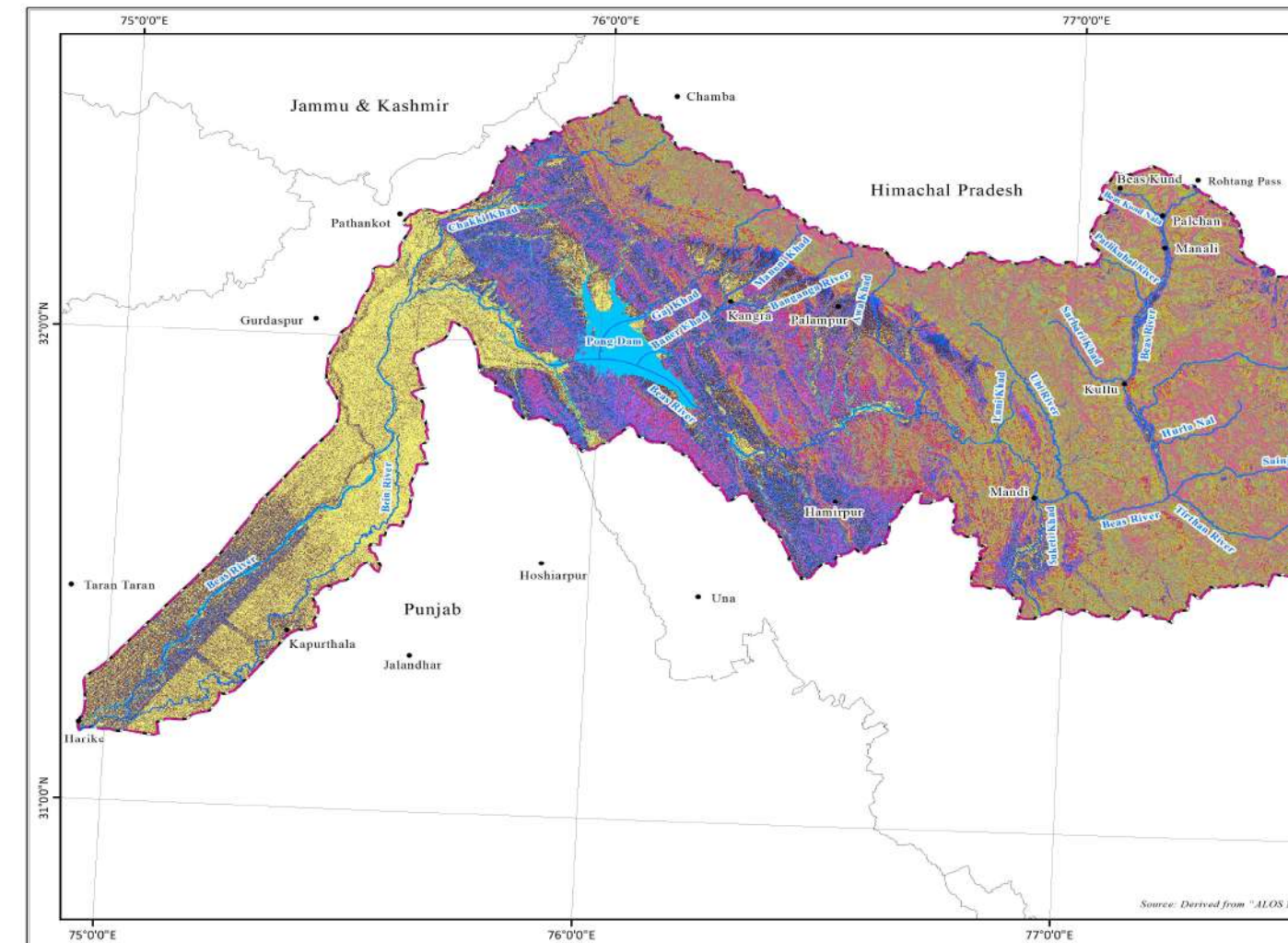


Fig. 2. 13 - Distribution of Beas Riverscape Area under Different Slope Categories

(iii) Aspect

Aspect, particularly in the Himalayan Mountains, influences the diversity and distribution of vegetation and microclimate. In the Himalaya, this effect can be seen to an extreme degree. North and south facing opposing slopes vary in their microclimate; light intensity, soil and air temperature, humidity, soil moisture and evaporation and duration of growing periods and these differences are closely associated with differences in vegetation composition and structure. In general, south facing slopes in the lower to upper temperate forests in the Middle and Greater Himalayas receive more sunlight. Hence, southern slopes are more xeric and warmer, supporting drought-resistant vegetation (grassy slopes and scrub) and less favourable for tree growth. In contrast, north facing slopes due to dense forest cover retain greater amount of moisture and are cold and humid. The northern slopes support moisture loving plants (Cantlon, 1953; FRI, 2016). Mostly, the drainage of the Beas River and a majority of its tributaries flow from north to south or south-westwards. Thus, run-off and sedimentation rates on these aspects are always prominent and higher. The spatial distribution of aspect in the Beas Riverscape has been derived from the ALOS DEM. A total of nine categories viz., North, North-East, East, South-East, South, South-West, West, North-West and the Flat land were analyzed in the Beas Riverscape. The area distribution under different aspect classes is presented in Table 2.27 and shown in Fig. 2.14 and Fig. 2.15.

Table 2. 27 - Distribution of Beas Riverscape Area in Different Aspect Categories

Sr.No.	Aspect	Area (in km ²)	Percentage of Total Area (%)
1	Flat (-1)	912.07	05.45
2	North (0-<22.5, ≥337.5-360)	1,731.99	10.34
3	Northeast (22.5-<67.5)	1,806.61	10.79
4	East (67.5-<112.5)	1,771.41	10.58
5	Southeast (112.5-<157.5)	1,988.92	11.88
6	South (157.5-<202.5)	2,013.37	12.03
7	Southwest (202.5-<247.5)	2,397.83	14.32
8	West (247.5-<292.5)	2,140.85	12.79
9	Northwest (292.5-<337.5)	1,979.96	11.83
Total		16,743.01	100.00

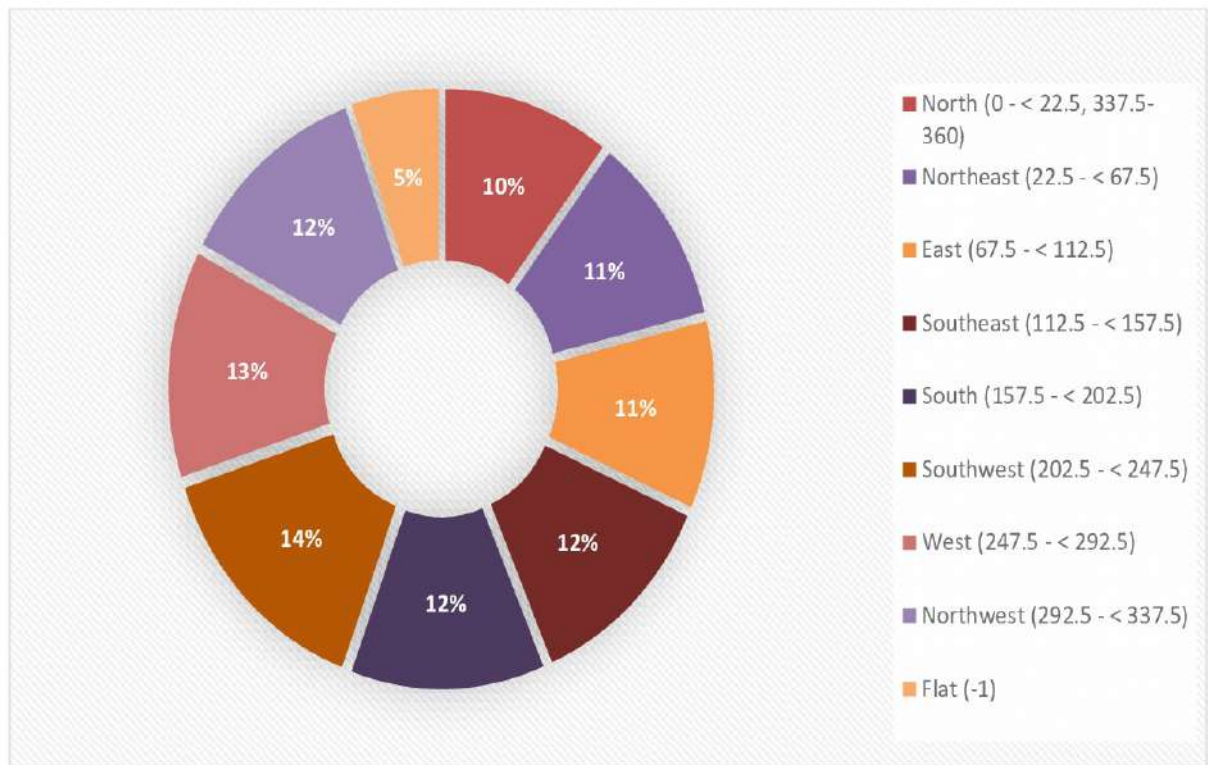


Fig. 2. 14 - Distribution of Beas Riverscape Area under Different Aspect Categories

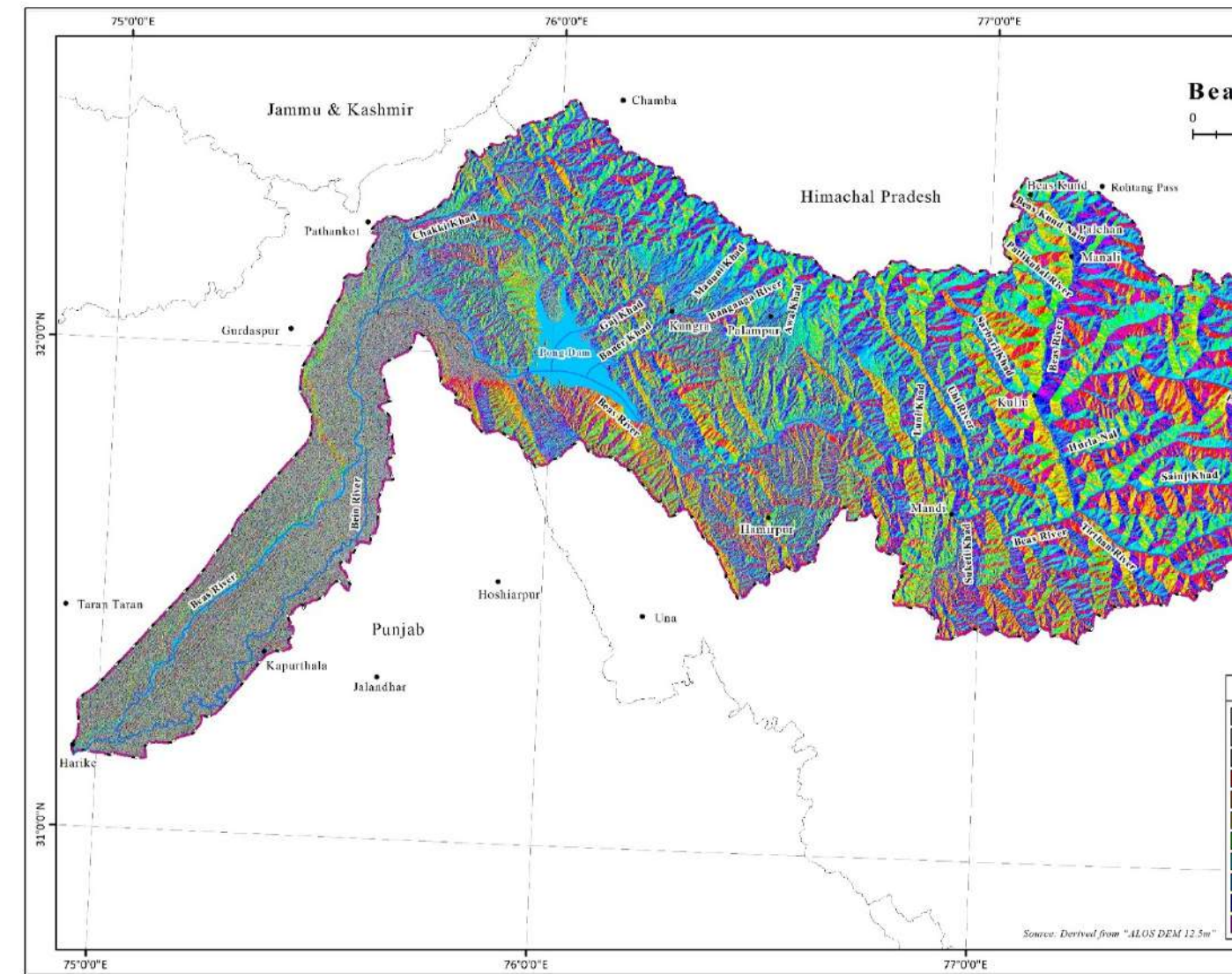


Fig. 2. 15 - Showing Distribution of Aspect within Beas Riverscape

(iv) Soil Types

Soil is a mixture of organic matter, minerals, gases, liquids, and organisms that together supports life. The earth's body of soil is called as the pedosphere and has four important functions to perform. These functions are: (a) provide medium for plant growth, (b) serves as a means of water storage, supply and purification, (c) help as a modifier of earth's atmosphere and store carbon, and (d) provide habitat for a wide range of organisms including invertebrates, microorganisms, etc. Soil is a product of several factors *viz.*, the influence of climate, relief (elevation), orientation, and slope of terrain), organisms, and the soils parent materials (original minerals) interacting over time. Soils continuously undergo development by way of numerous physical, chemical and biological processes including weathering and associated erosion. Natural ecosystems *i.e.*, forests, grasslands, wetlands and agroecosystems) are impacted in far reaching ways by the various processes carried out in the soil. Hence, from the perspective of present DPR, understanding of soils in the riverscape is critical as they form an important biotic variable that determines the suitability of site conditions for proposed forestry interventions, mainly tree and other plantations *i.e.*, grass, herbs, shrubs, medicinal plants, orchards, etc. Since choice of species mainly depends upon the soil type and soil depth, these parameters have been derived from the Soil map prepared by the NBSS-LUP for further use in modelling in the present study on geospatial analysis. A total of 17 soil type classes and one class of non-soil have been recorded in the Beas Riverscape (Table 2.28). Various soil types and their proportionate area estimates are presented in Table 2.28. The soil type - Typic Udorthents was the most dominant soil type in the Beas Riverscape as this soil type covered nearly 37% area of the riverscape. These types of soils are found on moderate to steep slopes, and moderately eroded. This was followed by Dystric Eutrochrepts occupying 19.36% of the riverscape and they are characterized as deep, well drained and thermic fine loamy soils. The soil type - Typic Cryorthents ranked third in the area proportion and was prominent in upper reaches in the north-eastern part of the riverscape and occurred in glacio-glacial valleys (Fig. 2.16 and Fig. 2.17).

Table 2. 28 - Distribution of Area under Different Soil Types and Other Land Attributes

Sr. No.	Soil type	Area(km ²)	Percentage of Total Area (%)
1	Dystric Eutrochrepts: Deep, well drained, thermic and fine-loamy soils on very steep slopes with loamy surface and severe erosion.	3,240.95	19.36
2	Fluventic Eutrochrepts: Coarse loamy, mixed, non-acedia and hypothermic soils.	32.29	0.19
3	Fluventic Ustochrepts: Very deep, moderately well drained coarse loamy soils, occurring on very gentle slopes in active alluvial plains with fluvial parent material.	141.92	0.85

Sr. No.	Soil type	Area(km ²)	Percentage of Total Area (%)
4	Lithic Cryorthents: Poorly developed soils, semi permanent snow, bank is simply a thin sandy A-horizon over a C-horizon.	306.92	1.83
5	Lithic Udorthents: These soils have a lithic contact within 50 cm of the surface and some of them have high biological activity above this lithic contact.	4.89	0.03
6	Typic Cryorthents: Soils of glacio-glacial valley with moderate slopes occupied with moderately shallow, excessively drained, sandy-skeletal, neutral to slightly acidic, moderately eroded, and strongly stony.	1,288.78	7.70
7	Typic Dystrichrepts: Sandy skeletal, mixed mineralogy soils, parent material is volcanic ash influenced loess over residuum from granite.	57.97	0.35
8	Typic Eutrichrepts: Deep, well drained, thermic, fine-loamy and calcareous soils on moderately steep slopes with loamy surface and severe erosion.	1,067.33	6.37
9	Typic Hapludalfs: Dominated the lower-lying sideslopes on the south-facing side, which are composed of colluvial materials weathered from sandstone and the underlying limestone residuum.	160.53	0.96
10	Typic Haplustalfs: Freely drained soils are moderately deep or deep to hard rock.	314.24	1.88
11	Typic Udifluvents: Have moderately good or good drainage, occur in relatively high areas on flood plains, and the water table is deeper than 50 cm all of the time.	1,129.48	6.75
12	Typic Udorthents: Found on moderate to steep slopes, are slightly to moderately acidic, moderately eroded, and moderate to strong stony.	6,153.25	36.75
13	Typic Ustifluvents: Very deep imperfectly drained fine soils occurring on flat to nearly level active alluvial plain.	516.50	3.08
14	Typic Ustipsamments: Sand that have deep ground water and a thick regolith.	511.19	3.05
15	Typic Ustochrepts: Coarse-loamy soils derived from mixed alluvium or residuum weathered from sand stone and shale.	723.84	4.32
16	Typic Ustorthents: Soils those are deep or moderately deep to hard rock and those do not have ground water within 150 cm.	131.95	0.79

Sr. No.	Soil type	Area(km ²)	Percentage of Total Area (%)
17	Udic Ustochrepts: Coarse-loamy soils derived from mixed alluvium or residuum weathered from sand stone and shale.	376.91	2.25
18	Non Soil: Areas that do not support plant growth are not considered but mapped. These may be glaciers, bedrock outcrops, urban land, active quarries, etc.	584.07	3.49
Grand		16,743.01	100

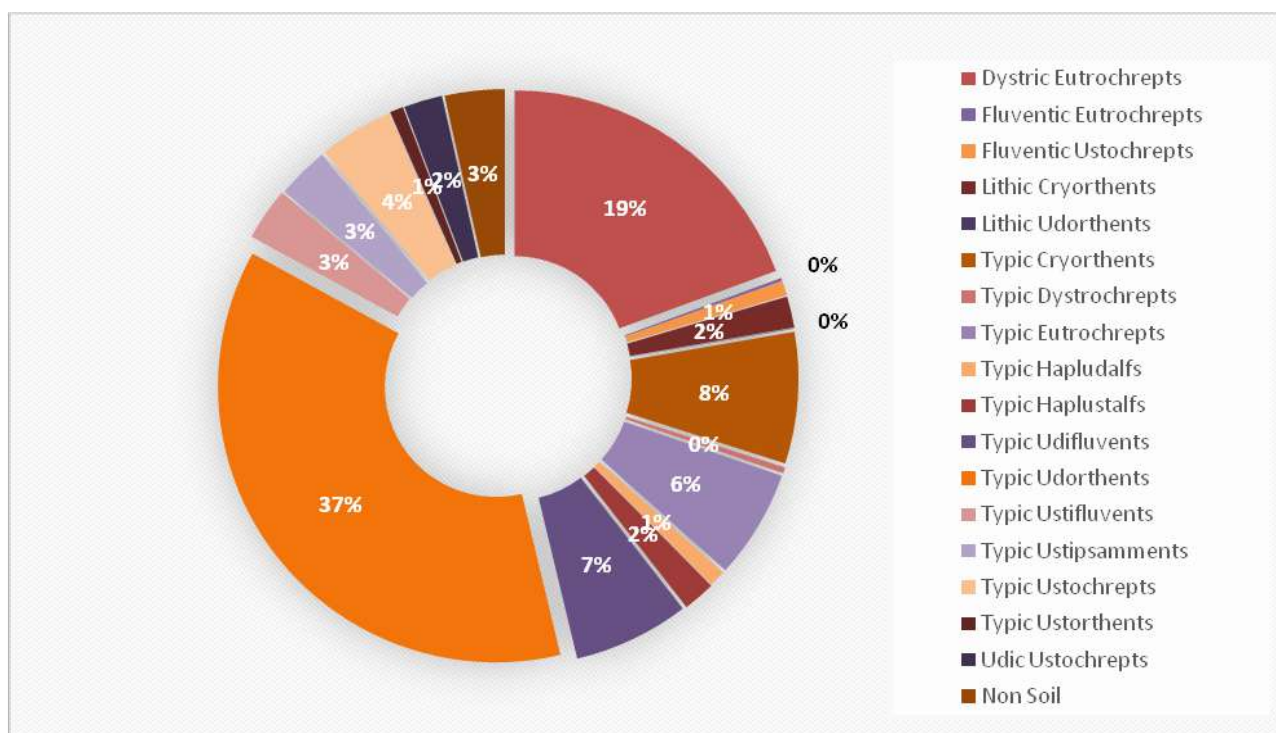


Fig. 2. 16 - Distribution of Area under different Categories of Soil Types or Categories

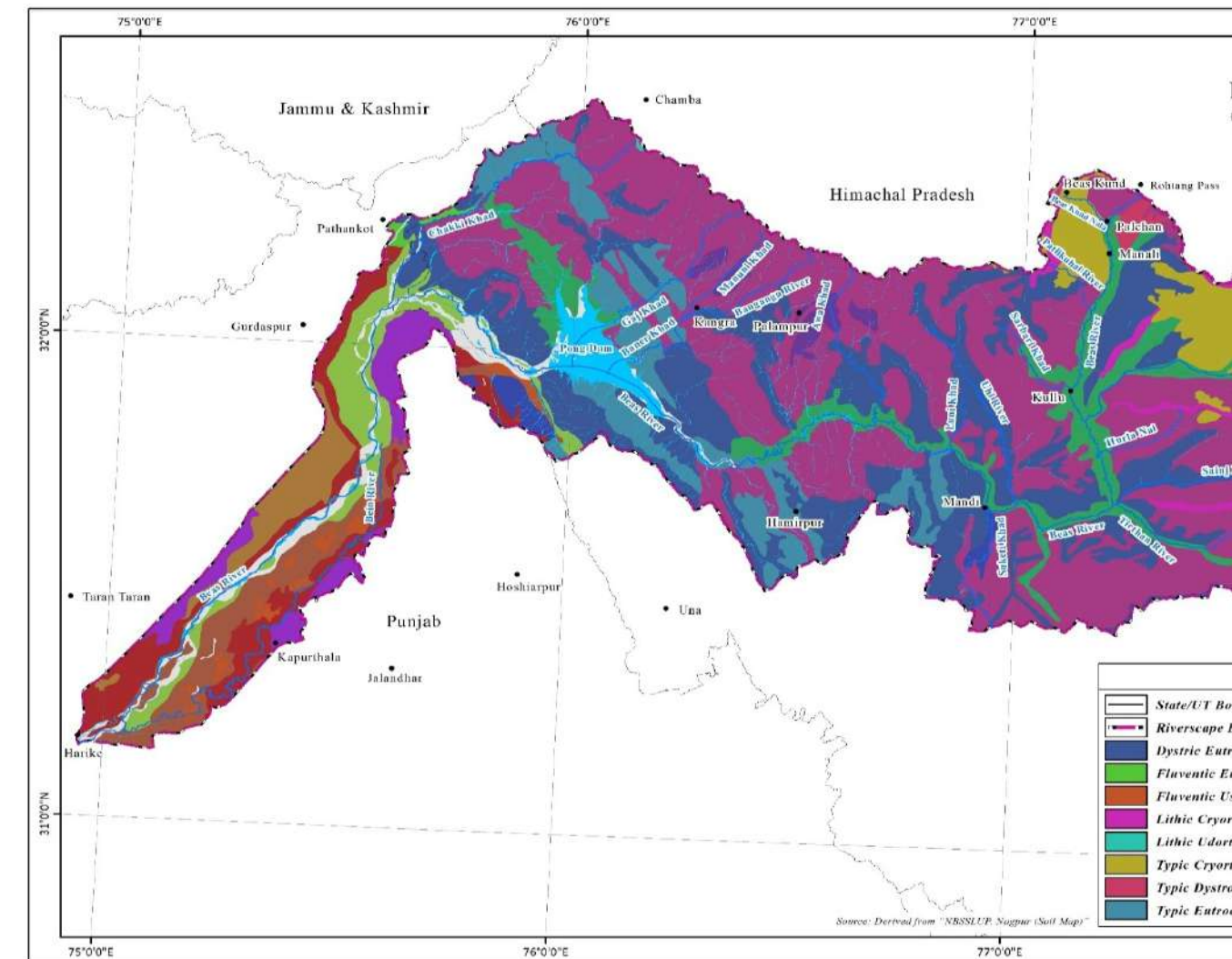


Fig. 2. 17 – The Distribution of Soil Types within Beas Riverscape

(v) Soil Depth

Soil depth, in addition to soil type, texture and structure can influence water availability, limit root growth and can influence nutrient access. Soil depth can greatly influence the type of plants that can grow in them. Deeper soils generally provide more water and nutrients to plants than more shallow soils. Thus, soil depth is another important variable for suggesting suitability of tree species for a plantation model. The depth is important for the penetration of the roots of plant or tree species. Four depth classes *viz.*, Very Deep, Moderately Deep, Deep and Shallow have been mapped in the Beas Riverscape. The distribution of area under different soil depth classes is provided in Table 2.29. Nearly 32% area of the riverscape has moderately deep soils while shallow soils accounted for 22.62% area of the riverscape. About 16% area of the riverscape has very deep soils while 26.84% area harbour deep soils (Fig. 2.18 and Fig. 2.19). Shallow soils are distinctly prominent in the northern and southeastern part of the riverscape. The larger mountainous part of the riverscape in Himachal Pradesh has moderately deep to deep soils. Very deep soils were conspicuously prominent in the alluvial plains or north western, lower part of the riverscape. The moderately deep soils predominantly occurred around the course of the main channel and various tributaries.

Table 2. 29 - Distribution of Areal Extent in Beas Riverscape under Different Soil Depth Categories

Sr. No.	Soil depth	Area (in km²)	Percentage of Total Area (%)
1	Very Deep	2,536.83	15.15
2	Moderately Deep	5,341.70	31.90
3	Deep	4,493.59	26.84
4	Shallow	3,786.82	22.62
5	Non Soil	584.07	3.49
Total		16,743.01	100.00

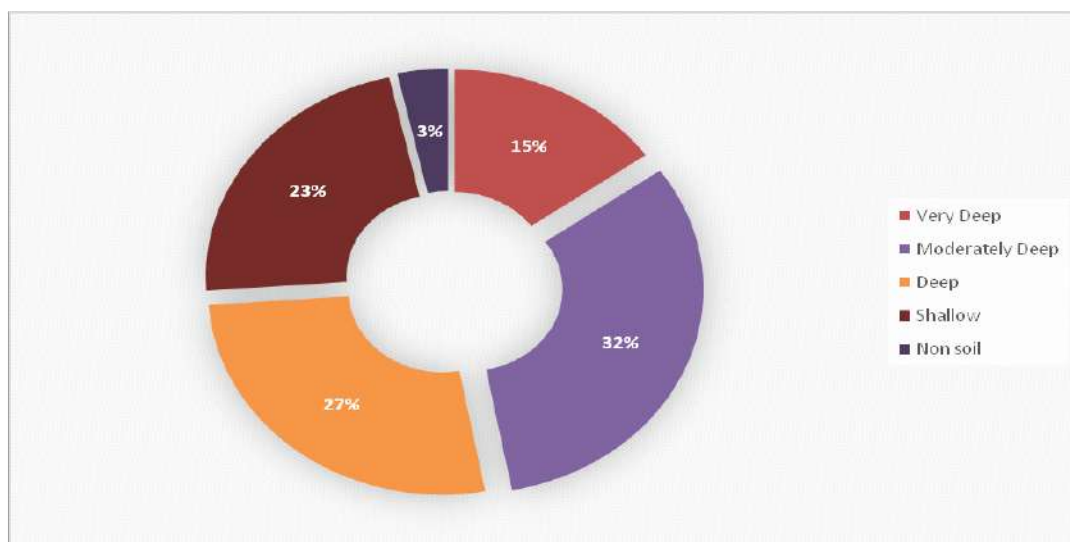


Fig. 2. 18 - Distribution of Areas under Different Soil Depth Categories

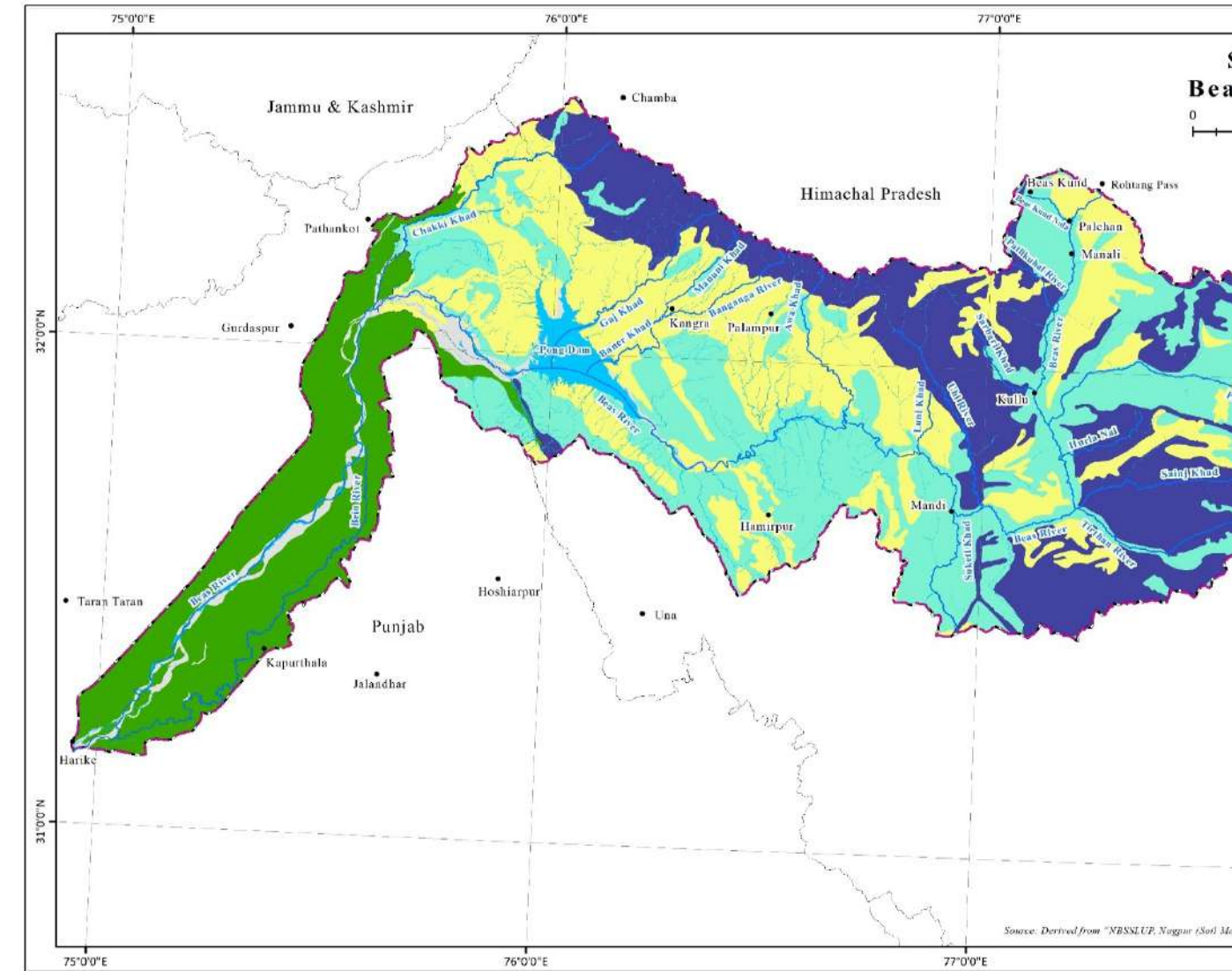


Fig. 2. 19 - Variation in Soil Depth in the Beas Riverscape

(vi) Soil Erosion

Soil erosion is the displacement of the upper layer of soil and it is one form of soil degradation. Soil erosion is a naturally occurring process caused by the dynamic activity of erosive agents i.e., water, ice, snow, air, plants, animals, and humans that affects all landforms. Soil erosion may be as low process that continues relatively unnoticed, or it may occur at an alarming rate causing a serious loss of top soil. Human activities caused by intensive agriculture, deforestation, construction/ widening of roads, construction of hydroelectric projects (HEPs), urban sprawl and erratic climatic conditions are some of the prominent factors responsible for soil erosion in the mountainous catchment of Beas River. Based on information obtained from the Indian Institute of Soil and Water Conservation, Dehra Dun, an insight on the status of soil erosion within the Beas Riverscape has been developed. Altogether, total five categories of erosion classes have been recorded in the riverscape viz., $< 5 \text{ t ha}^{-1} \text{ yr}^{-1}$; $> 5 \text{ t ha}^{-1} \text{ yr}^{-1}$ to $< 10 \text{ t ha}^{-1} \text{ yr}^{-1}$; $> 10 \text{ t ha}^{-1} \text{ yr}^{-1}$ to $< 20 \text{ t ha}^{-1} \text{ yr}^{-1}$; $> 20 \text{ t ha}^{-1} \text{ yr}^{-1}$ to $< 40 \text{ t ha}^{-1} \text{ yr}^{-1}$; and $> 40 \text{ t ha}^{-1} \text{ yr}^{-1}$. The distribution of areas under different erosion classes and their proportion are given in Table 2.30. Nearly 24% area of the riverscape was recorded under high and very high soil erosion categories. Only 10.58% area of the riverscape was under the category of very low erosion (Fig. 2.20 and Fig. 2.21). An area of 2,300.08 km² falls under non-soil category. These areas may not be suitable for forest plantations. It is evident from the Fig 2.21 that a larger part of the mountainous region in Kullu and Mandi Districts has moderate soil erosion while the mountainous part in Hamirpur, Kangra and Chamba Districts are prone to high to very high soil erosion. The bulk area in alluvial plains has very low soil erosion. Prominent areas with severe soil erosion were distributed in five to six pockets. The larger pockets of severe erosion were recorded around Manali, Parbati sub-basin, and Chakki tributary (Fig. 2.21).

Table 2. 30 - Distribution of Soil Erosion Categories in Beas Riverscape

Sr. No.	Soil Erosion ($\text{t ha}^{-1} \text{ yr}^{-1}$)	Erosion Intensity Class	Area (km ²)	Proportion of Total Area (%)
1	< 5	Very Low	4,222.38	10.58
2	5 to < 10	Low	674.74	10.34
3	10 to < 20	Medium	6,155.84	10.79
4	20 to < 40	High	1,676.05	12.03
5	≥ 40	Severe	1,713.92	11.88
6	Non Soil	-	2,300.08	14.32
Grand			16,743.01	12.79

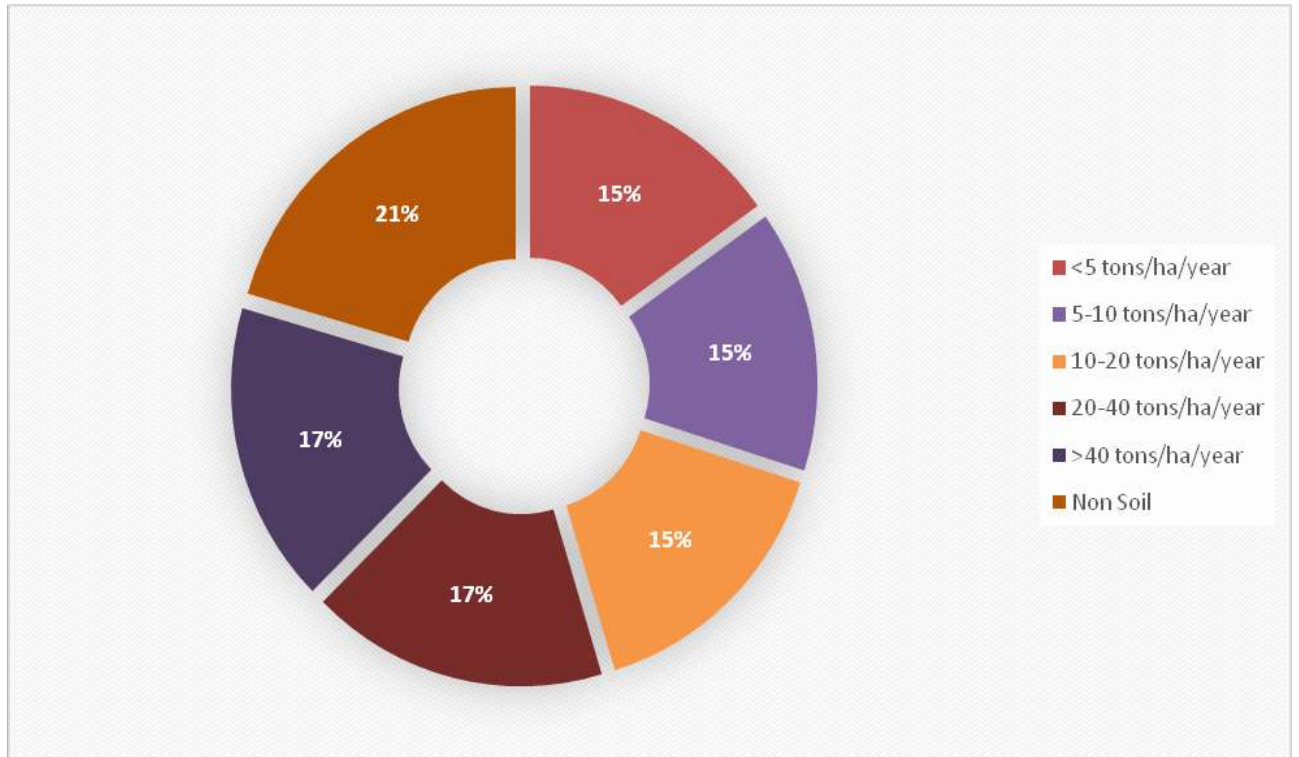


Fig. 2. 20 – Proportional Distribution Areas of Different Soil Erosion Categories in Beas Riverscape

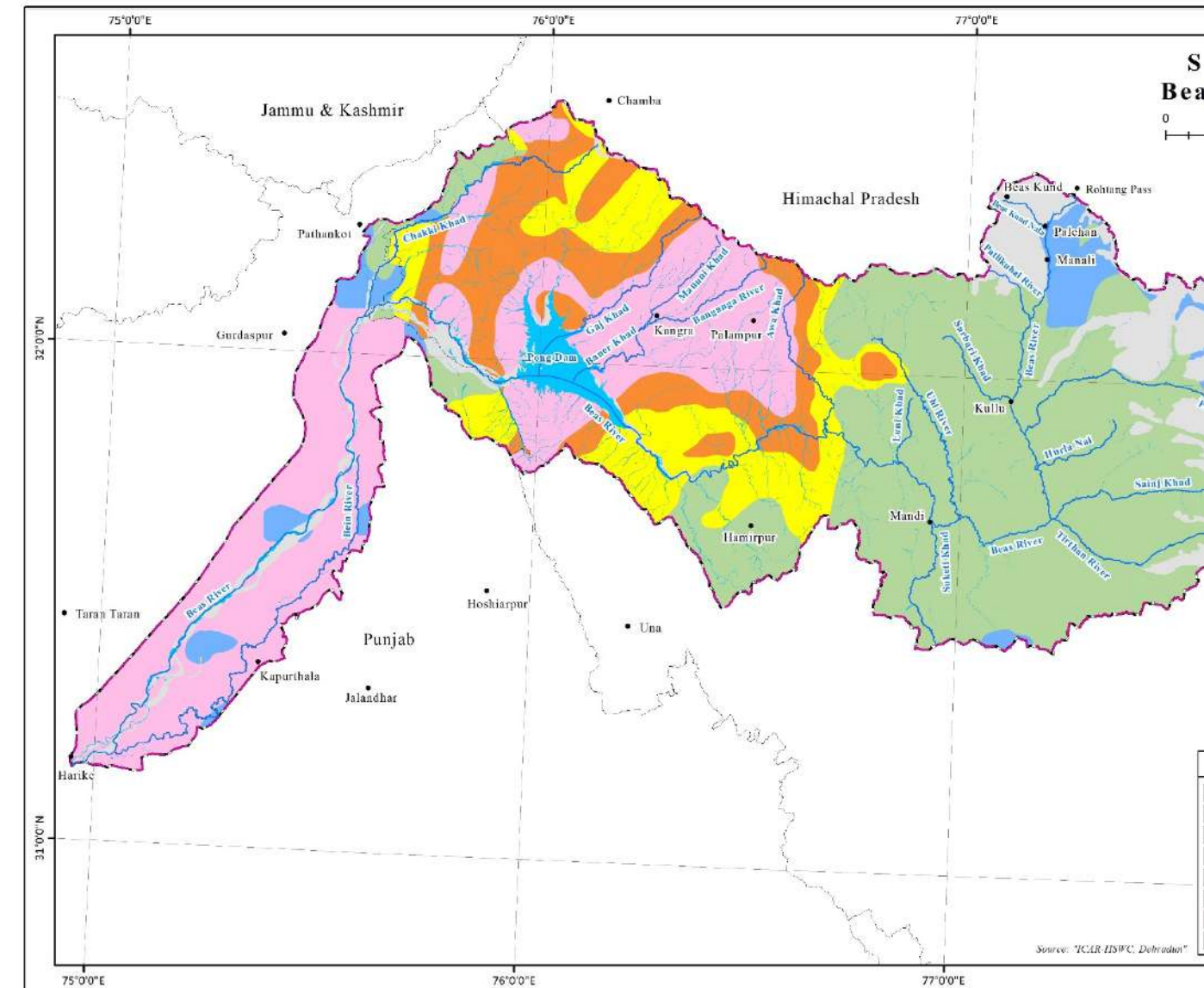


Fig. 2. 21 – The Status of Soil Erosion in Beas Riverscape

(vii) Forest Types and Forest Density

The information on forest types is of utmost importance in suggesting suitable sites for forestry interventions based on areas which do not have dense forest cover or which fall in the categories of scrub or grasslands along the river banks. The forest type and cover map have been prepared using data provided by the Forest Survey of India. Altogether, eight forest types and one non-forest categories were recorded in the Beas Riverscape. The non- forest category contributed almost 60% area of the riverscape. Thus, diverse forests and scrubs occurred only in about 40% area of the riverscape. The sub-tropical pine forest recorded the maximum area amongst various forest types and represented about 13.5% area of the riverscape. The Himalayan moist temperate forest represented about 13% area of the riverscape. Tropical dry deciduous forests covered 1,244.38 km² and covered 7.43% area of the riverscape. Sub-alpine forests, moist sub-alpine forests and dry sub-alpine forests together covered nearly 2.5% area of the riverscape (Table 2.31). The category of scrubs represented 3.77% area of the riverscape (Fig. 2.22). Table 2.32 on distribution of different forest cover categories in the Beas Riverscape revealed that a greater proportion (60.02%) of the riverscape falls under non-forest category (Fig. 2.22). Out of remaining area under different forest cover categories, the moderately dense forests occupied the highest cover and represented 42.09% of all forest types. Dense forests constituted 28.29% of all forest cover categories. The open forests represented 20.18% area of all forest types while scrubs represented a meager proportion of 9.41 of all forest types (Table 2.32). Fig 2.24 depicting forest types in riverscape clearly revealed the distribution of non-forest category in the upper reaches of Beas River Basin and the alluvial plains of Punjab. Tropical dry deciduous forests mainly occurred around Pong Dam Lake Sanctuary. The Himalayan moist temperate forests and Himalayan dry temperate Forests mainly concentrated in Kullu, Mandi, and Kangra Districts (Fig 2.24). Three forest types viz., Sub-Alpine Forests, Moist sub-alpine forest and Dry sub-alpine forests in very small patches predominantly also concentrated mainly in Mandi, Kangra and Kullu Districts. The non-forest area in two larger pockets was prominent in the riverscape, firstly, in north-eastern area and secondly, in the south-western portion of the alluvial plains (Fig 2.25). Forests within the riverscape belonging to two States i.e., Himachal Pradesh and Punjab are managed by 33 Forest Divisions, 102 Forest Ranges, 240 Forest Blocks and 738 Forest Beats. Out of total 33 Forest Divisions, 26 Forest Divisions are within Himachal Pradesh while remaining 7 Forest Divisions are in Punjab (Table 2.33). A small proportion of Dalhousie, Hamirpur, Una and Karsog Forest Divisions is also covered in the Beas riverscape. Likewise, the Beas riverscape incorporates parts of Pathankot, Gurdaspur, Dasuya, Amritsar, Jhalandhar and Tarn Taran Forest Divisions of Punjab (Fig. 2.26).

Table 2. 31 - Distribution of Forest Types Categories in Beas Riverscape

Sr. No.	Forest Type	Area (km ²)	Percentage of Total Area (%)
1	Dry Sub-Alpine Forests vegetation or Dry Alpine vegetation	109.59	0.65

2	Himalayan Dry Temperate Forests	47.92	0.29
3	Himalayan Moist Temperate Forests	2,251.69	13.44
4	Moist Sub- Alpine Forests	115.18	0.69
5	Sub-Alpine Forests	181.13	1.08
6	Sub tropical Pine Forests	2,305.08	13.76
7	Tropical Dry Deciduous Forests	1,053.32	6.29
8	Scrubs	630.55	3.77
9	Non- Forest	10,048.55	60.02
Grand		16,743.01	100

Table 2. 32 - Distribution of Forest Cover Categories in Beas Riverscape

Sr. No .	Forest Cover	Area (km ²)	Proportion Area of Beas Riverscape (%)	Proportion of Forest Cover (%)
1	Dense Forests	1,894.15	11.31	28.89
2	Moderately Dense Forests	2,818.17	16.83	42.09
3	Open Forests	1,351.59	8.07	20.08
4	Scrubs	630.55	3.77	9.41
5	Total Cover under Forests	6,694.46	39.98	100
6	Non Forest	10,048.55	60.02	-
	Total	16,743.01	100	

Table 2. 33 - Administrative Divisions of Forests in Beas Riverscape

State	Number of Divisions	Number of Ranges	Number of Beats
Himachal Pradesh	17	74	816
Punjab	8	31	87
Total	25	105	903

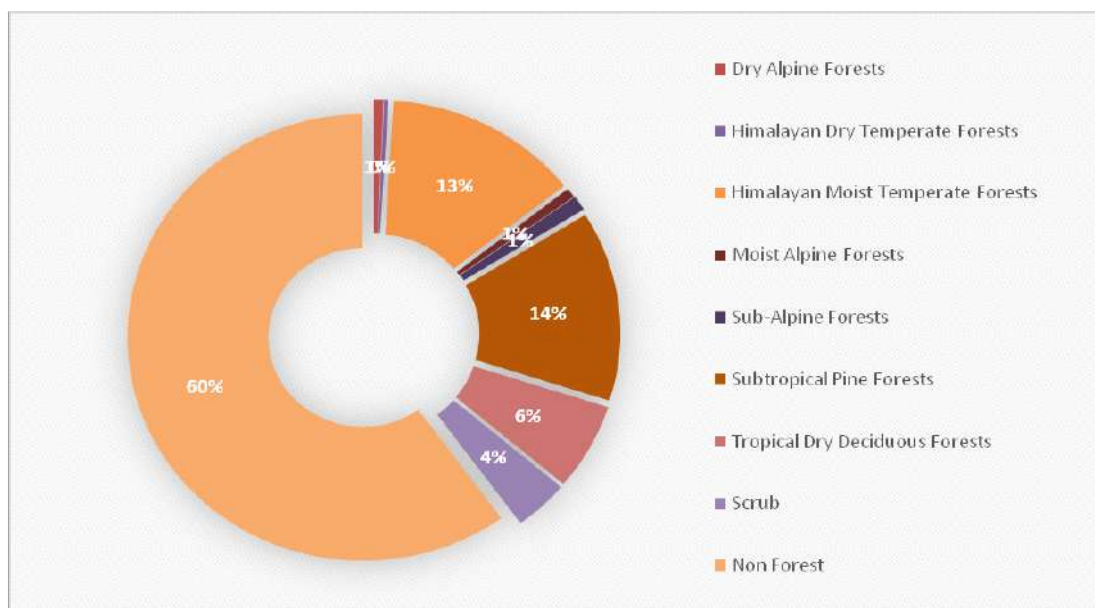


Fig. 2. 22 - Distribution of Areas under Different Categories of Forests Types within Beas Riverscape

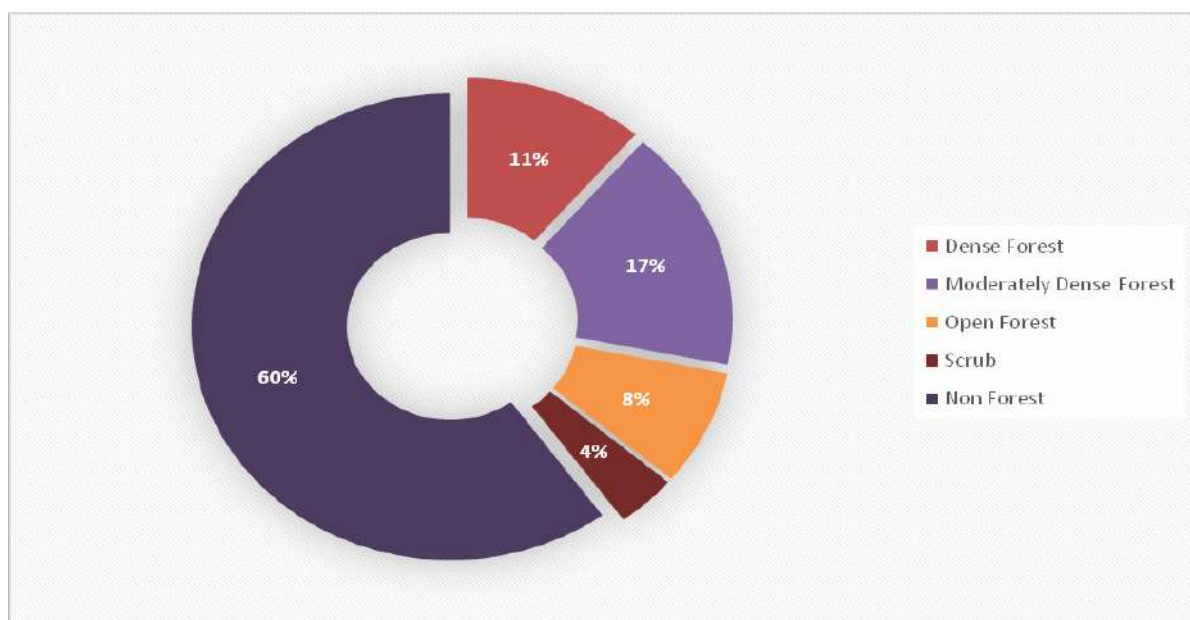


Fig. 2. 23 - Distribution of Areas under Different Categories of Forest Density in Beas Riverscape

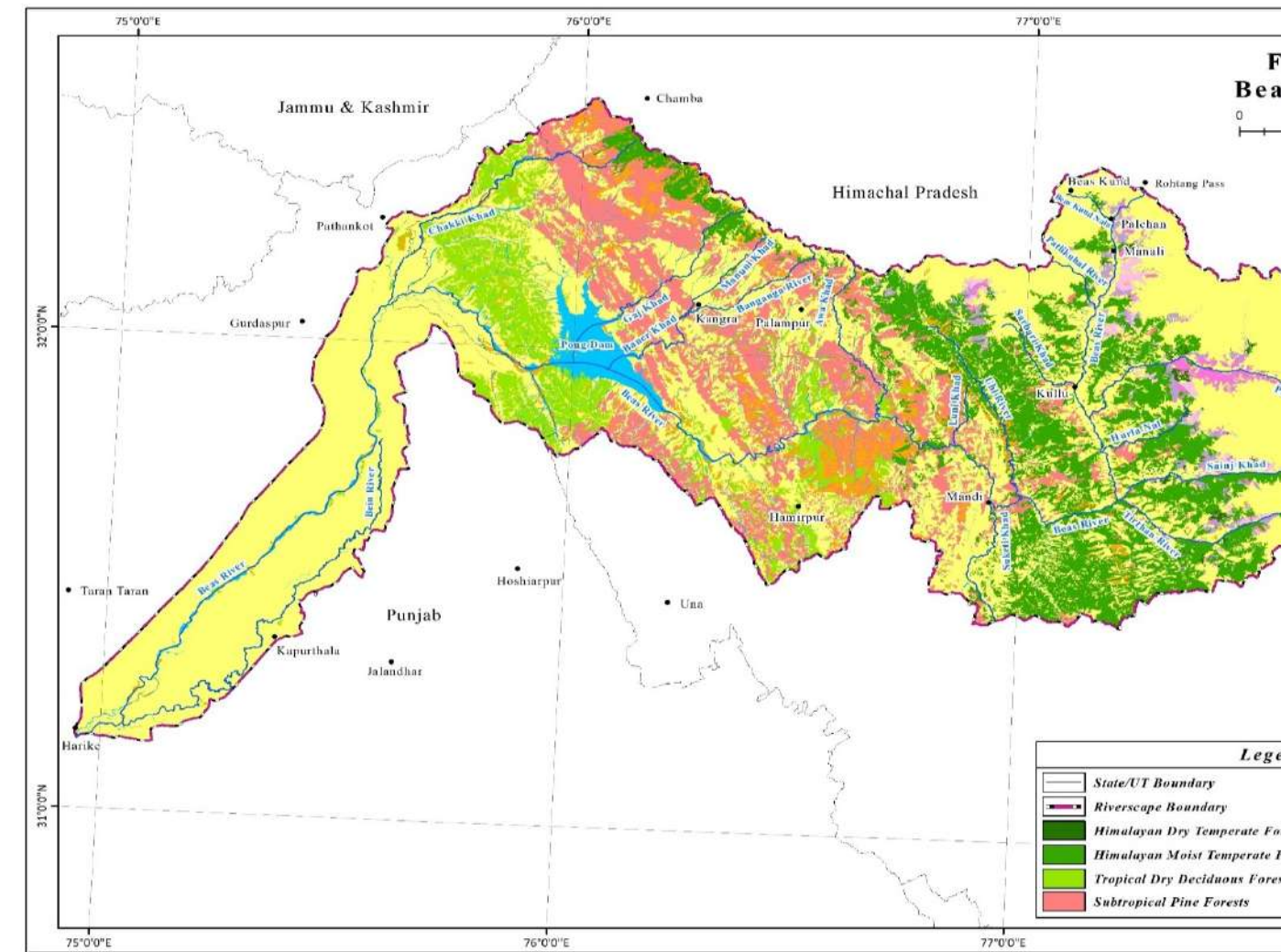


Fig. 2. 24 - The Distribution of Different Forest Types in Beas Riverscape

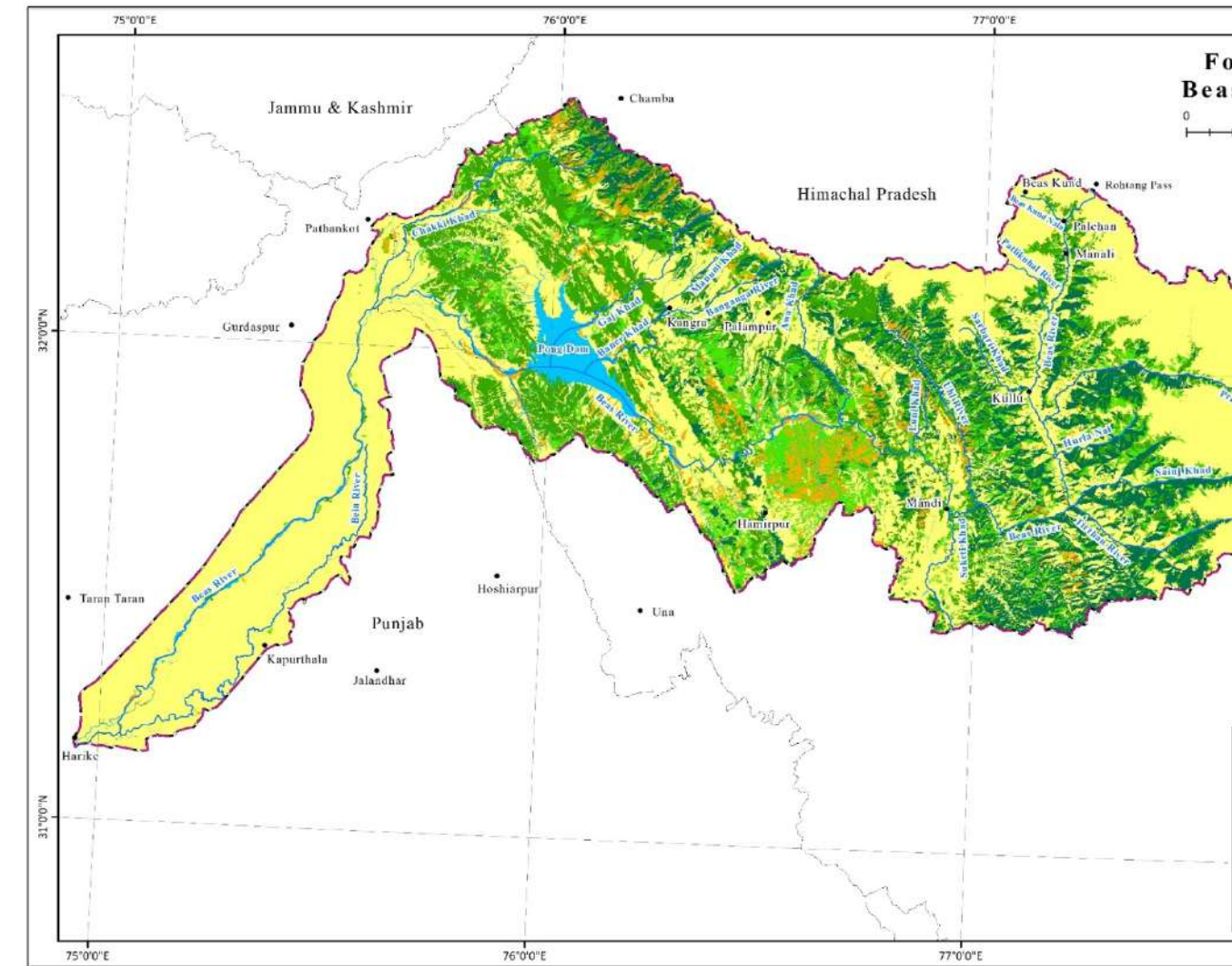


Fig. 2. 25 - The Distrubution of Different Forest Desnsity Classes in Beas Riverscape

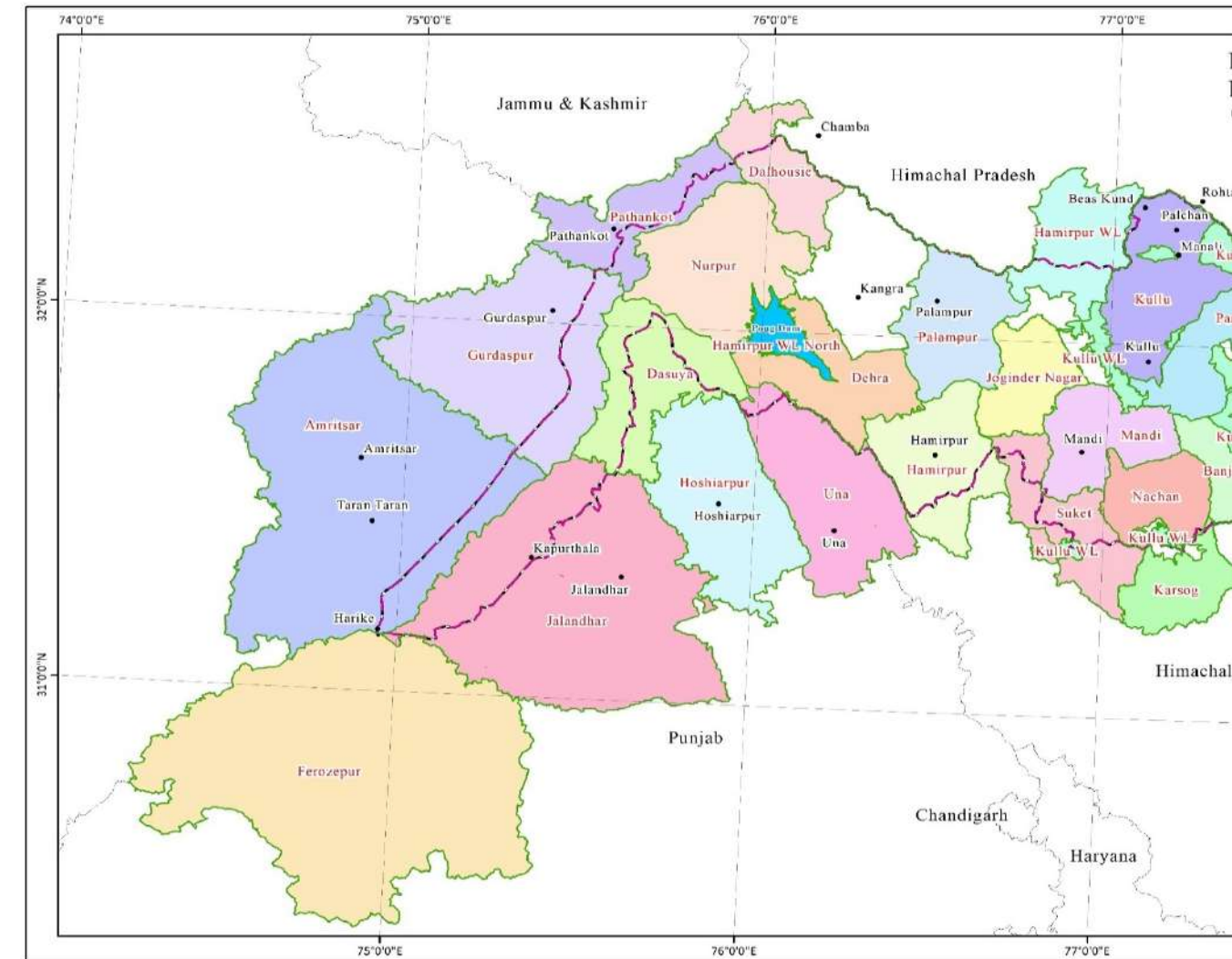


Fig. 2. 26 - Administrative Divisions of Forests in Beas Riverscape

(viii) Land Use and Land Cover

Land cover refers to a physical and biological cover over the surface of land including water, vegetation, bare soil, and/or artificial structures. Land use is defined in terms of syndromes of human activities such as agriculture, forestry and building construction that alter land surface processes including biogeochemistry, hydrology and biodiversity. Broadly, land use includes the social and economic purposes and context for and within which lands are managed or left unmanaged. Understanding of land use and land cover change (LULCC) also known as land change is important for planning conservation efforts in view of human induced modifications of Earth's terrestrial surface. An insight on land use/land cover is vital for land and natural resource management. The forgoing sections have provided an insight on diversity of forest types, extent of forest cover and changed in forest cover in the context of Himachal Pradesh and Punjab based on the information made available by FSI in its biennial assessments since 1987 (FSI, 2019). The present section specifically provides baseline information on land use land cover in the Beas Riverscape. The geospatial analysis of Beas Riverscape identified altogether 16 land use and land cover categories (Table 2.34). The maximum area of the riverscape was covered by agriculture, representing 35.29% extent of the total area (Fig. 2.27). Snow/Glaciers accounted for nearly 12.56% area of the riverscape. Two categories of rivers - river perennial and river dry/ river sand represented 3.45% area of the riverscape. Waterbody, wetland, and canal categories of LULC covered a meager area and represented 0.21% of the riverscape. Barren area within the riverscape represented 3.79%. Alpine pastures represented just 0.02% area of the riverscape while settlements covered 1.8% area of the riverscape. The distribution of land use and land cover categories in Beas Riverscape is depicted in Fig. 2.28.

Table 2. 34 - Distribution of Areas under Different Land Use and Land Cover Categories

Sr. No.	Land Use and Land Cover	Area (km ²)	Percentage of Riverscape Area (%)
A	Natural Categories		
1	Dense Forests	1,894.15	11.31
2	Moderately Dense Forests	2,818.17	16.83
3	Open Forests	1,351.59	8.07
4	Scrubs	630.55	3.77
5	Alpine Pastures	3.87	0.02
6	Clouds	459.77	2.75
7	Cloud Shadows	16.38	0.1
8	Snow/Glaciers	2,102.98	12.56

Sr. No.	Land Use and Land Cover	Area (km ²)	Percentage of Riverscape Area (%)
9	Waterbodies	3.64	0.02
10	Wetlands	26.12	0.16
11	River (Dry)/River Sand	194.23	1.16
12	River (Perennial)	382.72	2.29
13	Barren	634.9	3.79
Sub-Total of 'A'		10,519.07	62.82
B	Man-made Categories		
14	Agriculture	5,908.95	35.29
15	Settlement	310.06	1.85
16	Canal	4.93	0.03
Sub-Total of 'B'		6,223.94	37.23
Grand Total (A and B)		16,743.01	100

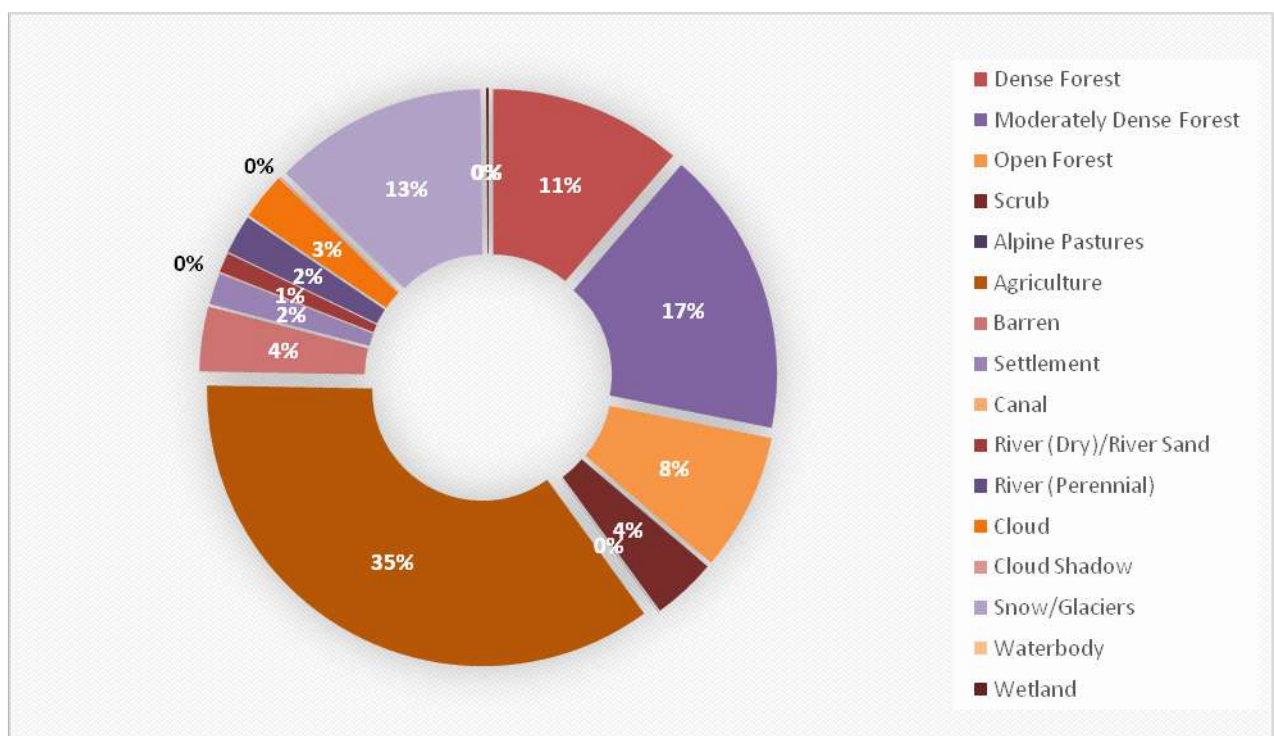


Fig. 2. 27 - Distribution of Land Use and Land Cover Categories in Beas Riverscape

(ix) Number of Patches in Major Land Use Categories

Number of patches and their size of a particular land use category provide great insight on the process of fragmentation. Patches of six land use categories were assessed. These land use categories are: Dense Forest, Moderately Dense Forest, Open Forest, Scrub, Agriculture and Barren and others were reclassified according to geometric interval. After reclassification number of patches and area of each class have been calculated. The maximum number of patches, being 1,872 was recorded in case of Moderately Dense Forests while the minimum number of patches, being 79 was registered in Barren Category (Table 2.35). Table 2.35 presents number of patches in select natural and man-made land use and land cover categories (Fig. 2.29 to Fig. 2.34).

In case of Dense Forest category, 1,517 patches were recorded. Out of these patches, nearly 50% patches were $<0.03 \text{ km}^2$ or $<3 \text{ ha}$ in size (Table 2.35 and Fig 2.30). The majority patches of dense forests were located in the Middle and Greater Himalayas that too around the main channel and tributaries in Kullu and Mandi Districts. In addition some larger patches of dense forests were clustered around the higher reaches of Dhauladhar Range.

Altogether, 3,001 patches of Moderately Dense Forests were recorded. Out of this, nearly 38% patches were $<0.15 \text{ km}^2$ or $<15 \text{ ha}$ in size (Fig. 2.30). The patches of this category were widely distributed all through the mountainous part of the Beas Riverscape.

In case of Open Forest category, in all 3,019 patches were registered. Out of this, nearly 15% patches were $<0.05 \text{ km}^2$ or $<5 \text{ ha}$. About 36.5% patches were $<0.11 \text{ km}^2$ or $<11 \text{ ha}$. It amply indicates that there is wide spread fragmentation of forests under this category resulting into large number of smaller patches (Fig. 2.31). The preponderance of patches of this category was conspicuous in Hamirpur District.

In all, 1,006 patches in case of scrub category were recorded and out of this, nearly 78% patches were of smaller size ($<0.55 \text{ km}^2$ or $<5.5 \text{ ha}$) (Fig. 2.32). The preponderance of scrub patches was distinctly in Hamirpur and Mandi Districts.

In the case of agriculture category, 2,583 patches were recorded. Nearly, 45% patches were of $<0.15 \text{ km}^2$ or 15 ha . The spatial pattern of agriculture patches revealed that agriculture in the upper part of the Beas Riverscape or in Kullu District primarily confined in narrow belt all along the main river or some select tributaries. Agriculture patches were widespread in Hamirpur and Kangra Districts while the lower part of the riverscape in Punjab plains was exclusively dominated by patches of agriculture (Fig. 2.33).

In yet another man-made category, 1,111 patches of barren class were registered in the entire riverscape. Notably, majority of these patches were wide spread in upper reaches in Kullu and Kangra Districts (Fig. 2.34). It amply indicates that there is hardly barren land left in other parts of the riverscape.

Table 2. 35 - Distribution of Patches in Various Natural and Man-made Land Use and Land Cover Categories

Sr. No.	Area (km²)	Number of Patches	Percent Representation (%)
Dense Forest			
1	0.00 - <0.13	367	24.19
2	0.13 - <0.3	394	25.97
3	0.3 - <0.77	377	24.85
4	≥0.77	379	24.99
Total		1,517	100.00
Moderate Dense Forest			
1	0.00 - <0.06	415	13.83
2	0.06 - <0.1	356	11.86
3	0.1 - <0.15	358	11.93
4	≥0.15	1,872	62.38
Total		3,001	100.00
Open Forest			
1	0.00 - <0.05	448	14.84
2	0.05 - <0.08	337	11.16
3	0.08 - <0.11	317	10.50
4	≥0.11	1,917	63.5
Total		3,019	100.00
Scrub			
1	0.00 - <0.09	216	21.47
2	0.09 - <0.21	337	33.50
3	0.21 - <0.55	227	22.56
4	≥0.55	226	22.47
Total		1,006	100.00
Agriculture			
1	0.00 - <0.05	419	16.22
2	0.05 - <0.09	347	13.43
3	0.09 - <0.15	389	15.07
4	≥0.15	1,428	55.28

Sr. No.	Area (km²)	Number of Patches	Percent Representation (%)
Total		2,583	100.00
Barren			
1	0.00 - <0.04	295	26.55
2	0.04 - <0.1	250	22.51
3	0.1 - <0.33	287	25.83
4	≥0.33	279	25.11
Total		1,111	100.00

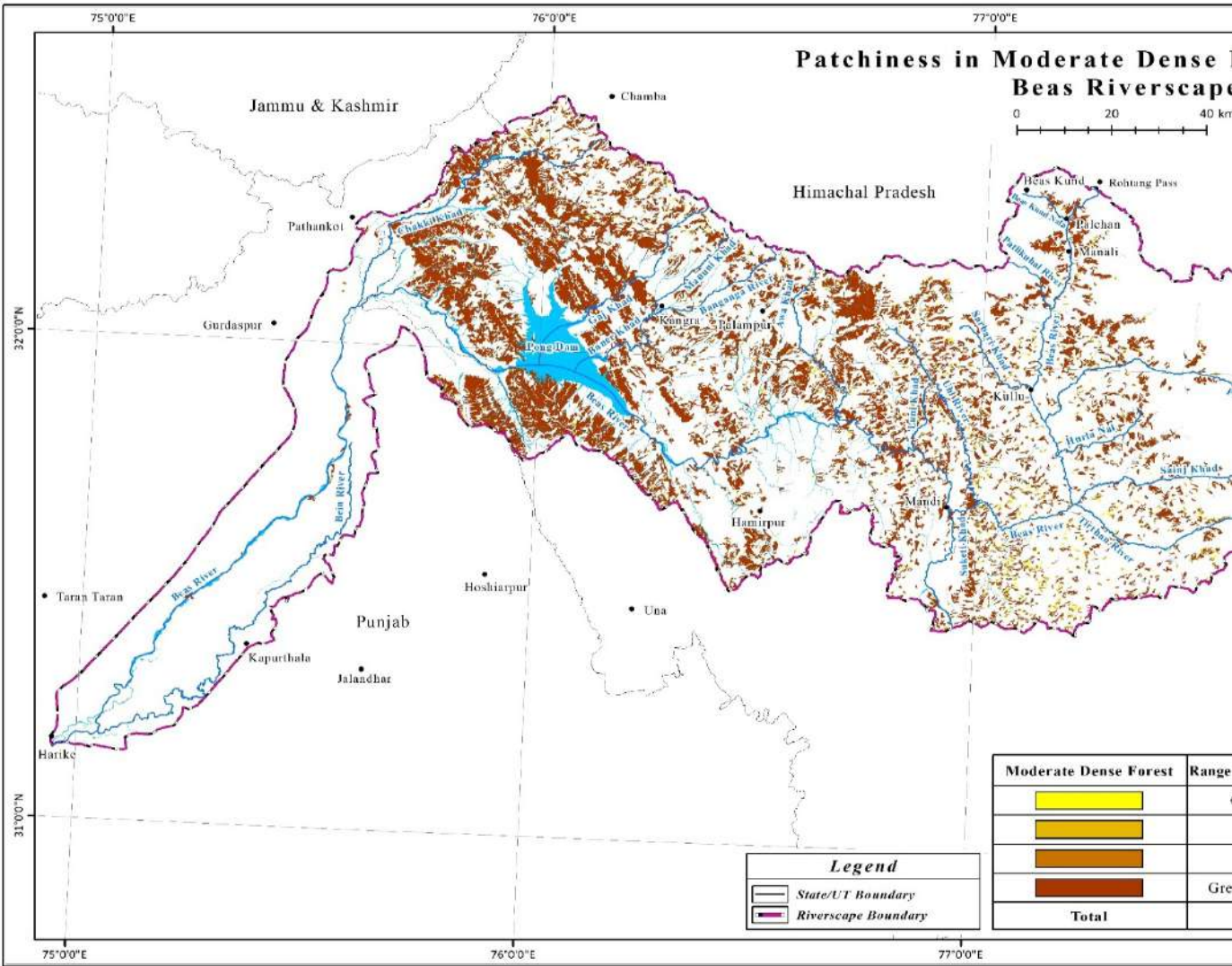


Fig. 2. 30 -The Beas Riverscape - Patchiness in Moderately Dense Forests

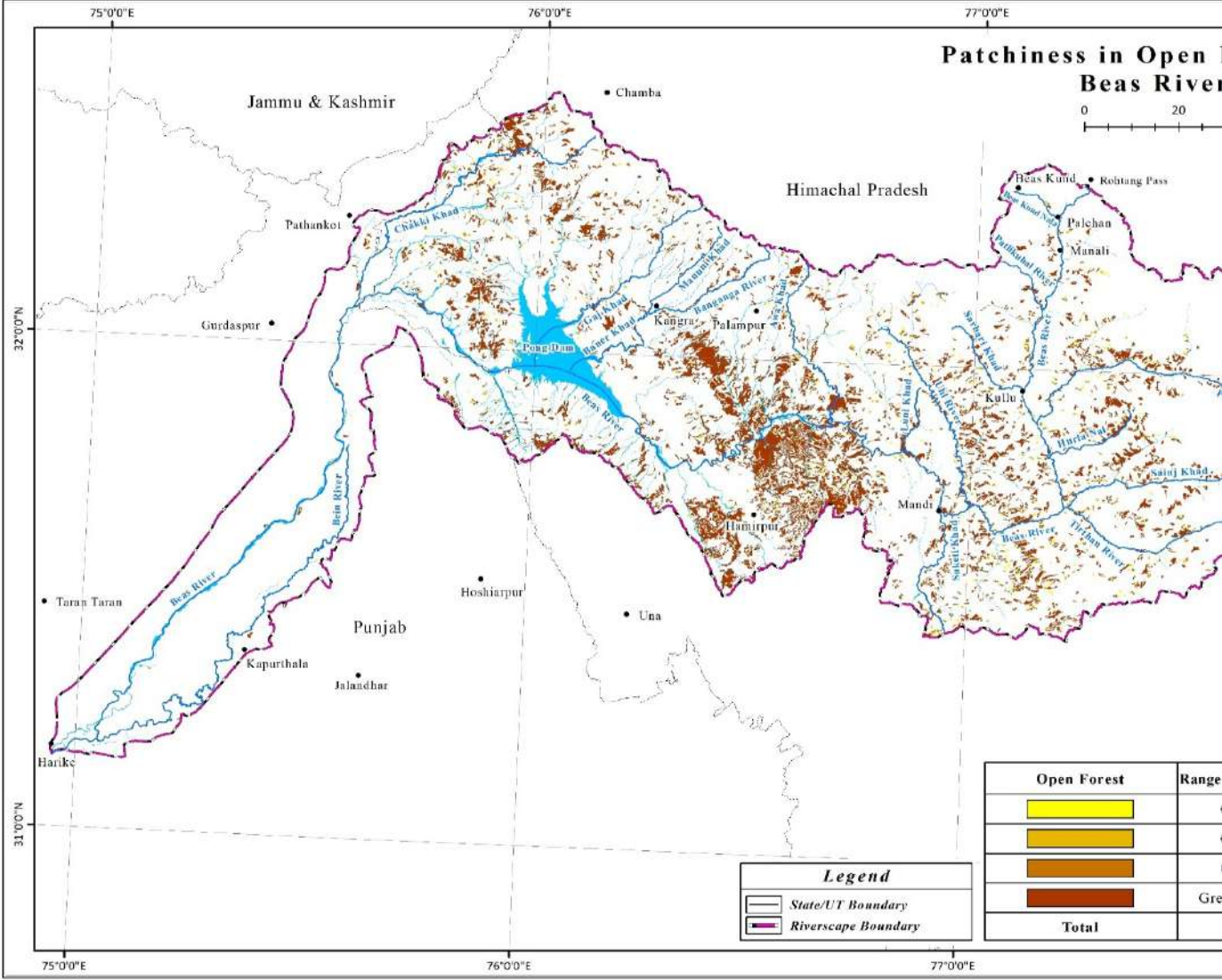


Fig. 2. 31 - The Beas Riverscape - Patchiness in Open Forests

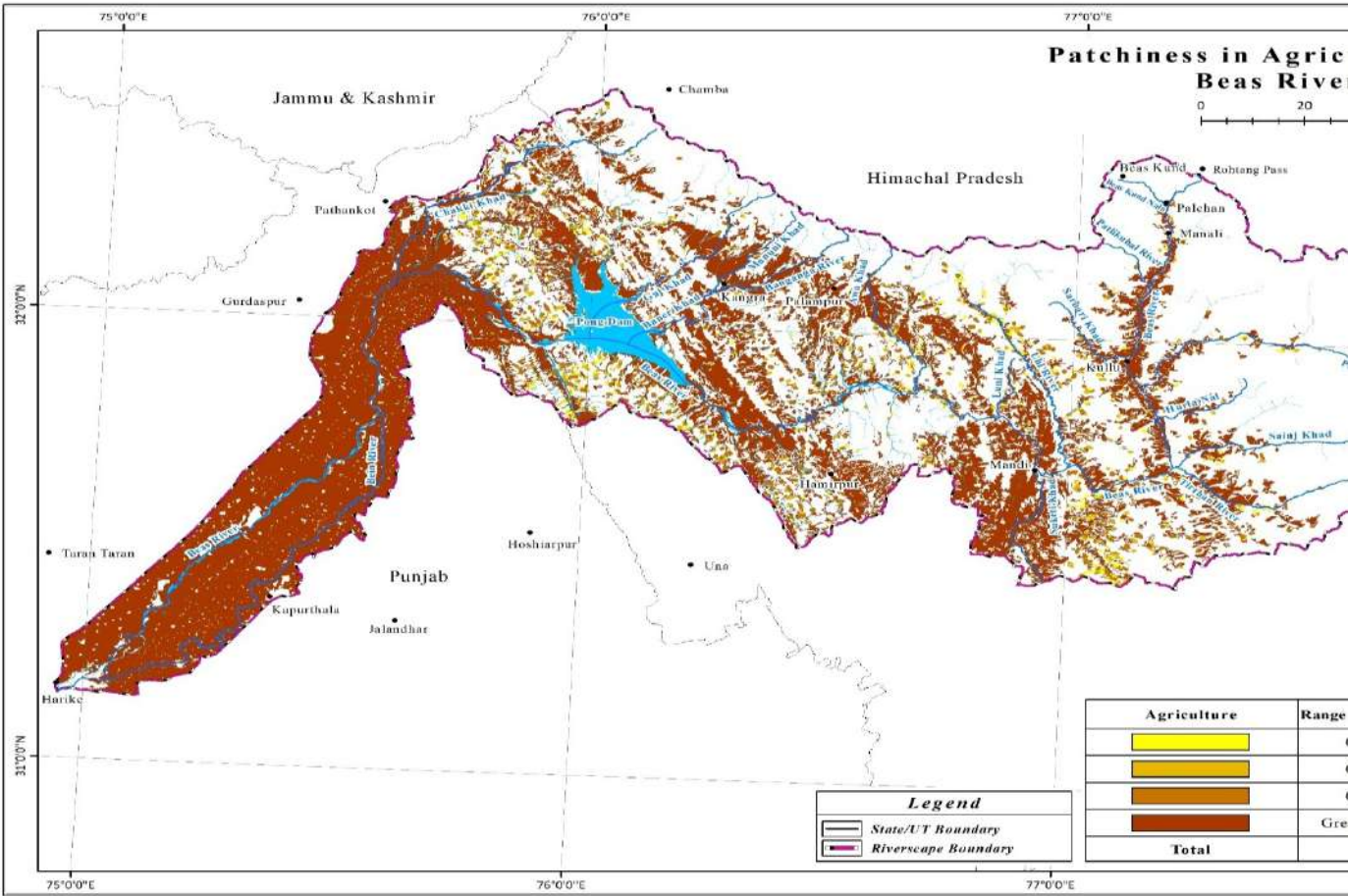


Fig. 2. 33 -The Riverscape - Patchiness in Agriculture

2.6. The Socio-Economic Environment

The nature has always been kind to man, as since time immemorial humans and their societies have an absolute dependence on natural ecosystems to provide food, water, energy, and other materials and services. Commonly, humans have exploited potentially renewable natural resources to the fullest for their own prosperity and as a result they suffer by the syndrome of resource degradation. Man's interference with natural processes is such that his activities have resulted in a very high and unsustainable rate of depletion of natural resources. Man has not only altered the natural ecosystems for his requirement but he has also changed his own environment to suit himself. Unplanned development and changing social structure, and culture and consumption patterns have immensely influenced the overall natural environment. Man, a powerful agent of change in space, himself undergoes change in time (Glikson, 1971). The resource degradation is one of the most important aspects of the current global environmental crisis, and it is a formidable obstacle to the achievement of a sustainable human economy. It has been lately realized that the 'natural capital' is key to achieve various goals of sustainable development. The term 'human environment' describes the space which surrounds human movement, work, habitation, rest and interaction – towns and villages, settlement influence areas, the rural and the accessible virgin landscape. This environment is generally defined as a set of biological and physical facts in space, as modified by man. Ecologists are attempting to understand the various linkages between humans and the natural ecosystems that sustain them.



Traditional house structures in the catchment

Riverine landscapes (riverscapes) are interconnected fresh water habitats that are commonly associated with diverse ecological, socio-economic, and cultural systems (Hand *et al.*, 2018). Riverscapes are complex, landscape-scale mosaics of connected river and stream habitats embedded in diverse ecological and socio-economic settings. Socio-ecological interactions among diverse stakeholders and often their competing demands complicate natural-resource conservation and management of riverscapes.

The Beas River, Beas Basin and Beas Riverscape are no exception as human settlements in the Upper Beas River Basin began well over 2,000 years ago, in a gradual drift northward from the lowlands up river valleys (Ohri, 1980; Tucker, 1997). However, the lower Beas River Basin in alluvial plains of Punjab has a long history of migration and settlement of innumerable races. The first traces of human habitation in India were found in the Punjab region. The Indus Valley Civilization flourished in antiquity before recorded history. The Punjab has had numerous recorded invasions, starting with the Vedic tribes. Alexander's march in Punjab terminated at the Beas River in 326 BC quashing his hope of crossing over to the other end of the world. The Greater Punjab region was annexed by the British East India Company from the Sikh Empire in 1849. In 1947, the Punjab Province of British India was divided along religious lines into West Punjab and East Punjab. The western part was assimilated into Pakistan while the east became part of India. Alongside of long history of the region, Beas as one of the Punjab rivers get mention in the context of *Sapta-Sindhu* in the sacred *Rig-Veda*, the first book of the sub-continent in the hitherto recorded history. The Beas River has been strongly associated with mythology, history, culture surrounding natural and man-made environments. Hence, it is significant and essential to understand the socio-economic environment in the context of Beas River from the perspective of its conservation and rejuvenation. The following part of the Chapter aims to appreciate the historical perspective on the management of forests, land and the people, demography and social conditions, their relationships with natural ecosystems, economic concerns and development, people's aspirations and implications for the natural environment and the people. In nutshell, the following section aims to describe the social milieu and highlights prominent socio-economic issues and their implications for conservation of the Beas Riverscape.

2.6.1 Historical Perspective – Creation of Forest Reserves, Timber Extraction, Commercialization of Forests and Deforestation

As already stated above, the process of human settlement in the mountainous part of Beas RiverBasin commenced nearly 2,000 years ago. However, the archaeological knowledge of the following centuries, especially regarding land use and agriculture is scanty. Hence, from the early British compilations one can put together a broad picture of 'traditional' land use and social structure. The mountain region above Punjab fell under British control as well. The new rulers moved quickly to establish the elaborate administrative structure which was already in place in other British regions of India. Soon they demonstrated that there are many potential links between hills and lowlands, and integrated hill life with broader north Indian region more fully than ever before. The traditional village life and resource use in the

Himalayan Mountains was relatively self-sufficient local system of subsistence, and interrelations with the natural world and the supernatural. As an agro-ecological system, forests, grazing lands and croplands were integrated. Throughout most of its history, this system had important ties to two dimensions of the outside world – politically powerful overlords and urban market linked with trade routes and both of them were controlled by different social groups. In the past, rural people in the mountains of Himachal Pradesh had very limited arable lands. The most important non-agriculture use of land in upper Beas River Basin was pastoralism. Villagers kept

larger flocks of sheep and goat and since long followed the migratory transhumant system. The upper Beas region maintained geography of sacred places. Most villages in hills had temples to ancient local gods and goddesses (*Devta's* and *Devi's*). Temple groves of the sacred deodar tree were under the care of the devtas, protected against cutting. Natural goods came to have money value through trade. A regional network of markets, fairs and trade routes linked the upper Beas Valley with far-flung locations, both in the north Indian lowlands and the northern reaches of the Himalayan Mountains (Tucker, 1997). Some farm production was grown as cash crops. The rising power of various Empires in lowland gradually reduced the mountain region to a status of dependency (Singh, 1991). Several of the pre-Mughal Muslim conquerors of the north Indian lowlands invaded the outer hills for plunder. In 1806, the Gurkha army of Nepal invaded Kangra in its westward sweep across the Himalaya. In 1839-40, the Sikh army conquered the upper reaches of Beas. They cut Himalayan timbers and floated them down in the Beas and Sutlej Rivers for use in Punjab. The Sikh power crumbled soon and in 1846 the British ceded Kangra and Kullu regions. The regions witnessed rise of modern administration under the British and the process of land settlement and expansion of agriculture commenced. Immediately after the British conquest, large extent of deodar trees were felled by contractors for new commercial markets in lowland Punjab and beyond, resulting severe damage to forest in the middle elevation belt (Stebbing, 1921). Soon under the Forestry Law of 1855, the first of its kind in British India, the haphazard approach of forest felling by private contractors was replaced by the governmental timber operations from 1864 onwards (Trevor, 1920; Samler, 1935). The Forest Law was refined in 1878 and by mid-1880s, the category of Reserved Forest required that they should be largely free of local rights, and a complete list of records was a prerequisite. Since this was not possible, few forests were declared as RFs while some areas were listed as Protected Forests (PFs). Even PFs included two classes: Demarcated Forests, in which rights were more extensive and a higher priority, and Undemarcated Forests, incorporating all other forests and wastelands not recorded in the land revenue settlement. Commercial timber trade placed increasing pressure on forests and resulted into gradual encroachment by Punjabi contractors and the arrival of the outside labourers. The first years of British control witnessed heavy felling of deodar forests in Kullu Valley by private contractors for the railways and the Public Works Department. The Northwestern Railways' demand for deodar sleeper exceeded the total supply of deodar.

The most challenging and complex issue in forests was grazing rights and the process of recognizing the grazing rights commenced and a detailed report on the demarcation and settlement of the Kullu forests was accomplished (Anderson, 1886). The Anderson's system

was finally adopted as Punjab Law in 1896. By 1900, the regulation of the village system depended on local Revenue and Forest Officers, working either together or at cross-purposes. Trevor revised the Working Plan for Kullu Forest Division in 1920 and until after independence of the country; there were no further major revisions of forest regulations in Kullu Division. Conflict between villagers and Forest Department under the system of Trevor's Working Plan was severe and as protest there were wide spread forest fires by villagers resulting into damage of forests. The British officials also introduced hunting and fishing when new generation guns gave sport hunters great fire power. In short, forests in upper reaches of Beas River Basin had long history of management of forests as they have been shaped by foresters, local people and their livestock for several centuries. The colonial era's major changes were commercial logging, introduction of fruit orchards, and slow expansion subsistence cropping. Undoubtedly, no serious reduction of flora occurred in the colonial century. However, during the phase of post-independence of the country, large scale felling and enhanced human disturbances greatly influenced the condition of forests in the upper Beas River Basin as the independent governments at the Centre/ State made a commitment to rapid economic and social development.

In Himachal Pradesh, the first priority was transport-infrastructure to overcome the severe inaccessibility of the mountains (Verma and Pratap, 1992). By 1950, the Mandi-Kullu road was jeepable, but it was metalled through the gorge below Aut by the 1970s. Once the transport-infrastructure was improved, the government pursued its second major priority of expansion of agriculture market. The area under fruit crops marked exponential rise from 1948 to 1988 while apple crop was 80% contributor (Verma and Pratap, 1992; Swaroop and Sikka, 1983). Subsequently, the new trend of growing vegetables for urban markets within the State, and farther away in the cities of Punjab and Haryana, and even Delhi commenced. The new tourism activities around Kullu and Manali which boomed in the 1970s also provided markets for fruits and vegetables. The environmental impact of the new horticulture was also complex. Heavy logging of the high forests became a major extension of the ecological impact of the market economy, throughout the Upper Beas Basin. Finally, from the 1960s onwards a major cropping change evolved, from the variety of traditional grains to mostly rice, wheat and maize. Yet another pressure on forests was built-up in the form of collection of NTFPs, particularly medicinal herbs and morel mushrooms. This was a different management challenge after the issue of grazing rights, for administrators as well as local people. Since the forest settlements from Anderson onwards placed no restrictions on anyone collecting the herbs, except in the protected areas. Until the 1960s, there was no significant commercial market for the major herbs, and no one anticipated that this would become a much larger organized market. In view of the above stated long history of management of forests, other natural ecosystems and in the process of rapid development, particularly after the country's independence and State's reorganization, the rural population in the hills has evidently left its local institutions far too weak and fragmented.

The situation of forests in Punjab, in the past and in the present time was quite different in comparison to Upper Beas River Basin. The State had a small extent of forests as it experiences the arid to semi-arid climatic conditions and natural forests were sparsely

distributed. All through, the forests in human dominated landscapes experienced traditional resource dependence and they were heavily exploited. The post-independence of the country, the thrust of the Central and State Governments was on expansion of agriculture, construction of reservoirs/ barrages/ canals for irrigation and establishment of hydroelectric projects (HEPs) for power generation, and grow more food programme under the ambitious programme of the Green Revolution. These activities not only neglected the scant and remnant forests in the State, but also the forestry sector including wildlife. Further, grasslands and wetlands were reclaimed for expansion of agriculture. Moreover, pollutants from agriculture and associated industries severely impacted the quality of water in all major rivers of the State and their tributaries. In the process, there was heavy toll of forests and wildlife including aquatic fauna. In 1960s and on other occasions, the GoI launched different schemes of plantation/ afforestation including the social forestry programme to meet the growing demands of fuel wood, fodder, etc. and also to expand the forest cover in the hills/ plains. However, most of these efforts were project/ scheme based or ad hoc in nature that too with mixed success and definitely not adequate to compensate what was lost by way of clear felling and other allied activities of forestry. Cumulatively, large-scale deforestation and other human disturbances (collection of fuel wood and fodder, livestock grazing, forest fires, and harvest of NTFPs, etc.) impacted the river environment downstream.

2.6.2 Land and the People

Two States, Himachal Pradesh and Punjab along the course of Beas River owing to enormous diversity of natural resources i.e., forests, grasslands, alpine pastures and wetlands including rivers) and wide range of opportunities in different sectors viz., agriculture, horticulture, medicinal plants, fisheries, food processing, pilgrimage, road network and highways, mining-sand/ boulder, hydropower projects, industries, nature adventure and tourism always worked as magnetic force to attract people from far flung areas. Thus, both States concerned with the Beas Riverscape are populous. Details on land and land use in two States and their people are provided below:

a. Land and Land Use

Collectively, two States along the course of Beas River cover 1,06,033 km² area and represents 3.23% geographical area of the country (Table 2.36). By and large, both States are near equal in their respective geographical area. However, one State is totally mountainous with high hills while the other State is in plains. Hence, both States are contrast in terms of topography and altitudinal gradient. The mountainous State of Himachal Pradesh represents 1.7% geographical area of the country while Punjab State represents only 1.53% area of the country. In terms of land use categories viz., forests, net area sown, permanent pastures and other grazing lands, and area not available for cultivation, both States exhibit contrasting situation. The extent of forest as land use category in Himachal Pradesh represented 24.21% area while in Punjab it was just 5.86%. Punjab is largely agriculture dominated State having the higher value of net area sown of 82.83% of the geographical extent while net area sown in

Himachal Pradesh accounted 11.9%. The extent of permanent pastures and other grazing lands was much higher (32.89%) than Punjab (0.14%). A larger proportion of geographical extent (24.82%) in Himachal Pradesh was not available for cultivation while the value of land use category on area not available for cultivation was 10.25%. Thus, it is clearly evident that the Upper Beas River Basin is rich in forests and permanent pastures and other grazing lands while the Lower Beas River Basin in alluvial plains distinctly had relatively meager area of these two land use categories (Table 2.36).



Mantalai – Origin of river Parbati, an important religious destination

Table 2. 36 – Land Use Pattern in Himachal Pradesh and Punjab

Sr.No.	Land Use	Land Use			
		Himachal Pradesh		Punjab	
		Area (km ²)	Per cent Geographical Area of Country/ State	Area (km ²)	Per cent Geographical Area of Country/ State
1	Total Geographical Area	55,673	1.7	50,360	1.53
2	Reporting Area for Land Utilization	45,490	100.00	50,330	100.00
3	Forests	11,010	24.21	2,950	5.86

4	Not Available for Cultivation	11,290	24.82	5,160	10.25
5	Permanent Pastures and other Grazing Lands	14,960	32.89	70	0.14
6	Land Under Miscellaneous Tree Crops and Groves	650	1.43	50	0.10
7	Culturable Wasteland	1,380	3.03	30	0.06
8	Fallow Lands other than Current Fallows	150	0.33	0	0.00
9	Current Fallows	640	1.41	370	0.74
10	Net Area Sown	5,410	11.90	41,690	82.83

b. Human Settlement and Demography

As per the Census 2011, human population of two States was 34.60 million, representing 7.08% of the country's population. Punjab had a population of 27.74 million while Himachal Pradesh had population 6.86 million (Table 2.37). While two States were near equal in the geographical extent, the human population in Punjab was nearly four times higher. In case of Himalayan State, the bulk population was rural contributing nearly 90% of the total population while in case of Punjab, 62.5% human population was rural and 38.1% urban. The proportions of urban and rural populations in case of Punjab were closer to the average of all India. The values of average population density ranged from 123 persons/ km² to 551 persons/ km² for Himachal Pradesh and Punjab, respectively. The average population density in Himachal Pradesh was nearly one third of the average population density of the country. However, the population density of Punjab was more than four times than the Himachal Pradesh. The decadal growth (2001-2011) of human population in Himachal Pradesh and Punjab was 12.94% and 13.89% against the value of 17.69% registered for the entire country. The livestock population in two States as per the 19th livestock census of 2012 ranged from 4.84 million to 8.11 million against the country's total livestock population of 512 million. Owing to the mountainous State, Himachal Pradesh was having 11 hill districts out of total 12 districts and two tribal districts. Punjab neither had hill district nor the tribal district (Census, 2011). Altogether, Punjab was having 22 districts as per the Census of 2011 against 640 districts in the country.

Table 2. 37 – Comparison of Demography of Two States - Himachal Pradesh and Punjab within the Beas Riverscape

Sr. No.	Variable	India	Himachal Pradesh	Punjab
1	Geographical Area (km ²)	32,87,263	55,673	50,362
2	Population (As per 2011 Census - million)	1,210.8	6.86	27.74
3	Urban (million)	377.11 (31.1%)	0.68 (9.91%)	10.39 (38.1%)
4	Rural (million)	830	6.17	17.34

Sr. No.	Variable	India	Himachal Pradesh	Punjab
		(68.58%)	(89.9%)	(62.5%)
5	Average Population Density (per km ²)	382	123	551
6	Livestock Population (As per the 19th Livestock Census in 2012; Values in million)	512.0	4.84	8.11
7	No. of Districts (as per Census 2011)	640	12	22
8	No. of Hill Districts	-	11	-
9	No. of Tribal Districts	-	2	-
10	Sex Ratio	940	972	895
11	Literacy (%)	74.04	82.80	75.8
12	Poverty Line (per capita/month as per 2011-12) Rural	972	708	830
13	Poverty Line (per capita/month as per 2011-12) Urban	1,457	888.3	960.8

(Source: Census of India, 2011)

(a) Sex Ratio, Literacy Rate and Poverty Line: The values of sex ratio in two States ranged from 895 in Punjab to 972 in Himachal Pradesh against the sex ratio of 940 in the country indicating that the proportion of female population in Punjab was lower than the India as well as Himachal Pradesh. Himachal Pradesh has higher rate of literacy, being 82.80% while Punjab had lower literacy rate of 75.8%. Both States had higher literacy rate than the country's average value of literacy. As per the estimates of the poverty line for 2011-12, the monthly per capita consumption expenditure in India for rural areas was of Rs. 972 while the monthly per capita expenditure in urban areas was Rs. 1,407. Against these values of poverty line, the values of poverty line in Himachal Pradesh were lower than Punjab. The monthly per capita expenditure in rural areas of Punjab was Rs. 830 which was higher against the country's average value of rural poverty line i.e., Rs. 816 per capita monthly expenditure. The value of estimated poverty line in urban areas of Himachal Pradesh was Rs. 883.30 monthly per capita expenditure.

(b) Culture and Religion: Culture refers to the cumulative deposit of knowledge, traditions, beliefs, values, experience, attitudes, meanings, hierarchies, religion, notion of time, spatial relations, concepts of the universe, and material objects and possessions acquired by the group of people in the course of generations through individual and group striving (Kumar, 2017). Culture of a place is exhibited by different aspects *viz.*, people and lifestyle, language, religion, art and craft, music and dance, fairs and festivals, and cuisines. Two North Indian States along the course of Beas River exhibit two distinct, rich, unique and vibrant cultures.

Himachal Pradesh, a mountainous Himalayan State known as *Dev Bhumi* until recent past was one of the few Indian States that had remained largely untouched by external customs and exposures, mainly owing to its difficult terrain. However, with the technological advancements, efficient road transport and communication systems, and linkages with markets in far flung areas, the State has changed rapidly. The State has three well defined eco-cultural zones viz., (a) the tribal belt dominated by Buddhism and Tibeto-Burmese language of the Himalayan group, (b) the middle belt adjoining the tribal areas, inhabited by communities following terrace cultivation, horticulture, and some elements of pastoralism, and (c) the lower and sub-montane areas inhabited by communities practicing settled cultivation and animal husbandry. The inhabitants of the latter two belts are mainly *Pahari* language speakers whereas in the first belt, only the *Gaddis*, *Pangwalas*, *Gujjars*, *Sipis* and some minor communities like *Swangla* speak *Pahari* language while rest speak a language akin to the Himalayan group of Tibeto-Burmees. Although the population is predominantly Hindu, the State also has small populations of Christians, Muslims, Sikhs and Buddhists (GoHP, 2000). The State is a multi-religious, multi-lingual, and multi-cultural due to migrations and settlements. Despite multi-religious society, religious harmony is being maintained in the State.



Being a Himalayan mountainous State and in general characterized by inaccessibility, fragility, marginality and diversity in a vast geographical extent and highly variable geo-climatic situation coupled with wide array of environmental risks, people of the State have adopted unique ways of living in harmony with nature's gift of natural resources. The culture of Himachal Pradesh has remained traditional and its ethnicity and originality have been retained to a great extent. The beauty of culture of the State lies in its simplicity. Culture is not only exuberant in the physical attires of the *Himachalis* but also in their festival celebrations, musical melodies, rhythmic dance and simple life style (Kumari and Punam, 2016).

Large proportion of the population does not belong to the aboriginal stock. Occasional waves of migration of considerable magnitude have taken place at different times. New settlers matrimonial alignments with the natives in the beginning of 9th century and continued for centuries (Nangia *et al.*, 1999). Institution of *Devta* (god) is the major religious establishment and generally each village has a *Devta* while some *Devta*'s have jurisdiction over several villages. People go to neighbouring *Devta* at every occasion, at the beginning or closer of

sowing, the harvesting time or any other auspicious occasion such as festival, marriage, birth and construction, etc. Numerous fairs and festivals exhibit their collective expression of the traditional and cultural values. Society is very closely knitted and on such occasions, all strata of society be it old and young, man and woman, and boys and girls in large number. They wear colourful dresses, caps and costumes. The portraits of *devtas* are made of wood and metal and are kept in village temple. However, they are frequently brought out from temple at the time of festivals and other public ceremonies. People seek guidance and blessing of *devta* on all occasions of important events in their life. Himachal Pradesh has been recognized a land of dance and music. The dance and music of the State is mainly religion-oriented where gods are invoked by singing and dancing during festivals. According to the belief, dancing when done with body and soul gets a person connected with the almighty. The local fairs and festivals have their unique attraction (Kumari and Punam, 2016, Nangia *et al.*, 1999). The State is well known for its various handicrafts *viz.*, carpets, shawls, caps, paintings, wood work, metal wear, leather works, etc. and worth appreciating. Pashmina shawl is one of the products in high demand. The rich culture and tradition of the State are reflected in its cuisine that encompasses a wide range of delicacies with a plethora of aroma and taste. However, traditional feast known as *Dham* is being prepared in *Himachali* style and served on special occasions such as marriages, local festivals and other important events. *Dham* forms an integral part of *Himachali* traditions (Tanwar *et al.*, 2018). The State harbours numerous historical and age old temples like the Manu temple and the Mata Hadimba temple in the beas catchment.

Despite the problems of centuries, Himachal's communities remained in perfect harmony and a strong faith in divinity and local adjustments developed gradually. With the emergence of principalities and local ruling hierarchical orders, though the people were subjugated to some inhuman exploitation yet there was a greater sense of security, oneness and identity in some way. This was a blessing in disguise in protecting age old traditions. The inhabitants remained backward in thought, belief and practices as there was no selfless guidance available to them. They depended on the meager resources available to them. They automatically stuck to age old traditions and way of life, and thus, utilized available resources in traditionally set styles. However, an upsurge in traditional system is visible due to technology advancement, urbanization, globalization, faster communication and a wide range of job opportunities coming forthwith, particularly, in the government and non-governmental sectors and as a result the younger generation is getting more and more to the new lifestyles, opening up vistas of competition and scientific advancement. Undoubtedly, Himachal Pradesh is an enchanting land with a mosaic of ethnic and diversified cultural panorma imbued with useful and magnificent traditional technologies and practices (GoHP, 2000).

The State of Punjab is fertile alluvial lowland situated in the west of Yamuna River, and bounded by the stony and highly broken slopes of the Himalayan Mountains in the north, the desert tract in the south, and rich Ganga plains in the east. Punjab has a cultural and ethnic background going back to the Indus Valley Civilization, which existed from 2,800-1,800 B.C., and was remarkable for its ordered cities and advance sanitation, excellent roads and uniquely structured society. Thus, Punjab has one of the oldest and richest cultures of the world. Its diversity and uniqueness is evident in the Punjabi poetry, philosophy, spirituality,

education, artistry, music, cuisine, science, technology, military warfare, architecture, traditions, values and history.

The culture of Punjab has its own unique fragrance and it is a land of dynamic people, portrays vitality and liveliness, which is amply reflected in the traditional culture. The culture of Punjab is unmatched. People of Punjab exhibit compassion and high spiritedness in their lifestyle. Punjab is known for their strong determination. There is artistry in every aspect of life in Punjab and an aura of embellishment dominates the place. The century-old culture in Punjab is renowned for its tolerance, progressiveness and logical approach to life as well. The culture of Punjab has undergone significant phases of evolution. Different phases can be broadly classified into three categories. The 'Ancient Punjab' had a rich baked-brick urban architecture. During the 'Middle Age', the State experienced several foreign invasions. Greek, Persian, Mongol and Afghan invasions had significant influence on the cultural landscape of the State. During this phase, the birth and growth of Sikhism occurred, giving a new dimension to the Punjabi culture. The rich and fertile land of the Punjab was meeting ground of different people and races. Its people descended from various stocks and consist of heterogeneous racial elements. Today, people from Punjab (prominently Sikhs) are distributed all over the world and as a result the traditional Punjabi culture has been expanded and strengthened in the western world as well. Punjab is inhabited by people of diverse socio-cultural dominations. They are basically of Indo-Aryan ethnic origin and belong to South Asia. Numerous invaders including British have invaded, settled and ruled the region, giving the State a unique culture. Punjab, being a multi-religious State has prominence of Sikhism and Hinduism religions while other religions like Islam, Christianity, Jainism and Buddhism also flourish, though relatively low in proportion. Punjabis celebrate several religious and seasonal festivals viz., Dussehra, Diwali, Lohri, Holi, Baisakhi, and several others. In addition, there are numerous anniversary celebrations as well in honour of 10 religious Gurus or leaders of Sikhism and various saints. Punjab is a land of legends, myths, folklore, and the Sufi philosophical and material culture which are carried forth by its continuing relevance to the present communities. Sikh identity arouses an image of potentially powerful, economic, political and cultural force. The Punjabi culture is renowned for variety of reasons as it reflects exclusiveness and liveliness of the people. The scope, history, sophistication and complexity of the culture are vast. Undoubtedly, the culture of Punjab is one of the distinctive culture found anywhere around the globe. The people of the State are friendly, hospitable, hard-working and relish living.

History has not been kind to the people of Punjab. The brutal division of the State during partition led to both carnage and to one of the biggest mass population movements during the 20th century. Amidst the riots, butchery and devastation, Punjabis of all religious persuasions suddenly found that they had to create new identities. Punjab has seen the extreme transformation due to shattering partition which ensued in many cultured changes.

People are regarded as born hosts and popular for having palate for eating. The philosophy of life for most of the Punjabis is to eat, drink and make merry. Punjab is known for being one of the greatest producer of rich and tasty food and the State bequeath the *Dhabha* culture, a way side eating joint (Kaur, 2013). The folk heritage of the Punjab reflects its thousands

years of history. The State has a very rich tradition of romantic dances, particularly the folk once. The vitality of people is vigorously displayed in their folk dances. Dances are typically performed at the time of celebrations such as crop harvest (*Baisakhi*), weddings, festivals, fairs, etc. The State had a rich tradition of arts and crafts and the richness of the land is reflected in its handicraft. The fascinating art works include mud work i.e., mud plaster on house walls in rural areas, metal work, *Phulkari* – an intricate needle and embroidery work, basketry, cotton flat woven rugs (*duries*), wood work, weaving, etc. and they provide enormous opportunities for varied markets (Kaur, 2013). Punjab is one of the prime destinations for pilgrimage in India as the State has a large number of holy shrines of equal religious significance. Apart from the world's largest and most visited *Gurdwara* – The Golden Temple and predominance of Sikh religious places, one can also visit a host of mosque dating back to the mughal times, temples and churches. In addition, the State is famous for the Beas city, a riverfront town on the Beas River as it is the headquarters of 'Radha Soami Satsang Beas (RSSB)'. Every year, millions of followers of RSSB travel to Beas to attend satsangs (discourses).

People, Occupation and Resource Dependence: Himachal Pradesh is the only State in the country whose 89.96% population lives in rural areas (Census, 2011). Traditionally, forests and pastures formed an important component of the village economy's resource base, boundaries between villages evolved to demarcate their access. Economic activities of the people living in rural areas can be divided into two broad categories i.e., subsistence and commercial. Prominent activities in the former category are agriculture and pastoralism. The major activities falling in the second category includes extraction of medicinal herbs and collection of mushrooms besides involvement of local people in wide range of occupations viz., trade and commerce, construction activities, transportation, small businesses – shops, professionals like carpenter, tailor, etc. and a small proportion of people in the service class. Agriculture is the main occupation of the people of Himachal Pradesh and has an important place in the economy of the State. Dependency on the agriculture and horticulture is imminent as it provides direct employment to about 62% of total workers of the State. Agriculture happens to be the premier source of State income. About 10% of the total State income comes from the agriculture and its allied sectors. The average land holding size is about one ha. According to the Agricultural Census (2010-11), 87.95% of the total holdings were of Small and Marginal farmers while 11.71% of holdings were owned by Semi-Medium and Medium farmers and only 0.3% holdings were owned by large farmers. In comparison to the mountainous State, the economy of Punjab was characterized by a productive, increasingly commercial agriculture, a diversity of small and medium scale industries, and the highest per capita income in the nation. Wheat and cotton are the principal crops. Livestock and poultry are also raised in large numbers. Industries with the largest number of workers include cotton, woolen and silk textiles, metal products and machinery, food and beverages, and transport equipment and parts. Other industries include hosiery, bicycles sewing machines and sporting goods.

Unlike Punjab State wherein the people's primary dependence for subsistence and commercial activities is on agriculture, the dependence of people in Himachal Pradesh, particularly, Middle Himalaya and the Greater Himalaya continue to be on diverse forests

along the altitudinal gradient for a variety of purposes including timber, fuelwood, fodder, livestock grazing, collection of medicinal herbs, etc. In fact, forests and livestock occupations provide much desired insurance against natural calamities and occasional failures of agriculture/ horticulture crops due to erratic patterns of climate.



Basket weaving with Hill Bamboo & Traditional Handloom

(c) Livestock: Two States along the Beas River account for nearly 2.52% country's livestock. The livestock sector in the State of Himachal Pradesh contributes around 28 to 30% of total agricultural produce. The sector has registered a high growth in gross value distribution as compared to the overall agriculture sector (Kumar *et al.*, 2012). The livestock population, though almost static, has witnessed increase in the population of buffalo and goats over time. According to 2012 livestock Census, the State had altogether 4.48 million livestock including 2.14 million cattle, 0.71 million buffalo, 0.80 million sheep, 1.11 million goat, 0.01 million horses and ponies, 0.02 million mules, and 2,921 yak, and other animals. Sheep rearing is one of the main occupations of the people in Himachal Pradesh. Rampur Bushari and Gaddi breeds are famous for indigenous carpet wool production. 37% of agricultural families rear sheep. 38% sheep in the State are crossbred (GoHP, 2017). Average decline in sheep population over last 15 years is to the extent of 1.67% per year. Migratory system is much prevalent as greater than 90% of State sheep and around 70% goat population is reared under this system. Several tribal communities are involved in migratory sheep husbandry (Sankhyan and Thakur, 2019). The majority of flocks now have goats and sheep in equal proportion but two to three decades earlier sheep use to be in majority. The migratory herds have been classified under three categories: (a) small flocks consisting 100 to 200 animals, (b) medium flocks having 200-350 animals, (c) and the large flocks with >350

animals. Migratory herds traverse through different forests along the altitudinal gradient so as to optimally utilize alpine pastures for grazing during summer. Sankhyan and Thakur (2019) concluded that the migratory system is the cornerstone of sheep farming in the State that is being practiced for long time and will remain as an integral part of the agro-economy of hill farming system. Nearly, 70% sheep population is migratory. In spite of various constraints, the migratory system is still sustainable owing to the fact that it is a very low input system which effectively counter balances its constraints and makes it a profitable venture. Sheep in the State produces about 3.08 million kg of wool, contributing about 8.2% of the country's wool production (Siril *et al.*, 2014).



Fodder: An important NTFP



Marginal farming with animals

As per the livestock Census 2012, Punjab State had 8.1 million total livestock including 2.42 million cattle, 5.16 million buffalo, 0.12 million sheep, 0.32 million goat and other animals. Livestock sector plays an important role in Punjab agriculture as evident from its contribution to the total agricultural GDP recorded at 36% during 2016-17 (Singh and Kaur, 2018).

According to Singh and Kumar (2018) the growth rate of livestock sector in last five-year period has been observed to be 5.05% as compared to only 0.46% in crop sector. The State is producing 11.28 MT of milk production of the country. The Punjab is leading milk producing State in the country. Tanwar and Verma (2017) assessed feed and fodder availability in Punjab *vis-à-vis* livestock population and reported the total annual availability of feed and fodder in the State to the extent of 24.24 MT against the requirement of 14.94 MT, thereby excess of around 62.18% per annum. They estimated availability of green fodder to the extent 3.31 MT on dry matter basis and excess fodder may be transported to the deficit area of the State as well as in other parts of the country by forming feed blocks.

(d) Agriculture and Allied Activities: Agriculture is the largest occupation and source of livelihood to most people in Himachal Pradesh and Punjab. In Himachal Pradesh, the agriculture is the source of livelihood for nearly 67% of the total population. Cultivation is mainly done on terraces as topography of the State is largely hills. The cultivation in hills is subjected to soil erosion since crop cultivation is usually on 5% to over 30% slopes. Nearly, 81% agriculture is rainfed. The size of land holdings up to 1 ha covers 61.5% farming community (GoHP, 2012). The small and marginal farmers put together account for 82.1% and cover an area of 43%. The medium farmers with holdings ranging from 2 ha to 10 ha cover an area of 47.2%. The agriculture workforce is nearly 35% of total population of which 63.25% are cultivators. The ratio of agriculture labourers to total workers forms only 2.66%. Agriculture in the State though made significant progress yet faces enormous challenges. Major challenges include: (a) land fragmentation and small size of land holdings leading to unremunerative agriculture; (b) hill agriculture is seriously constrained unless it is backed up by a scientifically designed strategic policy framework; (c) the society is undergoing changes in economic transitional phase as the joint family systems are becoming nuclear families and consequently working hands in agriculture are severely reduced; and (d) vagaries of weather. With the provision of irrigation in some of the districts, there is a clear cut shift in the cropping pattern. Major shift is from cereal crops to vegetable crops. Multiple cropping has also been introduced in irrigated area. The replacing crops are generally cash crops and have become a predominant factor in small farm management to earn cash in order to meet their input requirements and needs of the family money. However, this trend in certain situation is detrimental to meet the enhanced demands for cereal crops. Increasingly, there has been a heavy reliance on higher energy inputs in the form of tractors, diesel and electric pump sets and threshers. The State recorded the substantial increase nearly by four times in the number of tractors from 1987 to 1997. There has been a wide spread use of various chemicals in agriculture including fertilizers (NPK), pesticides, fungicides, herbicides and weedicides. The use of fertilizers has substantially increased from 34,852 MT in 1997-98 to 46,808 MT in 2003-04. In comparison to fertilizers, the use of farm yard manure has been progressively decreasing as nuclear families are hardly engaged in rearing cattle or domestic animals. There has been a sharp rise in the use of pesticides, particularly in vegetable crops. In recent times, various agriculture and horticulture crops face a serious threat from proliferation of invasive alien species and also by crop depredation due to increasing populations of wild pig and monkeys. In addition, the agriculture faces problems of market access, and inadequacy of soil and water conservation programmes. The hill agriculture has undergone a big transformation

in past five decades or so and conspicuous changes have occurred in cropping patterns, fruit orchards have replaced traditional cereal farming and cultivation of cash crops gained lot of significance (GoHP, 2012). The bullock cultivation is replaced by the use of tractors for cultivation. Use of fertilizers and other chemicals has gone very high. Several old crops and traditional/ local varieties have been replaced. New crops are being adopted to diversify crop cultivation. Mixed cropping is fading away. Farmers have become conscious about using the available water resources of which earlier they were ignorant. Definitely, there has been evident erosion in agro-biodiversity. The State has been bestowed with conducive environment for cultivation of large variety of horticulture crops *viz.*, fruits, vegetables, ornamental plants and herbs in prevailing wide range of agro-climatic conditions within the State. Presently, more than 30 fruit species are being grown. Prominent ones are: apple, apricot, peach, pear, plum, almond, walnut, pecan-nut, mandarin, sweet orange, mango, guava, papaya, litchi, kiwi, olive, and strawberry. Various fruit crops grown during 2017-18 in the State covered 2,30,852 ha, out of this apple with maximum extent of 1,12,634 ha was distinctly prominent and provided total production of 4,46,574 t (GoHP, 2018).

Like Himachal Pradesh, the State of Punjab has also made unparalleled progress in the agriculture since the advent of green revolution in the mid 60s with traditional agriculture progressively giving way to modern and commercial agriculture. Presently, 82% of the geographical area of the State is under cultivation and cropping intensity is around 191% with over 99% of the cultivatable area with under assured irrigation. The State has 41,370 km² area as net sown in 2015-16. The production food grain in the State increased from 3.16 MT in 1960-61 to 28.39 MT in 2015-16 as a result of introduction of High Yielding Varieties and new technologies to the hardworking and receptive farmers with the support of the government policies. The State known as ‘Granary of India’ has played key role in transforming India from grain importing nation to self reliant and export surplus nation. The State has highest yield of rice, being 4.41t/ha while the yield in case of wheat has been 5.04 t/ha. The State contributed 46.4% of wheat and 29% of rice to central pool during the year 2016-17. The stunning rise of food grain production from 11.92 MT in 1980-81 to 29.44 MT in 2013-14 was attributed to intensive use of farm chemicals. The consumption of chemical fertilizers (NPK) was increased from 0.76 MT to 1.71 MT in 2013-14. Enhanced use of nitrogenous fertilizers and relative under use of other fertilizers and micronutrients has led to imbalance in micronutrients in soils of the State. It is also worth mentioning here that 85% of water consumption in the State is accounted by the agriculture sector. Canals provide about 27% irrigation while tubewells contribute 73% irrigation. The number of tubewells has increased considerably in past decades. The groundwater is being overexploited to meet the increasing demand of water for irrigation. The present groundwater development in the State is 170% with groundwater in 80% geographical area of the State is over exploited. Farm mechanization has played a key role to bring a significant improvement in agriculture productivity in the State. Against the national average of one tractor per 62 ha net cultivated area in the country, Punjab has one tractor for every 8.17 ha of net cultivated land in the State. Farm mechanization in the State has reached at a saturation point. Punjab produced nearly 20 MT of rice straw and 17 MT of wheat straw annually and farmers practice open field burning of straw after combine harvesting. This straw burning during winter months has

been recognized as a major pollutant of air impacting the neighboring regions. Undoubtedly, the State has immensely helped the country in bringing the self reliance in food grain production and made significant contribution to the country's/ State economy. However, from the perspective of rivers, excessive groundwater abstraction and decline of water quality due to chemical pollutants are important concerns.

(e) Growing Tourism and Pressure on Forests: Two States along the course of Beas River are two important destinations for international, national and local tourists. High Himalayan Mountains, snow-covered peaks, lush green forests, beautiful valleys, gushing streams, mighty rivers, serene high altitude wetlands, spectacular wildlife, historical places, ancient temples, prominent religious and cultural sites, famous hill stations and enormous opportunities for adventure, nature, wildlife, and religious tourism collectively attracts visitors from far flung areas within the country and overseas. Tourism has assumed a phenomenal significance for economic development and employment generation, particularly in remote and backward areas. The environmental and geographic suitability of the State of Himachal Pradesh for tourism has undoubtedly provided endless opportunities for the development of tourism sector in the region.



Adventure tourism on the Beas

In Punjab, Amritsar is one of the famous cities, and it is one of the major tourist attractions in the State. The city is the home of the world famous Golden Temple apart from historic site (Jallianwala Bagh) and most popular place (Wagah-Attarin Border) on the Indo-Pak international border. Both States receive a huge number of tourists. While Himachal Pradesh

is having high flux mainly in summer season while Amritsar in Punjab gets tourists on the daily basis. Two important wetlands and Ramsar sites i.e., Pong Dam Lake and Harike Lake) owing to rich diversity of migratory birds and another fauna are important tourist sites in the Beas Basin. Recent rediscovery of Indus River dolphin will surely add value for visitors coming to Harike and other prominent sites in Punjab. A number of prominent PAs with rich and unique biodiversity also offer vast opportunities for the development of nature and wildlife tourism.

Undoubtedly, growing tourism activities in two States have immensely helped the tourism sector within the country and in these two States by way of providing enormous opportunities for employment and other sundry business for the locals. However, as the vast experience from other tourist destinations in the world illustrates, there have been adverse impact on the environment, particularly rivers including river Beas its tributaries and associated wetlands, and the socio-economics. Kuniyal *et al.* (2003) have described environmental impact of tourism in Kullu-Manali complex and highlighted issues of deforestation, excessive construction, of air and water pollution, solid waste management, etc. Pal and Pal (2016) studied tourism and its impact on socio-economic life of Shimla district and observed that it cannot be advocated that tourism should be stopped but should it be promoted and developed at the cost of socio economic environment. He recognized that tourism in the hill areas is a growing factor in the economy and tourism has become more egalitarian pursuit than what it used to be in the previous decades. According to them, unplanned, unchecked and mass tourism exerts a profound influence on the environment and ecology. Thus, they recommended that plans for the development of tourism be prepared on sound ecological, environmental and socio economic considerations (Pal and Pal, 2016). Chadha and Choudhari (2016) have studied the nature, problems and prospects of rural tourism in Punjab and recommended to develop an effective tourism promotion strategy incorporating opportunities for highlighting State's art and craft, cuisines, folk items and integration of excursion outings with the aim to promote rural tourism alongside professionally managed Harike and Kanjli wetlands. Kuniyal *et al.* (2007) examined tourism practices in alpine and sub-alpine areas as a case study of Rohtang Pass and surroundings close to the origin of Beas River in Kullu district and emphasized on involvement of local communities and local governments in environmental management, particularly regulation in traffic waste management and development of specific tourism sites.

Other Activities: Two States within the Beas River Basin have immense potential of hydropower generation. Accordingly, in last six decades or so a large number of major hydropower projects have been either commissioned or under execution or being investigated besides the establishment of small/ mini-micro hydel projects in both the States. Indeed, two States were pioneers in the country in implementing ambitious programmes on interlinking prominent rivers i.e., Beas and Sutlej, and Ravi and Beas so as to safeguard interests of India on account of water sharing under the Indus Water Treaty, 1960, expand irrigation potential in rainfed regions for grow more food programmes and to realize the goals of green revolution, generation of much desired hydropower, and providing water to water thirsty

regions in the desert State of Rajasthan, etc. On one hand, the major programmes on large dams/ barrages and hydropower projects (HEPs) have provided multiple benefits to the respective State and the nation as a whole, but at the same time these activities have caused enormous irrecoverable environmental damages. Himachal Pradesh has longer international border with China on its east while the State of Punjab has a long international border on its west with Pakistan. Hence, there is presence and enhanced activities of General Reserve Engineering Force (GREF), Boarder Road Organisation (BRO), Indian Armed Forces and Para Military Forces (BSF, CRPF, SSB, ITBP and CSIF) due to surveillance and protection of country's international borders with neighboring countries, maintenance of strategic road network and communication in high altitude areas, and protection of important installations (e.g., hydroelectric projects, reservoirs, barrages, etc.). On one hand these activities boost the local economy and provide enormous opportunities for local employment, efficient road communication and other basic amenities, but at the same time these activities pose additional pressure on scant and fast depleting natural resources in the fragile Himalayan region and cold/ hot desert regions. In last three decades or so, there was sudden spurt in activities related to the collection of medicinal and aromatic plants and other forest resources for commercial enterprises. The River Beas Basin in the mountainous tract of Himachal Pradesh and alluvial plains of Punjab have not only provided forest, agriculture, horticulture, fish, water for irrigation and hydropower resources but the river Beas and other prominent rivers in two States also provide enormous valuable resources viz., sand, boulders, *bajri*, from the river beds, thus, contribution in a significant way to the construction industry. Traditionally, the Beas and other rivers in Himachal Pradesh were used for transportation of timber logs and wood for railway sleepers, but currently prominent rivers are being used for water sports and recreation.

c. Development Programmes, Conservation Issues and Implications

Two States along the Beas River right from the ancient times as well as during past two centuries or so have been in the vanguard of all round development, starting with the process of civilization, invasions and wars, migration, settlement, forestry and forest management, agriculture expansion fisheries, creation of dams/ barrages and canals, establishment of hydropower projects (HEPs), interlinking of rivers, industrialization, pilgrimage and more so the tourism activities in the recent past. Most of these events, developments and activities had undeniable impact on the natural ecosystems in two States. Traditional resource dependence, growing commercial activities and enhanced multifarious demands of human and livestock further exerted enormous pressure on scant natural resources. The Central as well as concerned State governments and even local village level institutions/ communities have undertaken various initiatives to protect and conserve forests, wildlife, wetlands and other freshwater resources including rivers but the pressure surmounting and there is evident decline in biodiversity and the overall environment.

The forgoing description on the physical, biological and socio-economic environment in the context of Beas River Basin and the riverscape has attempted to offer an insight on the existing situation of diverse natural ecosystems and associated flora and fauna besides the

ecology of Beas River and its wider and complex environment. Certainly the process of human disturbances and decline in the quantity and quality of natural resources including freshwater have aggravated in several instances to the point of no return. In short, the present chapter on the Beas Riverscape and its environment has made an effort to provide an overview on the complex interrelationships of the Beas River with its broader environment and surroundings, highlighted important events/ activities and their implications alongside narrating the conservation significance and issues those need urgent attention in order to restore/ rejuvenate one of the important rivers i.e., Beas River so as to bring back its lost glory and conservation values.

d. SWOT Analysis of Beas River Ecosystem and its Environment

On the completion of extensive consultative process carried out as a part of the present task, and also on the basis of a thorough review undertaken to understand and appreciate the existing situation of the Beas River and its environment, its past trends, and implications, the SWOT Analysis was performed. The findings of the SWOT Analysis are summarized in Table 2.38.

Table 2. 38 – Summary of SWOT Analysis in the Context of Beas Riverscape and its Environment

Strength
▪ Beas River is one of the five major rivers of the Indus River System in India, fed by snow and glacial-melt. It forms second largest catchment area in the Himalayan Mountainous tract in the State of Himachal Pradesh and drains through the Great Himalaya, Middle Himalaya, and the Lower Himalaya before descending into Alluvial Plains of Punjab. ▪ Beas Riverscape exhibit varied landforms along vast range of altitudinal gradient and climatic conditions, and thus, harbours a wide range of forests, grasslands, alpine pastures and wetlands those are home to a variety of rare, endangered and threatened floral and faunal species. These diverse natural ecosystems not only provide enormous biodiversity values but significantly contribute for the maintenance of the ecological integrity, overall health and sustained environmental flows of the Beas River and its tributaries. ▪ The River Basin and the Beas Riverscape harbours a large number of glaciers, high-altitudinal lakes and extensive snow-capped peaks sustaining water flow in the river all through the year. ▪ The riverscape harbours several large, contiguous and compact forest blocks along the altitudinal gradient those constitute some of the important protected areas (PAs). The Great Himalayan National Park and its adjacent PAs are such examples and together they have been inscribed as the World Heritage Site (WHS) by the UNESCO in recognition of its global significance. ▪ The unique faunal of the high altitudinal region and recent re-discovery of the Indus River Dolphin in the lower most stretch of Beas River before its confluence with Sutlej at Harike after a lapse of several decades has not only enhanced the biodiversity value of the river/ Indus River System in India but also signifies the healthy river. ▪ The Beas River continues to be major source of varied economic values (e.g., drinking water, irrigation, hydropower, fish, sand, boulders, recreation, tourism, etc.) besides a source of prosperity and aspirations of different sectors, agencies, and local communities.

Additionally, in view of its religious and cultural values, the river also receives desired attention and support from the Central, State and Local Governments; user agencies and masses those are traditionally dependent on the river for subsistence, livelihoods and commercial activities.

Weakness

- The river, surrounding lands and its varied resources are excessively burdened due to high and competing demands of various sectors/ users, human needs and greed, abuse and neglect. As a result, the river ecosystem exhibits numerous signs of degradation and deterioration. Moreover, the survival of several tributaries and the ecological integrity of the main river have been threatened.
- Rapid retreat of the prominent Parbati Glacier within the riverscape along with melting of several other smaller glaciers with the Beas River basin, enhanced landslides, intense sedimentation and erosion, diversion of substantial water to the Sutlej River through Beas-Sutlej Link, resultant fragmentation and reduced connectivity (longitudinal, vertical, lateral and temporal) and e-flows, increased pollution, and excessive use/ exploitation of forests, alpine pastures and important wetlands are some of the main issues of concern.
- In spite the government has enacted multiple legislative acts relevant to forests, environment, wildlife, pollution control, waste management, etc.; formulated several relevant policies and strategies; established different authorities to regulate use of river resources, and numerous judiciary interventions in the recent decade, there are enormous challenges in enforcing laws and regulating use of river resources.
- Most agencies concerned with use of the water from river, regulation and law enforcement continue to work in isolation and overlook the complex and intricate environment of the river ecosystem and continue to adopt piecemeal and fragmentary approaches to management and conservation instead of much desired holistic and comprehensive perspective of the riverscape.

Opportunities

- The Beas River has been bestowed with enormous resources, power, capacity and potential to flourish, resist and recover (resiliency) even after natural catastrophes and human disturbances. Despite such exigencies and disturbances, the river has been able to withstand and cope with adverse impacts and continue to provide benefits of multiple goods and various other ecosystem services.
- In recent decades, various government sectors/ departments, law enforcement agencies, scientific organizations/ universities, non-governmental organizations, and civil society organizations have come forward to undertake researches on varied priority themes, standardise protocols for monitoring different processes and resources, and their execution. These efforts amply reflect the wider awakening and their meaningful involvement in conservation, and restoration initiatives. Thus, increasingly environment favourable to river ecosystem is being gradually built. In the process, a greater constituency of law enforcement agencies, policies and law makers, field practitioners, scientific experts, technocrats, corporates, religious leaders and masses is being established for the sake of conservation and revival of the Beas River to its past splendor and ecological integrity.

Threats

- The Beas River originates and flows through the high seismic zone that experiences several geological i.e., tectonic upheaval, seismic activities, and landslides, environmental i.e., avalanches, cloud- bursts, and climate change implications and human induced i.e., deforestation, diversion of river water, forest fires, conversion of forests/ grasslands/ wetlands to agriculture/ horticulture, air and water pollution, sand mining and disturbance to bedrock, construction of roads and hydropower projects HEPs, sewage and waste

- disposal from cities and townships, unregulated tourism, etc.) processes/ disturbances.
- Land and ecosystem degradation, enhanced demands of high HEPs, excessive abstraction of groundwater are some of the major threats to sustainability of river ecosystem.
 - Since multiple States share water and other resources (power) of the Beas River, controlled under the Indus Water Treaty, 1960, and several agencies involved in its use, regulation, and management of resources, often issues related to inter-State, Center- State, inter-agency coordinaton and cooperation crop-up.



Intense erosion and sedimentation from seasonal streams

2.7 Research and Monitoring

Research and monitoring are two interconnected, parallel and indispensable activities, vital for management of natural and manmade resources, businesses, industries, military operations, various developmental activities, etc. These two widely used activities help in developing the much desired information base, setting goals, and objectives, identification of problems and threat in achieving goals/ objectives, formulation of appropriate strategies besides facilitating policy and decision making and even creating new discoveries.

The thorough and comprehensive review of the river environment presented in the preceding sections has abundantly echoed the multi-faceted, intricate, elaborate nature of the river ecosystem and highlighted current efforts of various government and scientific agencies and a large number of experts representing a wide array of disciplines i.e., geology, glaciology, hydrology, engineering, soil science, forestry, botany, zoology, law, fishery, agriculture,

wildlife, environmental management, sociology, economics, etc. in developing, and offering an understanding of the complex and dynamic nature of the river and its tributaries from their origin to confluence/ mouth and also how different natural processes and human disturbances have influenced the overall ecology not only of the river but its adjacent ecosystems. The review also highlighted that most agencies continue to work in isolation and thus, the available information is widely scattered, patchy, segregated, and inadequate besides considerable information is either outdated/archival or not uniform and consistent in procedures/ protocols followed by them. Indeed, one has to fathom the ocean of information to understand and appreciate the numerous linkages, associations, inter-relationships, and implications among the intertwined variables of the physical, biological and socio-economic sub-environments. Certainly, there is a wide gap in the available informations and in majority instances; it offers limited insight (Table 2.39). The review on the river environment revealed that there is an urgency to improve, strengthen, augment and institutionalized current efforts so as to develop a holistic and comprehensive understanding on the intricate discipline of river and its environment.

Table 2. 39 - Type of Researches and Monitoring Efforts in the context of Beas Riverscape

Sr. No.	Type of Inventory and Monitoring	Implementing Agencies	Periodicity	References	Remarks
1.	The State and Fate of Himalayan Glaciers	Geological Survey of India ICIMOD SAC, ISRO	Broad based baseline information on glaciers exists and study/monitoring protocols standardized. No specific periodicity or consistency in procedures evident. Mostly, one time project based outputs. Longer gaps in monitoring. Appears as no single authority designated for monitoring and keeping long term database. Several	Himalayan Glaciers and Glacial Lakes – Bhambri and Bolch, 2009; Bolch <i>et al.</i> , 2012; SAC, 2016; Campbell, 2005; Kasturirangan <i>et al.</i> , 2013; Ravindra and Laluraj, 2012; Sharma <i>et al.</i> , 2013, Bahuguna <i>et al.</i> , 2007 and 2014; Kulkarani <i>et al.</i> , 2005, Dutta <i>et al.</i> , 2007.	Broad based insight on the state and fate of Himalayan Glaciers and Glacial Lakes region/basin-wise exists. Monitoring of glaciers in different basins during 2000-2011 undertaken. Glacier fluctuation in Beas River Basin monitored during 1972-2006. Alarming retreat of Parbati glacier during 1990-2001 reported. Inventory of

Sr. No.	Type of Inventory and Monitoring	Implementing Agencies	Periodicity	References	Remarks
			piecemeal, sporadic monitoring efforts by individual scientist or group of scientists for specific glacier or a basin level monitoring.		glaciers and glacial lakes by ICIMOD during 2002-2015 provided.
2.	Cryosphere, Snow Cover, Glacial Lakes and Permafrost	National Institute of Hydrology (NIH) SAC, ISRO Wadia Institute of Himalayan Geology (WIHG) H.P. State Centre on Climate Change (HPSCC) HIMCOSTE	Probably no specific designated agency. Sporadic and <i>ad hoc</i> initiatives by different agencies/ group of scientists. Lack of uniformity in procedures/ protocols, monitoring sites and even periodicity.	Permafrost – Allen <i>et al.</i> , 2016; Owen and England, 1998; Schmid <i>et al.</i> , 2015; Vaughen <i>et al.</i> , 2013. Inventory of GLOFs – Randhawa and Sharma, 2014	Mostly piecemeal efforts. SAC, ISRO carried out probably one time study on snow cover in different basins during 2000-2011. It was difficult to comprehend precise information on snow cover, GLOFs, etc. specific to the Beas River Basin.
3.	Surface and groundwater Resources and E-Flows	Central Water Commission (CWC) Central Ground Water Board (CGWB) – States Units State Council for Science and	Valuable information on the State-wise and District-wise ground water resources on annual basis is being provided by CGWB. Information on surface water, estimation of snow/ glacier	CGWB, 2019; Ahluwalia <i>et al.</i> , 2015, Vajja and Roy, 2005; Lakhera <i>et al.</i> , 2016; Kumar <i>et al.</i> , 2007; Jain and Kumar, 2014; Jain, 2015; Kumar	Desired information on ground water and surface water being provided on regular basis for each of the State/ District and prominent rivers. Likewise, valuable

Sr. No.	Type of Inventory and Monitoring	Implementing Agencies	Periodicity	References	Remarks
		Technology Department of Irrigation National Institute of Hydrology (NIH) Bhakra Beas Management Board (BBMB) Wadia Institute of Himalayan Geology (WIHG) Indian Institute of Technology (IIT), Roorkee International Water Management Institute (IWMI)	melt contribution on <i>ad hoc</i> basis-fragmentary studies. Evaluation of water Budget – river specific studies/ monitoring. Monitoring in specific stretches of river. Information on e-flows for Indian River basins based on longer stretches of time periods by IWMI.	<i>et al.</i>, 2017; WMO, 2019; Smakthin and Unputhas, 2006.	information on e-flow in case of prominent rivers and hydroelectric projects(HEPs) being generated. However, there is a need to organize large datasets for optimal use by various user agencies. Insight on e-flows for smaller streams/ tributaries of major rivers is desirable.
4.	Sediment Transport and Sediment Budget and Flooding	Various international and national agencies carry out the studies on sediments load in major rivers. National Institute of Hydrology (NIH) Indian	Methods to assess sediment fluxes in reservoirs have been improved using RS and GIS technologies. Piecemeal and fragmentary studies. No specific periodicity.	World/Asian rivers – Walling, 2008 and 2011 Wasson, 2003 Mega Dams – Gupta <i>et al.</i>, 2012 Pong and Bhakra Reservoirs – Jain <i>et al.</i>,	Review revealed that probably no specific national level agency responsible for comprehensive and adequate monitoring of sediment transport through various rivers, tributaries, and confluences.

Sr. No.	Type of Inventory and Monitoring	Implementing Agencies	Periodicity	References	Remarks
		Institute of Technology (IIT), Roorkee and Bombay Scientific studies on assessment of sedimentation in different reservoirs and role of mega dams in reducing sediment fluxes. Bhakra Beas Management Board (BBMB)		2002; Shukla <i>et al.</i>, 2017 Lesser Himalaya – Thirthan Watershed – Singh, 2011 Sediment Yield Assessment Large Basins – Garg and Jyotiprakash, 2012	Insight on sedimentation in Pong and Bhakra Reservoirs by Shukla <i>et al.</i>, 2017 provided desired information during past 35 and 45 years, respectively.
5.	Water quality	Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs) are the agencies for monitoring water quality in rivers and other water bodies. State and Central Govt. Institutions, Universities, and Scientists.	Regular monitoring of water quality on select permanent monitoring stations in different seasons relevant to prominent rivers and water bodies. Individual efforts are predominantly piecemeal or specific to a river/tributary stretch or a wetland.	CPCB, 2007; Kumar <i>et al.</i>, 2017; GoHP, 2012; HPSPCB, 2019 Beas River - Solanki and Khera, 2019; Kumar <i>et al.</i>, 2017; Awasthi and Tamot, 2010; Mishra and Nadda, 2014; Sharma and Walia, 2016	Standard guidelines for monitoring of water quality (parameters, tolerable range and periodicity) by MoEF&CC, CPCB and BIS are available. However, water monitoring in various rivers, tributaries and confluence points needs intensification.
6.	Forest	Forest Survey	FSI undertakes	Biennial	Much reliable,

Sr. No.	Type of Inventory and Monitoring	Implementing Agencies	Periodicity	References	Remarks
	Cover, Tree Cover, Forest Types, TOFs, Growing Stock and Carbon Sequestration	of India (FSI)	biennial assessment on overall forest cover – entire country, State and District-wise since 1987. Situation of forests including temporal changes in TOFs being provided on regular basis. Valuable insight on growing stock, carbon sequestration, forest fires, bamboos, etc. is also made available.	ISFRs by FSI	authentic and institutionalized process. Considering the significance of prominent rivers and their tributaries, it would be desirable that basin-wise information is also generated atleast on a periodical interval of five years to start with the available data. Considering the threat of weeds/ IAS (Invasive Alien species).
7.	Carnivores (Snow leopard, bears) and Herbivores	State Forest Department (SFD), Wildlife Wing WII ZSI NCF Snow Leopard Trust Local Universities/ State level	The Wildlife Wing of the State Forest Department organizes periodic/ annual assessments on population estimation of select species i.e., carnivores, ungulates and primates in select PAs. In recent years, NCF and HPFD have collaborated to monitor the	NCF, 2019; Lyngdoh <i>et al.</i> , 2014; HPFD, 2005	Efforts so far have been made mainly to standardized methods/ protocols for field surveys/ assessments/ monitoring of elusive snow leopard and its prey in vast rugged terrain and harsh climatic conditions. Concerted efforts,

Sr. No.	Type of Inventory and Monitoring	Implementing Agencies	Periodicity	References	Remarks
		Institutions Individual Experts/ Scientists	population of snow leopard and its prey. WII and ZSI have also intensified activities on field surveys/ assessments of faunal species in project mode.		collaborations are required to develop comprehensive scientific protocols to assess high altitude fauna and their habitat on periodic basis on the lines of All India Monitoring of Tiger, its Prey and Habitat as implemented by NTCA in all tiger range States/ UTs. Replication of similar efforts in the Himalayan States or the Project Snow Leopard States is desired.
8.	Fish Fauna	State Fishery Department National Bureau of Fish Genetic Resources (NBFGR) ZSI WII SANDRP WWF - India	Several institutions/ experts have carried out fragmentary/ isolated studies on the diversity, abundance and distribution of fish fauna in different rivers/stretches or other water bodies. By and large, most efforts are in the form of surveys/ research	Sehgal, 1974; Sharma and Tondon, 1990; Sugunan, 1995; Johal <i>et al.</i> , 2002; Dhanze and Dhanze, 2004; Moza and Mishra, 2007; Jagtap, 2013; Kumar and Khanna, 2014; Khan, 2016; Sharma, 2019	Considering the significance of fish fauna in river ecology, there is an urgent requirement to develop and adopt standard protocol for long term monitoring of fish fauna in the Beas River Basin/ Riverscape or relevant,

Sr. No.	Type of Inventory and Monitoring	Implementing Agencies	Periodicity	References	Remarks
			studies or one time initiative.		prominent rivers and tributaries in a State on the lines of Sarkar <i>et al.</i> , 2012 as adopted in the case of Ganga River.
9.	Herpetofauna	State Forest Department (SFD) ZSI WII WWF - India	So far, ZSI has made efforts to provide comprehensive insight on the diversity of herpetofauna in the concerned States. Sporadic studies have been carried out by experts from WII and WWF – India	WII ENVIS Bulletin, 1999; Sharma, 2019; Khan and Pant, 2015; Sharma and Sidhu, 2016	In general, the review of available information on herpetofauna in the context of Beas River and two concerned States revealed that there is highly inadequate information, particularly on their status, distribution and efforts to monitor them were conspicuously absent.
10.	Avifauna in general and waterfowls	State Forest Department (SFD), Wildlife Wing BNHS, Bird International WII WWF, ZSI India	The focus of avifaunal surveys, research studies and <i>ad hoc</i> fragmentary monitoring efforts have been restricted to preparation of checklists, galliforms and pheasants, waterbirds,	Garson, 1983; Gaston <i>et al.</i> , 1983; Pandey, 1989; Islam and Rahmani, 2004; Kumar, 2011; Jha and McKinley, 2014; Ramesh <i>et al.</i> , 1999; Jayapal <i>et al.</i> ,	As such planned long term monitoring of avifauna in the Beas River Basin or concerned two States is missing, except comprehensive and institutionalized monitoring of

Sr. No.	Type of Inventory and Monitoring	Implementing Agencies	Periodicity	References	Remarks
			particularly migratory in prominent wetlands.	2007; Pandey and Tondon, 2005; HPFD, 2005; Jindal <i>et al.</i> , 2013; Kumar, 2014; Singh, 2015; WII ENVIS Bulletin, 2017; HPFD, 2018a, b and c	avifauna particularly migratory waterfowls in select wetlands/ Ramsar sites or even some PAs.
11.	Aquatic Mammals (Indus River Dolphin and Otters)	State Forest Department (SFD), Wildlife Wing WWF-India WII	Diversity of three Otter species in Himachal Pradesh has been described. Preliminary insight on otter in Punjab was provided by Singh, (1999). Subsequently Khan (2015) has provided updated information on the occurrence of smooth-coated otter in Punjab. Behra <i>et al.</i> (2008) confirmed the occurrence of Indus River Dolphin in Beas River after its last report from India some hundred years ago. Khan (2013, 2014 and 2016) and Khan and Pant (2014) have provided	Sharma and Sidhu, 2016; Singh, 1999, Khan, 2015 Behra <i>et al.</i> , 2008; Khan, 2013 and 2016; Khan and Pant, 2014, 2015.	Mechanism for monitoring of otters in Beas River Basin and two concerned States is yet to be evolved and institutionalized. After confirmation of Indus Dolphin in Beas River Basin waters, regular monitoring of the species has been jointly initiated by the Punjab State Forest Department and WWF India. Considering the significance of aquatic mammalian biota, it is necessary that otters and dolphin are being monitored

Sr. No.	Type of Inventory and Monitoring	Implementing Agencies	Periodicity	References	Remarks
			information on status, distribution and population size of Indus Dolphin in Beas River.		on a regular basis on much shorter interval so as to keep track of these sensitive and specialized species.
12.	Socio-economic; Demography; Floristic Biodiversity; resource dependence on forests, grasslands, wetlands and river; ecosystem services collection of NTFPs including medicinal and aromatic plants; alternate income generation options.	Census of India Various Universities and Scientific Organizations (GBPIHE, HFRI, WII, WWF-India, FRI, BSF, CSIR-IHBT etc).	Insight on socio-economic situation in two States and District-wise is primarily available from decadal census. In addition, various agencies, departments and scientific institutions are contributing on the socio-economic theme and its different related aspects.	Census India, 2011 Tucker, 1999; Nangia <i>et al.</i> , 1999; Baviskar, 1998; Kumar <i>et al.</i> , 1999	There is an urgency to design and develop a comprehensive and well institutionalized monitoring covering various aspects of socio-economics, particularly resource dependence, collection of NTFPs, , community participation, access and benefit sharing, conflict, etc.
13.	Social and Village Level Institutions; Community Participation; Sustainable Livelihoods; and Vulnerability.	Disaster management Cell, State Government	Only a handful studies provide insight on village level institutions, sustainable livelihoods and vulnerability. However, the approach is largely fragmentary and widespread.	GoI, 2003; Kahlon <i>et al.</i> , 2014; TARU, 2015; SEEDS, 2009; Prasad <i>et al.</i> , 2016, Singh and Singh, 2018; GoHP, 2012; Chandel and Brar, 2010	Both concerned States are having several types of village level institutions created for various purposes. While some old, traditional village institutions are

Sr. No.	Type of Inventory and Monitoring	Implementing Agencies	Periodicity	References	Remarks
			In recent years, a large number of studies have come up with regard to hazards, vulnerability and risk analysis relevant to mountain hazard susceptibility livelihood security and climate change implications.		dying, several new institutions at village/ panchayat level are being created. There is an urgent need to have detailed study on such institution, their roles and contributions in natural resource management, particularly rivers and their tributaries.
14.	Impact of developmental projects (e.g., HEPs and road network), mass pilgrimage/ congregation and tourism.	Organizations under the MoEF&CC (e.g., FRI, WII, GBPNIHE, HFRI, NIC, Department of Energy, Govt. of H.P., etc.) Universities. Non-Governmental Organizations and individual experts.	Most EIA studies are project specific and often focusing either on limited components/ themes or specific aspects.	RSET, 2019; Himdhara, 2019; Nag, 2013; Kuniyal <i>et al.</i> , 2007	Information on various developmental projects and their monitoring is widely distributed among several organizations/ agencies. Recently, on the behest of the MoEF&CC, RSET (2019) carried out a cumulative impact and carrying capacity study of Beas River Basin. No institutional mechanism and appropriate databases.

Notably, the above review also revealed that current researches and monitoring activities have ignored in developing an understanding of the linkages between forested vegetation and forestry with river hydrology in a vast country like India wherein the Himalayan as well as other major rivers play crucial role in the maintenance of vital freshwater resources, ecology and prosperity of the region. Considering the looming water crisis and to ensure water security, it is of utmost importance to develop the discipline of Forest Hydrology in accordance with the socio-cultural milieu of the country. Further, there is a distinct deficiency of a reliable knowledge management centre in the context of rivers in India. Likewise, developed nations have gained considerable experience in restoration of rivers and appropriate applications of tools and techniques related to biofilters and bio-remediation. Priority attention and support for these activities at all levels is the need of the hour. The significance of research and monitoring in interrelated disciplines of river ecosystem cannot be undermined, if the country has to restore the river ecology neglected for a long. Thus, the present DPR proposes support for the long term, inter-disciplinary researches and monitoring activities as a precursor to the sustainable management of river ecosystems.



Himalayan Rivers originate from majestic mountains

3.1 River Management – Emerging Concept of Planning Areas

River managers face a wide array of challenges in managing rivers as they need to balance a range of competing interests, the complexity and scale of issues, and uncertainty over future conditions. The discipline of ‘River Management’ has evolved over time from one-dimensional responses at addressing a single issue (i.e., water quality), to more sophisticated approaches that involve both active management i.e., physically changing the river and landscape and passive management i.e., policy measures to change human behaviour. In the process, various concepts and approaches have emerged and evolved from the perspective of planning, assessment, management, and conservation of river ecosystems. These are river basin, watershed, riverscape, and riverscape management. A river basin is a portion of land drain by a river and its tributaries. A river basin is also known as catchment area, drainage basin, or catchment basin. Generally, river basins are separated by ridges, mountains, and hills. These drainages divide or landforms that divide river system are called watershed. Watersheds are part of river basin and a river basin may have several smaller sub-watersheds or micro-watersheds. The landscape approach to studying and managing river system – the ‘riverscape’ approach has become increasingly dominant in recent decades with numerous studies integrating rivers with their landscape context. According to Ward (1998), a riverine landscape indicates a holistic approach linking the rivers and its banks, or its riparian area,

within a fluvial system. The foregoing introductory chapter has emphasised the importance of a holistic perspective required for river management, wherein four types of connectivity, various interactions and exchanges all along the river course from origin to mouth occur and they contribute towards ecological processes and in maintenance of ecological integrity and river health. The rapidly evolving concept of riverscape now finds an important place in the growing literature on the river management. The concept of riverscape has been adopted for forestry interventions for rejuvenation of Ganga river (FRI, 2016). The riverscape approach integrates the broad scale physical, biological and aesthetic nature of river and aims to describe spatio-temporal pattern and processes over a stipulated time.

According to Naiman and Bilby (1998), the process of river or riverscape management can be constructed around four key questions: (a) what is the present condition of river ecosystem; (b) what are the desired ecosystem conditions; (c) what is feasible; and (d) how can the desired conditions be achieved? The role of science, both the natural as well as the social sciences in studying river ecosystems and providing technical information is vital for answering the first question. It is essential to understand what elements make the ecosystem and their functional inter-relationships. The science based technical information allows informed and informative debate about the ecosystem in question. The second question about desired ecosystem conditions is fundamentally about values. Values derive the way humankind interacts with the environment. Therefore, the second question highlights the importance of human use and their impact on the river ecosystem. Hence, it is essential to consider humans as an integral part of river ecosystem. The answer to the above second question provides the foundation on which programmes of resource and river management are built. The third question about feasibility implies the existence of limits and constraints. It rests heavily on trade-offs among competing interests and values. If society is to adopt the ecosystem paradigm as a basis for management, it will be necessary to accept the notion of limits (Naiman and Bilby, 1998). The final question about how the desired condition can be achieved implies the joining of policies and programmes in a synergy. Policies establish broad social objective while programmes are specific activities undertaken to move toward those objectives. Ecosystems are dynamic and ever changing, and unanticipated changes or uncertainty in the system is inevitable. The successful river management will have strong focus on ends and will continually adapt means to nudge the system towards those ends.

3.1.1 Global Insight on Riparian Corridors or Riparian Buffers

Different land use types exert varied influence on the freshwater environment including streams and river ecosystems as forestry and agricultural practices in surrounding lands, increasing expansion of road network along the river course, industrialization and urbanisation have the potential to degrade water quality and physical habitats within streams and rivers (Broadmedow and Nisbet, 2004). The concept of ‘riparian zone’ has already been introduced in the Chapter 1 (section 1.8.2) and its varied functions have been highlighted. The concept of ‘riparian corridors’ or ‘riparian buffers’ has gained wider acceptance as tools for protecting water quality, maintaining wildlife habitat and providing other benefits to

people and the environment (Lowrance *et al.*, 1998; USEPA, 1998; Wenger, 1999; Hawes and Smith, 2005) (Fig. 2.1).

Developing an understanding of the concept of riparian corridors or riparian buffers is of immense significance in the context of forestry interventions for river restoration. A riparian corridor (RC) forms a transition zone between the land, also known as the terrestrial environment, and the river or the water course or aquatic environment (NSW, 2012). In other words, the RC is a strip of vegetation that connects two or more larger patches of vegetation (i.e., habitat) and through which any organism will likely move over time. These landscape features are often referred to as ‘conservation corridors’, ‘wildlife corridors’ and ‘dispersal corridors’ (Fischer and Fischenich, 2000). The ‘riparian buffer strip’ is yet another term in use and defines a linear band of permanent vegetation adjacent to an aquatic ecosystem intended to maintain or improve water quality by trapping and removing non-point source pollutants (NPSP) (e.g., contaminants from herbicides and pesticides; nutrients from fertilizers; and sediments from upland soils) from both overland and shallow sub-surface flow (Fischer and Fischenich, 2000).



Riparian Forest as buffers

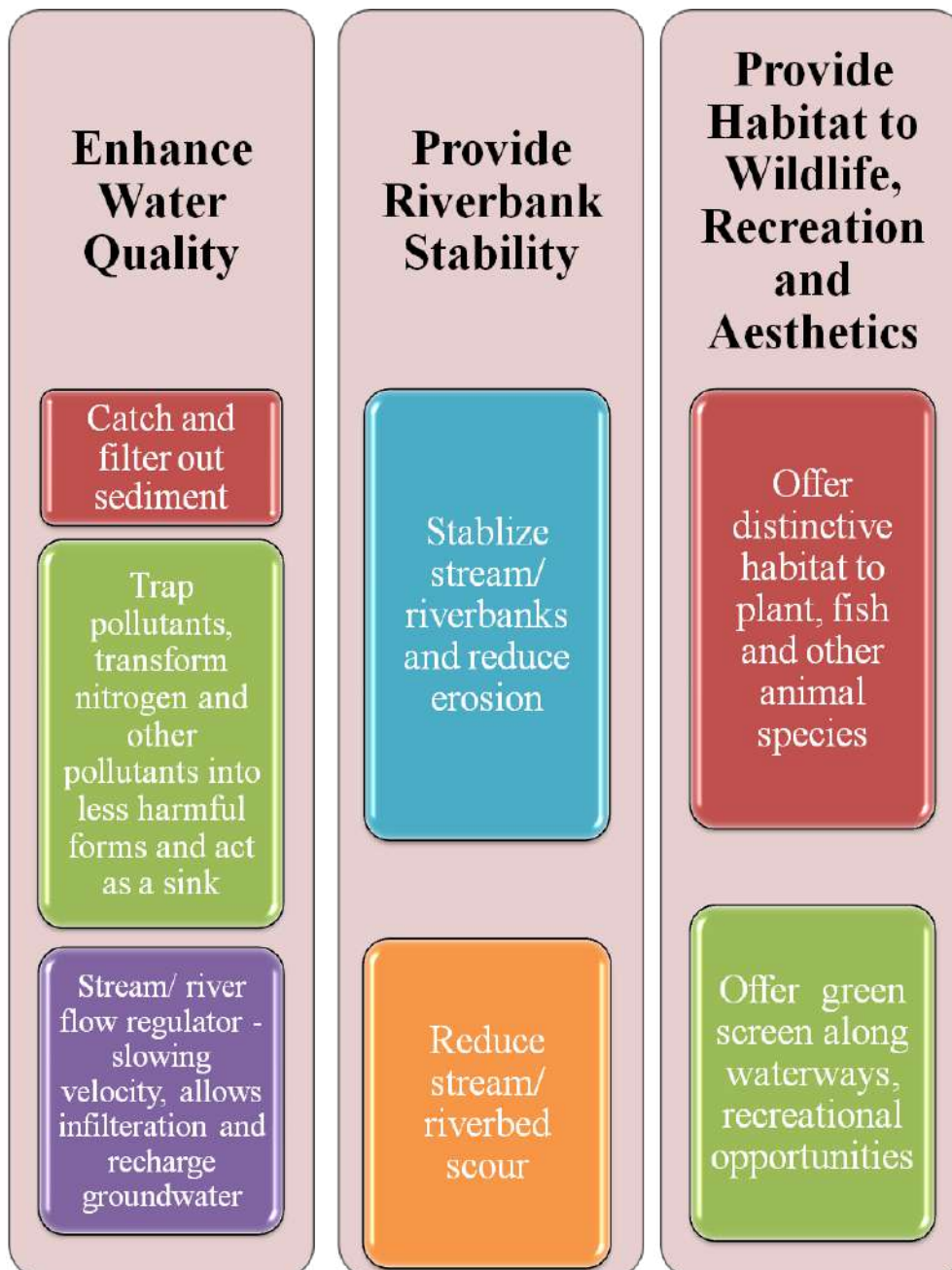


Fig. 3. 1- Functions of Riparian Buffer

Buffer strips could occur in a variety of forms *viz.*, herbaceous or grassy buffers, grassed waterways or forest riparian buffer strips. Welsch (1991) has defined three-zone systems in the riparian forest buffers performing different functions for protection and enhancement of water resources. These are: (a) the Zone I – Undisturbed Forest in the immediate vicinity of stream/river or flowing water; (b) the Zone II – Managed Forests; and (C) the Zone III – Runoff Control (Grasslands/ Pastures/ Farm lands). This three zone system was originally developed as a part of an initiative to protect the Chesapeake Bay in USA. The combination of vegetation types *i.e.*, trees, grasses, herbs and shrubs) helps maximize the efficiency and diversity of benefits that the riparian buffer provides (Hawes and Smith, 2005) (Fig. 3.2).

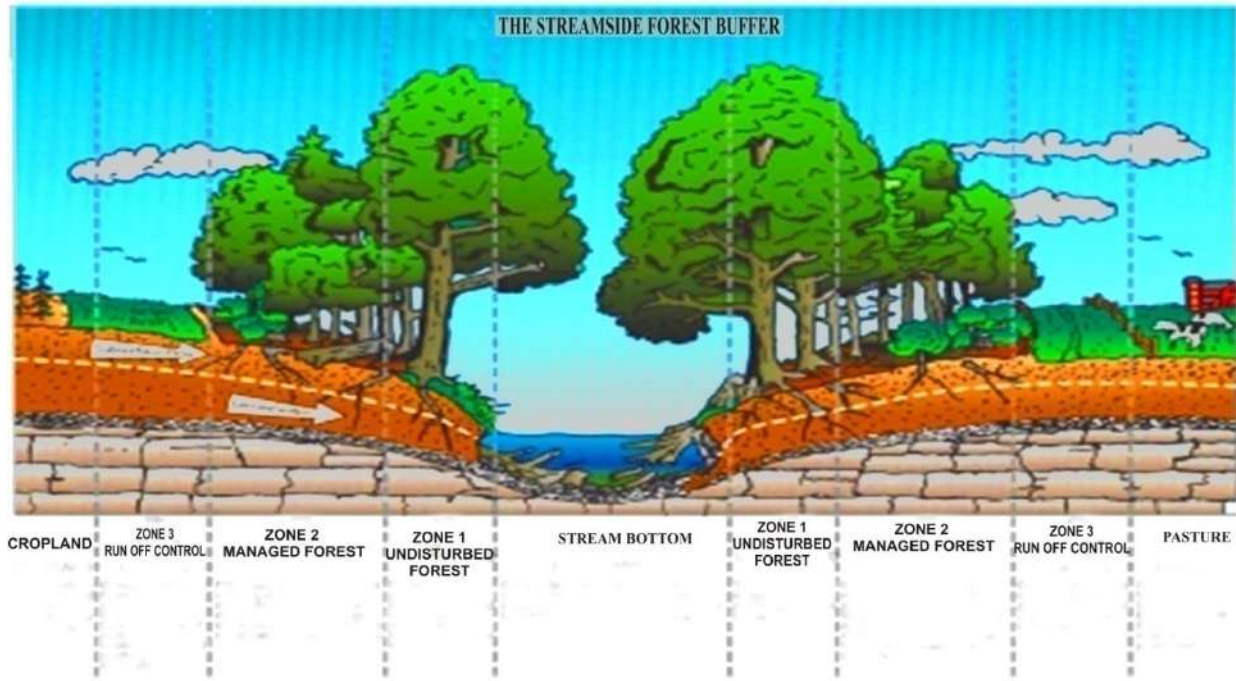


Fig. 3. 2- Three-Zone Systems in the Riparian Forest Buffers
(Source: Welsch, 1991)

Riparian corridors or buffers perform a wide range of important environmental functions including water quality enhancement, stormwater and floodwater management, stream bank and shoreline stabilization, water temperature modification, wildlife habitat protection, and absorption of airborne pollutants. These multiple benefits can translate into enhanced quality of life and substantial savings for the community (Baird and Wetmore, 2006). Riparian corridors not only catch and filter out sediment and debris from surface runoff, but also trap pollutants namely phosphorous, nitrogen, etc. from fertilizers, insecticides, pesticides, animal waste and convert them into less harmful forms. Riparian buffers also act as a sink when nutrients and excess water are taken up by root system and stored in biomass of trees. The riparian corridors immensely help in stream/ riverbank stability by slowing the velocity of runoff and by allowing the water to infiltrate and recharge the groundwater. Riparian buffer helps to reduce erosion and can reduce the amount of streambed or riverbed scour by absorbing surface runoff and slowing water velocity. Riparian buffers offer distinct habitat to a multitude of plant and animal species besides benefitting aquatic habitat, particularly the quality of water through shading, filtering, and moderating stream flow. Shade helps in moderating temperatures and maintaining cooler water that holds more oxygen and reduces stress on fish and other aquatic organisms. Forested buffers are especially valuable in providing a green screen along waterways, blocking views of nearby developments besides extending recreation opportunities and enriching overall aesthetics (Connecticut River Watershed, 2000). There are numerous researches worldwide on functional aspects of riparian corridors or buffers and there is a voluminous literature exists on the subject (Broadmeadow and Nisbet, 2004).

a. Issues with Maintaining a Riparian Corridor and Buffer Zone

There is no ‘one-size-fits-all’ description of an ideal riparian corridor or riparian buffer as several factors influence the effectiveness of buffers. These include slope, rainfall, rate of

water absorption into the soil, type of vegetation in the buffer, the amount of impervious surfaces, and other characteristic attributes specific to the terrain and site (Hawes and Smith, 2005). A large number of studies have been carried out to address and design riparian buffer zone. Most researches have focussed on buffer design, specifically with regard to forest buffer width, the type of vegetation assemblage, layout, and length. Guidelines for buffer width for various objectives (i.e., water quality, habitat and corridors for wildlife, riverbank stabilization, and flood attenuation) have been researched and prescribed (Wenger, 1999; Fischer and Fischenich, 2000). Proper widths for various objectives may vary significantly by a region as it depends on variety of environmental and physical factors. The width of buffer is also a function of the stream order (Strahler system). NSW (2012) has prescribed 20 m, 40 m, and 60 m width of riparian corridor in case of 1st order, 2nd order, and 3rd order streams/ water course types. Larger width of river corridors was recommended in the case of 4th order or greater streams/ river courses.

In view of a large number of factors influencing the buffer width, most Federal, State and Local Governments in the western countries have enacted relevant laws or have developed guidelines for protecting water courses and developing riparian buffer protection plans (Forestry Commission, 1998; Skogsstyrelsen, 2000; Forest Service, 2000; Blinn and Kilgore, 2001). In the USA, many state forestry agencies have published best management practices for riparian forests setting guidelines for the width on the riparian management zone and restrictions on harvesting for small perennial streams (Phillips *et al.*, 2000). Most studies and guidelines have prescribed the buffer width of maximum 100 m on either side of the bank. However, some studies have recommended higher riparian corridor width from the perspective of habitat for birds and other terrestrial animals (Hodges and Krementz, 1996). Wenger (1999) has provided an exhaustive review on riparian buffer width, extent and vegetation.

Unfortunately, in India, there is no well-defined guidelines that prescribe the width of the riparian buffer, except the Forest Working Plan(s) prepared by various Forest Divisions under the control of State Forest Departments often provide a prescription for the maintenance of a forest buffer strip along the stream and river banks depending upon the stream order wherein trees are not marked and prohibited to fell. Recently, the Rally for Rivers in its draft policy recommendations proposed solution and policy recommendation to develop tree cover by planting trees for a minimum of 1 km-width along the entire river course on either side of the river for revitalization of dying Indian Rivers (Isha Foundation, 2017).

b. River Ecology Concepts and the Riparian Buffers

Although, the principal objective of a riparian buffer may appear simple enough so as to protect the aquatic zone from disturbance by forest operations or any other land use on the adjacent land, it is important to understand the deeper logic and science behind the planning for such vegetation cover and plantations. In several instances, developing a riparian corridor may actually not be a natural aspect of the ecological system at all, and it must be clearly seen as a management initiative which is planned for the protection and restoration of river

water flow and quality. It is essential to appreciate the relevance of riparian buffer from the perspective of various basic concepts of river ecology viz., the river continuum concept, nutrient spiralling concept, etc.

3.1.2 Rationale for Selection of Reasonable River - Forest Buffer or Riparian Corridor

An appraisal of the exhaustive literature available on the theme of riparian corridors revealed that riparian buffers are complex ecosystems that provide habitat and improve the stream communities they shelter. Effective riparian vegetative corridor is vital for water flow, quality and river health. It is also evident that not only the natural riparian buffers have been lost in most places, particularly in human dominated country like India but also the lands surrounding streams and river courses have been drastically altered. The review of literature on the width of riparian corridor or forest buffer along river courses also revealed that there is wide variation in the global opinion on this priority theme as there cannot be 'one-size-fits-all'. Moreover, most of the available literature from Britain and other western countries pertain to streams and water courses of lower order.

The situation of major Indian Rivers, particularly the Himalayan Rivers namely the Indus, Ganga and Brahmaputra is conspicuously different in magnitude owing to their wider range in altitudinal gradient, steep slopes, and rugged terrain besides the fact that the Himalayan mountains depicts extremely high fragility due to unstable geological formations, proneness to natural disasters (i.e., high seismicity, avalanches, cloudbursts, highly variable tropical monsoonal rainfall patterns, resultant high sedimentation, landslides and floods), high biotic pressure (i.e., livestock grazing, extensive road network, wide spread densely populated habitations-townships, sequential multipurpose hydroelectric projects all along the river course, recurrent annual forest fires, industrial growth, etc.), especially in upper reaches or upstream area calls for altogether a different perspective and dimension for deciding the width of the riparian corridor.

The width of the Himalayan Rivers in high flood levels ranges from as low as 1 km to as high as to several kilometres. These rivers after descending the mountainous tract or after entering in the plains are highly braided and channels often change their course, resulting into creation of large number of river islands due to high siltation and enormous flow of sediments. In recent decades, the intensity of landslides and erodability in high altitude Himalayan Mountains has increased several folds owing to various natural factors and human disturbances. Further, most stretches of Himalayan Rivers from their origin to confluence with other rivers or mouth are overburdened by growing townships and large cities and in most instances either devoid of natural vegetation/ forests in proximity to highly fluctuating river banks or even well-defined riverine corridors. Moreover, most stretches of rivers in high altitude areas or in the plains are bounded by extensive orchards or agricultural lands. The urbanization along the major rivers and their tributaries has created concrete jungles in the immediate vicinity of river banks, damaging the aesthetics, natural flow regimes, enhanced localized flooding problems and direct influence on water quality due to sewage and waste disposal.

The pilot exercise on the preparation of DPR for forestry interventions in the context of Ganga River based on an extensive consultative process adopted the riverscape approach for proposed inputs. The consultative process was able to identify the critical requirement to treat the natural, agricultural and urban landscapes within the defined width of the delineated riverscape (5 km – main stem and 2 km – tributaries) on either side of the riverbank from the points of high flood levels of recent time. The rationale of 5 km and 2 km width/ buffer was applied on the main river once it has entered into the plains. However, in the case of high altitude areas of Himalayan Mountain State, the whole catchment formed the part of the riverscape for planning, assessment, and proposed forestry interventions (FRI, 2016).

3.2 Planning and Assessment Area – Preparation of DPR on Forestry Interventions

Recognising the significance of holistic and complex nature of a river, the recent focus of river rejuvenation in India is on the riverscape and the ecosystem based management approaches. These approaches obviously rely on the expanding literature on successful river conservation efforts and river restoration programmes elsewhere in the world. In the present assignment, the MoEF & CC has sought a DPR on forestry interventions for the Beas River from HFRI, Shimla. The Beas River after its origin from Beas Kund in Himachal Pradesh flows into the plains of Punjab. Hence, the entire river course is along two States. The drainage basin of river Beas is 22,262.1 km²/20,303 km² (Jain *et al.*, 2007; ADB, 2010).

For the present assignment, a riverscape covering an area of 16,743.01 km² was delineated for the purpose of planning, assessment and proposed forestry interventions on the Beas River. The select riverscape includes the entire catchment of Beas River in the mountainous State of Himachal Pradesh. Hence, area of all micro-watersheds relevant to the Beas River basin from its origin near to Rohtang Pass up to Pong dam at the inter-state boundary with Punjab covering a drainage area of 13,702.16 km² has been included as the major and the upper part of delineated riverscape and it represents 81.84% area of the riverscape. Likewise, the entire area of all relevant micro-watersheds in Punjab State covering an area of 3,040.85 km² has been included in the riverscape in view of the fact that the water spread area during the high flood period has covered the extreme limits of concerned micro-watersheds. Thus, the riverscape in Punjab represents 18.16% area.

Details of the riverscape under consideration from the point of view of present DPR and State-wise spatial extents are presented in Table 3.1 and Fig. 3.3.

Table 3. 1 - State Wise Spatial Extent of the Beas Riverscape

State/ UT	Geographical Area* (km ²)	Geographical Coordinates (From – To)		Area in Riverscape (in km ²)	Per Cent area of Riverscape
		Lat N	Long E		
Himachal Pradesh	55,673	31° 27' 12" N to 32° 31' 27" N	75 ° 35' 39" E to 77 ° 52' 7" E	13,702.16	81.84
Punjab	50,362	31° 4' 16" N to	74 ° 30' 40" E to	3,040.85	17.29

		32°27' 15"N	75 ° 56' 11" E		
Total of Two States	1,06,035			16,743.01	100.00

(Source: ISFR of Forest Survey of India, 2017)

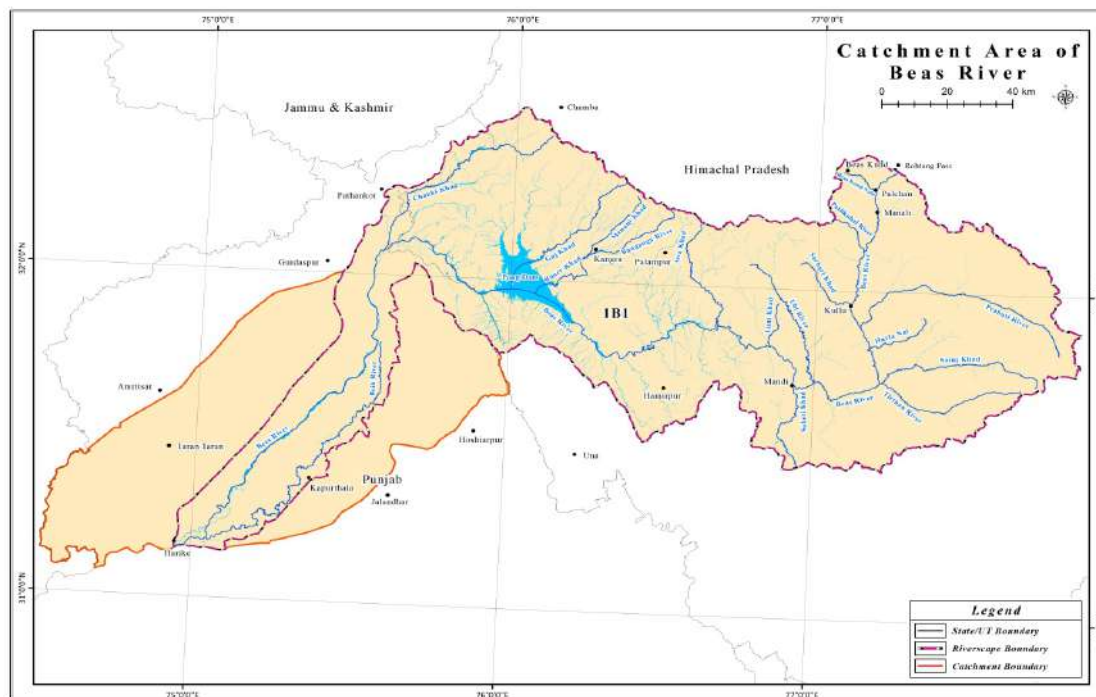


Fig. 3. 3- Beas Riverscape within Himachal Pradesh and Punjab

The State-wise details of districts, micro-watersheds, tributaries, major cities and town and the spatial extent incorporated in the Beas Riverscape are presented below:

Himachal Pradesh: The State of Himachal Pradesh, having a geographical area of 55,673 km² represents 1.69% geographical area of the country. Out of this, the spatial extent included in the Beas Riverscape from the State is 13,702.16 km² and it represents 81.84% area of the delineated Riverscape. The select area of the riverscape falls in five administrative districts of Himachal Pradesh. These districts are Kullu, Mandi, Kangra, Hamirpur and Chamba. Kullu district forms the upper reaches of Beas River basin while Mandi, Kangra and Hamirpur districts form the lower part of the basin. Very small area of Chamba district falls in the Beas River basin. Beas River and its 16 major tributaries *viz.*, Patlikul, Sarbari Khad, Parbati River, Hurla Nala, Sainj River, Thirthan River, Uhl River, Suketi Khad, Luni Khad, Awa Khad, Manuni Khad, Baner Khad, Banganga River, Chakki Khad, Gaj Khad, and Bein River falling in 1,977 micro-watersheds have been included in the riverscape for the purpose of planning, assessment and proposed interventions. Among the 16 tributaries, 15 originate in different parts of Himachal Pradesh from Pir Panjal Range, Great Himalayan and Dhauladhar Ranges while Bein River originates in Shivaliks, Punjab. Only, Chakki Khad that originates from the southern slopes of the Dhauladhar range in Himachal Pradesh continues to flow in Punjab while other tributaries join Beas River within the territory of Himachal Pradesh. Chakki Khad drains the south-western part of Himachal Pradesh and then enters Punjab to join the Beas River.

Punjab: The State of Punjab with a geographical area of 50,362 km² constitutes 1.53% of the geographical area of the country. Out of this, a small extent of 3,040.85 km² has been incorporated as a part of the Beas Riverscape. Thus, 18.16% area of the riverscape lies in the State of Punjab. Out of 20 districts of Punjab State, areas of only four administrative districts fall within the riverscape. These are Gurdaspur, Amritsar, Jalandhar and Tarn Taran. The select area of the Beas Riverscape in Punjab includes the main stem and only one tributary i.e., Bein River, and they fall in 372 micro-watersheds. Major cities and towns situated on the banks of Beas River and tributaries are Gurdaspur, Tanda, Hoshiarpur Katola, Dhnoa, Shri Hargobindpur, Nangal Labana, Dera Baba Jaimal Singh Ji, Jalalbad, Talwandi Choudhrian, etc.

3.3 The Approach – Preparation of DPR on Forestry Interventions

As stated earlier, the MoEF&CC and ICFRE had entrusted a major task to the HFRI, Shimla on the preparation of five separate DPRs of five tributaries (i.e., Beas, Chenab, Jhelum, Ravi and Sutlej) of the Indus River concurrently during the financial year 2019-20 and allowed one year time for the completion of assigned task. Hence, the HFRI undertook the entrusted task concurrently on DPRs of five rivers. The task was initiated in April, 2019. The Institute has constituted five independent teams, one for each of the river and each team included a Senior Scientist, Technical Officers, Project Fellows and Data Entry Operators. The work of these five teams was supervised and steered by a team of Senior Officials designated as the Team Leader, River Coordinator, Nodal Officer, Project Coordinator and Chief Project Coordinator for the purpose of DPRs. The HFRI also engaged consultants for providing desired resource inputs for the preparation of DPRs. In addition, the Institute had availed technical inputs from concerned experts/ agencies, particularly for the themes *viz.*, soil and water conservation, policy and law, Remote Sensing and Geographic Information System (GIS), and design and development of project web portal. The broad approach and the framework developed and adopted for the first time in the country in case of DPR specific to the Ganga river was employed for the preparation of five DPRs by HFRI (FRI, 2016). Accordingly, the approach in the preparatory phase for the present DPR on the Beas River included seven key steps *viz.*, (a) Project Initiation - Background Analysis/Contextual Analysis, (b) Analysis of Stakeholders and the Consultative Process, (c) Beas Riverscape - Situation and Problem Analysis, (d) Development of Web Portal – Collection and Analysis of Primary Field Data, (e) Objective Analysis and Strategic Planning, (f) Preparation of Draft DPR - Activities, Resource Planning and Schedule, and (g) Finalization of DPR, Implementation and Monitoring. These key steps and allied activities carried out as a part of the multi-pronged and multi-stakeholder consultative planning process for the preparation of DPR are diagrammatically presented in Fig. 3.4 and each of the key steps is briefly summarized below one by one:

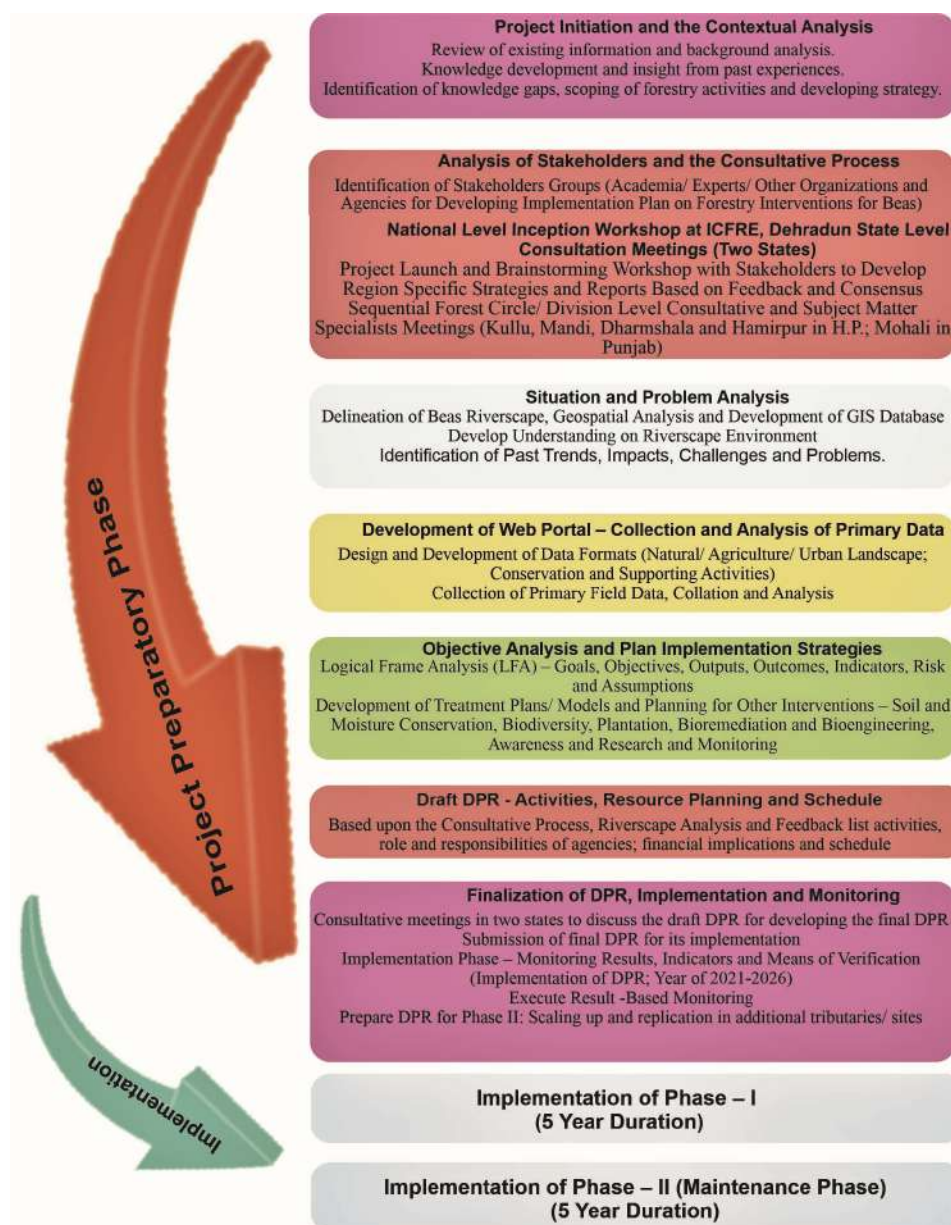


Fig. 3. 4- The Approach of Preparation of DPR for Forestry Interventions on Beas River

3.3.1 Project Initiation - Background Analysis/ Contextual Analysis

All ‘change processes’ are part of a wider context, a *project’s context* (overall environment). The project of present nature on forestry interventions for rejuvenation of Beas River is constantly influenced by economic, social and political processes that take place in society. The project planners and implementers thus seek information about the overall picture or the environment, including technical national and sectoral informations. Project activities started off by performing an overall preliminary study (*pre-study*), feasibility study or the inception phase. The pre-study involved the understanding and assessment of project’s external environment by collecting information about various related sectors, states and organisations involved as well as any data that existed about the target disciplines, sectors, themes, etc.

Further, it was realised that developing an understanding of the complex and dynamic nature of a river ecosystem and its linkages with forests and other surrounding landscapes requires adequate knowledge of relevant multi-disciplinary subjects and application of various technologies. There is a growing literature on the wider subject of river ecology and management besides a long historical perspective on the management of the each of the major river including the Beas River. Thus, the foremost key step in the present planning exercise on the preparation of DPR was a systematic review of vast available literature on the subject through internet surfing and library consultation. The websites of prominent international, national, and state level agencies and organisations dealing with any of the aspects related to river resources and conservation were extensively searched and required information was downloaded for developing the desired insight. The relevant secondary information from related organisations was also collected. The combined effort on the review of literature and collection of background information immensely helped in the contextual analysis. The contextual analysis also provided desired insight on the Beas riverscape and its three sub-environments (i.e., physical, biological and socio-economic).

3.3.2 Analysis of Stakeholders and the Consultative Process

The second vital step for successful planning and implementation required broader participation of stakeholders at all stages of planning of the project activities. Hence, it was essential to first identify which individuals and stakeholders affect and are affected by the project and which ones should be involved in the planning process. Likewise, it was critical to identify which stakeholders should be informed and involved during and after the project implementation. In the context of present assignment, broad five groups of stakeholders were identified as a part of the Step 1 on the contextual analysis. These five stakeholder groups included: (a) the Target group (primary and secondary target groups and beneficiaries); (b) Project owners and project groups; (c) Decision makers (at different levels, in organisations, at authorities and agencies, local politicians); (d) Experts and subject matter specialists; and (e) Financing agencies (those who sponsor/finance the project as well as state/ national or international financiers who shall support and fund the project implementation (FRI, 2016; Örtengren, 2016). The preparatory phase included the extensive consultative process with identified groups of stakeholder right from the beginning. Table 3.2 provides a broad-based

list of stakeholders in five identified groups, highlighting the prominent Central/ State Governments Ministries, Departments, Agencies, Organisations besides Civil Agencies and NGOs that were consulted or their representatives participated in Project Launch and Brainstorming Workshop and Subsequent Sequential Consultative Meetings organized for the purpose at the Forest Circle/ Division, and State Levels in two States lying along the main river course. Details of the consultative process and sequential meetings are presented in Table 3.3.

Table 3. 2 - Group of Stakeholders or their Representatives involved in the Consultation Process in Himachal Pradesh and Punjab

A. Target Groups (Primary and Secondary Target Groups and Beneficiaries)
Civil Society – Villagers, Farmers, Fishermen and Urban Population
State Forest Departments (SFDs)
Department of Agriculture
Department of Animal Husbandry
Department of Horticulture
Department of Soil and Water Conservation
Department of Fisheries
Department of Highways and PWDs
Department of Irrigation
Hydroelectric Projects
Department of Tourism
Para Military Forces
Panchayats
Municipal Corporations/ Municipal Boards
B. Project Owners and Partner Organisations
Ministry of Environment, Forest and Climate Change (MoEF&CC), New Delhi
Indian Council of Forestry Research and Education (ICFRE), Dehra Dun, Uttarakhand
State Forest Departments (SFDs) – Himachal Pradesh and Punjab
Himalayan Forest Research Institute, Shimla, Himachal Pradesh
C. Decision Makers
The Central Government Ministries/ Departments/ Agencies/ Organisations
NITI Aayog, New Delhi
Ministry of Environment, Forest and Climate Change (MoEF&CC), New Delhi
Ministry of Jal Shakti, New Delhi
Ministry of Youth Affairs and Sports (MoYA&S), New Delhi
Ministry of Rural Development (MoRD), New Delhi
Ministry of Panchayati Raj (MoPR), New Delhi
Ministry of Defence (MoD), New Delhi – Eco Task Force (ETF)
Ministry of Home Affairs, New Delhi, - Indo-Tibetan Border Police (ITBP)
Bhakra Beas Management Board (BBMB), Chandigarh
Central Water Commission (CWC), New Delhi
National River Conservation Directorate (NRCD), New Delhi
Central Pollution Control Board (CPCB), New Delhi
National Medicinal Plant Board (NMPB), New Delhi
National Biodiversity Authority (NBA), Chennai
Nehru Yuva Kendra Sangathan (NYKS), New Delhi
State Government Ministries/ Departments/ Agencies/ Organisations in States Himachal Pradesh and Punjab
State Governments and Concerned Ministries

State and District Administration
State Forest Department
State Forest Development Corporation
State Biodiversity Board
State Agriculture Department
Irrigation and Public Health Department
Horticulture Department
Department of Animal Husbandry
State Disaster Management Authority
State Pollution Control Board
D. Experts and Specialised Scientific Organisations
Indian Council of Forestry Research and Education (ICFRE)
Forest Research Institute (FRI)
Forest Survey of India (FSI)
Himalayan Forest Research Institute (HFRI)
Indian Institute of Soil and Water Conservation (IISWC)
National Institute of Hydrology (NIH) and Its Regional Centers
Central Water Commission (CWC)
Central Groundwater Board (CGWB)
Wildlife Institute of India (WII)
Indian Institute of Remote Sensing (IIRS)
Zoological Survey of India (ZSI)
Botanical Survey of India (BSI)
Survey of India (SOI)
National Horticulture Board (NHB)
National Bureau of Fish Genetic Resources (NBFGR)
Indian Agriculture Research Institute (IARI)
Centre of Inland Waters in South Asia (CIWSA)
Central Inland Fisheries Research Institute (CIFRI)
National Medicinal Plant Board (NMPB)
Bombay Natural History Society, Mumbai
WWF – India, New Delhi
Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh
Himachal Pradesh University, Shimla, Himachal Pradesh
CSK Himachal Pradesh Agriculture University, Palampur, Himachal Pradesh
Punjab Agriculture University (PAU), Ludhiana, Punjab
Punjab University, Chandigarh
Guru Nanak Dev University, Amritsar, Punjab
E. Sponsoring and Financing Agencies
Central Government – Ministry of Finance, MoEF & CC, MoJS, MoA, MoRD, Ministry of AYUSH, MoPR, and Indian Council of Forestry Research and Education (ICFRE)
State Government - Ministry of Finance/ Environment and Forests/ Rural Development/ Agriculture/ Tribal Affairs/ Panchayati Raj, etc.

Table 3.3 – Consultative Meetings at the National and State Levels for the Preparation of DPR

Sr.No.	Consultation Event	Venue, Date	No. of Participants
1	National Level Inception Workshop on Preparation of DPRs of Indian Major Rivers	24-25 April, 2019; ICFRE, Dehradun	61
2	Project Launch and Brainstorming	28-29 June, 2019	202

	Workshop	Hotel Holiday Home, Shimla	
3	First Consultative Meeting for Kullu Forest Circle, Himachal Pradesh	05 August, 2019 Office of the Kullu Forest Division, Kullu	45
4	Second Consultative Meeting for Dharamshala Forest Circle, Himachal Pradesh	19 August, 2019 Conference Hall, KFW – Mid Himalaya, Dharamshala, Kangra	46
5	State Level Consultative Meeting – Punjab	21 August, 2019 Forest Complex, Mohali, Punjab	63
6	Third Consultative Meeting for Hamirpur Forest Circle, Himachal Pradesh	23 August, 2019 Conference Hall, Forest Circle Office, Hamirpur	40
7	Fourth Consultative Meeting for Mandi Forest Circle, Himachal Pradesh	03 September, 2019 Conference Hall, Zila Parishad, Bhiuli, Mandi	55
8	Second State Consultative Meeting – Punjab to Discuss the Draft DPR	12 March, 2020 Forest Complex Mohali, Punjab	75
9	Second State Consultative Meeting – Himachal Pradesh to Discuss the Draft DPR	26 June, 2020 Video Conferencing	55

The following section provides the chronological summary of sequential Consultative Meetings at the National/State/Forest Circle levels and provides a gist of deliberations, recommendations, decisions and outcomes:

(i) National Level Inception Workshop on Preparation of DPRs of Indian Major Rivers (ICFRE, Dehra Dun; 24-25 April, 2019)

The ICFRE, Dehra Dun, being the Nodal and Coordinating Agency entrusted with the task to get DPRs for major Indian Rivers on forestry interventions, had organized the Inception Workshop at its Headquarters based at Dehra Dun on 24-25 April, 2019 under the Chairmanship of DG, ICFRE. The representatives (the Directors and Members of the Core Team) from all Regional Institutes of ICFRE those were involved in the preparation of DPRs and Resource Persons/ representatives from the Forest Research Institute (FRI), Dehra Dun; Indian Institute of Soil and Water Conservation (IISWC), Dehra Dun; Forest Survey of India (FSI), Dehra Dun; State Forest Department, Uttarakhand; *Namami Gange* - State Project Management Group), Dehra Dun besides professional agencies connected with RS and GIS; IT and Development of Web Portal; and select Resource Persons were the participants in the workshop. Altogether, there were 61 participants in 2-day workshop. The workshop also had four participants from HFRI. The objectives of the workshop included: (a) the familiarisation with the goals of the entrusted task, expected outputs and timelines; (b) development of an acquaintance with the approach and framework on the preparation of DPR adopted in the case of Ganga River during 2015-16; (c) creating awareness about the emerging and evolving concepts and strategies related to river ecology, linkages between forests and river, complex and dynamic nature of rivers, human disturbances in the context of river fragmentation, availability of water (e-flow), and water quality; (d) sharing of experiences and lesson learnt in the preparation of DPR on Ganga; (e) emphasizing on the need for adopting holistic and participatory approach based on the extensive consultations and the use of ‘riverscape

approach'; and (f) highlighting the need of knowledge management and sharing, science and results-based planning and monitoring, development of appropriate strategies for planning, assessment and implementation.

The select resource persons those were associated with the preparation of DPR on Ganga River made presentations and acquainted the workshop participants with the emerging concepts in the context of river conservation and broad framework and approach adopted for the preparation of DPR. The resource persons elaborated on the key steps and components involved, formats used for field data collection and the incorporated strategies on forestry interventions. The concepts of riverscape, its RS and GIS based geo-spatial analysis and the requirement of assessing and describing the riverscape environment were shared with the participants.

The workshop allowed intensive deliberations and working out the modalities and mechanisms for implementation of time bound major project involving nine major Indian River Basin Systems.

(ii) Project Launch and Brainstorming Workshop (Hotel Holiday Home, Shimla; 28-29 June, 2019)

The HFRI had organized the two days Project Launch and Brainstorming Workshop at Hotel Holiday Home (HHH), Shimla on 28-29, June 2019, primarily involving participants from three concerned States Himachal Pradesh, Punjab and Jammu and Kashmir (now J&K UT), those are associated with the preparation of DPRs of five tributaries of the Indus River Basin besides a large number of experts, resource persons and representatives from the State Forest Department and specialised national/ state level scientific organisations viz., the Forest Research Institute (FRI), Indian Institute of Soil and Water Conservation (IISWC), Indian Institute of Remote Sensing (IIRS), Forest Survey of India (FSI), Zoological Survey of India (ZSI), Botanical Survey of India (BSI), Central Water Commission (CWC), National Institute of Hydrology (NIH), and State Pollution Control Boards (SPCBs). Representatives of wide range of line agencies (i.e., Agriculture, Animal Husbandry, Horticulture, Medicinal Plants Board, Irrigation, Mining, Power, Rural Development, Hydroelectric Projects, Tourism, Himachal Pradesh Council of Science Technology and Environment (HIMCOSTE), State Biodiversity Board, etc.) also attended the workshop and actively participated in the workshop. Further, Experts and Subject Matter Specialists representing various Universities based in above three States were also invited.

The Workshop was inaugurated by the Hon'ble Forest Minister, Himachal Pradesh who in his inaugural address highlighted the need of water security, livelihoods, sustainable development and the priority agenda on rejuvenation of five rivers in the State of Himachal Pradesh, J&K and Punjab those are important tributaries of the Indus River Basin. He suggested adopting the approach/ framework on the lines of DPR on Ganga River and the efforts made under the National Mission for Clean Ganga (NMCG) and the *Namami Gange* program initiated by the Government of India (GoI). The Hon'ble Minister emphasized that the proposed plantation models should take into consideration the topography, geology, and forest types of the concerned areas keeping in view the varied landforms, climatic and

edaphic conditions in the mountainous states of H.P. and J&K. The PCCF and HoFFs of two States - H.P. and Punjab were the Guest of Honours on the occasion and in their addresses they emphasized on reduction of soil erosion in the hilly tract by appropriate soil and moisture conservation and forestry interventions. They assured the full corporation of their department(s) in the preparation of DPRs. The PCCF (Wildlife) and CWLW, H.P. was the Keynote Speaker of the Workshop and she not only introduced the concepts of river conservation and the approach adopted for the preparation of DPR on Ganga River in her earlier capacity as the Director, FRI, Dehra Dun, but also shared her experience and lessons learnt in the process of preparation of DPR with the workshop participants. The lead speaker on the occasion who was also associated with the preparation of DPR on Ganga River emphasized on global challenges, particularly the water crisis, the vital aspect of connectivity in the context of complex and dynamic river ecosystems besides the important aspects of ecological integrity and river health. The Director, HFRI, Shimla in his address informed the participants about the assigned task on five rivers and sought support of SFDs and other stakeholders of the states.

Altogether, in the inaugural and five technical sessions, there were 20 presentations by various Resource Persons and Experts. The Technical Session I included presentations by senior forest officials representing two States (H.P. and J&K) and they shared information on current efforts towards implementation of catchment area treatments plans, particularly soil and moisture conservation activities, development of appropriate technologies for afforestation including suitable nursery and plantation techniques. They emphasized on the micro-watershed treatment plans, snow water harvesting techniques, avalanche prone treatment area plans, selection of water efficient plant species, need for replenishment of medicinal plants, and a review of existing nursery techniques especially for plants relevant to the temperate and cold arid zone.

The Technical Session II included multiple presentations from the representative of the universities, scientific organisations and NGOs. These presentations highlighted that in Himachal Pradesh, nearly 30% area is under heavy erosion and about 50% area has medium soil erosion, causing displacement of around 280 MT of soil through water erosion every year losing 5.4 MT to 8.4 MT NPK per year, and hence enormous loss in productivity. This heavy loss of soil by erosion calls for urgent mechanical and vegetative measures for effective control of erosion and improving soil moisture condition. The representative from IISWC, Chandigarh informed that maps on soil erosion for H.P. and Punjab by his institute will help HFRI in the assigned task on the preparation of DPR. A Senior Expert in the field of soil and water conservation/ watershed management shared his experiences on the earlier efforts of watershed management programs carried out in the catchment of Swan River, Una, H.P. wherein the approach of treating whole watershed from top to bottom by adopting appropriate forestry interventions, pollution control measures, sewage treatment activities and allied actions for river rejuvenation was adopted. Based on experience gained, recommendations for treating the entire catchment with brushwood, bamboo plantations, stone check dams, and silt retention structures were made. Illustrating on the lessons learnt from the implementation of the World Bank supported 'Mid-Himalayan Watershed Project', the Resource Person informed the participants that the project covered in 10 Districts, 710

Panchayats, and 45 Development Blocks, has constructed check dams and water harvesting structures and as a result there was reduction and discharge from 40% to 20%, promotion of crop diversification, and increases in crop productivity and horticulture produce. The Resource Person from NERIL while highlighting the issues and concerns in preparation of DPR for rejuvenation of river emphasized for a need to collect primary as well secondary data with regard to topography, soil conditions and climatic patterns, and advocated for identification of critical areas, development of site specific plantation models, and selection of suitable native species in proposed plantation program.

During the Technical Session III, the Resource Person from the Central Water Commission, Shimla in his presentation recommended for effective management of factors responsible for degradation and deterioration of environmental flow and water quality. A priority need for treating solid waste and sewage disposal; and checking soil erosion, land mining, sedimentation flux, unsustainable land use, and industrial effluents was emphasized so as to seek uninterrupted flow and clean water in rivers under consideration. The Technical Session IV covered multiple presentations from specialised institutes and the State Pollution Control Board of Himachal Pradesh. The Experts from NIH, Western Himalayan Regional Centre, Jammu (J&K) broadly discussed the role of springs in the Himalayan Mountains and voiced concerns about their drying up, resulting in migration of as high as 200 million people living around those springs and traditionally dependent upon them. The house was informed about the structural, vegetative, and social measures for rejuvenation of springs. The Expert from IIRS, Dehra Dun emphasized on the geospatial support needed for the preparation of DPR and informed that a wide range of data on snow cover dynamics, land use change, socio-economic and climatic changes, hydrological and geospatial modeling, discharge data, forest fragmentation, vegetation and disturbance mapping, and biodiversity characterization are available with IIRS besides similar information/ data can be availed from NRSC, Hyderabad, WRIS and Bhuvan portal of ISRO. Likewise, the Resource Person from FSI, Dehra Dun informed about the availability of varied information viz., forest cover and forest type mapping, and extent and intensity of forest fires. He suggested to optimally use the information from the Web Map Service (WMS), and Digital Elevation Model (DEM) available with FSI while information on soil types can be obtained from BHUMI Portal of the NBSS, Nagpur. The resource person from the Punjab State Pollution Board informed about the high pollution level of Sutlej River due to sewage, industrial effluents and the major pollution/ impact by *Buddha Nallah* of Ludhiana. He recommended for appropriate measures like phyto-remediation and installation of bio-reactors in the *Buddha Nallah*.

The second day of the workshop was devoted to deliberate the Way Forward and the session was chaired by the PCCF (Wildlife) and CWLW, H.P. During deliberations, the following pertinent points and recommendations relevant to the proposed assignment on DPR emerged:

(a) Area of Consideration

The issue of delineation of riverscape was discussed at a great length as the participants were informed about the approach adopted for delineating Ganga Riverscape. Accordingly, the FRI, Dehra Dun has earlier incorporated the entire catchment of Ganga River in hilly state of Uttarakhand while a buffer of 5 km on either side from the HFL in the case of main stem and

2 km buffer on either side from the HFL in the case of selected tributaries once they have descended in the plains was included. Initially, some of participants were of the opinion to either consider the whole catchment or focus on the watershed approach. However, after considerable deliberations, the unanimous consensus was built to consider the entire catchment of a river in the mountainous Himalayan State as a major part of the riverscape while in the case of plains, a buffer of 5 km and 2 km for main stem and tributaries, respectively from the respective HFL was considered adequate for inclusion in the riverscape. It was also decided that selection of tributaries in the riverscape should be on the basis of silt load and water flow.

(b) Selection of Planting Material

Some participants were of the opinion that careful selection of suitable species for plantation/treatment models is prerequisite for effective recharge and rejuvenation of groundwater as in several instances *nallah* and streams were dried up due to plantations of Poplar and Eucalyptus. Finally, the consensus was built around selecting native and fast growing species those can provide multiple benefits and to avoid exotics and species those have high water requirement.

(c) Significance of Cryosphere

Concerns about declining glaciated area in each river basin, changing climatic and glacio-hydrological regimes of the Himalaya and effect of glacier recession on runoff were emphatically stressed upon. Implications of depleting cryosphere under changing climate on water, energy and food security particularly in Indus River Basin were highlighted. A need for estimating the snow and glacier melts, rainfall runoff, permafrost contribution and base flow at each of the sub-basin scale in the Indus River Basin was highlighted. The significance of protecting high altitude wetlands in the fore fields of glaciers in the upper Indus River Basin that play a vital role in maintaining the hydrological regimes of rivers was also emphasized.

(d) The Planning Process

The Chairperson of the session, in her concluding remarks strongly advocated for the adoption of riverscape concept on the lines of DPR on Ganga River and emphasized on the extensive and exhaustive consultative process involving various stakeholders. In view of the short time of one year for the preparation of DPR, she stressed upon the need to review the progress after 2 months so as to identify gaps and constraints in accomplishment of the targets and objectives. Contributions by stakeholders, especially the specialized organisations towards varied information required in the process of preparation of DPR were considered of paramount importance.

The 2-Day Workshop was successfully concluded and it could achieve its various objectives. Participants applauded the efforts made by HFRI in bringing together various stakeholders so as to discuss the priority agenda of river rejuvenation by forestry interventions and providing an opportunity to them for sharing their experiences and interactions. The workshop

concluded with a vote of thanks to the Chair, Resource Persons and participants and acknowledged significant contributions made by the participants.

(iii) First Consultative Meeting for Kullu Forest Circle, Himachal Pradesh (Office of the Divisional Forest Officer (Wildlife), Kullu; 05 August, 2019)

After the successful completion of the Project Launch and Brainstorming Workshop held at Shimla and introduction of the task on the preparation of DPRs of five rivers to varied stakeholders at the Regional level, the HFRI had decided to organize sequential meetings for consultation with the stakeholders at the level of each Forest Circle/ Division level in the State of H.P. and also to acquaint the forest officials, particularly the frontline staff with the process and templates for collecting primary field data that are required by HFRI in collation and synthesis of desired information and preparation of DPRs.

In the above response, the HFRI had organized the first Consultative Meeting and Training at the Kullu Forest Circle on 05 August, 2019. The Meeting was organized at the Office of the Divisional Forest Officer (Wildlife), Kullu, and was chaired by the CF, Kullu. More than 45 participants representing 15 Line departments of Kullu District attended the meeting. Prominent stakeholders in the meeting were from the State Forest Department including the CF, Kullu; DFO, Kullu; DFO, Seraj; DFO (Wildlife), Kullu; DFO (Hqrs), Kullu besides ACFs, RFOs and representatives from various Line Departments *viz.*, Agriculture, Horticulture, Public Works, Tourism, Irrigation and Public Health, and Public Relation Office. Scientists from GB Pant National Institute of Himalayan Environment and Sustainable Development (GBPNIHESD), Himachal regional centre, Mohal, Kullu unit and representatives of Hydroelectric Project – Parbati III; Presidents and Members of Nagar *Panchayats*, Bhuntar and Banjar; Executive Officer, Municipal Committee, Kullu; Project Director, JICA; and NGOs – the Society for Technology Development and Kullu Green Himalayan Welfare Society also actively participated in the Meeting. The HFRI scientists introduced the subject and the approach being employed for the preparation of DPR and sought cooperation and support of stakeholders in collection of primary and secondary information.

The representative from the Parbati Hydro-electric Project – III, Kullu in his presentation highlighted the efforts made by the project authorities towards soil and moisture conservation in collaboration with the SFD and narrated various initiatives undertaken *viz.*, development plan on fisheries and trout fish farm, reservoir rim treatment and green belt development. He conveyed that reduction in vegetation in the hilly tract is the main cause of silt load and stressed upon the need of plantations of trees and shrubs, especially of medicinal use in the catchment area. He also highlighted that proper management and disposal of solid waste from towns/ cities and effective mechanism for muck disposal besides environmental monitoring are essential and important activities.

The Senior Scientist and the Centre Head, GBPNIHESD, Kullu and Guest of Honour on the occasion suggested that the local communities, particularly farmers engaged in agricultural and horticultural activities may be given ample opportunities for active participation and

contributions for providing primary field information in the context of agriculture landscape that make an integral component of the delineated riverscape. He said that DPR should be dynamic and must have inbuilt component of monitoring and adaptive management. He also said that HFRI should develop an interactive web portal so the stakeholders can contribute and interact. He laid emphasis on the maintenance of e-flow during the lean period and focus on the management of springs.

The Project Director, JICA, Kullu while highlighting the need for solid waste and springshed management in the hills, emphasized for the inclusion of NGOs. She recommended that dumping sites must be kept away from the riverbanks. The meeting participants voiced their concerns about the pollution of river water and resultant health hazards. The workshop recommended to selection of native species for proposed plantations. The RFO, Patlikuh, Kullu, suggested for protection of flood prone areas.

The CF, Kullu and Chief Guest on the occasion in his concluding remarks stated that the State Forest Department has already been working on various aspects of the catchment. However, approach adopted so far has been isolated and the stakeholder meet organized by HFRI has provided a platform for involvement of the various line agencies. He opined that the consultative process adopted by HFRI will definitely help in providing desired inputs for envisaged holistic approach. He said that excessive anthropogenic pressure on natural resources compounded by wild animal menace is adversely affecting the existing land resources and resulting into human-wildlife conflicts. He stressed for a need to enrich the wildlife habitats by appropriate plantations of fruit bearing trees. He suggested for initiating studies on the impact of forest fires and soil erosion, and advocated for pro-active community participation and soil and moisture conservation works prior to undertaking plantation activities and capacity development on the theme of river hydrology, and nursery and plantation techniques. He also emphasized on innovative approaches to improve livelihoods of rural populations. In his opinion, the rejuvenation of Beas River Basin is of utmost importance and also in the interest of the State and its people. Before conclusion, he assured full cooperation of his department in providing desired field information required by HFRI in preparation of DPR on Beas river and shared an awakening slogan that ‘problem is global, but solution is local’. The representative scientists from HFRI conveyed his heartfelt thanks to the dignitaries, Resource Persons and the workshop participants for making the Consultative Meeting successful.

(iv) Second Consultative Meeting for Dharamshala Forest Circle, Himachal Pradesh (Conference Hall, KfW – Mid Himalaya, Dharamshala, Kangra; 19 August, 2019)

The second sequential Consultative Meeting for stakeholders of Kangra District and Dharamshala Forest Circle was organized at the Conference Hall, KfW – Mid Himalaya, Dharamshala, Kangra on 19 August, 2019. Varied stakeholders including forest officials and representatives of various line agencies, Municipal Corporation/Councils and select NGOs participated in the Meeting. The CF (Wildlife), Dharamshala was the Chief Guest while the CF, Dharamshala was the Guest of Honour on the occasion. The CCF, HFRI, Shimla and

other Technical Officers from the Institute as organizers introduced the subject of rejuvenation of Beas River and efforts to prepare the DPR. The CF (Wildlife), Dharamshala, in his Inaugural Address emphasized on strong linkages between forests and rivers and highlighted that how the humanity is dependent on these two natural ecosystems. He appreciated the initiatives taken by HFRI in preparation of DPR and involvement of varied stakeholders in the planning process. The representatives of CSK Himachal Pradesh Agriculture University, Palampur recommended for the development of site specific management plans and provision of funds for hiring of additional human power during the implementation phase of DPR. The Chairperson, Himalaya Niti Abhiyan (HNA), a reputed NGO associated with the *Chipko* Movement and winner of the 'Green India Award - 2019' briefed about the multifarious activities towards conservation and management of forests by his organisation at the grass-root level. He emphasized on the role of 'Rakha system' (village forest watchman system) and need to implement the same to safeguard forests in the region from destruction and deterioration owing to enhanced biotic activities and various ill-planned developmental projects. He stressed to defend local livelihoods, the environment and social equity with the idea of mountain specific sustainable development model. Based on his long experience of working with the local communities in the sectors of natural resource management and local self-governance, he firmly believed that community participation in protection and propagation of forests and rejuvenation of rivers is vital, and the proposed DPR should focus on community engagement in various works. The CF, Dharamshala and the Guest of Honour on the occasion emphasized that awareness campaign and works related to soil conservation are critical for the successful implementation of proposed forestry interventions. He also talked about the pivotal role of local communities and the significance of farmer's perspective in DPR planning and stressed on plantation of shrub and tree species on the river banks and in the catchment areas those have medicinal values. The DFO (Wildlife), Dharamshala laid emphasis on social disparities and the need for proper management and disposal of waste and muck followed by environmental monitoring. The Deputy Director, Tourism Department, Dharamshala provided valuable insight on the opportunities for developing tourism activities in the Beas River Basin. She stressed that water sports can be introduced and effective management of tourism sites is the need of the hour. She assured fullest cooperation of her department in the preparation of DPR. The DFO, Dharamshala provided his inputs regarding river basin rejuvenation and expressed his satisfaction about the formats developed by HFRI for collection of primary field data that would be required in the preparation of DPR. The Assistant Engineer, IPH Circle, Dharamshala suggested several measures those can be undertaken for reducing silt deposition in the river. The Secretary, EduCare, India, a NGO emphasized on high density plantations on the riverbanks alongside avenue plantations on the roadsides. The CCF and the representative Technical Officers from HFRI, Shimla provided the valuable resource inputs in filling data formats for natural, agriculture, and urban landscapes in the priority areas to be identified within the riverscape. Overall, the participants were happy and expressed their satisfaction about the organisation of the Consultative Meeting, involving varied stakeholders and allowing each of them to share their knowledge and experience gained while working in

the Beas River Basin. At the end, the HFRI team thanked all the participants for their active participation and valuable contributions.

(v) State Level Consultative Meeting – Punjab State (Forest Complex, Mohali, Punjab; 21 August, 2019)

Since, the Beas and two other tributaries (Sutlej and Ravi) of the Indus River Basin flow through the plains of Punjab, a Consultative Meeting at the state level was organized on the preparation of DPRs for rejuvenation of Beas, Sutlej and Ravi Rivers through forestry interventions on 21 August, 2019 at the Forest Complex, Mohali, Punjab. Nearly 60 participants representing various departments (i.e., Forest, Agriculture, Rural Development, Animal Husbandry, Water Resources, and Sewage Board) at the state level, Central Water Commission, Punjab Agriculture University and the World Wide Fund for Nature-India and other stakeholders attended the Meeting. The Hon'ble Forest Minister, Punjab was the Chief Guest on the occasion. The Director, HFRI along with a team of Scientists, Forest Officers, Technical Officers and project staff concerning three rivers attended the Meeting. Director, HFRI in his welcome address apprised the Guests and participants about the HFRI and DPR project. The PCCF and HoFF, Punjab was the Guest of Honour for this State Level Consultative Meeting. The Hon'ble Forest Minister in his Inaugural Address appreciated the efforts made by HFRI in preparation of DPRs so as to rejuvenate important rivers those flow through the State and strongly linked to the culture of Punjab and socio-economics of local communities. He said that clean air and clean water are essential for the human survival and well-being. The role of forests in improving the quantity and quality of water in rivers cannot be over-emphasized. He said that developmental activities as well as agriculture expansion and its intensification have caused serious loss of forests and degradation of rivers in particular in the State of Punjab. Now time has come to enhance the forest wealth of the State through plantations and protection of existing forests. He also shared details of various new initiatives undertaken by the Punjab Forest Department to green the state. Among them, efforts by 13,000 villages in the State to plant 550 plants in each village so as to grow more than seven million trees throughout the State as a part of the special commemorative celebrations on the occasion of 550th birth anniversary *Shri Guru Nanak Dev ji* is laudable.

The Senior Scientist and the River Coordinator (Sutlej), HFRI, Shimla through his detailed presentation made the meeting participants familiar with the agenda, approach and strategies relevant to the preparation of DPR and proposed forestry interventions. He also made participants acquainted about the various formats to be used for collection of primary field data.

The PCCF and HoFF, Punjab Forest Department and Guest of honour was of the opinion that HFRI should include the Ghaggar river in the exercise on the preparation of DPRs as this river is very important for Punjab and drains to Sutlej in Pakistan. He assured full cooperation of his department in the preparation of DPRs. The former PCCF and HoFF, Punjab State Forest Department also shared his experience and appreciated the efforts made by HFRI. Various resource persons having expertise in the field of soil and moisture conservation, water resources and agricultural research and extension also made elaborate presentation and

highlighted the past work done and provided valuable inputs and insight for the preparation of DPR. The Director, HFRI, Shimla in his presentation highlighted that the entrusted task on DPR is time-bound and all the concerned line agencies are requested to come forward and contribute in a meaningful way for the success of envisaged program on rejuvenation of rivers. The Project Coordinator (DPR) proposed the formal vote of thanks to the Hon'ble Forest Minister, Guests Resource Persons, senior officials and other workshop participants for active deliberations and valuable resource inputs.

(vi) Third Consultative Meeting - Hamirpur Forest Circle, Himachal Pradesh (Conference Hall, Forest Circle Office, Hamirpur; 23 August, 2019)

The Third Consultative Meeting at the Forest Circle level in Himachal Pradesh was organized in Hamirpur District involving wide ranging stakeholders representing the State Forest Department and different Line Departments, Panchayats, NIT, NGOs etc. The Meeting was organized at the Conference Hall, Forest Circle Office, Hamirpur, on 23rd August, 2019. About 40 participants representing different departments and organisations attended this important Meeting. The CF, Hamirpur Forest Circle was invited as the Chief Guest while CF (Wildlife), Dharamshala and Hamirpur Circle was the Guest of Honour at this priority event. The HFRI team included the Director and the senior scientists besides Technical Officers those have been entrusted the task to prepare the DPR on the Beas River. The Director, HFRI gave an overview of the proposed DPR and elaborated about the importance of rivers and their role in human well-being. He also highlighted the significance of forests, particularly in the mountainous tract of H.P. in reducing soil erosion besides multiple benefits provided by them to the society and other important functions performed *viz.*, carbon sequestration and storage, checking runoff and working as bio-filters. The former ACF, Hamirpur as one of the Resource Persons was of the view that smog produced through transport, mining and road construction activities have immense influence on green plants, particularly trees and effective regulations are required in this direction. The inadequate management of solid waste is one of the major threats in maintaining the river health. The Head, Horticulture Department, Hamirpur emphasized that stakeholder participation, particularly the community is essential not only in the preparation of DPR, but also in its implementation. He also voiced concerns about the monkey menace and issues related to livestock grazing and degradation of forest areas.

The CF, Hamirpur Circle laid stress on water discharge, mining issues, and the availability of water and its quality in river. He suggested for organizing more similar Meetings in collaboration with other concerned departments so as to develop desired baseline database required for the preparation of DPR. The DFO, Hamirpur in her presentation emphasized on soil conservation measures; check on unregulated mining activities, and schemes for maintenance of plantations. Further, she was of the opinion that appropriate opportunities for ecotourism can help in reducing the unregulated mining activities. She was also of the opinion that people participation is not only essential, but also critical for the success of ambitious programmes like rejuvenation of complex and dynamic rivers by forestry interventions. The representative from NIT, Hamirpur recommended for micro-planning. He

also shared his views on river conservation and propagation of medicinal plants. The Deputy Project Director, HOCDP-JICA-ODA, Hamirpur lamented on dumping of garbage and discussed issues of deforestation and solid waste management. The Environment Engineer as a representative of the HP State Pollution Control Board, Regional Office, Una and Hamirpur was of the opinion that the reducing extent of forests is the main cause of increase in silt load in the Beas River. Hence, he suggested potential initiatives that can be taken for the purpose of soil conservation works and creation of awareness among masses about river rejuvenation through forestry interventions. The Secretary, NIHAL, a non-governmental organisation was of the opinion that proposed forestry interventions to rejuvenate the river is a commendable initiative. This can be achieved only through a holistic approach and active engagement of stakeholders, particularly local communities. The Mining Officer, Department of Industries, Hamirpur conveyed that there is constant increase in solid waste flowing into the rivers through dumping, mining and construction activities. He emphasized for adopting a multi-pronged approach for river conservation. The Deputy Director, Department of Agriculture, Hamirpur provided valuable resource inputs regarding the rejuvenation of river and the preparation of DPR. He stressed upon a need to develop proper management plan for muck disposal. The Consultative Meeting not only brought diverse stakeholders together, but also facilitated in building alliances. The forest officials and other stakeholders assured full cooperation in providing field data essential for the preparation of DPR by HFRI. At the end, the HFRI team thanked the Chief Guest, the Guest of Honour, Resource Persons, representatives of line agencies and other participants for their active participation, valuable inputs and commitment to extend support in the preparation of DPR.

(vii) Fourth Consultative Meeting - Mandi Forest Circle, Himachal Pradesh (03 September, 2019; Conference Hall, Zila Parishad, Bhiuli, Mandi)

The Fourth Consultative Meeting in the sequence was organized for stakeholders and forest personnel of Mandi district on 03 September, 2019. The Meeting was organized at the Conference Hall, *Zila Parishad*, Bhiuli, Mandi. The Chairperson, *Zila Parishad*, Mandi was the Chief Guest and chaired the meeting and the CF, Forest Circle, Mandi was the Guest of Honour. The CCF and Project Coordinator, DPR, HFRI Shimla, along with a team of Scientists, Technical Officers and other project staff participated from the institute side. Nearly, 55 participants representing senior forest officials and wide range of stakeholders from different line agencies of Mandi district attended the Meeting. The CCF and Project Coordinator, DPR, HFRI, Shimla presented an overview on the preparation of DPR for forestry interventions to rejuvenate the Beas river on the lines of the *Namami Gange* and earlier DPR prepared in the context of Ganga River by FRI, Dehra Dun. He mentioned that rivers are arteries of lifelines of the catchment and forests play a pivotal role in the maintenance of the catchment values. However, in the past, forests were exploited and there has been considerable reduction in the extent. The mountainous state of Himachal Pradesh extensively suffers by landslides, soil erosion, and high sedimentation in rivers on account of natural and man-made factors. The unplanned development, enormous growth in road network, shrinkage in the extent of forests, expansion of agriculture, and sequential hydroelectric projects have cumulative effect on the river and its surrounding lands. Thus,

forestry interventions by way of soil conservation works, afforestation and other relevant conservation activities are being planned. The River Coordinator (Beas), HFRI delivered a detailed presentation on the preparation of DPR and the approach being adopted. He informed the participants that forestry interventions in natural, agriculture, and urban landscapes within the riverscape are proposed besides various conservation and supporting activities so as to achieve various objectives of the project. The CF, Mandi Forest Circle laid her concerns on the pollutants and waste products, being heavily dumped into the river leading to decline of water quality. Thus, solid waste management must be included as a key objective in the preparation of DPR. She also emphasized on proper check and management of pesticides and insecticides so their harmful effects to river ecosystem can be avoided. She urged all stakeholders to proactively contribute towards the preparation of DPR. The Chairperson, *Zila Parishad*, Mandi shared her view point by emphasizing freshwater is important for humanity and suggested to think and plan for restoration of water resources, particularly rivers at the grass root level. She appreciated the efforts being made by HFRI in involving diverse stakeholders and adopting a consultative planning approach for the purpose of preparation of DPR. According to the Executive Officer, Municipal Council, Mandi, the construction of roads and other development works are the major threats and they cause the destruction to natural resources. He stressed on the establishment of eco-parks.

The Junior Engineer, HP Pollution Control Board, Mandi suggested that awareness programmes must be added as an extension activity. According to him, efforts should be made to arrest soil erosion and silt should be checked before it drains in the river. The Assistant Professor, IIT, Mandi expressed his concern on the rising water level due to enhance silt deposition. In his view, heavy silt deposition and unchecked muck disposal by hydro-electric projects into the river are the main causes of river degradation. The Secretary, *Paryavaran Evam Gramin Vikaas Sansthan*, a NGO suggested that people participation must be ensured in the preparation of DPR. He cited the example of the Thames River in UK which was once biologically dead, but through public participation and concerted efforts made by people was revived as one of the cleanest river of the world. He said that the dumping sites need to be effectively managed. The District Agriculture Officer, Mandi proposed that provision should be made to develop earmarked areas for livestock grazing and feeding areas for monkeys. The Mining Officer, Department of Industries, Mandi emphasized on regulation of mining activities and the need for developing appropriate mechanisms for disposal and management of solid waste. The DFO, Mandi recommended that the existing CAT Plans being implemented by the Forest Department needs to be reviewed so as to incorporate innovative models incorporated in the DPR. The CCF, HFRI, Shimla wrapped up the Meeting with the assurance that recommendations and suggestions made during the Meeting will be definitely considered while preparing the DPR. At the end, the Team Leader, Beas, HFRI, Shimla conveyed his heartfelt thanks to the dignitaries, resource persons and workshop participants for their gracious presence and valuable inputs.

(viii) State Level Consultation - Punjab

Cosequent upon the preparation of final draft DPRs of three principal rivers of the Indus River system viz., Beas, Ravi and Sutlej, the final round of the Consultative Meeting for finalization of DPRs of three rivers through forestry interventions was organized on 12 March, 2020 at the Forest Complex Mohali, Punjab. Altogether, 75 numbers of participants representing various sectors, Central/ State Departments - R&D organizations, Punjab Forest Department and various other stakeholders like the State Pollution Control Board (SPCB), Indus Basin Organization (IBO), Bhakra Beas Management Board (BBMB), Central University, Bhatinda, Punjab; Punjab University, Chandigarh; Punjab Agriculture University, Ludhiana; Department of Water Resources, Mohali, Agriculture Department, Soil and Water Conservation Department, Punjab State Council for Science & Technology and NGOs attended the Meeting. The PCCF & HOFF, Punjab Forest Department was the Chief Guest on the occasion while the former Ex-PCCF & HOFF, Punjab Forest Department was the Guest of Honour. Shri Mohinder Pal, IFS, former Director, HFRI attended the meeting as a Special Guest.

Hon'ble Chief Guest in his inaugural address, applauded the proactive step taken by the Government of India for rejuvenating major river systems of the country through appropriate forestry interventions. He was of the opinion that this initiative would not only improve the quality and quantity of water but would also give much desired impetus to biodiversity conservation and ecosystem sustainability. Further, he stated that so far most of the studies on river have adopted an isolated and piecemeal approach but a holistic strategy in the context of river ecosystem as proposed in each DPR prepared by HFRI would go a long way. He suggested that minor changes may be considered in the proposed models keeping in view the topography of Punjab State. He emphasized for equal attention to the command area as provided in the watershed approach and urged to consider these aspects seriously. He also voiced concerns about the grazing and fodder issues, and stressed for the need to include nutritious grasses, medicinal plants and wild edible species in the proposed plantation models in each DPR. He suggested for creating a corpus absolutely for innovations.

The Director, HFRI, Shimla welcomed the Chief Guest, Guest of Honour distinguished guests and participants and provided the background of mammoth work done by the Institute before the learned audience. He said that the suggestions from participants will help in finalization of the DPRs of Ravi, Beas, and Sutlej Rivers flowing through Punjab. The Guest of Honour, appraised the chair and others about the implications of climate change, shrinkage of water resources, soil erosion and their effect on the agriculture sector. He stressed that no compromise should be made on the part of planting native tree species in various forestry interventions. The Nodal Officer – DPR Indus (Punjab) stressed for prioritization of agroforestry interventions in the State of Punjab. He also stated that the proposed cost norms for various models in different landscapes within the riverscape appears to be on lower side considering the prevailing rates in Punjab. He also suggested to arrange for a joint meeting of officials from the Punjab State Forest Department and HFRI, Shimla so as to relook various cost models before the finalization of DPRs and their submission to higher authorities.

The former Director, HFRI suggested for considering to include a High-Level Committee for effective monitoring of the DPR activities. He emphasized on the involvement of local communities during the implementation and maintenance phases also. The representative from the Institute of Soil and Water Conservation, Chandigarh categorically opined that there should be a proposal in the DPR on the monitoring of soil erosion. The official from Punjab State Remote Sensing Centre, Ludhiana, suggested that for the state level mapping high resolution satellite data would be desirable. He suggested that regular monitoring using modern tools of Remote Sensing during the implementation of DPR would be desirable. The representative from the Central University, Bathinda, suggested various species for removing heavy metal from polluted water and cleaning of contaminated soil. The Director, BBMB, Chandigarh put up a suggestion for including BBMB on the board and laid stress on the wide spread erosion in the river basins. The CF, Punjab suggested for inclusion of the enrichment models and to follow the SMAF guidelines for roadside plantations. He also suggested that the bund plantations to be included in the models and recommended for very dense plantations akin to the Japanese Model of Miyawaki which has been effective in rapid restoration of forest cover and restoration of soil by using a judicious choice of pioneer and secondary native species. River Coordinator – Beas, proposed vote of thanks to the Chief Guest, Guest of Honour, learned stakeholders and other participants for their active participation in deliberations and making valuable suggestions.

(ix) State Level Consultation – Himachal Pradesh

Under the prevailing circumstances owing to the lockdown situation due to COVID-19 pandemic, final round of the Consultative Meeting in the State of Himachal Pradesh was organized on 26 June, 2020 through video conferencing. The meeting was chaired by the PCCF & HOFF, H.P. and was primarily attended by forest officials of the State Forest Department including CCFs, CFs, DFOs and other Officers. In his address, the PCCF & HOFF praised efforts made by the team of HFRI and other stakeholders including the State Forest Department for their contribution in completing the mammoth task in time and advised especially CCFs, CFs, DFOs and other officers to actively participate in the deliberations and invited them to offer valuable comments/suggestions so as to finalize the DPRs, as their implementation will be largely carried out by the HPFD. The Director HFRI, Shimla in his address welcomed all the dignitaries, and other participants of HPFD. He presented an overview of each Draft DPR in context of four principal rivers *viz.*, Chenab, Ravi, Beas, and Sutlej whether originating or flowing through the Himalayan State of Himachal Pradesh.

Several queries were raised by the different officials of the State Forest Department. The CF, Rampur was of the opinion that the three years of maintenance proposed for plantations would not be adequate and thus, it should extent up to 5 years. He said that in order to reduce the local dependency on forests, it is necessary to promote ecotourism. The CF, Bilaspur was of the opinion that number of trees/ha proposed in some models appears to be on the lower side, and in some specific models mixed forests have been proposed while no pure forest has been proposed. The CF, Mandi Forest Circle was of the opinion that annual cost escalation should be @10% instead of proposed 7.5%. The Chief Project Coordinator, Solan enquired

whether the models are site specific or general in nature. The CCF, Chamba desired that there should be provision of the position of Data Entry Operator in the State Project Management Unit. The CF, Kullu stated that cost norms for some of the proposed models are on higher side in view of the existing circle rates and thus, there is a need to relook the cost norms for rationalization. Further, he also stated that in the case of Agriculture Landscape, particularly in the proposed Boundary and Block plantation model, proposed cost norm appears to be high. The Conservator cum Director, GHNP said the models projected for protected areas need to be different from models proposed in territorial forest divisions. On the line of Director, GHNP, the DFO (Wildlife), Dharamshala was also of the view that Wildlife Sanctuary areas need more shrub/herb/ grass plantations than other species and also stressed that habitat mapping activity in the protected areas for wild animals such as Brown bear, Musk deer need to be provisioned. The CF, Dharamshala enquired that which agency will implement various activities like Biofiltration, and Bioremediation under the Urban Landscape within the riverscape.

In response to the various queries by forest officials, the Director, HFRI responded that some species require three years of maintenance while others needs 5 years of maintenance. For the sake of both type of species, present DPRs have included average period of 4 years of maintenance for proposed plantations and for promoting ecotourism, appropriate provisions have already been made in the proposed model under the Urban Landscape. Various proposed models are site specific and primarily based on the altitude, forest type, local site conditions, etc. and DPRs do recognize the importance of trees, shrubs and herbs including tussock forming grasses while leaving adequate blank space in between for promoting natural regeneration of plants. Necessary provisions have been made for engaging adequate support and specialized project staff for the smooth implementation of DPR. The cost norms of the proposed models were finalised through an extensive consultative process involving concerned Forest Circles/ Divisions and keeping in view the existing scheduled rates with the SFDs. Considering specific needs of protected areas, separate models namely Riverine and Riparian Wildlife Management, and Wetland Management have been included. Various proposed activities in the Urban Landscape are of holistic in nature. Hence, proposed treatment models would involve varied Sectors/ Departments. However, plantation activity for biofiltration of waste water would primarily be carried out by the Forest Department. The PCCF cum HOFF and Chairperson of the Meeting in his concluding remarks advised that HFRI would ensure to suitably incorporate all comments/suggestions made by forest officials of HPFD for finalization of respective DPR. The meeting ended with formal vote of thanks by the Director, HFRI and he assured the Chairperson and other participants that all comments/ suggestions would be suitably incorporated in the final DPRs.

3.3.3 The Beas Riverscape – Situation and Problem Analysis

The third key step in the process of preparation of DPR was to delineate the Beas Riverscape for the purpose of planning, situation and problem analysis, developing an insight on the riverscape environment, and prioritization of areas for proposed forestry interventions. The background analysis/ contextual analysis and the consultative process adopted at the National, State and Forest Circle levels provided the much desired insight on the Beas River, its basin and tributaries, terrestrial and aquatic biodiversity, past management, associated States, and developmental activities. A riverscape within the larger river basin was delineated. Detailed geospatial analysis of the riverscape using remote sensing and GIS technologies was carried out. The approach adopted for application of remote sensing and GIS for geospatial analysis for the Beas riverscape is described in the section 2.4. It provided an understanding on the situation of physical attributes like land use and land cover, altitudinal variation, slope, aspect, soil, erosion, forest types and forest cover, fragmentation, etc. The review of secondary information from a variety of sources (national/state level agencies/departments, scientific organisations and universities) allowed developing an understanding on the riverscape environment (i.e., physical, biological, socio-economic) and identification of challenges, constraints, problems, and threats in river conservation. The situation analysis facilitated developing an insight on state specific challenges and threats as two States namely HP and Punjab

wherein the river flows depicts contrasting situation owing to large

Effluent outflow in water resources

variations in the physical, biological and socio-economic sub-environments. The consultative process and the sequential meetings with varied stakeholders definitely helped in the identification of focal problems in both the States, understanding their reasons/ causes, and effects or implications on the river itself and surrounding lands.

3.3.4 Development of Web Portal - Collection and Analysis of Primary Field Data

Above three steps of the process adopted allowed an insight on the hierarchical organisational structure of the states, river basin, and the Forest Department, being identified as the Nodal Agency for the purpose of planning and implementation of DPR. The present project has envisaged collection of primary field



data for the entire riverscape with the support of State Forest Department (SFD), Agriculture Department and other line agencies. Prior to the collection of primary field data, the essential requirement was on the design of field data formats, development of plantation and treatment models, and software for analysis of field data.

a. Suggested Plantation and Treatment Models

Earlier, in the case of Ganga River, the multi-disciplinary expertise available at the FRI, Dehra Dun has visualized three types of landscapes within the Ganga riverscape. These were: (i) Natural, (ii) Agriculture, (iii) Urban landscapes. Potential plantation models of varied nature were identified, designed and developed by the FRI Expert Team considering the type of natural ecosystems, native vegetation, soil conditions and agro-climatic zones. FRI has suggested a variety of models for each of the landscape type within the Himalayan State of Uttarakhand and the Ganga plains in the States of Uttar Pradesh, Bihar, Jharkhand and West Bengal. The purpose of various models planned in the natural landscape was primarily protection, eco-restoration and conservation. Each treatment/plantation model had incorporated details of various proposed activities planned, criteria for selection of sites, planting species, spacing, and cost norms during the establishment and maintenance phases. Altogether, 20 different models relevant to natural landscapes were suggested to four states, except the State of West Bengal. The State of West Bengal was requested to develop and suggest its own models keeping in view the larger extent of mangrove forest ecosystem and other state specific characteristics. States were asked to select and recommend appropriate modifications, if required in view of the local requirements and past experience.



Erosion in Shivaliks

Like the Ganga River, the Beas River also originates in the Himalayan Mountains and traverses a long distance in the mountainous State of Himachal Pradesh before it descends into the plains and flows through the State of Punjab before its confluence with Sutlej. By

and large, there is much more resemblance in the physical and biological sub-environments between two rivers. Thus, taking a clue from the past experience on development of treatment models, the multi-disciplinary expertise at HFRI developed in all 28 treatment/plantation models specific to natural, agriculture, and urban landscapes and shared them with the SFDs of H.P. and Punjab so as to seek their valuable feedback and modify, if the need arises. Finally, based on the feedback from two States, HFRI finalized 28 treatment models to be implemented in the case of Beas riverscape. These models were presented and discussed in the Final consultative Meetings held at Punjab Forest complex, Mohali. Inputs were obtained from the experts and participants, and models were finally validated.

b. Design of Field Data Formats and Training of Field Staff

HFRI has adopted five formats earlier developed and prescribed in the context of Ganga River by FRI, Dehra Dun and appropriately modified them as per the specific needs of the present DPR (Annexure 2). Brief details of five data formats used for collection of primary field data are provided below:

- (a) **Format I – Natural Landscape:** The format for natural Landscape was framed on the lines of Ganga DPR wherein various aspects of forestry interventions have been considered namely, protection, habitat improvement, soil and water conservation measures, control of exotics and alien species, afforestation/ reforestation activities, ecorestoration, biofilters and bioremediation, etc. The format is self explanatory and provides an insight on various attributes *viz.*, land use and land cover, altitudinal variation, slope, aspect, soil, erosion, forest types and forest cover, fragmentation, etc.
- (b) **Format II – Agriculture Landscape:** Keeping in view the wide range of agricultural and horticulture crops being practiced by farmers of Himachal Pradesh and Punjab, the format for agriculture landscape was designed to give impetus to enhance efficiency of agricultural lands by way of suitable soil and moisture conservation activities and planting of economically important trees and fruit species. Proposed activities aimed to improve the vegetation/ tree cover, productivity, and overall ecosystem services. The format included all vital information and was designed to understand the current practices so as to develop appropriate strategies.
- (c) **Format III – Urban Landscape**
A large proportion of the riverscape is represented by the urban/built-up environment. Thus, the third format pertained to the Urban Landscape. Urbanization is one of the human centric developmental activities which have shown adverse impact in the context of fluvial system and overall river environment. Most of the cities/ townships, industries, religious centers, hotels, etc. have been settled all along the banks of the river and its tributaries, ultimately leading to pollution by industrial effluents, urban sewage, and disposal of waste. Considering these problems, the format for the Urban Landscape was designed aiming for proposed activities *viz.*, bioremediation, biofilter, riverfront development, plantations in institutional and industrial estates, ecopark development, and avenue plantations in the urban areas.
- (d) **Format IV – Other Interventions**
In addition to three types of landscapes identified within the riverscape, conservation activities *viz.*, management of moraine, wetlands, riverine and riparian wildlife and soil and

water conservation were envisaged. These aspects were considered important from the perspective of river rejuvenation. Accordingly, all such aspects and variables were given due weightage while designing this specific format.

(e) Format V – Other Activities

The DPR has also envisaged varied activities in support of implementation of forestry interventions for river rejuvenation. Accordingly, the format was prescribed for this purpose specifically included proposals on participation of various NGOs, Nehru Yuva Kendras, and Civil Society, etc.

Details of these five data formats, types of information required, and the procedure to collect desired information were shared with stakeholders, particularly the forest officials and frontline staff during the consultative process and field training. Adequate soft and hard copies of formats were made and widely distributed to forest officials and other stakeholders during the consultative process and Training Programmes.

One of the objectives of the consultative meetings and specially organized field trainings for each Forest Division in two concerned States was to acquaint the forest officials, frontline staff and members of other agencies (e.g., agriculture sector) about the five data formats and provided hands on training to them about how to collect field data and fill the formats and what are precautions.

c. Development of Software and Web Portal

The State Forest Department of two States returned a large number of duly filled in field data forms to HFRI. Details of data forms received from two States are summarized in Table 3.4 Out of these forms, nearly 36.91 (605) % data sheets were meant for proposed interventions in natural landscapes while 6.65 (109) % data forms were proposed for plantation activities and other treatments in agriculture landscapes. Rest of 56.44 (925) % data forms were meant for proposed activities in urban landscapes, conservation interventions and supporting activities. Thus, 1639 data sheets contributed voluminous information and it was difficult to handle such large data sets manually in a short time available for the preparation of DPR. Hence, it necessitated to take help of software so as to effectively collate, analyse, synthesize, and interpret the voluminous data sets and retrieval of desired information relevant to each of the involved states/ forest divisions/ forest ranges and the three pre-defined landscapes within the riverscape. For this purpose, HFRI engaged a commercial vendor – M/s Reckon Web Solutions, Dehra Dun to develop a web based software.

Table 3. 4 - Summary of Data Formats

Sr. No.	Forest Division	NL	AL	UL	OT	OA	Total
Himachal Pradesh							
1	Kullu	60	6	7	3	-	76
2	Parvati	28	6	6	57	-	97
3	Seraj	43	6	7	48	-	104
4	G.H.N.P. Shamshi	-	-	-	3	-	
5	Kullu Wildlife	-	-	-	6	-	

6	Mandi	71	6	7	89	-	173
7	Nachan	21	6	7	46	-	80
8	Suket	4	6	10	21	-	41
9	Karsog	3	-	-	-	-	3
10	Joginder Nagar	36	6	6	119	-	167
11	Hamirpur	23	1	10	55	-	89
12	Dehra	29	6	7	32	-	74
13	Wildlife Hamirpur	-	-	-	2	-	2
14	Dharamshala	38	6	4	25	-	73
15	Palampur	57	6	4	60	-	127
16	Nurpur	23	12	3	22	-	60
17	Dalhousie	29	-	2	25	-	56
		465	73	80	613	-	1231
Punjab							
1	Pathankot Wildlife	-	-	-	1	-	1
2	Pathankot	6	6	3	2	-	17
3	Hoshiarpur	1	6	4	16	-	27
4	Dasuya	28	3	5	23	-	59
5	Gurdaspur	89	9	34	118	-	250
6	Amritsar	7	9	9	3	-	28
7	Jalandhar	9	3	5	4	-	21
8	Wildlife Ferozepur	-	-	-	5	-	5
		140	36	60	172	-	408
Grand Total		605	109	140	785	-	1639

The firm developed software in PHP/MySQL, server Linux based and that works on CodeIgniter Framework basis. It is a web based and easily accessed via internet. The software can compute cost calculations according to selected specified models for unlimited created models and is password protected. In the software, filed data was entered as per the five specified models, viz., natural, agriculture, and urban landscapes, conservation interventions and supporting activities, and can be saved in digital format. The software is capable of generating reports in the desired formats like; State-wise, District-wise, Division-wise, Model-wise and Activity-wise, and Annual Consolidated Reports can be generated to obtain insight on year-wise areas under different landscapes to be treated and corresponding costs.

3.3.5 Objective Analysis and Strategic Planning

The Chapter 1 (Section 1.8.9) has already highlighted the significance of the Logical Framework Analysis (LFA) and Results-Based Management (RBM) while section 1.8.10 has dealt upon the broad objectives of river rejuvenation efforts. These concepts emphasize on the structure and clarity of a results-oriented participatory planning process, the principles of 'change' and 'impact' of a development project, continuous monitoring and organisational learning. The consultative process with stakeholders allowed an understanding to develop the

long-term vision and goals that indicate the desired direction or pathways for actions and activities. In the process, it was also understood which changes the project can contribute in the longer term and why is the project important for the society, biodiversity and the river ecosystem. The multi-disciplinary team of HFRI with resource inputs from wide-range of stakeholders was able to decide the goals, objectives, outputs and outcomes that can be attained. The consultative process gave desired insight on the problems in achieving various objectives and identification of priority actions for rejuvenation of the river. Ultimately, the process also immensely helped in firming up the strategies for implementation of the project. Accordingly, it was decided that the programme implementation has to be concurrent in natural, agriculture and urban landscapes within the riverscape. Further, a variety of conservation and supporting activities would also be required for effective implementation, knowledge management and sharing, capacity development, monitoring, and adaptive management.

3.3.6 Preparation of Draft DPR – Activities, Resource Planning and Schedule

The aforesaid key steps and the process adopted ultimately helped HFRI in the preparation of draft DPR presenting the background information, situation analysis and environment of the delineated Beas riverscape, formulation of strategies, planning of specific activities, resource planning (i.e., manpower, equipment and the finances), and year-wise schedule of operations. Draft DPR (Vol. I and II) was shared with two involved States, SFDs and other stakeholders in the state as well as the National Level Consultation Meetings seeking their feedback and valuable inputs. Copies of the DPR were also submitted to the ICFRE, Dehra Dun and the MoEF&CC, New Delhi and comments were invited. Necessary presentations were also made at ICFRE and MoEF&CC for the inputs and validation and finalization of DPR.

3.3.7 Finalization of DPR, Implementation and Monitoring

The draft DPR was finalized incorporating the feedback and specific comments received from the respective states, SFDs, ICFRE and the MoEF&CC. Initially, the Implementation Phase I of five years has been planned for duration of five years by respective States and SFDs as the Nodal Agencies. A provision for inbuilt, Results-Based Monitoring has been made for continuous monitoring, organisational learning and adaptive management. The Phase II on Maintenance Phase of five year duration after the Phase I - Implementation Phase would deal with the maintenance of plantations raised in Phased I and scaling up of the activities, if required to cover the left over tributaries.

3.4 Beas Riverscape – Application of Remote Sensing and GIS for Geospatial Analysis

The planning and management of a major river like Beas flowing for a length of nearly 470 km from its source in the rugged mountains of the Greater Himalaya to its confluence with the Sutlej River in plains of Punjab state is a challenging task as the river has vast basin drained by numerous tributaries. The larger proportion of hilly tract in the basin, harsh climate, diverse forests along the altitudinal gradient, other land uses, human activities, and

wide-range of developmental projects all along the river course exert immense influence on the river, its flow and numerous associated ecological attributes and ecosystem processes. Different land uses, particularly forests or other types of vegetation cover are vital and serve as indicators for the quality and functioning of the riverine environment or the riverscape. Hence, the present assignment on the preparation of DPR for forestry interventions on Beas River required a thorough understanding not only of the Beas River, but its catchment, tributaries and even the surrounding lands and implications of enhanced human impact.

The Geospatial Technology, an emerging field of study that includes Remote Sensing (RS), Geographic Information System (GIS), and Global Positioning System (GPS) has enabled to acquire data that is referenced to the earth and its use for analysis, modeling, simulations, and visualization (Van Laake, 2000; Chaudhary, 2014; Kumar *et al.*, 2015; Thakur *et al.*, 2017). Thus, geospatial technology offers unparalleled help to study a wide-range of disciplines and have immense utility in natural resource management. The geospatial technology provides enormous opportunities for planning, assessment, management and monitoring of vast extent of river basin and the complex and dynamic river ecosystem. Geospatial technology also facilitates informed decisions based on the importance and priority of resources most of which are wide spread and sparse in nature. Geospatial technology can be used to create intelligent maps and models and to reveal spatial patterns that are embedded in large volumes of data that may not be accessed collectively or mapped otherwise. Geospatial technology has become an essential part of everyday life.

3.4.1 Remote Sensing Technology

Remote Sensing (RS) technologies have started to provide great insight in the scientific understanding, especially inaccessible and remote areas of the Himalaya, whose vastness, difficult terrain, harsh climatic conditions, and remoteness have precluded the scientific community in the past to collect data. RS techniques are providing new data sets and spatially referenced information to planners and policy makers for informed decisions. Recent advancements in RS by way of improved temporal frequency of data acquisition and enhanced spatial and spectral resolution have promised unparalleled opportunities for resource inventory and surveys, planning and monitoring of varied natural and man-made resources and objects. Collecting information via modern remote sensing platforms entails some unique benefits *viz.*, accessibility, persistence and accuracy. Important components of RS technology are data procurement, data processing and analysis. Hitherto, the natural resources, namely minerals, groundwater, soils, vegetation/ forest cover and surface water have been accessed and treated individually for optimal utilization. Since, most of these resources are interdependent and co-exist in nature; they need to be considered collectively for their optimal utilization and sustainability. This fact has led to the development of concept for integrated assessment of natural resources. Integrated assessment can be defined as an interdisciplinary and participatory process of combining, interpreting, and communicating knowledge from diverse scientific disciplines to allow a better understanding of complex phenomena (Rao, 2000). Integration of information on natural resources, socio-economic and climatic conditions and other related ancillary information in a holistic manner for

prescribing locale-specific intervention for a given area is very crucial (Rao, 2000). Understanding the complex water system or a river requires a holistic approach to integrate the concepts and ideas from different disciplines for sustainable management of river ecosystem or the riverscape. RS technologies offer a promising tool to integrate with the models for getting continuous input data in data scars regions. The launch of several Earth Observation (EO) sensors from advanced satellite provides world-wide continuous measurements on various hydrological components which are essential input data for understanding hydrological regimes and hydrological modeling (Kumar *et al.*, 2015). Remote Sensing techniques can be used to monitor water quality parameters (e.g., suspended sediments-turbidity, chlorophyll, and temperature). Since forests and rivers are strongly linked, RS techniques can generate valuable information regarding forest cover and forest types, changes in forest extent, human encroachment into forest land, forest fragmentation and suitability of a forest site for a particular species of wildlife. The accelerated rate of the deforestation, forest fragmentation, and forest degradation is not only a threat to continuous supply of forest products for the livelihood of local people and ecosystem services once they used to offer, but also has several adverse consequences on multiple levels, particularly the downstream and overall connectivity in the river. RS techniques have immensely helped in monitoring urban, green and non-green land changes in the surrounds of a river at the regional and local scale. The RS techniques have opened up avenues for understanding the channel morphology and dynamics, particularly the changes in the river course, and trends in sedimentation over a long period of time.

Advances in RS techniques definitely have advantage over traditional/ conventional cumbersome techniques in terms of spatial, spectral, radiometric and temporal data availability. It offers acquisition of real-time data from inaccessible or remote areas within a short span of time (Thakur *et al.*, 2017). Over the years, RS technology has become an efficient and powerful tool in assessment, exploration, evaluation, analysis, monitoring and management of water resources, particularly surface water in river ecosystems and groundwater for the long term societal benefits. RS technology is a rapidly changing domain with the advent of new improved sensors, platforms and application techniques which support new form of data and newer views of the landscapes/ riverscapes through which foresters, hydrologists and river scientists could better evaluate the Earth's surface and other specific features in the context of forests, rivers and other land uses.

In the context of Beas Riverscape, the RS technology was needed as a pre-requisite for delineation of boundaries of the riverscape keeping in view the farthest bank lines during the maximum flood period for the main river and its tributaries so as to avoid flood prone areas from the perspective of proposed forestry interventions. Further, the RS technology was of the immense utility in understanding the spatial patterns and processes in the context of diverse forests, other land uses, and identification of priority areas for proposed plantation sites and other forestry interventions. Assessment of the availability and condition of the natural resources is the first step for the planning and development of a plan for the sustainable resource development. Field managers, conservationists and decision makers often require quantitative information on the spatial distribution of land use types, their

conditions, as well as temporal changes in them (Mendis and Wadigamangawa, 1996; Al-Bilbisi and Tateishi, 2002; Sharma, 2002; FRI, 2016).

3.4.2 Geographic Information System (GIS)

The Geographic Information System (GIS) is basically an informative, computer based system using geographically referenced spatial and non-spatial data, and has ability to store, arrange, retrieve, classify, manipulate, analyse and present huge data sets and information in intelligible way (Howari *et al.*, 2007). GIS can handle large volumes of spatial data derived from a variety of sources such as field surveys, aerial surveys and space remote sensing, in addition to the already existing maps and reports. This involves bringing together diverse information from a variety of sources on a common platform. In the management of natural resources, there is a greater emphasis on integrate relationships over time and space, between resources/ species and the human impact overall. Hence, manager of such resources needs to incorporate ever more data in the decision-making process and applies GIS for the management and analysis of large data sets (Van Laake, 2000). Over the years, in order to be truly useful in natural resource management, the GIS have evolved from a data-centric tool to a process oriented tool box, with expansive functionality related to data management, query, and report generation. With the elaborate changes by way of improved knowledge about natural processes, changed perception of the natural environment, integrated policies and regulations regarding the use of natural resources, public involvement, and explosion in data availability and quality have posed new requirements to the manager and new requirements/ expectations to the GIS. This relates to the key issues of managing the database and also mining the database. Managing the spatial database is only one aspect of dealing with a large quantity of data. However, now more important is how to retrieve/ process desired information out of the mass of data (Van Laake, 2000). GIS helps in visualization of geospatial data, and the visualization is a convenient and effective way to communicate complex information. The GIS technology has been an instrumental breakthrough that permits examining natural resources and environmental issues in a geographic context. It also provides a means to investigate problems by allowing modeling various phenomena and examining their relationship, e.g., cause and effect relationship, in a place-based context, meaning it can analyse complex, integrated issues from local to global scales. In current scenario, GIS is regarded as an essential and efficient tool for studies especially for complex and dynamic fresh water resources. Its utilities and potentialities in hydro-geology and hydrologic modeling are only at its beginning, but many successful applications have already started to develop (Gossel *et al.*, 2004; Thakur *et al.*, 2007). Using satellite data and GIS, water bodies such as rivers, lakes, dams and reservoirs can be mapped in 3-D. Spatial water availability maps can be generated (Kumar *et al.*, 2015). The use of GIS has flooded almost every field in the engineering, natural and social sciences, offering accurate, efficient and reproducible methods for collecting, viewing and analysing a spatial and temporal data (Sonti, 2015). In short, GIS is a potential means of dealing with the complexity of natural resources.

3.4.3 Global Positioning System (GPS)

The Global Positioning System (GPS) technology has greatly enhances the ease and versatility of spatial data acquisition and diversifies the approaches with which it is integrated with remote sensing and GIS (Gao, 2002; Thakur *et al.*, 2017). GPS technology has rendered an excellent opportunity for location measurements, and has become an essential tool for management of agricultural and natural resources.

3.4.4 Geospatial Modeling

The integration of remote sensing (RS), geographic information system (GIS) and global positioning system (GPS) (3S) has opened up several new avenues. These are: (a) mapping - collection of thematic layers in geographic format, (b) measuring - rigorous mapping process and quantification, (c) modeling - a process to describe and simulate the present, past or future behaviour, and (d) monitoring - periodic assessment of conditions to record the shifts or changes in natural phenomena and human activities. The integration of three technologies has received considerable attention in the field of geospatial modeling, particularly the hydrological modeling (Thakur *et al.*, 2017) as the occurrence and movement of surface and ground water are controlled/ influenced by a wide range of variables *viz.*, macro and micro topography, geology, lithology, stratigraphy, structural control, geomorphology, soil types, land use/ cover, geological lineaments, etc. (Das, 1994; Thakur *et al.*, 2017). Three geographic-based technologies not only offer an ideal environment for integrating spatial and attribute data on natural resources and environment, but facilitate spatial modelling, and analytical processes to describe basic processes and properties for a given set of spatial features. According to Gao (2002), there are various diverse methods for the integration of RS, GIS and GPS. He described four models: (a) linear model (LM), (b) interactive model (IM), (c) hierarchical model (HM), and (d) complex model (CM). A large number of models, generally used to predict soil loss, sediment yield, nutrient loss, pollutant transport in watershed and groundwater movement have been developed. Various researchers have used the concept of RS–GPS–GIS integration in linear model in the fields of groundwater sitting sites, exploration, mapping lineaments, point pollution source, potential recharge sites and others. Interactive models have mostly been used by the agriculture scientists for estimating the crop yield. However, very few scientific studies have focused on the discussion about the type of integration (Thakur *et al.*, 2017). In most sectors, GIS applications are still being used as the advanced digital cartographic systems oriented towards the maintenance of digital geographic data and they are relatively inferior or in early stages to high level analysis and modeling abilities that are necessary for sustainable management of natural resources.

3.4.5 Application of RS, GIS and GPS in the Present Assignment

The present task on the preparation of DPR optimally used three technologies (i.e., RS, GIS and GPS). The foremost use of RS technique was to delineate the boundaries of the riverscape. Subsequently, RS and GIS were used for geospatial analysis of the riverscape and creating different thematic layers on various physical attributes (i.e., altitude, slope, aspect, soil, erosion, etc.), land use/cover, forest types and forest cover, and fragmentation so as to develop an insight on land use patterns, diversity, and intricacies from the perspective of

riverscape management. The main purpose of the use of RS and GIS technologies in the present assignment was to prioritize areas for proposed plantations and other forestry interventions in the natural, agriculture and urban landscapes within the riverscape. The field information coupled with prioritized areas helped in formulating plantation/ treatment models besides selection of planting species, etc. The GPS technology was optimally used for collection of primary field data, particularly in obtaining geographical coordinates of proposed sites in the prioritized areas. It was neither planned nor was it feasible to handle large field data sets manually. Hence, computer based web portal and a geospatial database in the GIS domain on the riverscape were created in the process of preparation of DPR.

a. RS and GIS Methodology

In the present assessment, image processing and GIS tools used were ERDAS Imagine 2018, Geo-Media Professional 2018, ArcGIS, etc. The GIS software provided the tools needed to store, analyse and display geographic information.

b. Satellite Data Used

Landsat 8 satellite data (for the month of November, 2018) was used for preparation of Land use/ Land cover map of the riverscape. The Row, Path along with Date of Pass of the satellite data used in the present assessment for two states of Himachal Pradesh and Punjab covering the whole riverscape is presented in Table 3.5. The satellite image (False Colour Composite) of the entire riverscape is shown in Fig. 3.5.

Table 3.5 - List of Data Downloaded and Used in the Present Assessment

State	Path	Row	Date of Pass	Satellite
Himachal Pradesh	147	038	10-Nov-2018	Landsat-8
Himachal Pradesh	148	038	17-Nov-2018	Landsat-8
Punjab	147	038	10-Nov-2018	Landsat-8
Punjab	148	038	17-Nov-2018	Landsat-8

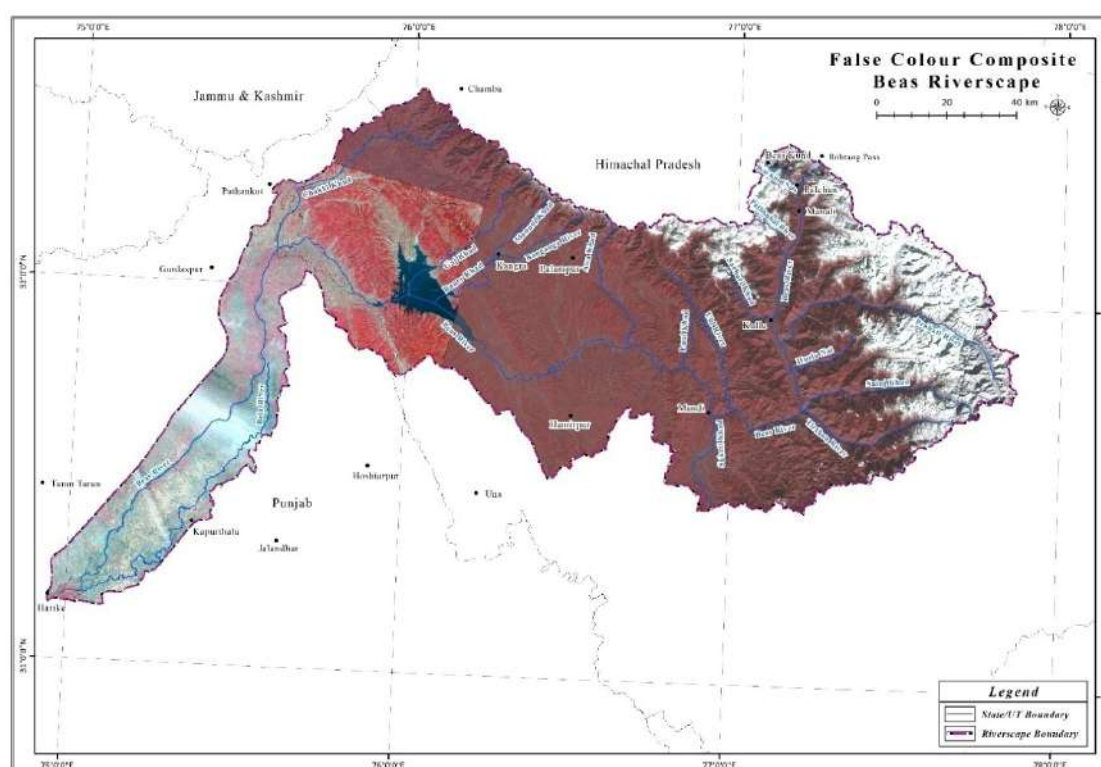


Fig. 3. 5- Satellite Image (False Colour Composite) of Beas Riverscape

c. Ancillary Data

Almost all of the ancillary information was obtained from the various government agencies under the control of Government of India. Information about the State and District boundaries for the riverscape used for analysis was obtained from the Survey of India. Boundaries of the Basin, Catchment, Sub-Catchment, Watershed and Micro-watershed were obtained from the National Soil and Land Use Survey of India, New Delhi. Village and Tehsil boundaries were obtained from the published document ‘Administrative Atlas of Himachal Pradesh’ and ‘Administrative Atlas of Punjab’ published by the Census of India (2011). Information on Forest Types and Forest Density for the year 2019 was obtained in digital format from the Forest Survey of India (FSI), Dehra Dun. Soil map and soil depth information were obtained from the published maps by the National Bureau of Soil Survey & Land Use Planning, Nagpur. Soil erosion data which is the backbone of multi-criteria analysis was obtained in GIS format from the Indian Institute of Soil and Water Conservation (IISWC), Dehra Dun. Topographical sheets on 1:50,000 scale obtained from the Survey of India were used for reference only. Bhuvan data was also referred, wherever required for the preparation of land use map. Information on boundaries of Forest Circle, Forest Division and Forest Ranges were obtained from the concerned State Forest Department of Himachal Pradesh and Punjab.

d. Data Downloading

Relevant Landsat-8 satellite datasets specific to the riverscape were downloaded from www.earthexplorer.usgs.gov. The time frame has been selected by keeping in mind the post-monsoon season allowing maximum differentiation in various land cover features. A list of data downloaded and used is given in Table 3.5.

e. Map to Image Registration as per Accepted Projection System

Image registration is one of the important components for area analysis and display of output on definite projection system as well as integration and modeling the land cover parameters. The projection parameters used in the current assessment are defined below:

Projection:	Lambert Conformal Conic
Spheroid:	WGS84
Datum:	WGS84
First Standard parallel	12° 28' 22.6"
Second Standard Parallel	35° 10' 22.10"
Longitude of Central meridian	82° 00' 00.00"

Latitude of origin of projection	20° 00' 00.00'
False Northing	2000000 m
False Easting	2000000 m

f. Spatial Data Creation and Analysis

Spatial database creation was considered as the most important step in Geospatial Modeling. Spatial integration of thematic layers was of utmost importance from the perspective of present assessment. Hence, a spatial database in the GIS domain for the riverscape was created.

g. Delineation of Riverscape Boundaries

The FRI, Dehra Dun based on an extensive consultative process and recommendations made at the National and State levels had adopted criteria for delineation of boundaries of the Ganga Riverscape for the purpose of preparation of DPR in 2015-16. Accordingly, the delineated riverscape included the entire catchment of Ganga River in the hilly Himalayan region of Uttarakhand state while a buffer of 5 km on either side from the high flood level (HFL) in the case of main stem of Ganga River once it has descended into the plains and a buffer of 2 km on either side from the HFL level in case of tributaries were incorporated (FRI, 2016). Initially, the criteria adopted for the delineation of riverscape boundaries by FRI in the case of Ganga River were considered appropriate for the Beas River as it is also a Himalayan river originating in higher reaches in the state of Himachal Pradesh. Hence, the entire catchment of Beas River in H.P on the basis of micro-watershed atlas published by the National Soil and Land Use Survey was included as the part of the riverscape. In addition, Landsat-8 satellite images of 2018 were used to create tentative riverscape boundaries covering 5 km buffer on either side of the bank line for the main channel of Beas River and 2 km on either side for the only tributary of Beas River i.e., Bein flows through the plains of Punjab state. However, during the State Level Consultative Meeting organized exclusively for Punjab at a later stage on 21 August, 2019, stakeholders informed about the extensive flooding much beyond from the original criteria of 5 km and 2 km buffer from HFL. After considerable deliberations, in the Consultative Meeting, it was proposed to cover all concerned micro watershed boundaries in the case of Beas main channel and its Bein tributary as part of the riverscape.

In view of the above recommendations by the stakeholders at Punjab State Level Meeting, the final Beas riverscape boundaries for the present DPR included the entire catchment area of Beas River including all tributaries in Himachal Pradesh while areas falling in the concerned micro-watersheds of the main channel and Bein tributary formed the part of riverscape in Punjab state. Following above approach, the delineated Beas Riverscape covered an extent of 16743.01 km² which represents 75% of the total catchment area of Beas River.

h. Selection and Demarcation of Watershed Boundaries up to Micro-watersheds

The watershed boundaries up to micro-watershed level were delineated using source maps from the Soil and Land Use Survey of India (SLUSI), New Delhi. The Micro Watershed Atlas of India prepared by SLUSI provides description on codification of micro-watersheds. Accordingly, each micro-watershed has been depicted with a code as per the codification standards in seven stages. All the seven stages are described below one by one so as to offer an understanding on the codes.

(a) Stage One: Water Resources Regions (WRR) – In the stage one, major ‘Water Resources Regions (WRR)’ in the country have been denoted using the Arabic Numerals viz., 1, 2, 3...

1. Indus drainage
2. Ganges drainage
3. Brahmaputra drainage
4. All drainages flowing in the Bay of Bengal except above Sl. No. 2 & 3.
5. All drainages flowing into the Arabian Sea except at Sl. No. 1.
6. Inland drainage in western Rajasthan, mostly ephemeral drainage. s

(b) Stage Two: Basin – Each WRR was divided into basins which constitutes big Individual River. They were denoted by capital English alphabets suffixed to WRR code for example A, B, C. Thus, the basin was denoted as 1B for Beas River.

(c) Stage Three: Catchment – Each basin was further divided into a number of catchments which mainly pertains to main tributaries or a group of contiguous small tributaries or individual stream. They were denoted by Arabic numeral suffixed to Basin Code as 1, 2, 3..... Thus, catchments were expressed as 1B1.

(d) Stage Four: Sub-catchments- The catchments were further subdivided into a number of sub-catchments, which were mainly smaller tributaries or streams. They were denoted by capital English alphabets suffixed to catchment code as A, B, C Thus, the sub-catchment was expressed as 1B1A.

(e) Stage Five: Watersheds – Each sub-catchment was further divided into a number of watersheds, which were the smallest hydrological unit delineated in 1:1 m Watershed Atlas of India in the macro level category. They were denoted by Arabic numerals suffixed to sub-catchment code as 1, 2, 3, and watershed was symbolized as 1B1A7.

(f) Stage Six: Sub-watersheds - This delineation and codification was transferred in 1:50,000 Survey of India topomaps for further delineation at micro level. The watersheds were subdivided in sub-watersheds which were either the banks of small tributaries or discreet

streamlet. They are denoted by small English alphabets suffixed to code of watershed. However, the use of e, i, o and l alphabets were avoided. Thus, the sub-watershed was expressed as, 1B1A7a.

(g) Stage Seven: Micro watersheds - The sub-watersheds were further divided to the smallest micro-level hydrological unit i.e., micro-watersheds which were part of small streams or streamlets. They were denoted by Arabic numerals, but restricted to 9 only and suffixed to the code of sub-watershed. This completed the delineation and codification at micro-level. Thus, the micro-watershed was coded as 1B1A7a1, 1B1A7a2, etc. The micro-watershed code 1B1A7a1 represents water resource region 1, basin 1B, catchment 1B1, sub-catchment 1B1A, watershed 1B1A7, and sub-watershed 1B1A7a.

Using the dataset from Micro-Watershed Atlas of India, layers of Catchment of Beas River, followed by sub-catchment, watershed and sub-watershed were derived. The entire Beas Riverscape included 4 sub-catchments, 25 watersheds, 326 sub-watersheds and 2,324 micro-watersheds (Table 3.6). In all, 1,977 micro-watersheds were included in the Himachal Pradesh part of riverscape while a small number of micro-watersheds (372) constituted the downstream part of the riverscape in Punjab (Table 3.6). However, some of the catchment units were common in two States. Thus, the actual number of different catchment units within the riverscape was slightly lesser in number. Fig. 3.6 to Fig 3.8 depicts sub-catchments, watersheds and micro-watersheds within the riverscape.

Table 3. 6 – Details on Various Catchment Categories within the Beas Riverscape

Sr. No.	Catchment Category	State-wise Representation of Catchment Units in the Riverscape		No. of Common Catchment Units in Two States	Actual Number of Catchment Units in the Riverscape
		Himachal Pradesh	Punjab		
1.	Sub-Catchments	04	01	01	04
2.	Watersheds	22	06	03	25
3.	Sub-watersheds	276	64	12	326
4.	Micro-watersheds	1,977	372	25	2,324

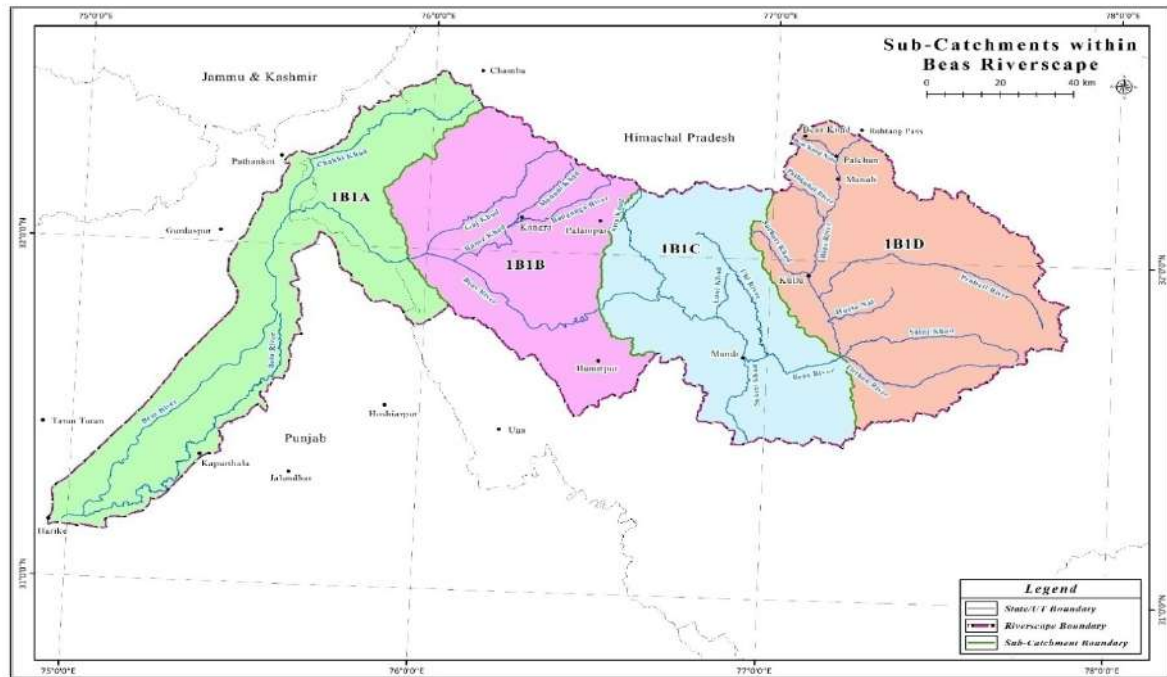


Fig. 3. 6 – Beas Riverscape with Tributaries and Sub-Catchments

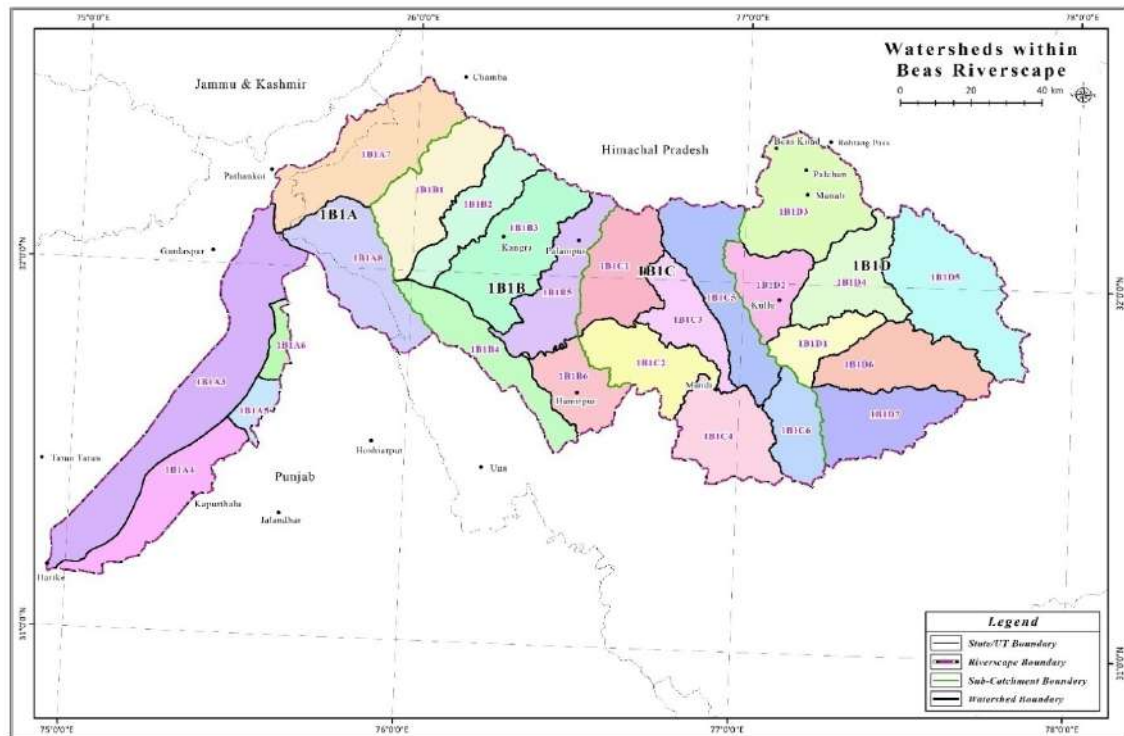


Fig. 3. 7– Beas Riverscape with Tributaries and Watersheds

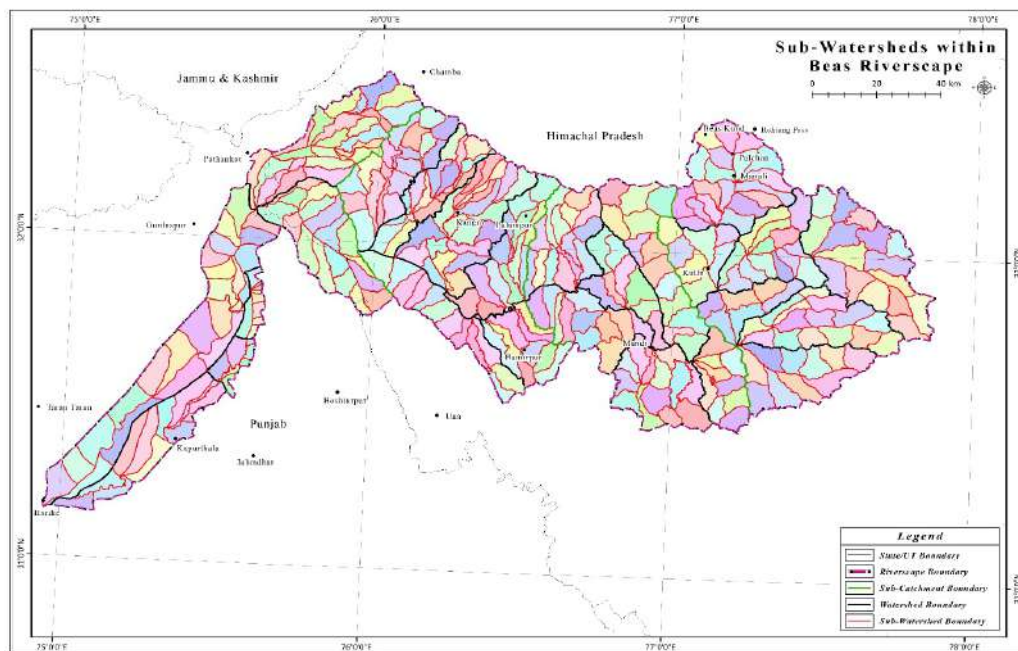


Fig. 3. 8– Beas Riverscape with Tributaries and Sub-Watersheds

i. Land Use/ Land Cover (LULC) Analysis

Land information is important to a wide variety of human activities such as agriculture, forestry, water resources, and other types of land resource management. The pre-processed

geometrically, radio-metrically corrected and resolution merged Landsat - 8 satellite datasets were displayed on screen for attempting visual interpretation of various land use classes. Standard image interpretation keys, viz., shape, size, colour, tone, texture, pattern, shadow, site, association, and phenology were used to generate Image Interpretation scheme. Onscreen visual interpretation technique was used for delineating major land use and land cover types i.e., Dense Forest, Moderately Dense Forest, Open Forest, Scrub, Agriculture, Alpine Pastures, Barren, Settlement, Canal, Water Body, Wetland, River (Dry)/River Sand, River (Perennial), Snow/Glaciers, etc. (Fig. 3.9 & Fig. 3.10). Each Land use and Land cover type is described below. Thus, the state-wise distribution of area under corresponding land cover and land use classes for the entire riverscape was computed.

(a) Agricultural Land

This landscape is primarily used for farming and production of food, fibre, horticulture, etc. They are mainly the lands with standing crops (i.e., cropland: bright red to red colour on satellite image), fallow land (i.e., un-cropped for one season or more seasons: yellow to greenish blue tone), agriculture plantations (i.e., tea, coffee, etc.), plantations (i.e., herbs, nurseries, orchards, etc; dark red to red and regular sharp edged shapes).

(b) Natural/Semi-natural Grassland

These are the areas of grasslands, dominated by the grasses and forbs. They appear in light red to light brown of varying sizes and irregular shapes.

(c) Alpine/Sub-alpine

These are the vegetation categories between the sub-alpine forests and permanent snow covered areas. An alpine zone commencement is variable and lies between 3,000-3,600 m asl.

(d) Barren

This is delineated on the basis of bright white to light blue to yellow to brown colour tone depending upon the rock types. These are located on isolated hill slopes, plateau, etc.

(e) Water bodies

This category comprises areas with surface water (i.e., ponds, lakes, rivers, canals, etc.). These can clearly be seen on a satellite image in blue to dark blue or cyan colour depending on the depth of water.

(f) Rivers (Perennial/ Dry)

These are natural course of water flowing on the land surface along a definite channel/ slope regularly or intermittently towards another water body in most cases, sea, another river, lake, marsh, etc. They appear in light to dark blue and irregular shape (non-linear). There are two major categories of rivers, perennial (flow continuously throughout the year) and dry (flow only during monsoon period).

(g) Canals

These are artificial water courses constructed for irrigation purpose, and have a regular linear shape on image.

(h) Forests

These are the areas bearing an association predominantly of trees and other vegetation types (within the notified forest boundaries).

Dense areas with dark red to red colour tone include canopy cover/ density of >70%.

Moderately Dense forest areas with red to light red in colour tone include the canopy cover/ density between 40-70%.

Open forest areas with light red colour tone include the canopy cover/ density between 10-40%.

Scrubs: This land is prone to deterioration due to erosion. These lands generally occupy higher locations. They appear light yellow to brown to greenish blue depending upon the surface moisture and vegetation cover. It varies in sizes from small to large and generally found agricultural field borders, river banks and alpine slopes.

(i) Built-up/Settlements

These are the areas of human habitation developed due to non-agricultural use and that has a cover of buildings, transport, and communication utilities associated with water, vegetation and vacant lands. They appear in dark bluish green in the core and bluish in the periphery. The size varies from small to big; can be centered, clustered, or in scattered form.

(j) Snow Covered/ Glacial Area

These are the areas under perpetual snow cover confined to the Himalayan region. It appears bright white to white in colour depending on the moisture and thickness of snow. It poses irregular shape and located in mountain peaks in the high altitude areas.

(k) Wetlands

These are submerged or water-saturated lands, natural or man-made, inland or coastal, vegetated or non-vegetated. They have greenish blue to cyan to brown colour depending upon different vegetation cover and depth of water.



Socio-Cultural & Ecological Consideration in Conserving Wetlands – Prashar Lake in Mandi District, HP.

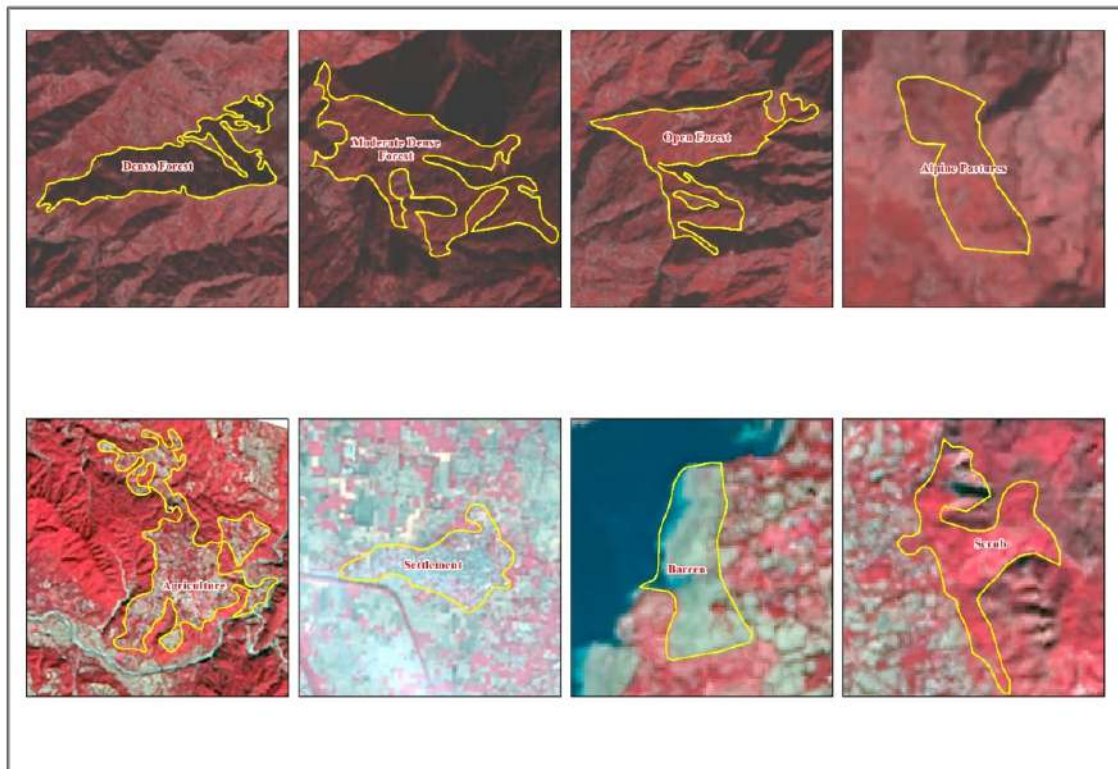


Fig. 3. 9 - Land Use and Land Cover Interpretation/ Classification Key

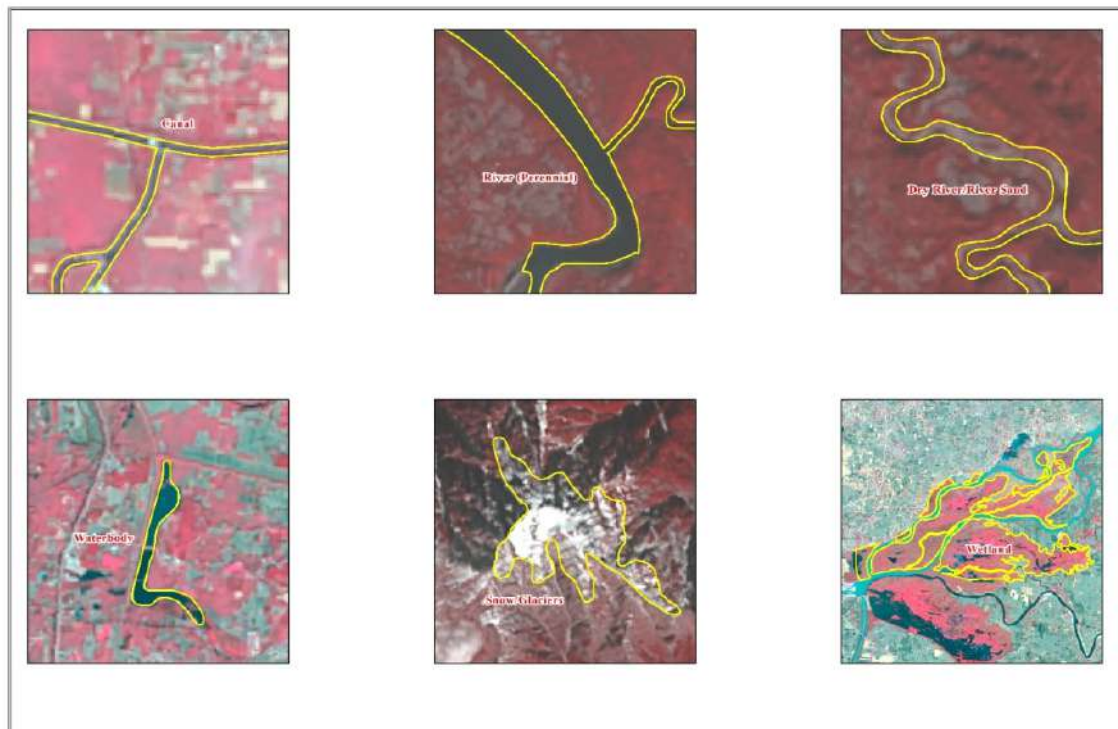


Fig. 3. 10- Land Use and Land Cover Interpretation/ Classification Key

j. **Prioritization of Suitable Areas for Proposed Forestry Interventions**

Diverse forests or other natural vegetation along the altitudinal gradient in the mountainous tract are one of the natural resources that is not only important for human life, but also critical for maintaining various ecological benefits, such as hydrological functions, erosion control, reducing surface runoff, soil fertility control, and rainwater infiltration (Kandari *et al.*, 2015; Silva *et al.*, 2017). Natural vegetation has been recognised as the most important soil cover in relation to other covers to conserve water resources and maintenance of hydrological processes. Replacing natural forests or the original land cover by other land uses, especially when it is associated with inadequate management practices, can cause changes in runoff and rainwater infiltration. This can also result in above normal levels of soil erosion and sediments carrying to the rivers and streams. Thus, the conservation of original land cover, particularly forests and other natural vegetation are of paramount importance in the maintenance of catchment or watershed capability.

Information of land suitability is the pre-requisite to prioritize suitable sites for various forestry interventions like soil and moisture conservation works, forest plantations, grassland/pasture development, wetland management, protection and maintenance of protected areas, etc. Specialisation of conservation actions can be accomplished through the prioritization of areas, which is one of the most effective and economical method in the management. The GIS assisted planning and decision making process by way of geospatial analysis and modeling has been recognised as an important tool for evaluation of land suitability and identification of priority areas for the purpose of proposed forestry interventions and other conservation measures required within the Beas Riverscape from the perspective of preparation of the present DPR. Kandari *et al.* (2015) have described an approach for land suitability evaluation for plantation and forest development based on multi-criteria approach. Likewise, Silva *et al.* (2017) adopted the multi-criteria evaluation for prioritization of areas for forest conservation, aiming at the maintenance of water resources.

The study on prioritization of areas for forestry interventions was carried out in the GIS environment using the cartographic database and the multi-criteria approach (Fig. 3.10). The multi-criteria evaluation approach used for the decision making process identified factors those represent characteristics of the delineated riverscape and/ or process that is considered in the present study. The process involved consultation of varied experts. In this context, initially four criteria (i.e., land use, slope, soil erosion rate and aspect) were considered appropriate based on the expert consultation and the group consensus. Accordingly, alteration in original land use/ land cover affects the hydrology and influences the water quality, especially in areas that suffered from the transformation of natural landscapes into other land uses (Farina, 1998; Galbraith and Burns, 2007; Baker and Miller, 2013; Tu, 2013). Slope was considered as the main factor related to soil erosion as the regions associated with high level of slopes are more susceptible to the erosion process (Valladares *et al.*, 2012). The slope factor is undoubtedly much pronounced and relevant in the context of Himalayan Rivers and the Beas Riverscape. The soil erosion rate reflects the suitability of land for forestry interventions from the perspective of river restoration from two points of view; i.e., (i) lands

with higher erosion rates require the priority attention as well as desired management intervention to reduce soil erosion; (ii) lands/ slopes with higher erosion rates need to be addressed on a priority so as to reduce the extent of sedimentation in streets and rivers. In the Himalayan Mountains, the aspect factor of topography is also considered important as the aspect facings of the terrain that receives the most quantitate of energy from the sun are associated with the highest values of temperate and rate of evapotranspiration and minor values of soil and air humidity (Rosenberg, 1974). Usually, the north facing aspect has dense forests while southern aspect is covered by grasses or sparse vegetation. Thus, northern aspect tends to conserve water and maintain high quantity of humidity in the soil while the southern aspect retains lower moisture. Silva *et al.* (2017) based on the prioritization with the importance of the criteria, reported that their study presented a correlation of 91% with land use/land cover, 52% with slope, 20% with flow accumulation, and only 1% with aspect and concluded that the aspect factor only had a local influence due to its low importance, which was attributed by the decision-making process. In the present study also, a comparison was made to identify the priority areas based on two ways. Firstly, taking into consideration the four factors of, land use/land cover, slope, erosion, and aspect. Secondly, just considering only three factors (i.e., land use/land cover, slope, and erosion) as recommended by Silva *et al.* (2017). Thus, the comparison made in the present effort also yielded the same insight as of Silva *et al.* (2017) wherein the aspect factor appeared to be of low importance and it hardly affected three categories of prioritization. Hence, in the present assignment, multi-criteria using three factors (i.e., land use/land cover, slope and erosion rate) with different weight/rank values as shown in Table 3.7 were considered appropriate for identification of priority areas for forestry interventions. Accordingly, the land use and land cover classes were merged in eight categories (i.e., Wetland, Dense Forest, Alpine Pasture/ Scrub, Open Forest, Agriculture, Barren, Settlement and Others) with weight/ rank values from 1 to 7. The slope factor included three categories (0° to $<30^\circ$; $\geq 30^\circ$ to $<40^\circ$; $\geq 40^\circ$) with values ranging from 1 to 3. The third factor on erosion rate ($\text{t ha}^{-1} \text{ year}^{-1}$) was categorized into five categories (<5 ; ≥ 5 - <10 ; ≥ 10 - <20 ; ≥ 20 - <40 ; ≥ 40) and assigned weight values ranging from 1.5 to 7.5.

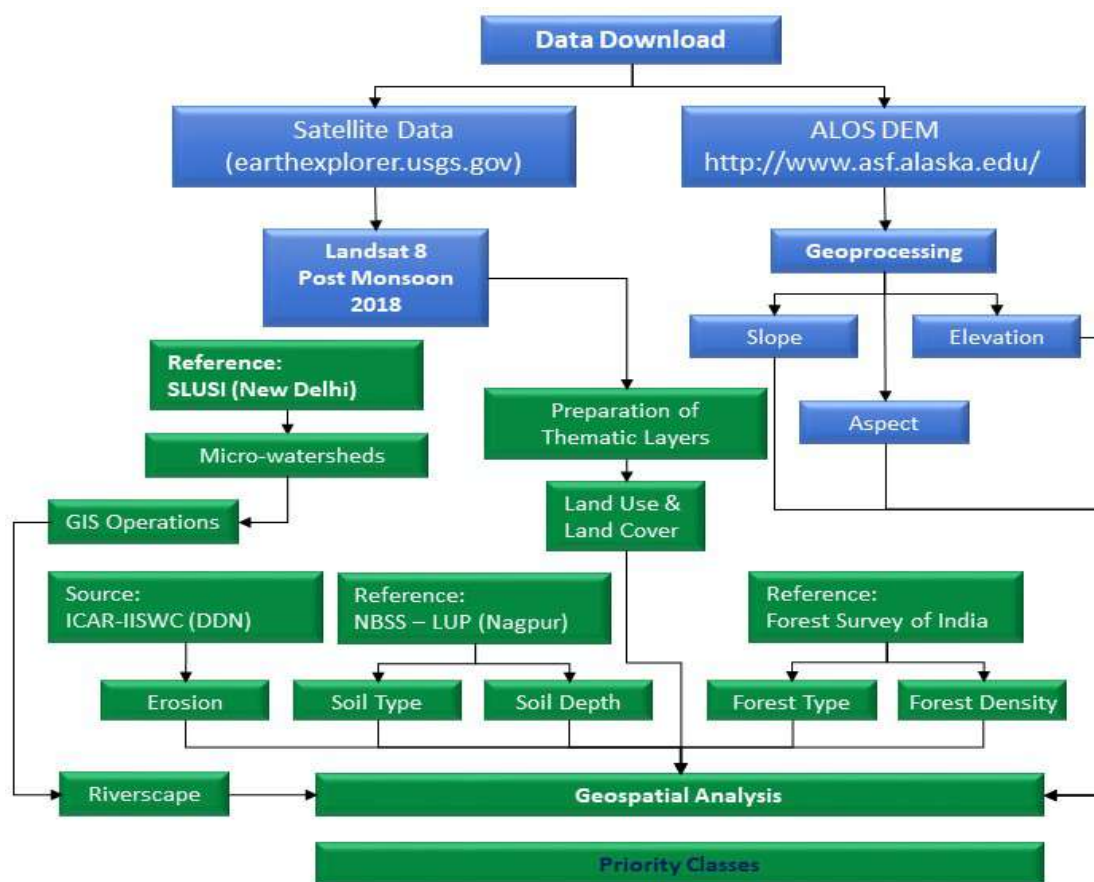


Fig. 3. 11 – The Adopted Approach for Geospatial Analysis and Prioritization of Areas

GIS overlay operations were carried out on three layers relevant to above stated three factors and the weightages for various combinations were combined together by means of addition to arrive at summed weightage for each combination. These values were then categorized into ‘High’, ‘Medium’, and ‘Low’ based on statistical quartile. For example, an Open Forest area was classified as ‘high priority’, if it has a slope category of 0° to 30°, and erosion rate in the category of >10 to <20 t/ha/year. Likewise, the same Open Forest area having slope category of >30° to <40° and falls in the erosion rate category of >5 to <10 t/ha/year has been classified as ‘moderate priority’.

Table 3. 7 – Selected Factors and their Weight Values for Identification of Priority Areas

Sr. No.	Land Use/ Land Cover Category	Weight/ Rank Value	Slope	Weight/ Rank Value	Erosion Rate (t ha ⁻¹ year ⁻¹)	Weight/ Rank Value
1	Wetland	7	0° to <30°	1	<5	1.5
2	Dense Forest	6	≥30° to <40°	2	≥5 to <10	3.0
3	Alpine Pasture/ Scrub	6	≥40°	3	≥10 to <20	4.5
4	Open Forest	5			≥20 to <40	6.0
5	Agriculture	4			≥40	7.5
6	Barren	3				
7	Settlement	2				
8	Others	1				

The information on priority zones within the Beas Riverscape deciphered on the basis of weightage given to three select factors is presented in Table 3.8. The resultant data on three priorities was subsequently depicted on a map showing low, medium and high priority zones.

Table 3.8 – Priority Zones for Forestry Intervention in the Beas Riverscape

Sr. No.	LULC	Slope	Erosion (t ha ⁻¹ year ⁻¹)	Weightage (LULC)	Weight age (Slope)	Weightage (Erosion)	Total	Priority
1	Dense Forest	0° to < 30°	<5	6	1	1.5	8.50	Moderate
2	Dense Forest	0° to < 30°	>40	6	1	7.5	14.50	High
3	Dense Forest	0° to < 30°	10 - 20	6	1	4.5	11.50	High
4	Dense Forest	0° to < 30°	20 - 40	6	1	6	13.00	High
5	Dense Forest	0° to < 30°	5 - 10	6	1	3	10.00	Moderate
6	Dense Forest	>30° to 40°	<5	6	2	1.5	9.50	Moderate
7	Dense Forest	>30° to 40°	>40	6	2	7.5	15.50	High
8	Dense Forest	>30° to 40°	10 - 20	6	2	4.5	12.50	High
9	Dense Forest	>30° to 40°	20 - 40	6	2	6	14.00	High
10	Dense Forest	>30° to 40°	5 – 10	6	2	3	11.00	High
11	Dense Forest	> 40°	<5	6	3	1.5	10.50	High
12	Dense Forest	>40°	>40	6	3	7.5	16.50	High
13	Dense Forest	>40°	10 – 20	6	3	4.5	13.50	High
14	Dense Forest	>40°	20 – 40	6	3	6	15.00	High
15	Dense Forest	>40°	5 – 10	6	3	3	12.00	High
16	Open Forest	0° to 30°	<5	5	1	1.5	7.50	Moderate
17	Open Forest	0° to 30°	>40	5	1	7.5	13.5180	High
18	Open Forest	0° to 30°	10 – 20	5	1	4.5	10.50	High
19	Open Forest	0° to 30°	20 – 40	5	1	6	12.00	High
20	Open Forest	0° to 30°	5 - 10	5	1	3	9.00	Moderate
21	Open Forest	30° to 40°	<5	5	2	1.5	8.50	Moderate
22	Open Forest	30° to 40°	>40	5	2	7.5	14.50	High
23	Open Forest	30° to 40°	10 - 20	5	2	4.5	11.50	High
24	Open Forest	30° to 40°	20 - 40	5	2	6	13.00	High
25	Open Forest	30° to 40°	5 - 10	5	2	3	10.00	Moderate
26	Open Forest	>40°	<5	5	3	1.5	9.50	Moderate

Sr. No.	LULC	Slope	Erosion (t ha ⁻¹ year ⁻¹)	Weightage (LULC)	Weight age (Slope)	Weightage (Erosion)	Total	Priority
27	Open Forest	>40°	>40	5	3	7.5	15.50	High
28	Open Forest	>40°	10 - 20	5	3	4.5	12.50	High
29	Open Forest	>40°	20 - 40	5	3	6	14.00	High
30	Open Forest	>40°	5 - 10	5	3	3	11.00	High
31	Alpine Pasture/Scrub	0° to 30	<5	6	1	1.5	8.50	Moderate
32	Alpine Pasture/Scrub	0° to 30	>40	6	1	7.5	14.50	High
33	Alpine Pasture/Scrub	0° to 30	10 - 20	6	1	4.5	11.50	High
34	Alpine Pasture/Scrub	0° to 30	5 - 10	6	1	3	10.00	Moderate
35	Alpine Pasture/Scrub	30° to 40°	<5	6	2	1.5	9.50	Moderate
36	Alpine Pasture/Scrub	30° to 40°	>40	6	2	7.5	15.50	High
37	Alpine Pasture/Scrub	30° to 40°	10 - 20	6	2	4.5	12.50	High
38	Alpine Pasture/Scrub	30° to 40°	5 - 10	6	2	3	11.00	High
39	Alpine Pasture/Scrub	>40°	<5	6	3	1.5	10.50	High
40	Alpine Pasture/Scrub	>40°	>40	6	3	7.5	16.50	High
41	Alpine Pasture/Scrub	>40°	10 - 20	6	3	4.5	13.50	High
42	Alpine Pasture/Scrub	>40°	5 - 10	6	3	3	12.00	High
43	Agriculture	0° to 30°	<5	4	1	1.5	6.50	Low
44	Agriculture	0° to 30°	>40	4	1	7.5	12.50	High
45	Agriculture	0° to 30°	10 - 20	4	1	4.5	9.50	Moderate
46	Agriculture	0° to 30°	20 - 40	4	1	6	11.00	High
47	Agriculture	0° to 30°	5 - 10	4	1	3	8.00	Moderate
48	Agriculture	30° to 40°	<5	4	2	1.5	7.50	Moderate
49	Agriculture	30° to 40°	>40	4	2	7.5	13.50	High
50	Agriculture	30° to 40°	10 - 20	4	2	4.5	10.50	High
51	Agriculture	30° to 40°	20 - 40	4	2	6	12.00	High
52	Agriculture	30° to 40°	5 - 10	4	2	3	9.00	Moderate
53	Agriculture	>40°	<5	4	3	1.5	8.50	Moderate
54	Agriculture	>40°	>40	4	3	7.5	14.50	High
55	Agriculture	>40°	10 - 20	4	3	4.5	11.50	High

Sr. No.	LULC	Slope	Erosion (t ha ⁻¹ year ⁻¹)	Weightage (LULC)	Weight age (Slope)	Weightage (Erosion)	Total	Priority
56	Agriculture	>40°	20 - 40	4	3	6	13.00	High
57	Agriculture	>40°	5 - 10	4	3	3	10.00	Moderate
58	Barren	0° to 30°	<5	3	1	1.5	5.50	Low
59	Barren	0° to 30°	>40	3	1	7.5	11.50	High
60	Barren	0° to 30°	10 - 20	3	1	4.5	8.50	Moderate
61	Barren	0° to 30°	20 - 40	3	1	6	10.00	Moderate
62	Barren	0° to 30°	5 - 10	3	1	3	7.00	Low
63	Barren	30° to 40°	<5	3	2	1.5	6.50	Low
64	Barren	30° to 40°	>40	3	2	7.5	12.50	High
65	Barren	30° to 40°	10 - 20	3	2	4.5	9.50	Moderate
66	Barren	30° to 40°	20 - 40	3	2	6	11.00	High
67	Barren	30° to 40°	5 - 10	3	2	3	8.00	Moderate
68	Barren	>40°	<5	3	3	1.5	7.50	Moderate
69	Barren	>40°	>40	3	3	7.5	13.50	High
70	Barren	>40°	10 - 20	3	3	4.5	10.50	High
71	Barren	>40°	20 - 40	3	3	6	12.00	High
72	Barren	>40°	5 - 10	3	3	3	9.00	Moderate
73	Wetland	0° to 30°	<5	7	1	1.5	9.50	Moderate
74	Others	0° to 30°	<5	1	1	1.5	3.50	Low
75	Others	0° to 30°	>40	1	1	7.5	9.50	Moderate
76	Others	0° to 30°	10 - 20	1	1	4.5	6.50	Low
77	Others	0° to 30°	20 - 40	1	1	6	8.00	Moderate
78	Others	0° to 30°	5 - 10	1	1	3	5.00	Low
79	Others	30° to 40°	<5	1	2	1.5	4.50	Low
80	Others	30° to 40°	>40	1	2	7.5	10.50	High
81	Others	30° to 40°	10 - 20	1	2	4.5	7.50	Moderate
82	Others	30° to 40°	20 - 40	1	2	6	9.00	Moderate
83	Others	30° to 40°	5 - 10	1	2	3	6.00	Low
84	Others	>40°	<5	1	3	1.5	5.50	Low
85	Others	>40°	>40	1	3	7.5	11.50	High

Sr. No.	LULC	Slope	Erosion (t ha ⁻¹ year ⁻¹)	Weightage (LULC)	Weight age (Slope)	Weightage (Erosion)	Total	Priority
86	Others	>40°	10 - 20	1	3	4.5	8.50	Moderate
87	Others	>40°	20 - 40	1	3	6	10.00	Moderate
88	Others	>40°	5 - 10	1	3	3	7.00	Low
89	Settlement	0° to 30°	<5	2	1	1.5	4.50	Low
90	Settlement	0° to 30°	>40	2	1	7.5	10.50	High
91	Settlement	0° to 30°	10 - 20	2	1	4.5	7.50	Moderate
92	Settlement	0° to 30°	20 - 40	2	1	6	9.00	Moderate
93	Settlement	0° to 30°	5 - 10	2	1	3	6.00	Low
94	Settlement	30° to 40°	<5	2	2	1.5	5.50	Low
95	Settlement	30° to 40°	>40	2	2	7.5	11.50	High
96	Settlement	30° to 40°	10 - 20	2	2	4.5	8.50	Moderate
97	Settlement	30° to 40°	20 - 40	2	2	6	10.00	Moderate
98	Settlement	30° to 40°	5 - 10	2	2	3	7.00	Low
99	Settlement	>40°	<5	2	3	1.5	6.50	Low
100	Settlement	>40°	>40	2	3	7.5	12.50	High
101	Settlement	>40°	10 - 20	2	3	4.5	9.50	Moderate
102	Settlement	>40°	20 - 40	2	3	6	11.00	High
103	Settlement	>40°	5 - 10	2	3	3	8.00	Moderate

k. Riverscape – Secondary Information, Collation and Synthesis

The physical, biological, and socio-economic sub-environments forming the overall environment of the riverscape are broadly controlled by four independent landscape components namely, climate, topography (land surface shape), geological substrate, and land cover besides human disturbances by way of various developmental works (i.e., road network, hydroelectric projects, industries, habitations, and urban lands) along the river course or beyond in the larger catchment. An understanding of the overall environment of the riverscape from the perspective of river rejuvenation, forestry interventions, biodiversity conservation, community engagement, awareness, livelihoods, and sustainable development is the prerequisite. A wide range of background information on the above three sub-environments exists in the available literature. The first step (background analysis/contextual analysis) of the broad approach adopted for the preparation of DPR provided much desired insight on the riverscape environment. The primary sources of relevant information on physical attributes and socio-economic condition were different agencies/ organisations at the state and national levels. Much of the information on the biological sub-environment (i.e.,

biodiversity, forests, alpine pastures, wetlands, floodplain, wildlife and their habitats, threatened species, protected areas, conservation initiatives, etc.) was collected from the MoEF&CC, ICFRE, FSI, FRI, HFRI, WII, GBPNIHESD, WWF-India, State Department(s) – Forest, Agriculture, Animal Husbandry, Fisheries, Science, Technology and Environment, Medicinal Plants, etc., and state level universities. Information thus, obtained from departments/ agencies or collected from respective websites were optimally used for the synthesis of an insight on biological sub-environment of the riverscape. Hence, a large number of studies and reports were referred in the synthesis. The demographic and other socio-economic information was either obtained from the state government websites or downloaded from the primary web source of censusindia.gov.in.

4.1 Legislative, Policy and Institutional Context

The preceding Chapters have introduced the wider subject of river ecosystem and elaborated on its intricate and dynamic nature. These Chapters also highlighted the strong linkages of a river with the catchment, forests, other natural ecosystems, surrounding lands, developmental activities, climate, and the people. Although, the previous Chapters have offered adequate insight on the wide range of issues that need to be pondered in the context of Beas Riverscape, yet there are some other priority aspects *viz.*, legal and policy framework, and the institutional context have an important bearing on the initiatives and programmes aiming to restore the Beas to its original sanctity and fame. Hence, it is imperative to review the existing legal framework, comprehend policy directives, appreciate institutional arrangements, and accustom with the prominent orders by the judiciary those are relevant to the river conservation and implementation of present DPR on forestry interventions. Therefore, the present Chapter is an effort to provide the much-desired understanding on the subject.

Locating the legal, policy and institutional context is not an easy task. Rivers flow through states and nations; between cities and villages; between forest and farms, and through pristine areas to heavily polluted stretches. The law considers ‘water’ and ‘rivers’ as two distinct entities. Within water itself, further complications arise: water is a subject within the exclusive domain of the State but law on water pollution is a subject on which the Parliament has enacted legislation. Though ‘rivers’ come under the purview of the State Government, interstate rivers do not. Further, the use of rivers within a State’s territory is regulated not only by inter-state agreements but also by international obligations. Though the development of large hydropower projects has been the focus of environmental concern, there is a need to focus on the cumulative impact due to large number of small and micro hydropower projects in different stages of planning and execution as also many other activities that threaten the ecological integrity of the river system. Most importantly, the law and institutions need to gear itself to the realities of climate change. In general, India’s law on natural resources have predominantly focused on meeting mostly the developmental needs of the nation to a large extent. However, such law meets local aspirations to a very limited extent. This situation needs to be changed by focusing on both the sustainability and vulnerability of resources. The institutional mechanism and legal system must focus on the risks the river systems and the dependent communities will face in view of receding glaciers and warmer climate.

4.2 The Beas Perspective

The Beas River has an important role in the development of environmental jurisprudence in India. It was in view of the construction on the banks of Beas and the resultant diversion of the river, that the Supreme Court of India in the case of *M.C. Mehta vs. Kamal Nath* (1997) invoked the ‘Public Trust Doctrine’ in holding that the State is only the Trustee of the river

and forest and as a trustee could not use the resources which are contrary to the purpose and objective of the Trust. In addition to the public trust doctrine, the Supreme Court also for the first time held that ‘pollution is a civil wrong’. The principle enunciated by the Supreme Court in the Span Motel case has been relied upon and expanded by both the Supreme Court and the High Court in several subsequent judgments to further the development of environmental jurisprudence in the country.

Rivers have sustained not just the ecosystem but have been responsible for the growth of human civilisation and various cultures. Every river; big or small, have been instrumental in shaping the destiny of the people who inhabit the basin. The health of the river in a way reflects the health of a society. A clean flowing river can be regarded as an indicator of not just a healthy ecosystem but also of the state of governance. How a Nation or State manages its rivers is a good indicator of how it governs its citizens. A healthy river is not just good for the ecology, but it is a key factor that contributes to the well-being of the society at large. After all, polluted water has serious health consequences; a floodplain which is destroyed leads to increased flood risk and decline in fish impact livelihoods and food source. The list is endless. Despite the intrinsic link between river and human well-being, the policy thrust over the last few decades have been to regard a flowing river as a ‘waste’. A river today has to justify its existence by providing multiple benefits to society e.g., electricity to the people, sand and boulder for construction and water for drinking, irrigation and industrial needs. In addition, it is the recipient of all the industrial effluents and domestic sewage. If that was not enough, climate threat has today emerged as the new irreversible threat to the very existence of rivers. The rapidly melting glaciers may give an illusion of an increase in water supply; however, it will not be long before it will be evident that the source for all the water will be gone. The impact of climate change will be all the more visible in the Himalayan Rivers which are snow fed.

River governance, in light of the above facts and looming reality presents peculiar challenge. Challenges have to be met, not only for the sake of the river, but also for the sake of humanity. The erratic weather patterns are now a reality and unless the law and policies take this reality into account, developing a plan to govern rivers is going to be a futile exercise.

The Beas River, therefore, poses serious policy challenge. Being a Himalayan River, it is subjected to the impact of climate change. The flows are not going to be the same. Added to this is increased human dependence due to industrial and other demands. The floodplains, the area most important to absorb the ‘climate shock’ are today seen as the prime areas for various types of constructions. The sand and boulders, the key material which reduces the velocity of water are being removed to meet the demands of building and construction sectors. The Himalayas are today the most dammed mountain range in the world. Yet, new dams are being planned across the length and breadth of the Himalayas, including the Beas River.

The last few years have seen some significant developments with respect to the river governance. The Uttarakhand High Court had conferred the status of legal personhood on the

river Ganga in the case of Mohd. Salim vs. State of Uttarakhand (2017). This judgment was subsequently stayed by the Supreme Court in July, 2017 and the matter is still pending for final adjudication. There can be debate and discussion on both the utility as well as implication of the judgment by the Uttarakhand High Court. However, there is no denial that the Judgment has drawn attention to the need to focus on rivers as something more than just a natural resource to be harnessed for human needs. At another level, the National Ganga Council has been notified by the Central Government as well as the State Ganga River Conservation Authority, and District Ganga Committees (MoWR, RD & GR, 2016). The formation of the three-tiered system is recognition of the need for a basin level governance structure which focuses on the ecology rather than the issue of water distribution.

There needs to be a radical rethink into the manner in which the system governs the rivers. The issue is not just choosing between centralised vs. decentralised or between national vs. state. The key issue is whether the law, policy and institutions are able to meet the challenges arising out of both the human demands and the reality of climate change. This Chapter focuses on the laws, policies and the institutions and the way forward for rejuvenating the Beas River. For the purpose of convenience, this Chapter first lists out the general framework of laws applicable to the Basin. Subsequently, the Chapter delves into detailed explanation of the legislative and institutional framework to deal with sector specific/issue specific problems that are critical to an effective implementation of the Beas rejuvenation programme.

4.3 Mandate under the Constitution of India

The Article 48A of the Constitution of India puts an obligation on the State to protect and improve the environment and to safeguard the forests and wildlife of the country. The Supreme Court in the case of N.D. Jayal and Ors. vs. Union of India and Ors. (2004) has emphasised on the role of the State in protecting the environment in several cases by bringing it under the ambit of 'Right to Life' under the Article 21 of the Constitution. In a recent judgment in the case of the State of Meghalaya vs. All Dimas Students Union (2019), the Court has taken a strict view of the constitutional mandate on the State under the Article 48A by holding that '*in cases pertaining to environmental matter the State has to act as facilitator and not as obstructionist*'. A corresponding duty has also been cast upon every citizen under Article 51A (g), in the form of 'fundamental duties', to protect and improve the natural environment, including forests, lakes, rivers and wildlife, and to have compassion for living creatures. The Supreme Court in its judgment in the case between the Association for Environment Protection vs. State of Kerala and Ors. (2013) has invoked Article 48A and intrinsically connecting it with the Public Trust Doctrine while directing for demolition of an illegal hotel construction on the banks of river Periyar in Kerala.

With respect to rivers, it is important to locate this subject under the Constitutional scheme, i.e., power to legislate on rivers. The 7th Schedule to the Constitution, drawing on the provisions of Article 246 classifies subjects into three different lists- the Union List, State List and the Concurrent List. While 'regulation and development of inter-State rivers and river valleys' finds mention at Entry 56 of the Union List, the subject of 'water' falls within the State List at Entry 17. This dichotomy in the Constitutional set-up calls for a concerted

effort between the Central Government as well as the State Government with respect to rejuvenation, especially in the Beas context, since the River flows through both Himachal Pradesh as well as Punjab. Another constitutional provision which is relevant is the Article 249, which permits the Central Government to legislate on a subject mentioned in the State List in the national interest. The most relevant enactment dealing with issues of water pollution, i.e., the Water (Prevention and Control of Pollution) Act, 1974 was enacted invoking the said provision of the Constitution.

4.4 Policies and Laws – Implications for River Conservation

The Government of India and different States have enacted several laws and formulated various policies in the context of environment, water, forest, wildlife, biodiversity, etc. those have implications in the context of river conservation. The following sections attempts to summarize prominent implications.

4.4.1 The National Forest Policy, 1988

The National Forest Policy was promulgated by the Central Government as a basic document enumerating the principles to be followed while undertaking any activity in forest areas as well as in conservation/rejuvenation efforts of forest areas in the country. Therefore, the National Forest Policy would be an important guide to have an effective rejuvenation programme in place. The policy was relied on by the Supreme Court in the case of *Lafarge Umiam vs. Union of India and Ors.* (2011) wherein the Court directed that the National Forest Policy must be read as a part of the Environment (Protection) Act, 1986 and the Forest (Conservation) Act, 1980. The directions of the Court are noteworthy:

*“The time has come for this Court to declare and we hereby declare that the **National Forest Policy, 1988** which lays down far-reaching principles must necessarily govern the grant of permissions under Section 2 of the Forest (Conservation) Act, 1980 as the same provides the road map to ecological protection and improvement under the Environment (Protection) Act, 1986. The principles/guidelines mentioned in the National Forest Policy, 1988 should be read as part of the provisions of the Environment (Protection) Act, 1986 read together with the Forest (Conservation) Act, 1980. This direction is required to be given because there is no machinery even today established for implementation of the said National Forest Policy, 1988 read with the Forest (Conservation) Act, 1980. Section 3 of the Environment (Protection) Act, 1986 confers a power coupled with duty and, thus, it is incumbent on the Central Government, as hereinafter indicated, to appoint an appropriate authority, preferably in the form of regulator, at the State and at the Central level for ensuring implementation of the National Forest Policy, 1988.”*

One of the important principles outlined in the National Forest Policy included checking soil erosion and denudation in the catchment areas of rivers, lakes, reservoirs in the ‘interest of soil and water conservation, for mitigating floods and droughts and for the retardation of

siltation of reservoirs' (MoEF, 1988). The National Forest Policy also emphasised on the need to include community and ensure their active participation in conservation and rejuvenation efforts of the forest areas.

4.4.2 The National Water Policy, 2012

The Central Government has issued an overarching policy on utilisation and conservation of water resources of the country. The first such policy was issued in 1987 which had laid down the hierarchy of use of water resources- drinking water, irrigation, hydropower, navigation and industrial/other uses. This policy was revisited in 2002 and again in 2012- which is the policy currently in force (MoWR, 2012). The National Water Policy lists out the guiding principles for implementation of laws related to sustainable utilisation and conservation of water resources. The Policy identified that water must not be simply considered as a scarce resource but also the sustainers of life and ecology. Therefore, water needs to be managed as a community resource held, by the State, under public trust doctrine to achieve food security, livelihood, and equitable and sustainable development for all (Takacs, 2008). The Policy also recognised the need for encompassing issues relating to climate change while planning and appraising any activity which involves utilisation of water (MoWR, 2012). These overarching principles, especially relating to community participation as well as climate adaption become critical when formulating and implementing a rejuvenation programme for the Beas River.

4.4.3 The Indus Water Treaty, 1960

The Indus Water Treaty, 1960 is one of the oldest trans-boundary River sharing treaties to be signed in the world. It has been hailed as being one of the most successful treaties on trans-boundary water sharing (Hanes, 2017). As per the treaty, India and Pakistan have agreed to demarcate the six rivers which fall within the Indus Basin for their respective use, management and exploitation of resources. Thus, as per the Treaty, India has full rights of use and exploitation of the three eastern rivers, i.e., the Beas, Ravi and Sutlej (IWT, 1960); whereas, Pakistan has unfettered rights of exploitation of the western rivers, i.e., the Indus, Chenab and Jhelum and India has limited rights on the catchment area of these rivers within Indian territory (IWT, 1960).

As per the provisions of the Treaty, if either party wants to exploit resources of a river which has been assigned to the other party, an elaborate mechanism has been laid down. This includes consultations, filing of objections, sharing of data, etc. The Indus Permanent Commission was also set up as per the Treaty which has been tasked with ensuring proper implementation of the Treaty. In case of any dispute regarding any activity, the Treaty has specific provisions with respect to dispute resolution. For the purpose of the current Chapter, the Indus Treaty does not have much relevance, as India has unfettered rights over the Beas River.

4.4.4 Hydro Power Projects - Ensuring that the River Flows

For ensuring that a river is healthy and free flowing, it is important to ensure that there is minimal hindrance or diversion of the channel. In this context, it would be important to consider the effect of the proliferation of hydropower projects in the Beas Basin. Hydropower projects have a significant impact on river flow, including flow of silt, nutrients and movement of faunal species up and down the river. This includes the impact on river ecology as well as the related aquatic and terrestrial biodiversity. Each hydropower project, irrespective of the size typically involves a dam, de-silting chamber, a Head race tunnel (typically underground) leading the silt free water from the de-silting chamber to the turbines, a power station and tail race tunnel that takes the water from the power station back to the river downstream from the dam, the distance between the dam and the point where the tail race tunnel meets the river could be several kilometres downstream from the dam, dumping of muck generated during construction of the project, approach roads, township for the employees of the project, mining for the materials required for the project, catchment area treatment and compensatory afforestation when forest land is required for the project. Thus, the construction of a hydropower project does not merely result in obstruction/ diversion of the flow of the river, it also has severe impact on the surrounding areas- submergence of forests and non-forest areas which supports rich biodiversity, loss of habitat as a result of such diversion, impact of construction of roads and other allied infrastructure, dumping of muck, etc.

The National Green Tribunal (NGT) in its judgment in the case of *Paryavaran Sanrakshan Sangharsh Samiti, Lippa vs. Union of India and Ors.* (2016) on the Kashang Stage II and III HEPs in Kinnaur District highlighted their following concerns regarding the unsustainable growth of hydropower projects in the State of Himachal Pradesh:

“12. Before proceeding further, we have felt an imperative need to make some observations, having noticed the magnitude of and the scale at which hydro projects are being set up in the State of Himachal Pradesh.

13. From the order of the Hon’ble High Court of Himachal Pradesh dated 23.12.2009 in CWPIL No. 24 of 2009 it is revealed that there were as many as 150 hydel projects under varying stages of construction in the State as on the date of the order. We do not know how many more have been added thereafter. By the said order, a High Level One Man Committee constituted of one Mr. Ajay Shukla, Additional Chief Secretary (Forests) was appointed directing him to submit a report on various issues asserted out in the order. The report submitted by the Committee is, to state the least, most alarming.

14. Our conviction on the adverse consequence on the environment highlighted by the One Man Committee as reproduced above appears to be well justified in view of the reply Annexure A-9 furnished by the Executive Engineer, IPH Division R/Peo, District

Kinnaur, Department of I& PH, Government of Himachal Pradesh in response to an application under the RTI Act. The letter reveals that as many as 167 water sources have been adversely affected in the project areas of Karcham Wangtu HEP which is another project on the same river. Water sources that have dried up and where discharge of water have been affected or reduced in the same area were 35 and 66 in number, respectively. These illustrate the adverse effect on only one aspect of the environment within just one project area. We can, therefore, well imagine the cumulative impact of the 150 projects.”

In specific context of the Beas Sub-Basin in Himachal Pradesh, as per official estimates, there is a hydropower potential of 4877.70 MW (for >5 MW projects), distributed among 51 hydropower projects spread throughout the basin (RSET, 2019). Out of these 51 projects, 22 projects are commissioned (total installed capacity 2820.90 MW), 5 are under construction (total installed capacity 947 MW), 20 are at various stages of investigations (total installed capacity 1028.90 MW) and 4 are yet to be allotted. There are an estimated 327 projects of small hydel projects of 5 MW or under are also at different stages of development (Him Urja, 2018). Thus, there is a need to look at this issue and the legislative and policy tools to ensure minimum impact on the River Beas from this sector. The problem is magnified in light of the cascade model of hydropower development being adopted in Himachal Pradesh. In contrast to a reservoir-based dam, recent trend shows a shift towards run-off-the-river hydropower projects in India. This cascade model means that at the tail of one project, the head of the next is located, thereby creating a cascade/series of these projects built bumper to bumper on the streams and rivers to harness the capacity of the rivers to produce power to its maximum. Other significant impact of hydropower projects are the associated impact of road and other infrastructure development (Shukla Report). Special emphasis on this sector has to be given in light of climate change related discussion.

While regulating hydropower projects, the following laws become pertinent:-

(a) Environmental Clearance under the EIA Notification, 2006

As per the scheme under the EIA Notification, 2006, a hydropower project proposing more than 50 MW power generation would require obtaining prior Environmental Clearance from the Ministry of Environment, Forest and Climate Change and if the power generation is 25 MW or more but less than 50 MW, clearance has to be obtained from the State Level Environmental Impact Assessment Authority (SEIAA). While applying for such clearance, the Project Proponent must undertake an Environment Impact Assessment Study (EIA) and conduct public consultations with the affected communities and submit the report to the Expert Appraisal Committee (EAC) or the State Expert Appraisal Committee (SEAC). Before grant of such clearance, the concerned EAC or SEAC and the regulatory Authority is mandated to conduct a ‘detailed scrutiny’ of the documents submitted and then recommend

for grant or rejection of the Environmental Clearance (MoEF, 2006). An Environmental Clearance, if granted is valid for a period of ten years.

It is mandatory for the project proponent to submit six monthly compliance reports of the conditions of the Environmental Clearance (MOEF, 2006). The Environmental Clearance for hydro projects usually has specific conditions with respect of the construction phase of the dam i.e., muck disposal plans, height of the dam, etc. These conditions need to be strictly monitored at the construction stage. During operation phase, the conditions relating to release of minimum environmental flows, Catchment Area Treatment Plan, etc. are pertinent. Thus, the Environmental Clearance becomes an important instrument to ensure minimal damage to the river system. In specific context of the Beas River, the Tirthan Valley was declared as a 'No-go' area in 2005 by the Himachal Pradesh Government, and the stark difference between the Tirthan Valley as well as the Sainj Valley which is heavily dammed is noteworthy (Theophilus, 2014).

In this context, it may be noted that the Ministry of Environment, Forest and Climate Change had commissioned Cumulative Impact Assessment and Carrying Capacity Study ('CIA and CCS Study') for important river basins across the country. The CIA & CCS Study for Beas Sub-Basin in Himachal Pradesh has received the approval of the Expert Appraisal Committee of the Ministry in its meeting dated 28.01.2019. It may be noted that even though the CIA & CCS Study approved by the MoEF&CC gives certain recommendations regarding projects which are proposed to come up on the Beas River, it must be noted that the existing projects have already caused huge loss in terms of habitat loss, loss of migratory routes and loss of pristine forest cover in the catchment area which are all integral parts of a river ecosystem (MoEF&CC, 2019). A perusal of study report also revealed that it lacked in any documented evidence of any effort towards public consultations as local communities were not involved at any stage in the preparation of the report. This indicates inadequacy of the existing law. Further, the report does not take into account the cumulative impact of about 313 small hydel projects on the river and its basin.

(b) Forest Clearance under the Forest (Conservation) Act, 1980

In addition to obtaining the Environmental Clearance, in most cases hydropower projects require prior Forest Clearance under the Section 2 of the Forest (Conservation) Act, 1980 for diversion of forest land. As mentioned earlier, around 40% of the land use in the basin in Himachal Pradesh falls under forest category. Under the Forest Clearance process, what is most critical is the Cost-Benefit Analysis which has to be undertaken by the User Agency which is to be scrutinised by the Central Government before granting Forest Clearance. As per the Guidelines of the MoEF&CC, while considering a proposal for diversion of forest land, it is essential that ecological and environmental losses and eco-economic distress caused to the people who are displaced are weighted against economic and social gains (MoEF&CC, 2017). Thus, the cost of ecosystem services and fragmentation of wildlife and economic distress to the displaced communities, and cost of settlement of these communities should be added as cost of diversion in addition to the project cost.

(c) Settlement of Forest Rights of Forest Dwelling Communities under the Forest Rights Act, 2006

An important aspect of Forest Clearance process is the mandatory requirement of settlement of forest rights of tribal communities and obtaining consent from the *Gram Sabhas* concerned under the provisions of the ‘Scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006. In this regard, the Ministry has issued letter dated 3.08.2009 wherein the Ministry has listed out the necessary compliances to be undertaken by the User Agency and the State Government before the grant of Forest Clearance under the Section 2 of the Forest (Conservation) Act, 1980. The said condition has been categorically brought under the purview of State/UTs it is now mandatory as per the Forest (Conservation) Rules, 2003, vide amendment dated 06.03.2017 (MoEF, 2003).

(d) Dealing with Prolific Growth of Mini-Hydro Projects:

As mentioned earlier, there is a serious need to relook at the issue of mini hydropower projects in the State of Himachal Pradesh. It may be noted that small hydropower projects (SHPs) (1MW to <25MW) are not included under the purview of the EIA Notification, 2006 of the Environmental (Protection) Act, 1986. Hence, all SHPs are legally exempted from requiring environmental clearances and conducting environment impact assessment and public hearings. This is primarily due to the assumption that small hydropower projects, on account of being ‘small’ will have minimal or no adverse environmental and social impacts. In the context of the Beas River, it may be noted that in Kangra, the tributaries originating in the Dhauladhar Range are feeders for *kuhls* (traditional irrigation channels) that support irrigation for paddy cultivation in the region. The holdings are small and the production is very low. Cultivation is not possible by tractors because the fields are small and terraced. However, the prolific growth of SHPs in the basin has been detrimental and has adversely affected the functioning of these *kuhls*.

Thus, what has been overlooked is that small projects are coming up on the smaller streams which sustain local livelihoods of remotely located poor communities and fragile but bio-diverse ecosystems in numerous ways. Across the state, these streams support the traditional irrigation channels or *kuhls*. Watermills are run on these and in many places they even supply drinking water to villages (Himdhara Collective, 2016). When looked at from a larger basin perspective, there is a need for assessing the cumulative impact of SHPs and bringing the same under a definite legal regime which looks at the cumulative impact of the project as well as ensures that the project is being permitted with the consent of the local people.

4.4.5 Protecting the Protected Areas - Ensuring Proper Conservation of Wildlife Habitats in the Basin

The Beas Basin supports a rich biodiversity. In fact, the sub-basin in Himachal Pradesh is home to diverse species, not just mammalian, but also avian and aquatic species. As per the CIA & CCS Study for Beas Sub-Basin in Himachal Pradesh, there are ten Wildlife Sanctuaries and three National Parks in the Beas Basin in Himachal Pradesh (RSET, 2019).

However, it may be noted that there are no Community Reserve or Nature Conservation Reserves notified under the provisions of the Wildlife (Protection) Act, 1972 as well as Biodiversity Heritage Sites under the Biological Diversity Act, 2002.

Under the provisions of the Section 35 (6) of the Wildlife (Protection) Act, 1972, there is a specific prohibition on destroying or damaging or diverting the habitat of any wild animal by any act or diverting, stopping or enhancing the flow of water inside or outside the National Park. Similar provision for protection of Wildlife Sanctuaries has been given in Section 29. These activities are allowed on the exception that a permit is granted by the Chief Wildlife Warden and that no such permit granted unless the State Government is satisfied in consultation with the National Board for Wildlife that such removal of wildlife from the national park or the change in the flow of water into or outside the national park is necessary for the improvement and better management of wildlife therein.

The Beas Sub-Basin is rich in avifaunal biodiversity (RSET, 2019). In this context, it may be noted that nine Important Bird Areas (IBAs) have been designated based upon the criteria defined by Birdlife International. IBAs are conservation areas of international significance for conservation of birds at the global, regional or sub-regional level. According to the BirdLife International, designation of IBAs is based on standardised criteria, namely:

- (i) Hold significant numbers of one or more globally threatened bird species,
- (ii) Be one of a set of sites that together hold a suite of restricted-range species or biome-restricted species, and
- (iii) Have exceptionally large numbers of migratory or congregatory birds.

In the Beas Sub-Basin in Himachal Pradesh, most of the IBAs harbour critically endangered Western Tragopan and Vulnerable Cheer pheasant (RSET, 2019).

Another such process of identification conducted by the International Union for Conservation of Nature (IUCN, 2016) is that of Key Biodiversity Areas (KBA). KBAs is an umbrella term commonly used to include areas that contribute to the global persistence of biodiversity, including vital habitat for threatened plant and animal species in terrestrial, freshwater and marine ecosystems. Globally, KBAs are designated based on 11 criteria defined under five broad categories of threatened biodiversity; geographically restricted biodiversity; ecological integrity; biological processes; and, irreplaceability. The criteria for designating a site as KBA have been described in the document 'Global Standard for the Identification of Key Biodiversity Areas (2016)'. The IUCN has identified 531 KBA sites in India. Globally KBAs are designated based on 11 criteria defined under five broad categories of threatened biodiversity; geographically restricted biodiversity; ecological integrity; biological processes; and, irreplaceability (WII, 2017). Although, these are not legally notified, the fact that these 531 areas qualify as KBA reflects their ecological importance. There are 27 KBAs identified within the State of Himachal Pradesh. Out of this, Beas Sub-Basin in Himachal Pradesh has 10 KBAs while Punjab State has 11 KBAs. Prominent amongst them are the: Great Himalayan National Park Conservation Area World Heritage Site, Pong Dam Lake Sanctuary and Harike Sanctuary.

The Beas Sub-Basin in Himachal Pradesh is also known to support at least 80 fish species (RSET, 2019). This becomes important in light of proliferation of hydro projects in the basin which pose a serious threat to several native and endemic species of fish, affecting their spawning habits and impeding migratory routes. The issue of proper ecological flow assessments and ensuring proper flow in the river to support the rich flora and fauna thus, becomes essential and critical.

4.4.6 Eco Sensitive Zone - An Effective Conservation Tool for River Beas

Eco Sensitive Zone (ESZ) around a Protected Area is declared and notified under the section 3(v) of the Environment (Protection) Act, 1986 and Rule 5 (viii) & (x) of the Environment (Protection) Rules. The purpose of notifying Eco-Sensitive Zones around Protected Areas is to create a kind of ‘shock absorber’ for such areas, and they would also act as a transition zone from areas that are highly protected to areas requiring lower protection. The status of the ESZ around the protected areas in Beas Sub-Basin is given in Table 4.1.

Table 4. 1 - Protected Areas within the Beas Basin and the Status of ESZ Notifications

Sr. No.	Protected Areas	Area (km ²)	Status of ESZ Notification	Extent of ESZ as per the Notification
Wildlife Sanctuaries				
1	Dhauladhar Wildlife Sanctuary	982.86	Draft Notification (13/01/2016)	Up to 1.0 km along the southern and south-west boundary of Dhauladhar WLS
2	Kanawar Wildlife Sanctuary	107.29	Draft Notification (28/04/2016)	Up to 2.7 km, except on the south-eastern side as this part is connected to the Great Himalayan NP
3	Khokhan Wildlife Sanctuary	14.94	Draft Notification (04/03/2016)	Up to 2.75 km around the WLS.
4	Manali Wildlife Sanctuary	29.00	Draft Notification (04/03/2016)	Up to 4km around the WLS
5	Sainj Wildlife Sanctuary**	90.00	-	-
6	Pong Dam Lake Wildlife Sanctuary	207.59	Draft Notification (17/11/2016)	Up to 1.5 km around the WLS
7	Tirthan Wildlife Sanctuary**	61.00	-	-
8	Shikari Devi Wildlife Sanctuary	29.94	Draft Notification (04/03/2016)	Varying from 50m to 2km around the WLS
9	Nargu Wildlife Sanctuary	132.37	Draft Notification (08/03/2016)	Upto 1 km around the WLS
10	Kais Wildlife Sanctuary	12.61	Draft Notification (24/04/2016)	Up to 50 m to 2.1 km around the WLS
National Parks				
11	Great Himalayan National Park**	754.40	-	
12	Khirganga National Park**	710.00	Draft Notification (25/07/2016)	
13	Indrakilla National Park	104.00	Final Notification Issued (17.01.2018)	

Sr. No.	Protected Areas	Area (km ²)	Status of ESZ Notification	Extent of ESZ as per the Notification
14	Great Himalayan National Park Conservation Area (GHNPCA)**	1615.40	Draft Notification (22/08/2016)	Extent upto 6 km around the GHNPCA, except eastern side, north-eastern side and northern side, due to three Protected Areas namely, Rupin Bhabha Wildlife Sanctuary, Pin Valley National Park and Kanawar Wildlife Sanctuary are contiguous in these sides

**Great Himalayan National Park Conservation Area includes Sainj WLS, Tirthan WLS, Great Himalayan National Park and Khirganga National Park
(Source: RSET, 2019)

It is evident from the Table 4.1 that most of the Protected Areas have draft notification issued for the Eco Sensitive Zone (ESZ) nearly four years ago and they await the issuance of final notification. It is ponderable whether the extent of the proposed ESZs would be sufficient to act as a 'shock absorber'. With respect to the proposed prohibited activities, most of the Draft Notifications stipulate a conditional prohibition - for instance 'construction of a major thermal power project or hydropower project' finds mention in the list of prohibited activities. However, the Notification states that it is 'prohibited (except as otherwise) provided as per the applicable law' (MoEF&CC, 2016). There is a definite need to strengthen these provisions and ensure that the activities permitted in the 'buffer zone/ ESZ' are minimal. The Beas River and its tributaries are flowing through these protected areas, or their ESZ. While the provisions of the Wildlife (Protection) Act, 1972 do provide certain safeguards, ensuring properly demarcated ESZ is a much more effective conservation tool for rejuvenating rivers, since it covers not only the river and its ecology, but also the catchment area, in terms of regulation of permissible activities. This is so because the Notification which is issued under the provisions of the Environment (Protection) Act, 1986 have mandatory provisions with respect to activities which are prohibited and which are permissible but with certain conditions. In most cases, river sand/boulder mining and setting up of stone crusher units within the notified ESZ are prohibited. The State of Himachal Pradesh needs to take proactive steps and consult the Ministry of Environment, Forest and Climate Change for notifying the final Notifications of ESZ for the protected areas falling within the Basin.

With respect to the Punjab Sub-Basin of Beas River, there are two Wildlife Sanctuaries and three Community Reserves in Gurdaspur and Hoshiarpur Districts. The Beas River flows through the Beas River Conservation Reserve (BRCR). Moreover, the BRCR is newly notified conservation reserve in 2017 and it includes a longer stretch (185 km) of the main river with all channels and the government lands. It is important to mention here that the Beas River stretch in Punjab is the only habitat in India which supports the Indus River Dolphin (*Platanista gangetica minor*) which is critically endangered species with about only a dozen individuals that too in a smaller stretch of about 70 km (Khan, 2016). Thus, there is a critical need to prepare a specific conservation action plan for this unique and critically endangered species which is already facing serious threats due to habitat loss, reduced river connectivity

(longitudinal, vertical, lateral and temporal) owing to physical barriers (reservoirs and barrages), overfishing, pollution from untreated industrial effluents and domestic sewage.

4.4.7 Conservation of Wetlands

Diverse wetlands, particularly riverine wetlands are an important component of a river system and they play a critical role in improving flood protection, recharging ground water and increasing the biodiversity, thus providing several ecological services. The State is under a legal obligation both under the Wetland Rules, 2017 issued in accordance of the provisions of the Environment (Protection) Act, 1986 as well as responsible to fulfil the India's international commitments to the Convention on Migratory Species (CMS), the Ramsar Convention and the Convention on Biological Diversity to protect and preserve wetlands as well as the avian ecology that they support.

The State of Himachal Pradesh has notified the constitution of the State Wetland Authority in 2017 itself (SCST&E, 2017). However, as per the recent update available until January, 2020, Punjab was yet to notify the constitution of State Wetland Authority. Although, both States have been protecting various important wetlands and several of them have been legally designated as Wildlife Sanctuary or as the 'Wetlands of National Importance' or even as the 'Ramsar sites', it is not clear as to how much progress has been made with respect to the identification and notification of wetlands in the State as per the Wetland Rules, 2017. The timeline as per the Rules for various steps in the identification of wetlands as well as notification is given in the Table 4.2.

Table 4. 2 – The Wetland Rules, 2017 - Key Steps and Relevant Timelines

Sr. No.	Activity	Timeline as per Rules
1	Constitution of Technical Committee to review brief documents, management plans and advise on any technical matter referred by the Wetland Authority; and constitution of Grievance Committee consisting of four members to provide a mechanism for hearing and forwarding the grievances raised by public to the Authority	3 months from date of publication of Rules.
2	Prepare a list of all wetlands of the State or Union Territory	3 months from date of publication of Rules.
3	Prepare a list of wetlands to be notified,	6 months from date of publication of Rules.
4	Prepare a comprehensive digital inventory of all wetlands	1 year from date of publication of Rules.

It is clear that the State of Himachal Pradesh as well as Punjab are yet to undertake these mandatory steps as per the Wetland Rules, 2017. Therefore, it is necessary to initiate and complete, in a time bound manner, the process of identification and notification of wetlands under the provisions of the Wetland Rules, 2017 so that they come under legal protection. It may be noted that the main river channel is specifically excluded from the legal definition of Wetland under the Rule 2(g) of the Wetlands (Conservation and Management) Rules, 2017 (MoEF&CC, 2017). However, the wetlands which are part of the basin, or which form part of

the larger catchment area of the river are important from the perspective of a holistic approach adopted for river restoration and conservation.

4.4.8 Mineral Extraction and Industrial Land Use - Ensuring Sustainable Extraction and Replenishment of Minerals

(a) River Sand/Boulder Mining

The River Beas and its tributaries are not unknown to the problems of large scale illegal and unscientific mining, especially in Himachal Pradesh. The ill effects of river sand mining have got judicially acknowledged in several cases by the Supreme Court as well as the National Green Tribunal. In 2012, the Supreme Court in the case of Deepak Kumar vs. State of Haryana and Ors. (2012) had noted with serious concern:

‘Sand mining on either side of the rivers is one of the causes of environmental degradation and also a threat to the biodiversity. Over the years, India’s rivers and the Riparian ecology have been badly affected by the alarming rate of unrestricted sand mining which damage the ecosystem of rivers and safety of bridges, weakening of river beds, destruction of natural habitats of organisms living on the river beds, affects fish breeding and migration, spells disaster for the conservation of many bird species, increases saline water in the rivers etc. Extraction of alluvial material from within the or near a streambed has a direct impact on the stream’s physical habitat characteristics. These include bed elevation, substrate composition and stability, in-stream roughness elements, depth velocity, turbidity, sediment transport, stream discharge and temperature. Altering these habitat characteristics can have deleterious impacts on both in-stream biota and the associated riparian habitat. The demand for sand continues day by day as building and construction of new infrastructures expansion of existing ones is continuous thereby placing immense pressure on the supply of the sand resource and hence mining activities are going on legally without any restrictions. Lack of proper planning and sand management cause disturbance of marine ecosystem and also upset the ability of natural marine processes to replenish the sand.’

The Supreme Court had thus directed that all river sand mining projects irrespective of the area would mandatorily require prior Environmental Clearance under the provisions of the EIA Notification to ensure that impact from such projects is minimized and mitigated to the extent possible. Thus, any rejuvenation efforts for Beas River would necessarily have to concentrate on creating effective mechanism to deal with illegal mining and regulate the mining activities in the river and its basin.

Under the legislative domain, regulation of mining of sand and boulder material falls under the purview of the State Government as per the provisions of the Mines and Minerals (Development and Regulation) Act, 1957 (MMDR Act) (MoM, 1957). In addition to this, mining of minor minerals require prior Environmental Clearance under the provisions of the

EIA Notification, 2006 (MoEF, 2006). Accordingly, the purview of environmental clearance of mining would vary in three categories depending upon the mining lease area.

With respect to B2 category (<25 ha lease area) projects, before granting clearance, there is a pre-requisite condition regarding preparation of District Survey Reports (DSRs) with the objective of 'identification of areas of aggradations or deposition where mining can be allowed; and identification of areas of erosion and proximity to infrastructural structures and installations where mining should be prohibited and calculation of annual rate of replenishment and allowing time for replenishment after mining in that area'. The idea is to make a prior assessment of the available reserves in the river and to extract the same in a sustainable manner without adversely impacting the river ecology. These reports are to be updated every five years as per the EIA Notification, 2006. For the state of Himachal Pradesh, DSRs are available for all the five districts falling in the Beas Sub-Basin- Kullu, Mandi, Hamirpur, Kangra, and Chamba on the website of the Department of Industries, Government of Himachal Pradesh. The MoEF&CC has also issued sustainable sand mining guidelines in 2016 which, inter-alia, addresses the issues relating to regulation of sand mining (MoEF&CC, 2016).

(b) Stone Crusher Units

In 2014, the Government of Himachal Pradesh has issued mandatory sitting criteria under the provisions of the Environment (Protection) Act, 1986 (GoHP, 2014). The Notification prohibits setting of stone crushers within 500 m of lakes, wetlands and reservoirs of irrigation schemes, hydropower projects and within 100m of a canal or 'perennial rivulet'. The Notification further mandates a joint inspection by a Committee which includes the Divisional Forest Officer as a member. The Committee has to ensure that no proposal for setting up of a stone crusher is violating the sitting criteria. Interestingly, the National Green Tribunal is currently considering the said notification with respect to the distance from rivulets in the case of Bhag Singh vs. State of Himachal Pradesh and Ors. (NGT, 2019). The issue before the Tribunal is whether the distance of 100m needs to be maintained only with respect to perennial rivulets. In an order dated 29.10.2018, the Tribunal applying the Precautionary Principle held as follows:

*8. A reference to above Entry shows that there is prohibition for location of a stone crusher within 100 m from springs, canals, reservoirs or functional water supply schemes and natural water schemes. **The rivulets of perennial nature are specifically included in the said expression but it cannot be read as excluding non-perennial water bodies.** The object of the regulatory notification issued under the Environment (Protection) Act, 1986 is to protect the ecology from the adverse impact of location of a stone crusher nearby. The intention is not to permit a stone crusher within 100 m of a water body. Importance of protection of water bodies can hardly be over-emphasized. **Interpretation of a regulatory provision must be consistent with the 'precautionary principle' and 'sustainable development principle'.** Location of a stone crusher very close to a water body is against the*

principle of ‘sustainable development’ as well as the ‘precautionary principle’.
The above Notification cannot be read as meaning that stone crushers can be allowed to be located just on the edge of a water body even if such water body is not perennial. Thus, the stone crushers set up within 100 m of a water body will be illegal and in violation of the Environment (Protection) Act, 1986 and the Notification issued thereunder.

9. Accordingly, the consent to operate granted to any stone crusher in the State of Himachal Pradesh within 100 m of a water body will stand quashed. The Himachal Pradesh State Pollution Control Board will take steps to stop operation of any such stone crusher and furnish a report to this Tribunal within two months’.

The said order came to be challenged by the State of Himachal Pradesh and several stone crusher units before the Hon’ble Supreme Court on the ground that they were not heard by the Tribunal while passing such orders. The Supreme Court thus, remanded the matter back for the Tribunal to consider the submissions of the State as well as the Stone Crushers. The Tribunal by order dated 02.04.2019 constituted an Expert Committee to look into this issue and give recommendations. As per order dated 10.07.2019, the Tribunal had noted the recommendations of the Expert Committee that the minimum distance from any watercourse should be 100 m irrespective of the nature of the water course-perennial or non-perennial. Thus, any crusher units in violation of the sitting criteria must be shut down. The following observation is noteworthy:

“10. Non-perennial rivers may have different characteristics and may function very differently in maintaining hydrological and ecological balance. Non-perennial rivers is relatively sensitive to change and can easily lead to degradation of the river system. Degradation of such non-perennial rivers caused by man through development and use of the river as a water source can result in water scarcity and climate change. All such rivers are hydrologically and ecologically sensitive and changes to their hydrological regime can have far reaching effects on the river flow and the biota that can cause dramatic negative changes....

As observed in order dated 02.04.2019, in view of ‘Precautionary’ and ‘Sustainable Development’ principles of environment law and the statutory scheme providing that consent to operate or consent to establish is required to be renewed every year in the light of situation which may prevail. It is difficult to hold that a vested right to continue any activities accrues irrespective of impact on environment.”

The department responsible for such action would be the Pollution Control Board as well as the concerned Deputy Commissioner/District Magistrate. Ensuring such polluting industries does not have an adverse impact on the river and its catchment area is an important facet of river rejuvenation. It may be noted that similar sitting criteria have been notified by the Punjab Government in 2013 (GoP, 2013).

4.4.9 Catchment Area Conservation Measures

While looking at rejuvenating a river, it is important not to just consider the river in isolation. A river is more than just the channel of flowing water, and has to be understood in terms of its catchment, the river bed, banks and floodplain as well as the vegetation on the floodplain. A healthy catchment area is thus, integral to ensuring healthy river. In this regard, issues which need to be considered include measures for floodplain protection and to ensure efficient retention capacity of rain water in the soil.

Floodplain: Protection of floodplains is critical to river conservation and ensuring good river health. They also support ecological diversity in a river system by providing carbon and supply of nutrients to river channel, which finally governs productivity of the entire river system and by providing geomorphic (habitat) diversity in river space to support biodiversity (Richards *et al.*, 2002; Gurnell and Petts, 2002; Thoms, 2003). It is thus, very important that floodplains are correctly demarcated and protected. The importance of floodplain demarcation has been highlighted in several cases before the National Green Tribunal with regard to rivers in Maharashtra and river Yamuna in Delhi and Agra. Zoning of the floodplain by demarcating prohibited zone and regulatory zone is an efficient tool for protecting and conserving floodplains. For instance in the State of Maharashtra, as early as 1989, the Government had issued an order directing for demarcation of the floodplain into prohibited zone (blue zone) as an active floodplain is also a good counter measure against flooding (GoM, 1989).

4.4.10 Water Quality - Ensuring No Untreated Sewage/Industrial Effluent Falls into the River

Water pollution is predominantly dealt with by the Water (Prevention and Control of Pollution) Act, 1974. This is done by mandating a process of regulating discharge of domestic sewage or industrial effluent through a regime of grant of 'prior consent' by the SPCB. Thus, the Act stipulates a mandatory regime for every industry, process, activity, etc. to obtain prior consent from the concerned State Pollution Control Board (SPCB) for such a discharge of sewage or industrial effluent (GoI, 1974). The provision lays down a two-pronged consent regime- a prior consent to be obtained before establishing the unit/industry and consent to be obtained after setting up of the unit/industry, but before starting operations. These consents are referred to as 'Consent to Establish (CTE)' and 'Consent to Operate (CTO)'. The CTE is granted on the basis of the location of the proposed site, its pollution potential, proximity to sensitive areas etc. Once the plant/unit/industry is set up, on the basis of the compliance status of the conditions stipulated in the CTE, the SPCB grants the CTO. As per the Section 49 of Water (Prevention and Control of Pollution) Act, 1974, the SPCB may also initiate penal proceedings against the violator for the harm caused to the environment due to violation/non-compliance of the consent conditions (GoI, 1974).

A major component of rejuvenation of river Beas would also be tackling the outfall of untreated sewage and industrial effluent into the river. As per the data available with the

Central Pollution Control Board (CPCB), two stretches of Beas River in Himachal Pradesh have been identified as the polluted stretches (Table 4.3) (CPCB, 2015).

Table 4.3 - Identified Polluted Stretches in Beas Basin

River Name	Stretch Identified	Towns Identified	Approximate Length of the River Stretch (km)
Beas	Kullu to Dehra Gopipur	Sanot, Kullu	80
Suketi Khad	Mandi To Behna	Mandi, Samkhetar, Kartapur	06

(Source: CPCB, 2015)

As per the available information on the website of the Himachal Pradesh SPCB, the water quality of Beas River in each district has been tested and the results clearly show that the river is receiving a large amount of untreated effluent as well sewage.

Even as Beas enters the plains in Punjab, the River and its tributaries are subjected to high levels of pollution from agricultural run-off from pesticides and fertilizers as well as untreated sewage and industrial effluent from the towns of Gurdaspur, Hoshiarpur, Amritsar and Kapurthala.

Taking cognisance of the above referred CPCB report, the NGT has passed several directions in a *suo moto* case, wherein the Tribunal has directed for setting up of ‘River Rejuvenation Committees (RRC)’ in each State to come out with implementable action plans to rejuvenate the identified polluted river stretches in each State (NGT, 2018a). The matter is being monitored by the Tribunal on a regular basis. Thus, the RRC would be an integral stakeholder while discussing rejuvenation of the rivers of the Indus Basin as a whole. In this regard, the Himachal Pradesh SPCB has prepared an action plan for the Rejuvenation of River Beas in Himachal Pradesh (HPSPCB, 2018). The said report identifies the following areas as part of the action plan-rain water harvesting/ ground water recharge aspects, maintaining e-flows, water shed management, use of treated sewage, good irrigation practice, and development of biodiversity parks. In addition, to the broader monitoring by the NGT in the above-mentioned case, the Tribunal has also passed elaborate directions in a case (Sobha Singh and Ors. vs. State of Punjab and Ors.; OA No. 916 of 2018) relating to river pollution in river Beas as well as Sutlej in Punjab (NGT, 2018b). The directions, *inter alia*, include construction and proper operation of Common Effluent Treatment Plants (CETP) in industrial clusters as well as plugging untreated sewage by passing specific directions to the Punjab Water Supply and Sewerage Board (PWSSB). The implementation of these directions is being overseen by a Monitoring Committee which is headed by a former Judge of the Punjab & Haryana High Court.

Thus, in specific context of river Beas, there has to be concerted efforts by the respective SPCBs, Water Supply and Sewerage Boards as well as the Municipal Corporations to ensure plugging of untreated sewage and industrial effluents into the river. It would also be

important that there is an effective co-ordination between the various Courts/Tribunal appointed Committees.

4.4.11 Urbanisation/Tourism Woes- How Green is ‘Ecotourism’?

One of the biggest challenges threatening the health of river Beas, especially in the State of Himachal Pradesh is the tremendous impact and stress on the river due to unsustainable tourism activities. In the causes of degradation of rivers, urbanisation and the heavy inflow of tourists both are emerging as problems because of the disposal of solid waste, encroachment upon the river waterway and water extraction involved (Himdhara). The Kullu and Kangra Districts have rapidly urbanised and have large tourist traffic. In fact, to save the Beas River from pollution, the NGT in 2013 had ordered to close 34 hotels located along river banks in Kullu and Manali as they were operating without obtaining required permissions from the pollution control board (NGT, 2019). In fact, the High Court of Himachal Pradesh had taken cognizance of the unchecked construction activities on the floodplains of river Beas in the year 1998 and had directed that no new construction shall be permitted within 500 m from the banks of river Beas and river Ravi in the municipal towns and under the Panchayat jurisdiction of the State (H.P High Court, 1998). Order was also applied to Mandi town area falling from Mandi to Manali, directions in relation to mining, etc. were also passed by the same Court. In 2017, the NGT had passed spate of directions in a case dealing with unauthorised construction and unsustainable tourism practices in Manali town and had directed the authorities to carry out demolition drives of all illegal and unauthorised constructions in the area (NGT, 2017). In September 2019, the Tribunal also directed for a carrying capacity study to be conducted by a Special Expert Committee for the towns of Manali and McLeodganj. In its judgment dated 18.12.2017, the Tribunal noted as follows with regard to the unauthorised construction on the floodplain of Beas River:

‘16. ...The constructions were permitted on the river Banks/floodplains, contrary to the permissible gradient and in the green areas. Huge construction of concrete has been permitted in the eco-sensitive area. It has created a blot on the beauty of the natural and pristine hills and put intolerable pressure on the natural resources. They had even gone to the extent of cutting of hills and converting them into plains for construction purposes. In those beautiful areas of Himalayas, no appropriate measure for management of municipal solid waste and sewage system had been taken and measures for environment protection were directed to be taken on repeated occasions.

17. It was in such cases that Hon'ble Supreme Court of India had directed that compounding is not to be done with the violations that are deliberate in design and are reckless or motivated. Only marginal or insignificant accidental violations made unconsciously after endure to comply with the requirements of law can alone qualify for regularisation of compounding, which itself is not a rule but a rare exception. ...

18. Following the above principle, the Tribunal noticed various judgments including one referred above had also directed demolition as there could be no escape from compliance to the law and adherence to the principle of sustainable development. The persons who raise constructions without even taking recourse to the prescribed procedure for grant of sanction of plans and raise huge constructions particularly on the river bank or floodplain and in violation of other norms related to the protection of natural resources and environment cannot even be heard to take up plea of regularisation or compounding.'

Increased tourism to places like Manali has had an adverse impact in terms of waste disposal as well. Thus, there is a dire need for complete overhauling of the waste management system in these areas, as invariably the plastic waste and municipal solid waste ends up in the river Beas (National Herald, 2019).

To ensure that tourism activities are sustainable, and achieve the true meaning of 'ecotourism', it is critical that the concerned authorities- local government, municipal corporations as well as the pollution control board take effective steps to comply with laws relating to issuance of construction licenses, and consents required under the Air (Prevention and Control of Pollution) Act, 1981 and the Water (Prevention and Control of Pollution) Act, 1974, compliance with the various Waste Management Rules including the Solid Waste Management Rules, 2016, Plastic Waste Management Rules, 2016, Construction and Demolition Waste Rules, 2016, etc. (MoEF, 2016).

In the Beas Basin, amongst all tourism related activities, camping and river rafting remains largely unregulated. The unsustainable practices arising out of these activities have received judicial notice in the past, with respect to river Ganga in the State of Uttarakhand. The NGT has discussed in detail the adverse impact of unsustainable rafting and camping activities on the river as well as the forest areas along the banks of the river (NGT, 2015). Holding that beach camping would constitute a 'non-forest' activity, the Tribunal held that the provisions of the Forest (Conservation) Act, 1980 would be applicable to these activities. Further, the State of Uttarakhand was directed to develop a regulatory regime for such activities to ensure minimum damage to the river as well as its floodplains. A similar approach may be adopted by the State of Himachal Pradesh in ensuring that such activities have minimal impact on the Beas River and its floodplains.

4.4.12 Involving Communities in River Rejuvenation Efforts

Any effort of river rejuvenation would not be successful unless and until local communities, dependent upon the river are actively consulted and engaged with. There are several legal policy tools which can be referred to and employed to achieve this key process. In fact, the National Forest Policy and the National Water Policy recognises the critical role played by communities in ensuring conservation as well as the rejuvenation of the forest land as well as water resources in the country. Communities can be involved with the help of the following laws/policies which are in force:

(a) The Forest Rights Act, 2006

The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006 can also be used as an effective tool to empower and engage with tribal communities to participate in the rejuvenation efforts of river Beas. As per the Section 3 (1) (i) of the FRA, 2006, the forest dwelling tribal communities and traditional forest dwelling communities have community forest rights whereby they are empowered to protect, regenerate, conserve and manage a community forest resource (MoEF&CC, 2006). By acknowledging title of communities to the forested areas in the catchment area of the river, the State Government can actively engage in specific conservation and rejuvenation measures for Beas Basin, especially in Himachal Pradesh.

(b) The Biological Diversity Act, 2002

As per the Biological Diversity Act, 2002, it is mandatory for every local self-governing institution in both rural and urban areas to constitute the Biodiversity Management Committee (BMC) within their area of jurisdiction. The objective behind BMC constitution is promotion of conservation, sustainable use and documentation of biological diversity. One of the important functions of the BMC is to prepare and maintain the 'Peoples' Biodiversity Register (PBR)' in consultation with the local people. A PBR comprehensively documents information on the availability and knowledge of local biological resources (those falling within the territorial jurisdiction of the BMC), their medicinal or any other use of traditional knowledge associated with them. The PBR thus prepared then serves as a legal document which confirms the sovereign rights of that BMC over the resources documented in the PBR. In addition to preparation of a PBR, the roles and responsibilities of a BMC take various forms such as eco-restoration of the local biodiversity, management of sacred groves and sacred water bodies, conservation of traditional varieties/breeds of economically important plants and animals. Thus, the BMC can be actively consulted while undertaking specific measures to rejuvenate the river. Further, the PBRs can be a good source of knowledge of indigenous species of plants and trees which can be considered while undertaking plantation drives, or afforestation measures.

The NGT is also monitoring the implementation of the provisions of the Biological Diversity Act, 2002 (NGT, 2016). As per the latest report of the MoEF&CC to the Tribunal as on August 2019, in the State of Himachal Pradesh, out of 3,370 local bodies, BMCs have been constituted in 730 only, which imply the compliance rate is only 21.66%. With respect to preparation of PBRs, only six BMCs have prepared the same. With respect to the State of Punjab, out of 1,477 local bodies, BMCs have been constituted only in 74 i.e., 5% compliance rate. 43 BMCs have prepared PBRs. In a series of orders, the Tribunal has issued strict directions to all State Governments and Union Territories to ensure 100% compliance with respect to constitution of BMCs and preparation of PBRs by 31.01.2020. In case of non-compliance, the Tribunal has imposed a hefty penalty of 10 lakh per month on the defaulting States. The Tribunal in August, 2019 emphasised on the importance of the Act of 2002 as follows (NGT, 2016):

2. *The Act was enacted to provide for conservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits and for matters connected therewith or incidental thereto with a view to give effect to the United Nations Convention on Biological Diversity (CBD) which came into force on 29.12.1993. The Act seeks to regulate access to biological resources and fair and equitable sharing of benefits arising out of utilization of biological resources by constituting National Biodiversity Authority (NBA) to advise the Central Government and the State Governments on steps towards conservation of biodiversity, sustainable use of its components, equitable sharing of benefits and allied issues. The Act also contains provision for establishment of State Biodiversity Boards to advise the State Government on the subject. The Central Government has to develop national strategies, plans and programmes for conservation and promotion and sustainable use of biodiversity. At local level, every local body has to constitute BMC.*

The Rules based on the CBD provide that the BMCs have to prepare PBRs containing comprehensive information on availability and knowledge of local biological resources, their medicinal or any other use and Traditional Knowledge (TK) associated with them.

6. *Having regard to the laudable objective to meet the necessity of conservation of biological diversity, delay of more than 16 years in complying with the mandate of law is a matter of serious concern. ...*

9. *India is one of the recognized mega-diverse countries of the world, harbouring nearly 7-8% of the recorded species of the world, and representing 4 of the 34 globally identified biodiversity hotspots. India is also a vast repository of traditional knowledge associated with biological resources. So far, over 91,200 species of animals and 45,500 species of plants have been documented in the ten biogeographic regions of the country. The indigenous and local communities are a repository of traditional knowledge and their knowledge and practices help in conservation and sustainable development of the biodiversity. In the past, India has already faced bio-piracy. There is, thus, urgent need to document the knowledge of the local communities in the form of PBRs.*

10. *As per certain studies, PBRs help the State and the local communities to become aware of the valuable resources being harvested in their area which can be utilised for the overall social and economic development of the State. Furthermore, PBRs also help in conservation of the traditional practices and knowledge of the local community. Studies on the issue of access and benefit sharing (ABS) show that non establishment of BMCs and absence of PBRs deprives the local communities of the advantage of the biological resources. PBRs not only document the knowledge, they also help in identification of benefit claimers.'*

4.4.13 Identifying Stakeholders

This Section identifies the various official Departments and their role in ensuring that the rejuvenation of river Beas is effective and successful. It is also important to have an active

coordination between these departments and ensure that there is no overlapping of functions. Table 4.4 describes the role of each of the Department that has been identified on the basis of the discussion in the preceding section.

Table 4. 4 – The Official Stakeholders and Their Roles

Department	Roles
State Pollution Control Board (SPCB)	▪ Not to grant ‘Consent to Establish (CTE)’ in ecologically sensitive areas. Consent should not be granted as a matter of routine. ▪ The practice of granting stand alone Consent should be done away with and should be based on carrying capacity assessment. ▪ The renewal of consent to operate should not be a mechanical process but should be based on proper ground verification. ▪ The SPCB should put special focus on the main objective of the Water Act, 1974 i.e., maintaining the wholesomeness of water by any project seeking approval. ▪ Projects which are granted Environmental or Forest Clearance should not be granted Consent to Establish as a matter of routine. The SPCB should play a proactive role in examining the impact of the project on the water quality including e-flow. ▪ The small hydro projects are currently operating under Consent to operate granted by the SPCB under the Water Act, 1974. The condition includes the protection of riparian rights of the people as well as maintaining the flow. There needs to be an objective assessment of the level of compliance with these conditions. ▪ Monitoring water quality under the Water (Prevention and Control of Pollution) Act, 1974 and its Rules.
State Water Department/ Sewerage Board	▪ Proper maintenance of Sewage Treatment Plants (STPs) and ensuring that no untreated sewage is discharged into the river or its Tributaries. ▪ Ensuring that the treated water is meeting the standards set under the Environment (Protection) Act, 1986 and the Water (Prevention and Control of Pollution) Act, 1974.
State Environment Impact Assessment Authority (SEIAA)	▪ The SEIAA along the SEAC are key bodies for protection of the Beas Sub Basin. However, the SEIAA and SEAC grant approvals to project without a thorough assessment of its likely impact on the ecology. No consideration is given as to what impact the proposed project will have on the river and the riverine ecosystem. It is essential that before any project is allowed, the SEAC and SEIAA should conduct a thorough assessment of the proposed site; examine the project along with other projects which have similar effect and take a decision keeping the totality of environmental situation into account. Both, ground truthing and GIS application should be relied on. ▪ There is a need to make the SEAC and SEIAA as robust institutions which have both the capacity and ability to take decision that protect the environment rather than favouring destructive projects. Areas which have crossed the threshold in terms of its cumulative impact

Department	Roles
	should have a moratorium in place. ▪ Instead of general compliance condition, site specific and project specific conditions should be imposed. ▪ Third party monitoring which also involves the local community should be done by SEIAA specifically for those projects which are seeking expansion of the production capacity.
Regional Office, Ministry of Environment Forest and Climate Change	▪ Monitoring of compliance of conditions stipulated in the Environmental Clearance granted under the EIA Notification, especially with respect to e-flow from hydro projects.
Forest Department	▪ Ensuring proper implementation of forestry measures including catchment area treatment, compensatory afforestation, etc. ▪ Ensuring active synergies and via-media between the communities and other departments in rejuvenation efforts.
Irrigation Department/Revenue Department	▪ Floodplain demarcation once in 25 years and once in hundred years.
Municipal Corporations/ Panchayats	▪ Compliance and monitoring of the Waste Rules, 2016 under the Environment (Protection) Act, 1986- especially segregation of waste at source and ensuring plastic waste is disposed of as per the provisions of the Plastic Waste Rules, 2016 and does not find its way into the River. ▪ Ensuring no buildings or construction activities are permitted on the active floodplains or banks of the river.
Town and Country Planning	▪ Ensuring proper safeguards are provided for the river in the Development Plans of the cities on the banks of the River.
Tourism Department	▪ Preparation of an effective policy on ecotourism which emphasises on mandatory safeguardson the river banks, and prohibits any construction on the river bank, and its active floodplain. ▪ To develop proper guidelines/regulatory regime to regulate the river rafting and camping activities in line with the judgment of the National Green Tribunal in SAFE vs. Union of India & Ors.
River Rejuvenation Committees (constituted under the orders of the National Green Tribunal)	▪ Coordination between all the official departments in ensuring proper and effective rejuvenation efforts. ▪ Effective implementation of the action plan submitted to the National Green Tribunal.
Biodiversity Management Committees (BMC)	▪ Preparation of PBRs and utilising traditional knowledge of communities for ensuring better catchment area treatment measures in the form of afforestation, etc. ▪ Ensuring PBRs are used as an effective tool in terms of documentation of biodiversity and thereby ensuring proper impact assessment of any developmental activity that is proposed in the Basin.

4.4.14 Legal Support for River Conservation

The foregoing overview has cited different laws and at the same time incorporated reference to a wide range of rules, policies, authorities, and definitions those are fundamental from the

perspective of legal and policy foundations relevant to the conservation of complex and dynamic river ecosystems while highlighting important judgements by various Courts addressing degradation of natural ecosystems and directives given to concerned agencies. The overview attempted to provide an insight into the existing legal environment that supports river conservation. Thus, it is considered apt to summarize and also provide brief narration on relevant laws, rules, policies, and even definitions for better appreciation by different stakeholders involved in planning, assessment, protection, management, regulation and use of wide array of river resources (Table 4.5 to 4.8)

Table 4. 5 – Various Legislations, Policies, Authorities and Definitions Relevant in the Context of River Management

A - Legislative Acts			
Sr. No.	Applicable Law/ Policy	Relevant Provisions	Implications in Context of River Management
1	Constitution of India	Article 21 – Right to life Article 48A – Directive Principle of State Policy for protection and improvement of environment Schedule VII – Legislative competence of Union and State Governments	Interpreted to include the right to water and the right to clean environment The Government should aim to improve the environment and natural resources The Union Government has the power of regulation and development of inter-State rivers; and also to implement obligations under international agreements (including agreements for the protection of the environment and biodiversity) The State Government has the power to make laws relating to land use, water and water bodies Forests and the protection of wildlife fall in the Concurrent List
2	Environment (Protection) Act, 1986	Umbrella legislation enabling the Central Government to develop rules and policies for the protection of environment The Central Government can impose restrictions of areas in which any industries/ activities may be carried out. It can also appoint authorities for the appropriate implementation of laws or protection of certain region	The Rules on specific aspects are discussed below The Central Government has wide powers to designate an area / stretch for restriction of activities, and an appropriate authority may be appointed for the protection of the region

A - Legislative Acts			
Sr. No.	Applicable Law/ Policy	Relevant Provisions	Implications in Context of River Management
3	Environment Impact Assessment Notification, 2006	Outlines the process of conducting the environment impact assessment and obtaining environment clearance Category 'A' projects (with hydroelectric component ≥ 50 MW and or irrigation component $\geq 10,000$ ha) need the clearance of the MoEF&CC (after being appraised and recommended by the Expert Appraisal Authority (EAC)) Category 'B' projects (with hydroelectric component < 50 MW and ≥ 25 MW and or irrigation component $< 10,000$ ha) require the clearance of the State Environment Impact Assessment Authority (SEIAA)	The clearance granted usually contains a list of management and mitigation measures. For river valley projects, this could be minimum flows, catchment area treatment and other management and mitigation measures.
4	Wetlands (Conservation and Management) Rules, 2010	The State Government has to identify the 'protected wetlands' in the State and prepare a 'brief document'. The 'protected wetlands' are ultimately notified by the Central Government on the recommendation of the Central Wetlands Regulatory Authority	Wetlands form a critical part of river basins and affect the drainage and water quality. The wetlands along the river system should be identified and notified as 'protected wetlands'.
5	Municipal Solid Waste (Management and Handling) Rules, 2000	Provides for collection, segregation and disposal of solid waste The State Pollution Control Board is responsible for monitoring the compliance of standards of groundwater, leachate, etc.	The disposal of untreated municipal and industrial waste deteriorates the water quality. This has to be prevented, and compliance with the standards have to be strictly monitored
6	Coastal Regulation Zone Notification, 2011	Restricts activities along the coast, depending on the nature of the activity, distance from the High Tide Line and the level of development of the region	A similar approach can be adopted in the case of zoning of activities along the river/stream
7	Indian Forest Act, 1927	Establishes the rights and powers of government authority over forests and forest products.	Applicable to the Reserved Forests and Protected Forests around the river banks. Also applicable in the context of the use and transportation of forest produce in these areas.
8	Forest (Conservation) Act, 1972	No forest land can be diverted for non-forest purpose by the State Government without the prior approval of the central government	The hydrological impact for the change in land-use; especially for sensitive and vulnerable areas along river banks should be reflected in the decision-

A - Legislative Acts			
Sr. No.	Applicable Law/ Policy	Relevant Provisions	Implications in Context of River Management
			making in respect of Forest Clearance. Where granted, adequate management and mitigation measures should be prescribed, and strictly implemented and monitored
9	Wildlife (Protection) Act, 1972	Provides for protection to all species of plants and animals with special provisions of higher level of protection for specific species. Also provides for the demarcation of 'Protected Areas' for the protection of wildlife and their habitat	The definition of 'wildlife' includes not only the identified species, but also any animal and vegetation (aquatic and terrestrial) which forms part of any habitat The provisions of this Act could be used to demarcate and plan critical stretches of the Beas and its tributaries for the protection of endangered species and their habitats
10	Water (Prevention and Control of Pollution) Act, 1974	Powers of the Central Pollution Control Board include providing guidance and technical assistance to states on prevention, control and abatement of water pollution All industries/operations involving any sewage or waste requires to obtain a consent to establish and Operate from the State Pollution Control Board	Forestry interventions should be recognized as an integral approach for the improvement of water quality. Effluents and discharges from industrial and sewage units should be adequately treated and strictly monitored
11	Biological Diversity Act, 2002	The Central Government can develop strategies/plans for the conservation and sustainable use of biological resources For areas rich in biological diversity/habitats threatened by overuse, abuse or neglect, the central government can direct the state governments to take appropriate measures. The Act also provides for cross-sectoral plans, programmes and policies The Act provides for protection of intellectual property rights and appropriated access and benefit sharing mechanisms	The biodiversity of the Beas is threatened by over-use and unregulated pollution. The Central Government may utilize the broad mandate under the Act to integrate forestry interventions for conserving the river biodiversity in Beas Cross-sectoral plans, incorporating the forestry, hydrology, wildlife issues, and other relevant sectors to the basin should be developed Use of biodiversity resources at different levels (national, state, and local) must consider aspect of IPR and ABS for compliance

A - Legislative Acts			
Sr. No.	Applicable Law/ Policy	Relevant Provisions	Implications in Context of River Management
12	National Forest Policy, 1988	Articulates the strategies and principles of forest conservation in India Objectives include checking soil erosion in catchment areas of rivers; soil and water conservation, mitigating floods and droughts and reducing siltation of reservoirs Recognizes that forest cover should be increased rapidly on hill slopes, in catchment areas of rivers, lakes, etc	The policies constitute an important recognition of the close relationship between river systems and forests. The principles and strategies of the Policy should be articulated in legal and executive action
13	National Water Policy, 2012	Acknowledges that characteristics of catchment areas of streams, rivers and recharge zones of aquifers are affected by land use and land cover changes, affecting water resource availability and quality	
14	Guidelines on Sustainable Sand-Mining, 2015	The guidelines suggest a mandatory cumulative impact of all mining proposals. It also provides for monitoring, inter alia, changes in river bed, channel morphology, aquatic and riverine habitat	The components of a river bed, like sand, boulder and gravels in the river bed play a significant role in maintaining the ecology of a river system.
15	Guidelines on Felling and Transit Regulations for Tree Species Grown on Non-Forest Private Lands, 2014	States should develop a simple and uniform regulatory procedure of tree felling and transit pass. It also provides for a simple and decentralized methodology for maintenance of records of tree plantation, and the use of information technology to regularly update verification of plantation and felling of trees	This will be crucial for implementation of forestry interventions along the Beas and the utilization of forest produce by communities in a sustainable manner
16	Guidelines for Conservation, Development and Management of Urban Greens, 2013	Integration of green areas in master plans of cities; guidelines for maintaining and enhancing tree cover; felling/ removal of trees only after scientific assessment	Relevant for mainstreaming forestry interventions for the Beas in urban areas
17	Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Right)	The law concerns the rights of forest-dwelling communities to land and other resources, denied to them over decades as a result of the continuance of colonial forest laws in India. Right to hold and live in the forest land under the individual or common occupation for habitation or for self-cultivation for	

A - Legislative Acts			
Sr. No.	Applicable Law/ Policy	Relevant Provisions	Implications in Context of River Management
		livelihood by a member or members of a forest dwelling Scheduled Tribe or other traditional forest dwellers (Samant <i>et al.</i> , 2018).	
18	Himachal Pradesh Forest Produce Transit (Land Routes) Rules	To ensure that the forest produce/ species are extracted from the prescribed area in the approved extraction cycle and that the extraction has been done in a sustainable manner and has not caused any ecological or environmental damage (Samant <i>et al.</i> , 2018).	
19	Establishment of Processing units for NTFP''	Consent for Establishment and Consent for Operation are to be obtained from the State Pollution Control Board prior to establishment and commencement of operations, respectively (Samant <i>et al.</i> , 2018).	
20	Eco-sensitive Zone Notifications 2015	The activities in areas around Wildlife Sanctuaries and National Parks are regulated from the perspective of conservation of wildlife	
21	Air (Prevention and Control of Pollution) Act (and subsequent amendments) 1981	To provide for the prevention, control and abatement of air pollution and for the establishment of Boards to carry out these purposes.	The air pollution deteriorates environment. This has to be prevented and compliance with the standards has to be strictly monitored.

(Source: Modified and Adopted from FRI, 2016)

Table 4. 6 – Various Definitions Relevant in the Context of River Management

Definitions			
Sr. No.	Term	Definition	Implications in Context of River Management
1	Forest Land	Any land under the control of State/ UT Forest Department is considered as the Forest Land. The term ‘Forest land’ defines; the land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use. (FRA, 2015) The term ‘forest’ is not be applicable on the plantations raised on private lands (Guidelines for the application of the Forest (Conservation) Act, 1980, 2003).	The definition of what constitutes 'Forest land' is important for the decision-making in relation to felling of trees for use/ diversion of land.
2	River	A river is a hydrological and ecological system, which is a natural, living, organic whole. A river system has to be understood in terms of its sediments and nutrients transported by it, its catchment, the river bed, river bank, floodplain as well as the vegetation on the floodplain. (Delhi Declaration at India Rivers Week, 2014) The term ‘river basin’ encompasses the surface and subsurface water resources, soil and land resources, wetlands and associated ecosystems, including those coastal and near shore marine systems that are hydrologically or ecologically linked to the river basin (Handbook on Ramsar Convention, 2010).	The conceptual understanding of a river should includes both its components (which includes the river bed and nutrients, biodiversity, sediment besides water), as well as its functions. The close interrelation between land use and river systems should be emphasized.
3	River Corridor	Land area adjacent to a river that is required to accommodate the dimensions, slope, planform and buffer of the naturally stable channel and that is necessary for the natural maintenance of natural restoration of a dynamic equilibrium condition and	The National Water Policy, 2012 specifically mentions the preservation of river corridors.

Definitions			
Sr. No.	Term	Definition	Implications in Context of River Management
		for minimization of fluvial erosion hazards, as delineated by the Agency in accordance with river corridor protection procedures (Rule 29-201, Vermont Flood Hazard Area and River corridor Rule)	
4	Environment flow (e-flow)	Environmental flows, or e-flows, describe the quantity, timing and quality of water flows required to sustain freshwater and estuarine ecosystem and the human livelihoods and well-being that depend on these ecosystems (Brisbane Declaration, 2007).	Hydro-engineering structures lead to large scale impoundment or diversion of water. Maintaining environmental flows is essential for ensuring that rivers are able to continue their ecological functions. A three member Committee (which includes the MoWR,RD&GR and the MoEF&CC) recommended arriving at an e-flow regime on the basis of temporal versions in depth of flow required for the survival of keystone species, longitudinal connectivity in all seasons and lateral connectivity of active flood plain (March, 2015).
5	Biodiversity	"Biological diversity" means the variability among living organisms from all sources and the ecological complexes of which they are part, and includes diversity within species or between species and of eco-systems (Section 2(b), Biological diversity Act, 2002).	River systems support, and provide habitat to a wide range of life forms and habitats. Rivers also provide important connectivity and migration paths.
6	Wildlife	Includes any animal, aquatic or land vegetation which forms part of any habitat (Section 2(37), Wildlife (Protection) Act, 1972.	In addition to the specific species referred to in the Wildlife (Protection) Act, river systems and vegetation along rivers, especially those declared to be 'protected areas' would also constitute wildlife.
7	Wetland	'an area of marsh, fen, peatland or water; natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt,	Wetlands serve as a link between the land and the water, and provide a range of services that benefit all

Definitions			
Sr. No.	Term	Definition	Implications in Context of River Management
		including areas of marine water the depth of which at low tide does not exceed six m and includes all inland waters such as lakes, reservoir, tanks, backwaters, lagoon, creeks, estuaries and man-made wetland and the zone of direct influence on wetland that is to say that drainage area or catchment region of the wetlands as determined by the authority but does not include main river channels, paddy fields and coastal wetlands'(Section 2(g), Wetlands (Conservation and Management) Rules, 2010).	aspects of river activities. The critical linkage between wetlands, water and river basin management is emphasized in the Ramsar Convention on Wetlands.
8	Cumulative Impact Assessment	Cumulative effects generally refer to impacts that are additive or interactive (synergistic) in nature and result from multiple activities over time, including the project being assessed. (NGT, Vimal Bhai vs. MoEF&CC & Others, 2011)	The natural flow of rivers is severely altered through hydro-engineering structures, as well as associated land use. The cumulative impacts of all existing and proposed activities should be factored into the decision-making of clearance for projects, as well as river basin management.
9	Eco-centrism	(there is a) 'moral imperative to respect intrinsic value, inter dependence and integrity of all forms of life. Eco-centrism supports the protection of all life forms, not just those which are of value to humans or their needs and underlines the fact that humans are just one among the various life forms on earth' (Supreme Court, T.N. Godavarman Thirumalpad vs. UOI, 2005)	Rivers should be viewed as critical ecosystems, rather than merely a 'water resource'. This is fundamental to the premise of river basin management.

Table 4. 7 – Various Authorities Relevant in the Context of River Management

Sr. No.	Relevant Authorities	
	Authority	Functions
1	Central Empowered Committee	Constituted under the Environmental (Protection) Act pursuant to the Order of the Supreme Court in 2002 for all matters relating to the application of the Forest (conservation) Act, 1972
2	Expert Appraisal Committee	Constituted under the EIA Notification to appraise and grant clearance for projects
3	Pollution Control Board	The Central Pollution Control Board is entrusted with promoting the cleanliness of the streams (including rivers and sea). And laying down the standards of quality of water. State Pollution Control Board can establish standards for discharge of effluents. It is also responsible for minimizing water pollution through granting consent for the establishment and operation of units.
4	Water Quality Assessment Authority	Constituted under the Environment (Protection) Act to standardize methods for monitoring of water quality and ensuring quality of data generation and utilization. The powers and functions of the authority include preparing schemes for restriction of discharge of treated sewage/ trade effluent on land, rivers and other water bodies with a view to mitigating crisis of water quality The authority can also review the status of quality of national water resources (both surface and ground water) and identify 'hot spots' for taking necessary actions for improvement in water quality.
5	Central Water Commission	Central Water Commission (CWC) is a premier Technical Organization of India in the field of Water Resources and is presently functioning as an attached office of the Ministry of Jal Shakti, Department of Water Resources, River Development and Ganga Rejuvenation, Government of India. The Commission is entrusted with the general responsibilities of initiating, coordinating and furthering in consultation of the State Governments concerned, schemes for control, conservation and utilization of water resources throughout the country, for purpose of Flood Control, Irrigation, Navigation, Drinking Water Supply and Water Power Development.
6	National Green Tribunal	The National Green Tribunal (NGT) has been established under the National Green Tribunal Act, 2010 for effective and expeditious disposal of cases relating to environmental protection and conservation of forests and other natural resources including enforcement of any legal right relating to environment

Sr. No.	Relevant Authorities	
	Authority	Functions
		and giving relief and compensation for damages to persons and property and for matters connected therewith or incidental thereto. It is a specialized body equipped with the necessary expertise to handle environmental disputes involving multi-disciplinary issues.

(Source: Modified and Adopted from FRI, 2016)

Table 4. 8 – Various Conservation and Management Tools Relevant in the Context of River Management

Conservation and Management Tools		
Sr. No.	Conservation/ Management tools	Implications in Context of River Management
1	Cumulative Impact Assessment and Carrying Capacity Study	The impact assessment of individual projects in isolation does not reflect the combined impact of a cascading development of projects in river basins, which may be significantly higher. The carrying capacity of the river basin should be carefully studied and the impact resulting from all past, present and foreseeable developments in the region should be viewed in light of the carrying capacity of the river basin. This is a fundamental tool for sustainable river development planning. An Office Memorandum (OM) of the MoEF&CC dated 29.5.2013 requires State Governments to conduct Cumulative Impact Assessment and Carrying Capacity study of river basins, As per the OM: ‘Cumulative impact study of a basin would reflect the cumulative impact of commissioned/up-coming hydropower projects in the basin on environmental flows, biodiversity, muck disposal sites, traffic flow in the region, R&R issues, etc. It should be incumbent on the

Conservation and Management Tools		
Sr. No.	Conservation/ Management tools	Implications in Context of River Management
		developer to incorporate all possible and potential impact of other project (s) in the basin to get a cumulative impact assessment done’. The carrying capacity study of a river basin is important to plan optimal number of power projects in a basin. All State Governments will be required to get such studies done for river basins in their State. The carrying capacity study report would be made a prerequisite for considering EF/FC cases of projects of any basin’. The Cumulative Impact Assessment and Carrying Capacity in case of Beas Sub-Basin in Himachal Pradesh has already been completed and accepted by the EAC of the MoEF&CC.
2	Environmental Flows	The report on Cumulative Impact Assessment and Carrying Capacity study in the context of e-flows provide insight on the directions by the Government of India/ NGT and current status on e-flow in case of each HEP.
3	Development Master Plans for Cities	The NGT has asked the State authorities to demarcate the floodplain for the flood once in 25 years and to prohibit any kind of development activity in such areas. (NGT, Manoj Misra vs. Union of India, 2015). Guidelines for Conservation, Development and Management of Urban Greens, 2013 provide for integration of existing trees/ green areas within the development master plans of cities.

Conservation and Management Tools		
Sr. No.	Conservation/ Management tools	Implications in Context of River Management
4	Eco-Sensitive Zone and Zonal Master Plan	The MoEF&CC has notified ESZs in context of several PAs in two States. In some cases, final notifications are awaited. The State Government has to prepare a Zonal Master Plan, which has to be approved by the MoEF&CC. The Plan should specifically address issues like restoration of denuded areas, conservation of water bodiesmanagement of catchment area, and soil and moisture conservation.
5	‘Brief Document’ under the Wetlands Rules	The State Government has to identify the ‘protected wetlands’ in the State and submit the proposal to the Central Wetlands Regulatory Authority. Considering the important function of wetlands in river basins, they should be included in the Brief Document, and adequate measures should be undertaken to improve and conserve these wetlands.
6	Memorandum of Understanding between Joint Forest Management Committee and the Forest Department of the State	The MoU should contain location-specific work programme for forestry initiatives, and also provide for the consumption and livelihood needs of forest dependent communities.
7	Working Plans of the Forest Department of the State	The Working Plan lays down the manner in which trees within forest areas can be felled. State governments are responsible for drawing up a working Plan to ensure sustainable forest management and utilization practices. The Working Plan should also enable the proper and simultaneous application of different legislations relating to forests, wildlife and biodiversity. The National Working Plan Code, 2014 of the MoEF&CC

Conservation and Management Tools		
Sr. No.	Conservation/ Management tools	Implications in Context of River Management
		provides a uniform code for drawing up the Working Plans of each Forest Division by State Government.

(Source: Modified and Adopted from FRI, 2016)

4.4.15 Implications and the Way Forward

The management issues those are involved in the conservation and restoration of the river Beas are numerous, intricate and challenging. The policy and legal provisions need to facilitate the management of rivers and factors affecting them. It is pertinent to address and fulfil the gaps in the existing regulatory mechanism. Some of the gaps can be potentially addressed within the existing regulatory framework while others may require a fresh look and inclusion of appropriate provisions or revision of existing once. The past experience illustrates that the piecemeal and fragmentary approach to river conservation, particularly the environmental impact assessment has not yielded desired insight and failed to reflect a true and comprehensive picture of the range of impacts. The relationships between upstream and downstream, forests and their hydrological functions, river and surrounding lands have been poorly understood. Until the studies or decision-making process factor in the intricate relationships and incorporate cumulative assessment of impacts and evaluate carrying capacity of rivers, outcomes will continue to remain sub-optimal.

The degraded river ecosystems require restoration and efficient management for not only the long term sustainability of the river but also for the associated biodiversity and the ecosystem services they offer. A comprehensive approach towards management of forests is thus essential. It is necessary to apply the provisions of the various existing laws relevant to forest, environment and the biological diversity collectively so as to accomplish the goals of long term protection of forests along with the rivers. The existing legal and policy framework can immensely help in the following:

- (a) Declaration of select biodiversity rich river stretches of conservation priority as protected areas under the Wildlife (Protection) Act, 1972.
- (b) Declaration of biodiversity rich areas as the biodiversity heritage sites under the Biological Diversity Act, 2002.
- (c) Declaration of identified areas as the ecologically sensitive sites under the Environment (Protection) Act, 1986.
- (d) Ensuring Cumulative EIA as well as Comprehensive EIA with respect to any developmental project or biotic interference such as sand and bolder mining.
- (e) Facilitating implementation of the Wetland Rules, 2010, particularly in demarcation of the zone of influence as far as wetland areas are adjacent to rivers.

The maintenance of e-flow is critical for ensuring the river connectivity and various ecological processes. Therefore, it is important to enforce the rules/ directives relevant to e-flow issued from time to time. It is important that any proposal for diversion of forest land in

close proximity to the river or its tributary is examined thoroughly and carefully to avoid any adverse implications on river ecosystem. Considering the vast extent of river from its origin to confluence/mouth, a wide range of stakeholders (agencies, departments, users, etc.) involved, and intricate nature of river, it would be desirable to designate an appropriate river authority in case of each of the prominent river of the country. Undoubtedly, there is a strong mandate and available avenues within the existing legal framework to develop proactive interventions with adequate legal backing for river restoration and conservation. Moreover, the existing legal framework has been adequately supplemented with insightful judicial interpretations and specific directives for implementation and to develop a rich body of environmental jurisprudence. The above overview has amply reflected that the existing legal and policy framework is adequate to take care of the complexities of rivers in human dominated country like India.

4.5 Institutions and Implementing Agencies – Central and State Government

The preceding Chapters and the forgoing sections have given ample idea about the wide array of government and non-governmental agencies at the Centre and State levels besides diverse stakeholders and the civil society those are involved with the prominent disciplines/sectors of forest management, wildlife conservation, environmental management, water resource management, river development and restoration of rivers in the country. The Chapter 3 on the Beas riverscape and its environment has appropriately highlighted the intricacies of the physical, biological and socio-economic sub-environments in the context of river besides numerous sectors and agencies directly connected and responsible for the maintenance of uninterrupted e-flows and clean water of river Beas. In general, the Union Ministry of Jal Shakti and the Ministry of Environment, Forest and Climate Change at the centre are the two prominent ministries those are directly concerned with the river Beas, its environment, and much desirable restoration process. Details of the Ministry of Jal Shakti, its mandate, programmes and activities have already been provided. From the perspective of Beas River, the role of Bhakra – Beas Management Board (BBMB) has also been highlighted. However, from the perspective of proposed forestry interventions, details of the implementing agencies at the National and State levels are much desirable. Hence, the following section provide details on the MoEF&CC as the nodal agency for overseeing and steering the programme implementation; the ICFRE, Dehra Dun and its regional institute i.e., the HFRI, Shimla as the national partner organization for capacity development and monitoring; and the pivotal role of the concerned State Forest Department in two States as the implementing agencies.

4.5.1 The MoEF&CC

The MoEF&CC at the centre is the nodal ministry responsible for the planning, promotion, coordination and overseeing the implementation of country's environmental and forestry policies and programmes aiming for sustainable management of wide range of natural ecosystems (forests, grasslands, wetlands including lakes and rivers, and coastal and marine), associated biodiversity, ensuring the welfare of animals, and the prevention and abatement of pollution. While implementing various policies and programmes related to forests,

environment and wildlife, the Ministry is guided by the principle of sustainable development and enhancement of human well-being. The Ministry also serves as the nodal agency in the country for the United Nations Environment Programme (UNEP), South Asia Cooperative Environment Programme (SACEP), International Centre for Integrated Mountain Development (ICMOD), and for the follow up of the strategies and programmes of the United Nations Conference on Environment and Development (UNCED). The Ministry is also entrusted with important tasks related to multilateral bodies such as the Commission on Sustainable Development (CSD), Global Environmental Facility (GEF), and of regional bodies like the Economic and Social Council for Asia and Pacific (ESCAP) and the South Asian Association for Regional Cooperation (SAARC) on matters related to the environment. The Ministry is entrusted to implement programmes related to various international conventions *viz.*, the United Nations Convention on Biological Diversity (UNCBD), United Nations Convention on Combat of Desertification (UNCCD), United Nations Framework on Climate Change (UNFCCC), Ramsar Convention on Wetlands, Convention on Control of International Trade in Endangered Species of Wild Fauna and Flora (CITES), etc. for which the country is signatory and thus, committed. Till recent past the MoEF&CC also dealt with the various programmes and activities related to river Ganga *viz.*, the Ganga Action Plan, National Ganga River Basin Authority (NGRBA), and National Mission for Clean Ganga. These subjects and activities were transferred to the Ministry of Water Resources (presently Ministry of Jal Shakti) with its enlarged mandate. The MoEF&CC is supported in its mandate, functions and responsibilities by wide range of Authorities, Agencies, Organizations/ Institutions and Sub-ordinate offices.

4.5.2 The ICFRE and HFRI

The Indian Council for Forestry Research and Education (ICFRE), an autonomous Council under the MoEF&CC is supported by nine regional institutes and four advanced centres in performing the wide range of functions across the country those include conduct of forestry research; transfer of innovative technologies in the field of forestry relevant to the different biogeographic regions of the country to the States/ UTs and other agencies; and to impart forestry education. The Himalayan Forest Research Institute (HFRI) at Shimla is one of the regional institutions under the umbrella of ICFRE and mandated to generate, preserve, disseminate and advance knowledge, technologies and solutions for addressing issues arising out of interactions between people and forests and environment on a sustained basis through research, education and outreach and the specific goal of contributing research relevant to the conservation of Western Himalayan forests and forest ecosystems. The HFRI has been assigned the jurisdiction of two Union Territories – Jammu and Kashmir and Ladakh, and one State i.e., Himachal Pradesh. As stated earlier in the Chapter 1, the MoEF&CC has entrusted a major task to ICFRE on the preparation of DPRs on forestry interventions for rejuvenation of major Indian rivers. Considering the expertise and appropriate location of HFRI in the Himalayan State of Himachal Pradesh, the ICFRE assigned the responsibility of preparing the DPR on the Beas River along with four other DPRs on major rivers of the Indus River system. The HFRI with its long standing of past more than three decades and expertise in the field of forestry relevant to the western Himalayas, multi-disciplinary scientific staff

including practising professional foresters, well-placed vast campus amidst deodar forests and adequately equipped various laboratories and other physical infrastructure is the most appropriate Government of India's scientific agency not only for the preparation of present DPR but for its effective implementation, capacity development and monitoring through the State Forest Department (s) of two States. The HFRI has strong network with various forestry related sister institutions under the umbrella of ICFRE as well as other organizations and other sister institutions under the MoEF&CC.

4.5.3 Institutional Framework of State Forest Departments

As per the Constitution of India, the subjects of Forests, Wildlife and Environment are in the Concurrent List. Accordingly, the MoEF&CC is the nodal agency in the administrative structure of the Central Government for the planning, promotion, co-ordination and overseeing the implementation of India's environmental, forestry and wildlife policies and programmes. However, the State Forest Department (SFD) in each State/UT is the custodian of forests and wildlife of the State, besides being responsible for management, conservation, and protection of the environment (land, water and air). The SFD is also responsible for the management of forest lands or Recorded Forest Area, irrespective the type of vegetation these lands harbour. The State Governments and SFDs are mandated for the enforcement of laws and implementation of various policies and strategies enacted/ formulated by the Central Ministry from time to time.

(a) Mandate of State Forest Departments

The history of scientific management of forests in India is older more than 154 years as in 1864, the British Regime established the 'Imperial Forest Department'. Dietrich Brandis, a German forest officer, was appointed as the Inspector General of Forests. The stated mandate of the Department was scientific management of the forests to exploit it on a sustained basis for primarily timber products. The Indian Forest Act of 1865 extended the British colonialism in India and claimed over forests in India. The 1865 Act was a precursor to the Forest Act of 1878, which truncated the centuries-old traditional use by communities of their forests and secured the colonial government's control over the forestry. The act of 1865 empowered the British Government to declare any land covered with trees as a government forest and make rules to manage it. The government mainly used the woods for manufacture of railway sleepers. This law also made teak wood a government property. Thus, the Forest Department is one of the oldest organized Departments to be formed in the country. It was during this time that large tracts of the forest were brought under the State control through the process of reservation under the Indian Forest Act, 1878 and later under the Indian Forest Act, 1927. The Government of India Act 1935, transferred forestry to the Provisional List. The management of the forests went into the hands of the provincial government in 1935 and even today the Forest Departments in the States/ UTs are managing the forests under the respective State Governments/UT administration. Since the subject of forestry was shifted to the concurrent list in the year 1977, the Central Government plays an important role, particularly at the policy level in the management of the forests. The Forest Department has

also been credited as the oldest institution adopting the principle of sustainability by way of natural timber yield estimates which subsequently matured into the elaborate Working Plans as early as the nineteenth century (FRI, 2016). During 150 years or so, both the discipline of forestry as well as the mandate, objectives, strategies and working have undergone sea changes. Since then, emerging needs led to paradigm shift in forest management. Thus, the forest management gradually moved from exploitation to conservation, multiple use to multiple benefits, sustainable yield to sustainable management, species to ecosystem management, authoritative (policing) type of management to participatory approaches to management, just silviculture to modern technologies like Remote Sensing, GIS and GPS. Obviously, the SFDs have evolved into multi-purpose, adaptable and dynamic organizations, ready to tackle multifarious challenges relevant to forestry, wildlife management, biodiversity conservation, rural development, human environment, integrated watershed management, eco-restoration, river restoration/rejuvenation, climate change mitigation and adaptation, and sustainable development.

In view of the above, the primary mandate of SFDs can be summarized as below:

- protection of forests, enforcement of various laws, and management of forests pests
- creation of physical infrastructure (forest roads, patrolling stations, waterholes, barriers, watch towers, etc.) and their management
- implementation of silviculture-based forest management
- afforestation and restoration activities to increase forest cover of the State/Country
- conservation of forests and other natural ecosystems (grasslands, alpine pastures, wetlands including rivers, coastal and marine)
- integrated watershed management through soil and moisture conservation works and afforestation
- wildlife management and conservation of biodiversity including population estimation of prominent wildlife
- ecodevelopment, joint forest management, improvement of livelihoods, management of sustainable livelihoods in forest fringe villages and protected areas;
- promotion and management of nature tourism/ eco-tourism in forests/PAs
- mitigation of PA-people and human-wildlife conflict
- nature education, nature interpretation, mass awareness, outreach and advocacy
- research and monitoring activities
- establishment and maintenance of forestry/wildlife/PA management/ biodiversity conservation related databases
- capacity development

Thus, from the above long list of activities of the SFDs, it is amply clear that scope of works and mandates have significantly enlarged and diversified in just 150 years or so. Most of the activities, roles, responsibilities, and functions cut across different disciplines viz., silviculture, ecology, hydrology, law, socio-economics, etc. Guided by scientific principles and administrative excellence, the newer perspective of natural resource management requires adoption of landscape/riverscape/seascape approach to conservation. In past three

decades or so, the SFDs have been successful in providing the desired thrust on the ecosystem management, landscape approach, and participatory approaches so as to contribute to the larger agenda of sustainable development. In the process, the focus of working of SFDs has shifted from small extent of forest stands/ coupes to large landscapes those incorporate protected areas, managed forests and the dominating 'matrix'. The newer approaches seek inter-agency cooperation and sectoral convergence in order to meet diverse goals and multiple objectives of forestry. Hence, in recent decades, SFDs have been working in close cooperation of allied sectors.

4.4.3.2 Multi-Sectoral Convergence

The newer requirements of above stated enlarged scope, mandate and adopted holistic approaches to conservation and sustainable management of forests for multiple values, demand that SFDs work in close cooperation with various line agencies, Gram Panchayats and other local self-governance bodies at the grassroots level, NGOs and local communities. The new mandate has made the SFDs a focal point of convergence among various allied departments. Accordingly, in recent decades, increasingly SFDs have worked in partnership with the Department of Agriculture and Horticulture, Department of Animal Husbandry, Public Works Department, Public Health Department, Department of Tribal Development, Panchayati Raj, Revenue Department, Irrigation Department, District Rural Development Agency, Department of Science and Technology, etc. and SFDs have made considerable contribution in various centrally sponsored schemes relying on inter-sectoral convergence. In past 3-4 decades, the SFDs have implemented several externally funded forestry and conservation projects by various international agencies viz., the World Bank, International Development Agency (IDA), Global Environmental Facility (GEF), United Nations Development Programme (UNDP), Food and Agriculture Organization (FAO), United States Agency for International Development (USAID), Japan International Cooperation Agency (JICA), German Developmental Agency (GIZ), etc. and gained considerable experience. Majority of these externally funded projects required working with various stakeholders including line agencies and local communities seeking multi-sectoral convergence. In addition, SFDs extensively consult and either avail expertise or resources from various forestry institutions, other state/ national level scientific organisations, universities, State Biodiversity Boards, National Medicinal Plant Board, National Bamboo Mission, National Afforestation and Ecodevelopment Board in meeting various R&D needs or capacity development programmes.

(b) Decentralised Approach

The National Forest Policy, 1988 and the National Wildlife Action Plan, 1984 envisaged people-centric approach towards management of forest and wildlife resources in the country and laid emphasis on participatory and decentralized approaches involving local communities, both in decision making as well as in programme implementation. In past four decades or so, the SFDs witnessed a paradigm shift from top down approach to bottom up approach. The SFDs adopted the concept and approach of the Joint Forest Management

(JFM), promoting the creation of Joint Forest Management Committees (JFMCs) so as to restore degraded forest areas and elicit people's support in forest and wildlife conservation. JFMCs are known by different names in various States, such as *Van Sanrakshan Samiti* (VSS), Village Forest Development Committees (VFDCs), Village Forest Protection Committees (VFPCs) and Village Forest Development Societies (VFDSs). However, their functions were essentially similar to each other. These Community Based Organisations (CBOs) included the local representatives in the executive body and all the adult villagers as member in the general body. The CBOs were either registered as Societies under the Society Registration Act, 1860 or as a constituent of the Division-level Forest Development Agency (FDA) which in turn is registered under the Society Registration Act. The MoEF has issued detailed rules and Operational Guidelines of National Afforestation Project (NAP) including benefit sharing mechanism under JFM. In accordance with these guidelines, the respective State government also framed resolutions and rules for implementation. The JFMCs across the country along with SFDs carried out forestry activities related to protection, regeneration, afforestation, utilization and sustainable management of forest areas allotted to them. Certainly, the initiative on the formation of CBOs by the SFDs was a significant move towards the process of decentralization and people's empowerment. Already existing JFMCs and their variants in two States (Himachal Pradesh and Punjab) can be optimally utilize for ensuring public participation and eliciting their support at all the stages *viz.*, planning, implementation, monitoring and evaluation of any major project related to management of forests, wildlife or river restoration.

(c) Forest Administration and Management Units

From the foregoing description, it is evident that forestry discipline and the SFDs in the country have long history and the Forest Department is amongst the well organised and well evolved departments. SFDs are hierarchical in their organisational setup and field functioning. For smooth and efficient functioning, each SFD is divided into several forest circles. Each Forest Circle includes a few Forest Divisions. Each Division consists of several Forest Ranges constituted by a few Blocks/Sections. Each Block/Section is sub-divided into several Forest Beats. Each Beat generally has an average jurisdictional area of a few km² to even larger block up to 50-60 km². The SFD is generally headed by the senior most Indian Forest Service (IFS) Officer in the apex pay scale and rank of the Principal Chief Conservator of Forest (PCCF) who is also the Head of Forest Force (HoFF). The larger State may have 2-4 PCCFs to support the HoFF in specific roles *viz.*, Planning and Administration, Wildlife, Working Plan, JFM, Finance etc. The Forest Circles are being supervised and commanded by a team of senior officials at the rank of Conservator of Forests. In addition, there could be CFs for specific functional thematic areas. In larger States, the senior forest official at the level of the Chief Conservator of the Forest (CCF) or Addl. PCCF may be assigned responsibility to supervise the forest functioning in a region incorporating jurisdiction of multiple forest circles. The organisational structure of a typical SFD is presented in Fig. 4.1. Usually, the administrative units are mostly delineated on the ground in accordance with boundaries of the watershed. The smallest unit of administration and forest management is the Forest Beat under the charge of a Forest Guard (FG), supported by a few forest watchers

and casual labourers. The beat officer or a forest guard is usually having a jurisdiction over 4-6 forest compartments, each having area of 2-4 km². Each forest block/section is looked after by a Deputy Range Officer (DRO)/ Forester while a Range Forest Officer (RFO) is the supervisor of 2-5 DROs. In the hierarchy of the Forest Department, generally from FG to RFO are considered as the field level implementing officials while officials above RFO are involved in planning and decision making.

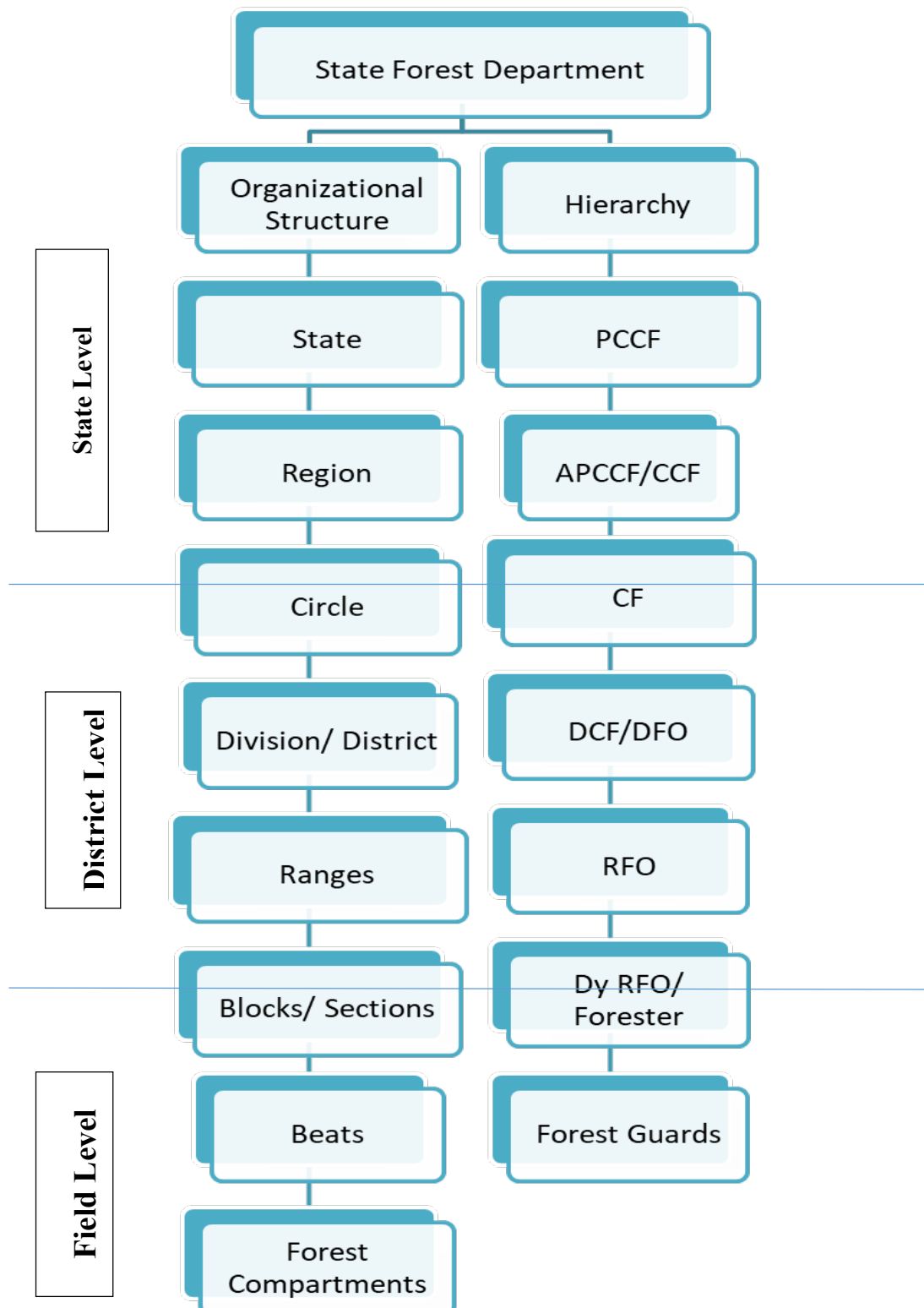


Fig. 4. 1 - The Organisational Structure and the Hierarchy of State Forest Department

(d) Projects and Schemes Operated by SFDs

The SFDs have been executing a wide array of projects and schemes in order to accomplish entrusted mandates and fulfil the requirements of various goals and objectives. These projects and schemes can be grouped as: (a) the State Government funded schemes, (b) the Centrally Sponsored Schemes (CSS), and (c) the Externally Aided Projects (EAPs). In addition, the SFDs of two concerned States have been implementing various ‘Catchment Area Treatment (CAT) Plans’ prepared as compensatory approach towards different hydroelectric projects (Table 4.9). The Externally Aided Projects sponsored/supported by the various international agencies (IDA, JICA, GIZ, etc.) have provided a new focus on the incorporation of modern technologies *viz.*, Information Technology, Remote Sensing and GIS, people-centric and participatory approaches in the fields of forestry and forest managements. The IDA funded ‘Forestry Research, Education and Extension Project (FREEP)’ facilitated comprehensive, multidisciplinary research and monitoring project in the Great Himalayan National Park and adjacent Sanctuaries and other forest lands. The project attempted to demonstrate the eco-development approach in the context of these priority conservation PA sites. Hence, over the years, SFDs have gained considerable experience in execution of major projects on wide range of emerging themes involving different stakeholders including local communities. The Government of India, MoEF&CC has also been formulating and implementing a variety of CSSs in different States/UTs covering priority themes of afforestation, ecodevelopment, snow leopard conservation (Project Snow Leopard), wetland conservation, protected area management, management of threatened species and their habitats, biosphere reserve programme, etc. Fig. 4.2 present a broad nature and components of schemes implemented by SFDs. Thus, it is amply clear that SFDs have diversified their activities over the past decades so as to implement numerous projects/schemes sponsored by the State/ Central Government or different international agencies. Hence, the SFDs in two States along the course of Beas have adequate experience in implementing the present DPR on proposed forestry interventions.

Table 4. 9 – Diversity of Projects and Schemes Implemented by SFDs of Two States

State Government Schemes	Centrally Sponsored Schemes	Externally Aided Projects
Afforestation/ Reforestation	Afforestation/ Reforestation (National Afforestation Programme - NAP, Green India Mission – GIM, Compensatory Afforestation Fund Management and Planning Authority- CAMPA)	JICA assisted Punjab Afforestation Project (I) and (II) The World Bank/ IDA supported Forestry Projects
Soil and Water Conservation Structures	Livelihood Improvement (NAP, GIM) Catchment Area Treatment (CAT) Plans	The World Bank assisted Himachal Pradesh Forests for Prosperity Project JFM – Participatory Forest

		Management for Kandi Region
Public Distribution of Plants	Planting and Restocking Bamboo (National Bamboo Mission (NBM))	IDA funded Forestry Research, Education and Extension Project
Cultivation and Plantation of Medicinal Plants	Augmenting Medicinal Plants (National Medicinal Plants Board (NMPB))	‘Securing Livelihoods, Conservation, Sustainable Use and Restoration of High Range Himalayan Ecosystems - SECURE Himalaya’ focusing on Integrated Development of Landscapes
	Watershed Management and Livelihoods (Integrated Watershed Development Programme - IWDP, Integrated Watershed Management Programme – IWMP)	The World Bank assisted HP Integrated Development Project on Sustainable Land and Water Development Project JBIC supported Swan River Watershed Project in Himachal Pradesh
	Soil and Water Conservation (NAP, GIM, IWMP, CAMPA)	The World Bank supported Mid Himalayan Watershed Management Project
	Integrated Development of Wildlife Habitats - IDWH	USAID Forest PLUS Program India supported Project on Ecosystem Based Forest Management focusing on Carbon Sequestration and Climate Change
	Project Snow Leopard	Punjab Biodiversity and natural Resource Conservation Project JICA supported Himachal Pradesh Forest Eco-Systems Climate Proofing Project

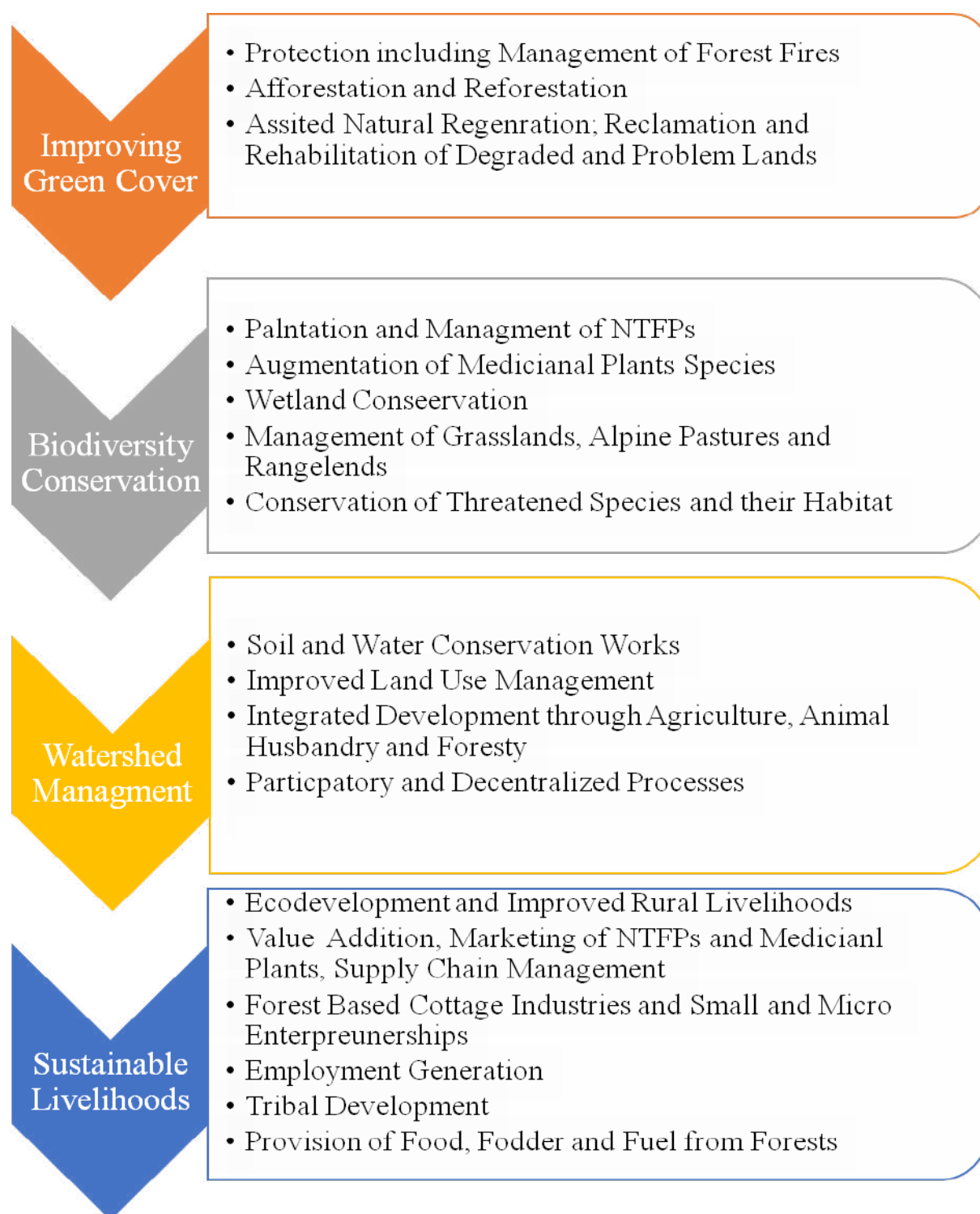


Fig. 4. 2 - Broad Nature and Components of Schemes Implemented by SFDs

(e) Expertise and Capacity

The SFDs manned by the Indian Forest Service (IFS) and State Forest Service (SFS) officers not only have the well-organized hierarchical organizational setup, state-wide infrastructure, and long experience of managing diverse forests alongside other natural ecosystems, but also have much desired capacity, multi-disciplinary expertise and well equipped with modern equipment, tools and technologies. This makes the SFDs more amenable to capacity development at even short notice to adopt newer approaches and improved methods and also to diversify as per the emerging needs in the fields of ecosystem management, climate change mitigation and adaptation, river conservation and sustainable development.

4.5.4 The Indian Armed Forces and Central Armed Police Forces

The Republic of India has the military force represented by the Indian Armed Forces (IAFs) consisting of three professional uniformed services *viz.*, the Indian Army, the Indian Navy, and the Indian Air Force. In addition, the Indian Armed Forces are supported by the Central Armed Police Forces (CAPFs), formerly referred as the Paramilitary Forces. However, the Union Ministry of Home Affairs (MoHA) adopted uniform nomenclature of CAPF in the case of six forces *viz.*, CRPF, BSF, ITBP, CISF, SSB, and the NSG. As such, the primary mandates of the IAFs and CAPFs include: protection of the frontiers to safeguard the country's sovereignty, and important and sensitive establishments (airports, sea ports, industrial units, hydroelectric projects, temples, etc.), but these forces have also been helping in conservation of nature and wildlife resources in difficult terrain and harsh climatic conditions all along the frontiers of the country whether on the land or in coastal and marine water. Further, under the aegis of MoEF&CC and Ministry of Defense (MoD), dedicated force such as the Eco Task Force (ETF) was raised as the Territorial Army unit in conjunction with States to take on challenging assignments in the ecologically fragile and sensitive areas. The ETF battalions have successfully achieved twin objectives of their establishment: (a) eco-regeneration of degraded areas, and (b) rehabilitation of ex-serviceman. Presently, nine infantry battalions (TA), comprising 22 operational companies are carrying out afforestation in difficult and degraded areas in States/ UTs of Uttarakhand, Rajasthan, J&K, Ladakh, Delhi, Himachal Pradesh, Assam and Maharashtra. In addition, a Composite ETF (CETF) for National Mission for Clean Ganga has also been raised at Allahabad. One company each at Kanpur, Varanasi and Allahabad have been planned for the said mission. Till date, various ETF battalions across the country have planted nearly 60.8 million saplings and covered an area of 727.4 km², with 75-80% of survival rate. The CETF is supposed to patrol the sensitive river areas for protection for biodiversity and other tasks such as safeguarding the river from pollution and illegal sand mining, etc. The ETF Battalion at Kufri in Himachal Pradesh and its two units has done commendable work in the Himalayan State since 2005-06. In recent past, the High Court of Himachal Pradesh had ordered for involving ETFs for protecting different rivers of the State from illegal sand mining. Recognizing the past contributions and experience of ETFs in ecological restoration of degraded land and protecting rivers like Ganga, the potential of ETF battalions can be utilized in forestry interventions in difficult areas in Kullu district as well as along the river

stretches in Punjab State so as to protect the river from industrial pollution, illegal activities including protection of biodiversity, particularly critically endangered species like the Indus River dolphin and its habitat. Accordingly, activities by one Battalion with two units in Himachal Pradesh has been provisioned during the proposed Implementation Phase and the Maintenance Phase.

4.5.5 Other Government and Local Agencies

Besides the State Forest Department and Central Armed Police Forces, particularly ETF, there are several other State Government agencies and local bodies those have important role in regulation of river uses and river restoration. Amongst these the prominent sectors/agencies are: The Department of Agriculture, Department of Animal Husbandry, Department of Soil and Water Conservation, State Pollution Control Board and Municipal Boards/Corporations. The concerned SFD as the nodal agency may appropriately involve the Department of Agriculture in plantation activities in agriculture landscapes within the riverscape. The DPR envisages substantial resource inputs towards SMC works. Thus, Department of Soil and Water Conservation can be opted on board for technical support and implementation. Other agencies can help in plantation activities in educational /industrial estates besides in supporting activities like awareness campaigns, participatory monitoring, etc.

4.5.6 Beas River and the Civil Society

The civil society represents the collective group of individuals, non-governmental organizations and institutions in a society that mark interests and will of citizens, and also referred as the ‘third sector’ of the society, distinct from the government and corporate. The civil society plays a wide variety of roles by way of development of social institutions at various levels for specific purposes viz., promotion of cultural and religious values, campaigns against social evils, protection and conservation of nature, and other social welfare measures including relief operations during natural disasters and other stresses and disturbances. Beas River flows through prominent cities and towns and the river and its tributaries throughout their journey from origin to confluence are surrounded by densely populated human habitations, the civil society can play vital role in creation of mass awareness, protection of river and river resources, and allied activities. The religious bodies (e.g., *village devta*, temples, *gurdwaras*, *Radha Soami Satsang*, etc.) can also play vital role in efforts towards river restoration. Likewise, numerous organizations and institutions (e.g., *Panchayats*, JFMCS, Ecodevelopment Committees, Biodiversity Management Committees – BMCs, *Aanganwari* Workers, *Nehru Yuva Kendras* (NYKs), National Service Scheme – NSS, etc.) can be of utmost importance and they can be involved in awareness campaigns, cleaning drives for river and surrounding lands, protection and monitoring, and also implementation of proposed forestry interventions.

(a) Nehru Yuva Kendras

The Ministry of Youth Affairs and Sports (MoYA&S), Government of India is the nodal ministry responsible for the establishment of *Nehru Yuva Kendras* (NYKs) since 1972 with the objective of providing rural youth avenues to take part in the process of nation building as well as offer opportunities for the development of their personality and skills. In 1987-88, the MoYA&S set up the *Nehru Yuva Kendra Sangathan* (NYKS), an autonomous organization under the ministry to oversee working of NYKs. The NYKS is the largest grassroots level voluntary organization that channelizes the power of youth in the age group of 13-35 years on the principles of voluntarism, self-help and community participation. The NYKs has a country wide network of village-based Youth Clubs and *Mahila Mandals*. Its network of 28 Zonal offices, 501 District level offices, and more than 1.25 lakh Youth Clubs in nearly half of the villages of the country constitute a large force of voluntary movement under the auspices of the MoYA&S. The vast network of youth and *Mahila Mandals* operating at village level could be meaningfully involved in the effective implementation of proposed forestry interventions.

(b) National Service Scheme

Yet another student voluntary group named as the National Service Scheme (NSS), under the MoYA&S exists. The NSS was launched in 1969 during the Mahatma Gandhi's Birth Centenary Year. Today, NSS has more than 3.2 million student volunteers enrolled in over 298 universities and +2 Senior Secondary Councils and Directorate of Vocational Education all over the country. The community service rendered by NSS volunteers undertakes varied works related to intensive development in adopted villages, conduct of medico-social surveys, setting up of medical centres, programmes of mass immunization, cleaning, afforestation, etc. Thus, the NSS can be involved in proposed forestry interventions for rejuvenation of Beas and its tributaries and also in creation of mass awareness campaigns.

(c) Seechewal Initiative to Clean Bein River

Seechewal initiative in Punjab is associated with rejuvenation of Guru Nanak Dev Ji's historic river Kali Bein, 160-km long tributary of the Beas, flowing through Doaba, the fertile central alluvial plains of Punjab. Padma Shri awardee Sant Balbir Singh Seechewal, from village Seechewal in district Jalandhar, Punjab is widely popular as 'Eco Baba' and 'Welfare Baba' in India and abroad mobilized numberless people (*sangat*) round the globe for the voluntary *Kar Sewa* of rejuvenation of river Kali Bein. Sant Seechewal began the *Kar Sewa* in July, 2000 when the Kali Bein River was on the verge of death due to severe domestic and industrial pollution. *Sangat* removed water hyacinth, de-silted the river, restored flow of clean water, planted fruit and ornamental trees, developed the river front and created picnic spots for pilgrims and visitors. As a result of restoration of water flow, thousands of hectares of land were reclaimed from water-logging in Tehsil Dasuya, Hoshiarpur, from desertification in Kapurthala District, and from floods in the Mand area of confluence of Beas and Sutlej Rivers. It has also improved the quality of ground water and promoted recharging of water table. Thus, the initiative taken by Sant Seechewal's *Sangat* has proved significantly

beneficial for the people of Punjab, both economically and environmentally. One of the important offshoot of above initiative has been the constitution of Holy Bein Project Committee, a joint venture of the Punjab government and Sant Seechewal for making the river totally pollution free by making alternative arrangements for the sewage water of villages and towns in Doaba as recommended by Sant Seechewal. It is unique synergy mission in which the government provides funds while manual labour is offered voluntarily by public under the leadership of Sant Seechewal. Farmers of the region are happy as the initiative has brought back prosperity in the region. The efforts of eco-friendly model of development by Sant Seechewal were highly appreciated by the former President of India Late Dr. Abdul Kalam and he visited the historical city of Sultanpur Lodhi in Kapurthala District, one of the prominent sites of *Kar Sewa*. Sant Seechewal distributed plants free of cost among the people as *Prasad* of the Guru and people planted them with reverence and religious devotion, turning the Doaba area into a lush green belt. The commendable work of Sant Seechewal was hence been applauded and accoladed far and wide. The successful Seechewal's initiative provides an adequate clue that how local communities can be mobilized and engaged in eco-restoration works of a dying river. The various approaches adopted by the initiative can be roped in for replication in the context of river Beas or its tributaries those have been severely deteriorated.

4.6 Relevance in Implementation of DPR

The foregoing description has aptly facilitated the broad-based understanding of pertinent laws, policies and institutions in the context of management and restoration of river and proposed forestry interventions. At the same time, the vital likely role of wide range of central and state government organizations including the SFD, Central Armed Police Forces and Civil Society that in implementation of the present DPR has been highlighted.



Beas River near village Gagrewal, Tarn Taran, Punjab

5.1 The Beas River Ecosystem – Environmental Trends

The Chapter 2 in Part I has attempted to describe the existing situation of the Beas River and its holistic environment based on a comprehensive appraisal of the physical, biological and socio-economic sub-environments. In the process, the Chapter has provided the appropriate baseline information alongside highlighted the past trends, major challenges, constraints, problems, and issues. The Chapter not only provided an abridged account of various linkages between the Beas River and other adjacent natural ecosystems, socio-economics, and developmental activities within the basin/ Beas Riverscape, but also aptly summarized causes and concerns of environmental degradation of the river and surrounding lands over a long period owing to various natural and anthropogenic drivers and stressors. The past trends of environmental degradation of various associated natural ecosystems (i.e., forests, grasslands, and wetlands) along the course of Beas River profoundly reflected that human activities have perilously influenced not only the river, but also all its tributaries and associated natural ecosystems, and in turn the vital life support systems. Thus, factors responsible for extensive destruction, deterioration, and degradation resulting in decline of ecological integrity and the river health were adequately documented. The degradation of land and water resources,

erosion of biodiversity, enhanced levels of resource use and pollution, and likely implications of climate change were emphasized. The appraisal also revealed that extensive environmental degradation is the precursor to poverty, unsustainable livelihoods, growing conflicts, damage of property and physical assets, water crisis, food insecurity, and overall vulnerability of communities and the natural ecosystems. The need of the hour is to ensure that rapid development and rising prosperity in the basin/ riverscape occur in such a way that they do not jeopardize the natural ecosystems offering multiple ecosystem services on which the human survival depends.

5.2 Key Thrust Areas

India is not alone in its fight against the declining state of her environment, but internationally obliged and committed to address issues arising due to depletion of global commons and resultant rising global concerns *viz.*, degradation of land and water resources, poverty, water crisis, hunger, malnutrition, climate change, etc. besides other social issues related to gender, equity, security, and peace. Alarmed at growing environmental concerns and depleting state of natural ecosystems, particularly rivers, the GoI has undertaken several policies and legislative initiatives and launched multi-focal area programmes so as to address priority concerns about land and ecosystem degradation, dwindling biodiversity, ever increasing pollution and implications of climate change that are closely inter-twined and in most instances share common drivers and stressors. In past four to five decades, India has initiated actions to either halt or reverse the process of environmental degradation by way of numerous country-wide programmes and implementation of global and national level strategies relevant to different sectors *viz.*, sustainable land and ecosystem management, conservation of biodiversity, watershed management, urban environment, climate change, rural livelihoods, and sustainable development. In her quest to address various environmental and social issues, India has also joined bandwagon of global conventions and committed to fulfill its global obligations and assurances. India has a firm belief in conservation of biodiversity as a national priority and recognizes its crucial linkages with the livelihood and well-being of millions of her people, particularly the poor and the vulnerable. India's National Biodiversity Action Plan (NBAP), formulated through a comprehensive inter-ministerial process and approved by the Union Cabinet in 2008, was developed prior to CBD's Strategic Plan for Biodiversity (2011-2020) and the Aichi Biodiversity Targets (CBD, 2010). India's fifth National Report (NR 5) on the Convention on Biological Diversity made a special effort to assess the funding support for spending about Rs. 92,000 million in 2013-2014 on activities that have a direct as well as indirect bearing on conservation of biodiversity (MoEF&CC, 2014). Likewise, much prior to the signing of the Paris Agreement biodiversity conservation in India and reported that country was on Climate Change, the country has formulated the National Action Plan on Climate Change (NAPCC) in 2008 with eight specific missions and adopted the multi-pronged strategy to address issues related to climate change mitigation and adaptation.

Considering the significance of rivers, river development and priority to rejuvenate the major rivers of the country, the GoI declared the Ganga River as the India's 'National River' in

2008, constituted the National Ganga River Basin Authority (NGRBA) on 20 February, 2009 and established National Council for Rejuvenation, Protection and Management of Ganga River in 2011, and created the National Mission for Clean Ganga (NMCG) as the implementation wing of the National Ganga Council. Subsequently, the Union Government approved a comprehensive mission i.e., the National Water Mission (NWM) in 2012 and also renamed the Ministry of Water Resources (MoWR) as the Ministry of Water Resources, River Development and Rejuvenation of Ganga (MoWR, RD&GR) in 2014. The Government of India soon faced the challenge of restoration of Ganga River and recognized the multi-sectoral, multi-dimensional and multi-stakeholder nature of the river ecosystem and in view of this key ministries comprising of (a) MoWR, RD&GR, (b) MoEF&CC, (c) MoS, (d) MoT, (e) MoUD, (f) MoDW&S, and (g) MoRD worked together to arrive at an action plan on Ganga River. The Union Budget 2014-15 announced the setting of an Integrated Ganga Conservation Mission called 'Namami Gange' and since then the Central Government and concerned State Governments are implementing the Namami Gange programme. In May 2019, this Ministry was merged with Ministry of Drinking Water and Sanitation to form the Ministry of Jal Shakti. Thus, it is evident that the subjects of water resources, rivers, and river restoration are not only amongst the highest priority agendas of the current government, but also the Government is fully committed to achieve the mission goals in a time bound manner. Further, the present DPR and concurrent preparation of DPRs of other major Indian rivers testify the priority and commitment of the Union Government towards restoration/rejuvenation of rivers.

5.3 The Vision, Mission, Goals, and Objectives

Broadly, the present Plan aims to contribute towards the clean and healthy Beas River by way of continuous flow (*Aviral Dhara*) and clean water (*Nirmal Dhara*) besides maintenance of ecological and geological integrities. The following shared vision emerged for the Implementation Plan based on an extensive consultative process carried out as a part of the larger exercise undertaken to prepare this DPR.

Vision: Various conservation values of the Beas River are identified, recognized, conserved, restored, and maintained in order to ensure the ecosystem diversity, ecological integrity and healthy river while allowing sustained flow of ecosystem services and other uses/ benefits essential for all life forms and the prosperity of the region.

Mission: The mission is to accomplish the above shared vision by adopting multi-pronged strategy and pursue of five specific strategic priorities: (a) address drivers of environmental degradation and arrest biodiversity loss, (b) adopt integrated, innovative and nature based solutions, (c) enhance resilience and adaptation, (d) build alliances and foster synergies, and (e) opt for the right influential models and interventions so as to achieve reduced pressure on biodiversity, restore degraded ecosystems, promote sustainable use of biological and water resources, enhance capacities, mainstream biodiversity, augment policy and law support, and facilitate science based efficient decision making.

Goals: In view of the above and in accordance with the national and global level priorities, commitments, agendas, strategies, and approaches, the Implementation Plan on proposed forestry interventions seeks to address the following focal areas or goals in an integrated manner.

- (e) **Riverscape Management:** Aiming a holistic riverine landscape (riverscape) approach for sustainable management of Beas River, its banks, or its riparian areas, within its fluvial system.
- (f) **Aviral Dhara, Nirmal Dhara, Ecological Rejuvenation and Biodiversity Conservation:** Aim to address the drivers and stressors of river ecosystem and promote sustainable use by balancing ecological requirements with the needs of sustainable livelihoods.
- (g) **Improved Ecosystem Services and Sustainable Livelihoods:** This goal aims to specifically seek enhanced ecosystem services so as to maintain sustainable livelihoods.
- (h) **Effective Implementation, Knowledge Management, and Innovative Approaches:** This goal aims to ensure effective implementation of the project, knowledge management, development of innovative approaches (i.e., nursery techniques, afforestation, bio-filters and bioremediation), and adoption of appropriate modern technologies.

Project Objectives, Outcomes and Outputs: This Plan aims to fulfill the requirements of above stated four focal areas in a phased manner and visualizes specific outputs and outcomes. Hence, the following objectives are set-forth.

Project Objectives

1. To promote an enabling environment for sustainable land and river ecosystem-based management approaches focusing on reduced soil erosion, enhanced forest/ vegetation cover in the buffer zone, enhanced connectivity and e-flow, and ecological restoration of Beas River and its tributaries.
2. To carry out appropriate forestry interventions to restore river connectivity, enhance e-flow, improve water quality, and conserve the terrestrial and aquatic biota within the Beas Riverscape.
3. To promote improved ecosystem services and support sustainable livelihood opportunities for local communities, particularly forest dwellers, fishermen and other vulnerable groups.
4. To adopt, integrate and implement innovative approaches and modern technologies for restoration of Beas and its tributaries, knowledge management, enhanced capacity, and monitoring and evaluation.

Project Outcomes

Above Plan objectives will be achieved through the following outcomes:

1. Creation of an enabling environment for climate resilient, sustainable terrestrial, aquatic (river and wetlands), and floodplain ecosystem management.
2. Inter-agency and civil society driven, climate resilient approaches for appropriate forestry and other allied interventions demonstrated in adequate extent(s) of natural, agriculture, and urban landscapes of the riverscape.
3. Enhanced ecosystem services from natural (forest, grassland, river, and wetland) ecosystems, agro-ecosystems, and urban landscapes.
4. Sustainable livelihoods, particularly of forest dwellers, fishermen and other vulnerable groups.
5. Capacities for adaptive management, learning, and replication of project lessons are developed.

The following specific outputs are foreseen under the above stated outcomes:

Outcome 1: Creation of an enabling environment for climate resilient, sustainable terrestrial, aquatic (river and wetlands), and floodplain ecosystem management

The purpose of this significant outcome is to build an appropriate environment wherein multiple agencies/sectors working for various production sectors (i.e., forest, watershed, agriculture, livestock, mining, tourism, tribal welfare, infrastructure development hydropower, communication, highways, and waterways) converge and adopt climate resilient and sustainable approaches of terrestrial, aquatic and floodplain ecosystem management by mainstreaming biodiversity concerns. These sectors shall also work together so as to address gaps and inadequacies in realizing global and national policy objectives relevant to the environment, biodiversity, water resources and climate change. Following outputs are envisaged to accomplish above broad-based outcome:

Output 1.1 *Enhanced levels and enabling environment created for:*

- (a) Multi-sector convergence, alliances, and integration;
- (b) Favorable National and State level policies (i.e., forest, agriculture, animal husbandry, watershed management, river management, tribal welfare, infrastructure development, tourism, etc.) those reflect principles of climate resilience, sustainable land and ecosystem management, and mainstreaming biodiversity concerns in production sectors.

A wide range of policies and legislative acts concerning the above stated different production/ environment sectors already exist. The Chapter 4 has adequately elaborated on the existing laws and policies and also provided a comprehensive list of relevant laws and policies. So far, fragmentary and preliminary efforts have been made for inter-agency cooperation and convergence and even adoption of landscape/ riverscape/ seascape approaches to conservation and ecosystem management. Nevertheless, the current experience on the sectoral convergence is grossly inadequate. The preceding Chapters describing the existing situation of the Beas River and its environment have highlighted numerous interrelationships and complexities in a river ecosystem and adequately summarized causative factors responsible for the extensive environmental degradation and narrated that

how various production sectors have influenced the river ecology. The appraisal of river environment in the context of Beas River amply revealed for the urgent requirements of adopting a comprehensive and holistic approach for river restoration, inter-agency cooperation and sectoral convergence, mainstreaming biodiversity concerns in production sectors, and the need for harmonization amongst competing and conflicting sectors through adequate support of relevant policies and enforcement of laws. This Plan on the proposed forestry interventions will provide an opportunity to bring diverse stakeholders/ agencies/ sectors/ civil society organizations together for the realization of above stated vision and goals relevant to healthy river and sustainable ecosystem. SFDs in two concerned States would be the primary Implementing Agencies (IAs) and they would facilitate the process for this vital output while working with different agencies/ sectors and CSOs. The National Level Nodal Organization (HFRI) would be responsible for technical backstopping, and monitoring and evaluation besides the current role being played on planning and preparation of the present DPR. A highly consultative and cooperative approach is being planned in creating the enabling policy environment, and developing recommendations and mechanisms for programme implementation. The Nodal Institution (HFRI) and two primary IAs (SFDs) in Himachal Pradesh and Punjab would be required to play a major role in addressing the threats arising from the climate change and suitably integrate them with current land use, production sectors, and ecosystem management.

Output 1.2 *Capacity of government officials and civil society organizations is developed in promoting community driven, climate resilient, sustainable land and ecosystem approaches, and holistic approach to management of river ecosystem.*

The Project aims to propose extensive plantation activities in natural, agriculture, and urban landscapes so as to enhance the forest cover, provide multiple benefits to local communities and help in the processes relevant to retention of water, recharge of ground water, functioning of bio-filters, and bio-remediation. In addition, varied activities viz., soil and moisture conservation works, grassland and rangeland management, wetland management, cultivation of medicinal and aromatic plants, weed management, conservation of threatened species, riverfront development, etc. are also being considered and planned. Obviously, various proposed activities will be undertaken on the Government as well as community/ private lands. The SFDs will be the IAs in case of planned activities on the Government owned forest lands and protected areas. However, large scale efforts those are being planned on private agriculture lands and other lands (i.e., revenue, urban, and riverfronts) owned by the various government agencies, proposed activities are being planned through CAPFs (ITBP, Eco Task Force) and CSOs (*Panchayats, Gram Sabhas, JFMCs, EDCs, BMCs, NYKS-Youth Clubs and Mahila Mandals, NGOs, Religious Organizations, etc.*). Inter-agency cooperation and sectoral convergence are essential for the success of project of this nature. Awareness campaigns for masses, particularly women and youth are being planned. Capacity development of government officials, CSOs and local communities is being planned. Innovative approaches viz., bio-filters and bio-remediations are being considered alongside incorporation of modern technologies (i.e., RS and GIS, meteorological, water quality,

monitoring of aquatic animals – telemetry, etc.) has been envisaged. The project includes the logical framework analysis and results based monitoring. Capacity development of officials and CSOs in these aspects is vital and thus, being appropriately addressed in the plan.

Outcome 2: Inter-agency and civil society driven, climate resilient approaches for appropriate forestry and other allied interventions demonstrated in adequate extent(s) of natural, agriculture, and urban landscapes of the riverscape.

The riverscape includes wide ranging natural ecosystems (i.e., terrestrial, aquatic, and floodplain) besides vast agriculture and urban landscapes. Forestry interventions in such landscapes are envisaged.

Output 2.1 *Plans to reduce/check erosion in the mountainous region and floodplains of Beas River and its tributaries by appropriate soil and moisture conservation works and development of optimal strategy for riverbed mining. Sites of landslides are adequately treated and stabilized*

Project plans for considerable inputs by way of appropriate soil and moisture conservation works so as to check and reduce erosion and treating specific sites of landslides within the riverscape. At the same time, convergence of related sectors, development of policy framework on sand mining in river beds would be initiated and guidelines developed.

Output 2.2 *Plans for restored and sustainably managed forest lands, agriculture lands in targeted villages and forestry interventions in urban environment for improved forest/vegetation cover achieved. Enhanced assisted natural regeneration through improved protection and other measures is also accomplished.*

The Project's main focus is on an integrated ecosystem management approach in the context of river Beas by taking into account all diverse natural (i.e., forest, grassland, and wetland) ecosystems by adopting sustainable land and ecosystem management principles. The primary objective of this output would be to improve the forest/ vegetation cover in the mountainous part of the riverscape in Himachal Pradesh and Punjab Plains. In addition, this output envisages appropriate tree cover and Trees Outside the Forest (TOF) through suitable plantations on private agriculture lands and various other government lands (i.e., along canals, cantonments, schools, institutions, public facilities, riverfronts, and urban landscapes). Enhanced forest and vegetation cover will directly help in improved biodiversity, productivity, reduction in erosion, and efficient functioning of bio-filters.

Output 2.3 *Plans for improved protected area management by implementing appropriate protection strategies, habitat management (e.g., weed control and water management), research and monitoring inputs, and enhanced capacity.*

The Beas Riverscape includes several small and widely scattered a few large protected areas along the altitudinal gradient in its mountainous part as well as in the lower part of alluvial

plains. These protected areas include some of the prominent National Parks viz., GHNP, Khirganga and Inderkilla NPs; numerous high altitude and other wetlands including three Ramsar Sites (Pong Dam Lake, Harike Lake and Beas River Conservation Reserve) besides a number of sanctuaries, conservation and community reserves. Recently created the Beas River Conservation Reserve and Ramsar site in Punjab attains special significance as it harbours the last surviving, small population of the critically endangered Indus River Dolphin in Indian waters. Several PAs sites have been designated as IBAs. The GHNP and other contiguous adjacent PAs forming the complex of GHNP, is the World Heritage Site. These PAs are repository of representative biodiversity and facilitate various ecological and evolutionary processes including climate resilience. Majority of these PAs suffer on account of smaller size, large PA-People interface, traditional resource dependence, proliferation of invasive alien species, and incompatible land use in their surrounds. It is pertinent to protect and improve these PAs from the perspective of biodiversity values and a wide range of ecosystem services they offer to the local populace including serving as an important catchment area in the context of Beas and its tributaries. Therefore, the Plan envisages multiple activities aiming to support the protection of these PAs; management of threatened species and their habitats including weeds, development of essential physical infrastructure, eco-development, research and monitoring, awareness campaign and ecotourism, and capacity development.

Output 2.4 *Plans for improved management of prominent wetlands in the riverscape by protection, restoration, zoning, habitat management, and wise use of wetland resources.*

The riverscape harbours diverse natural and manmade wetlands along the river course as well as in proximity to the main channel of Beas River or its tributaries. They are not just biological supermarkets but have vital role in maintenance of environmental flow, water purification, groundwater recharge, and control of floods besides majority of them are major attraction for tourism activities. Most wetlands are threatened on account of enhanced siltation, chemical pollutants from agriculture landscapes, and influence of industrial effluents and sewage disposal from cities/ towns. The Plan visualizes a wide range of activities for management and conservation of wetlands within the riverscape and continues to provide multiple benefits to the society as well as to the river ecosystem. The monitoring of wetlands, particularly the resident and migratory birds is an important planned activity in the present DPR.

Output 2.5 *Plans for improved riverfronts and development of eco-parks.*

The Beas River and its prominent tributaries traverse through major cities/ towns within two States besides important locations of pilgrimage and tourism activities. The Plan envisages the development of riverfronts and eco-parks in select locations so as to enhance the potential of ecotourism in such sites provide improved livelihoods to local people by way of ecotourism, and ultimately to help the river ecosystem from pollutants and other biotic disturbances in prominent stretches.

Output 2.6 *Plans for development of forests and river-based ecotourism.*

In past four to five decades, there has been exponential increase in tourism activities all along the Beas River, its tributaries, and adjoining forested tracts. Two concerned States within the riverscape are major attractions for such activities. Moreover, in past, local inhabitants have primarily relied on natural resources from terrestrial and aquatic ecosystems for their subsistence and commercial activities and obviously there has been an excessive pressure on harvest and collection of scarce forest and river resources. Hence, it is essential to provide Alternate Income Generation (AIG) activities to local communities and engage them meaningfully in various efforts towards protection and conservation of natural ecosystems. Thus, the Plan envisages activities those promote and provide support for the development of alternate income generation activities by way of ecotourism, and allied Small and Micro Entrepreneurships (SMEs) so as to enhance income of communities, traditionally dependent on forests and other natural resources for their subsistence.

Outcome 3: Enhanced ecosystem services from natural (i.e., forest, grassland, river, and wetland ecosystems), agro-ecosystems, and urban landscapes

Since time immemorial, varied natural ecosystems have been offering a wide range of ecosystem services to the human society and in most instances these services have drastically declined owing to the fact the very foundation and existence of natural ecosystems have been severely impacted by growing population, unplanned development and other human disturbances. Thus, there is an urgency not only to curb adverse human activities, restore degraded ecosystems including manmade agro-ecosystems and even the built-up environment. Hence, planned activities by way of protection, afforestation, reforestation, assisted natural regeneration, weed control and management, water management, etc. have been envisaged in the plan.

Output 3.1 *Plans for reduced traditional forest dependence, developed alternate income generation activities, improved livelihoods, and facilitate establishment of viable Small and Micro-Enterprises (SMEs).*

The rural population in remote, rugged terrain and harsh climatic conditions of the upper mountainous part constitutes nearly 90% population of Himachal Pradesh. Traditionally, the rural population has primarily depended on forests and livestock for majority of their daily requirements. Gradual expansion of agriculture and horticulture and various developmental activities in the region enhanced opportunities for improved livelihoods. However, a substantial section of the rural society is either the 'Below the Poverty Line (BPL)' or continues to solely depend upon natural resources, primarily diverse forests including alpine pastures, wetlands and rivers. A significant portion of the rural population depends upon the collection of medicinal herbs and other NTFPs. There is ample opportunity to reduce traditional resource dependence by way of AIGs and SMEs. Over past few decades, various ethnic groups, particularly women have been engaged in area specific handicrafts and allied cottage industries. However, there is enormous scope to organize communities in AIGs and SMEs by developing and supporting appropriate mechanisms for linkages with markets and supply chain management.

Output 3.2 *Plans for enhanced levels of protection, conservation, and sustainable harvests of medicinal and aromatic plants and development of herbal gardens.*

Specifically, the mountainous tract of Himachal Pradesh in middle and higher altitudes has been bestowed with enormous diversity of Medicinal and Aromatic Plants (MAPs). Traditionally, local people have been collecting and using such plants for their own consumption and varied uses in remote areas. However, once the road network was created and avenues for commercial requirements were opened up, there was sudden spurt in activities related to harvest, collection, cultivation, and marketing of MAPs. In turn, these activities have expanded human disturbances in high altitude natural areas. The Plan envisages select treatment models related to the cultivation of MAPs in natural and agriculture landscapes, and development of herbal gardens within the riverscape. The Plan also envisages to create awareness and scientific know how about the harvest, collection and cultivation of MAPs so as to enhance the productivity and reduce degradation of natural areas.

Outcome 4: Sustainable livelihoods, particularly of forest dwellers, fishermen and other vulnerable groups

One of the major outcomes expected from the implementation of present DPR on forestry interventions pertains to improved rural livelihoods, particularly, of forest dwellers, fishermen specifically in Punjab and other vulnerable groups inhabiting the remote mountainous tract or living along the stretches of river Beas or its tributaries. The concept of sustainable livelihoods provided by the Department for International Development (DFID), UK emphasized on the maintenance of five livelihood assets *viz.*, human, natural, financial, physical, and social. The uncertain climatic conditions and other natural exigencies pose enormous challenges, risks and vulnerability of forest dwellers, fishermen and other susceptible and weaker groups. The plan lays equal emphasize on ecological restoration and the sustainable livelihoods. Hence, essential and priority activities supporting the sustainable livelihoods of local populace are being planned. Efforts will be made to make them aware about the significance of natural capital besides other prominent livelihoods assets such as human and social.

Outcome 5: Capacities for adaptive management, learning, and replication of project lessons are developed

One of the five outcomes envisaged from the implementation of the project pertains to enhanced capacity for adaptive management of natural resources including the river ecosystem. The following two outputs are foreseen:

Output 4.1 *Plans developed for integrated, science based, and community-based monitoring and assessment of impacts, as well as periodic evaluation of the project.*

The natural resource management demands comprehensive and holistic approaches besides adoption of the principle of adaptive management. Increasingly, the international and national development agencies emphasize on the Results Based Monitoring (RBM) as an essential and integral activity of a developmental project related to any sector. Considering the long stretches of the river, its tributaries, vast extent of the riverscape, diverse natural resources and stakeholders involved, and wide range of activities planned in natural, agriculture, and urban landscapes besides several conservation and supporting activities across two States along huge investments, it is essential to devise science, evidence and indicator-based diagnostic concurrent monitoring so as to ascertain the impact of planned activities on the river ecosystem, its wider environment, and the rural livelihoods. The concept of adaptive management requires monitoring, learning and adaption. Thus, the Plan aims to incorporate participatory and community driven monitoring system.

Output 4.2 *Plans for documentation of lessons learned and preparation of information dissemination products for wider audiences and applicability*

The wider subject of river conservation and restoration in India is relatively much newer and visibly, there is hardly any evidence of successful and well documented experiences. Indeed, the river restoration is a herculean task in human dominated country like India wherein there is the presence of human all around and their varied intensive activities have adversely impacted the natural environment. The only little experience available is from the implementation of ambitious Namami Gange programme on the Ganga River and some sporadic efforts such as the Seechewal initiative in the case of Kali Bein River in Punjab. Hence, it is important to document the experiences and lessons learned in the planning, implementation, and monitoring of project execution of this nature. Accordingly, the plan envisages activities related to documentation of project execution, lessons learned and wider dissemination of knowledge gained for appropriate replication in case of other rivers and their tributaries. Till date, there is no singular agency in the country that provides comprehensive and holistic insight as well as information on the river ecosystem. The appraisal of river environment evidently reflected this shortcoming. Hence, there is an urgency to develop the Knowledge Management Centre on the much desired and priority subject of river conservation and restoration. At the same time, there is vast opportunity to develop innovative approaches for execution of forestry interventions along the river, its tributaries, and the catchment. Thus, this specific output pertains to development of innovative approaches suitable for different agroclimatic conditions within the riverscape besides documentation of experiences and lesson learned, dissemination and replication of similar efforts as either the part of proposed Phase II of the project or elsewhere.

5.4 Problems in Achieving Objectives

The Chapters 2 and 4 have appropriately highlighted the multitude of problems, constraints issues and threat associated with the river environment, specifically with restoration efforts. The Chapter 2 also made revelations on basis of SWOT analysis. The actual and potential problems identified in achieving various project objectives are as follows:

- a. Fragility of the Himalayan environment owing to increased seismic activity and active landslides, wide spread soil and riverbank erosion, and enhanced sedimentation.
- b. Harsh climatic conditions, erratic and changing patterns of snowfall, rainfall, and ambient temperature, unpredictable avalanches, retreat of glaciers, increase snowmelt and runoff; and prevailing uncertainties.
- c. Rugged terrain, steep slopes, inaccessible areas, shallow soil depth and low soil fertility.
- d. Alteration in river course by linking river or diversion of water; sequential physical barriers by construction of dams, barrages, and establishments of HEPs.
- e. Traditional resource dependence, enhanced biotic activities, and human disturbances on natural ecosystems; limited opportunities for alternate occupation and income generation; unsustainable harvest practices; illiteracy, lack of awareness, and poverty and vulnerable communities.
- f. Widespread and extensive land use changes and faulty land use; expansion and intensification of agriculture and horticulture; and excessive use of fertilizers, pesticides, weedicides, etc.
- g. Encroachment of forest lands, PAs, and other natural ecosystems; and all round rapid developmental activities like expanding highways, widening of road network, mushrooming of cities/towns, irrigation and hydropower projects, transmission lines, etc.
- h. Forest fragmentation, enhanced patchiness, habitat loss and degradation of terrestrial and aquatic ecosystems by proliferation of invasive alien species and decline in productivity and lack of regeneration of native species.
- i. Erosion of biodiversity value, smaller and isolated populations of threatened species and reduced distributional range of prominent faunal species.
- j. Enhanced pilgrimage, mass congregation, and unplanned and unregulated tourism activities and allied developmental activities and their impact on terrestrial and aquatic ecosystems including rivers, their flow and water quality.
- k. Fragmentary approach of environmental impact assessment in case of sequential developmental projects and inadequate efforts for cumulative assessments.
- l. Multiplicity of policies and laws, isolationist, conflicting or counterproductive strategies/ approaches adopted by different agencies/ sectors, lack of sectoral convergence, and lackadaisical law enforcement and implications of judiciary activism.
- m. Inadequate researches, databases, and baseline information, ineffective monitoring, lack of technological support, innovations and inadequate capacity.

5.5 Strategies

The preceding section has presented the shared vision of the Implementation Plan (IP) along with four broad goals aiming to address four distinct thrust areas relevant to the river conservation and restoration. These thrust areas are: (a) sustainable land and riverscape management through appropriate forestry interventions, (b) conservation of biodiversity in the terrestrial and aquatic environment of the river, (c) enhanced benefits and sustainable livelihoods, and (d) project implementation, knowledge management and innovative approaches. In order to achieve four goals through proposed project on forestry interventions, important supporting activities such as policy level interventions, strategic adaptive research and development, innovative and low-cost bioengineering methods for stream/riverbank

stabilization, participatory monitoring, evaluation, awareness, capacity development, and project management are also envisaged. The Implementation Plan has incorporated four Project Objectives with five broad outcomes and twelve specific outputs.

The developed understanding on the riverscape environment has amply revealed that the riverscape is a mosaic of varied land uses and it includes: (a) natural ecosystems, (b) rural system predominated by agro-ecosystems, and (c) built-up urban environment represented by cities and towns. Each of these broad land use categories represents significant area of the riverscape with unique conditions and situation, and varied use patterns, ownerships and management needs. Hereafter, three broad land use categories within the riverscape are being referred as the 'Natural', 'Agriculture' and 'Urban' landscapes. These three landscapes immensely influence the intricate and vibrant nature of Beas River ecosystem, especially the environmental flow, water quality, and aquatic biota besides terrestrial biodiversity in surrounding lands, and the various ecological and fluvial processes of the *lotic* system. Hence, in view of the prominence of three types of landscape elements within the riverscape, a multipronged strategy for proposed forestry interventions addressing specific requirements of each of the land use type/ landscape category has been planned for the execution as a part of the implementation plan during the Phase I (5-year duration). The Phase I will be followed by Phase II (Maintenance Phase). As a part of the broader strategy, zoning within the riverscape is visualized keeping in view three distinct landscape categories and specific targeted forestry interventions those are being planned in each of the zone.

5.5.1 Zoning and Lower Order Zone Plans

Three broad and distinct landscape types or 'three zones' have been deciphered within the riverscape for the purpose of proposed forestry interventions. The following section presents an elaborate account of specific forestry interventions in each of the zone or represents the self-contained 'Lower Order Zone Plan' for the Natural, Agriculture and Urban landscapes, respectively within the riverscape.

Following three lower order zone plans/ landscape plans in the riverscape are incorporated for the purpose of proposed forestry interventions.

(a) Natural Landscape (NL)

The distribution of different land use and land cover categories within the Beas Riverscape revealed that various categories of land use/ land cover within the natural environment represented nearly 63% extent of the riverscape. Prominent natural land use and land cover categories were: diverse forests, scrubs, and alpine pastures covering about 40% area of the riverscape; 16% area was under snow/ glaciers, clouds and cloud shadow; and 3.79% area was barren. In addition, perennial rivers and river (dry)/river sand covered 3.45% area of the riverscape while wetlands and water bodies represented just 0.18% area. Thus, the 'Natural Landscape' constitutes the largest zone within the riverscape. Hence, from the perspective of forestry interventions, this zone acquires the greatest significance for river conservation and restoration. Various planned forestry interventions, thus, include protection, habitat

improvement and management by way of soil and water conservation works, weed control, afforestation/ reforestation, eco-restoration, bio-filters and bio-remediation, etc. Keeping in view the diversity of forests and other natural ecosystems, native vegetation, soil conditions, and agroclimatic zones, potential models of various types of forestry interventions, particularly potential plantation models were identified, designed and developed by the HFRI using its multi-disciplinary expert knowledge. For developing treatment models, insights obtained from the consultative process, field acquaintance, professional judgment, forest working plans, and CAT plans were optimally used. Suggested models for the natural landscape, segregated into two broad groups: (a) models for the Himalayan Mountainous tract in Himachal Pradesh, and (b) models for the alluvial plains of Punjab. The primary purpose of various models planned and proposed in the natural landscape is protection, eco-restoration, and conservation. Each recommended treatment model includes background information on site characteristics, recommended plant species for the proposed plantation besides details on spacing, quantity of different activities and man days during the establishment year as well as in subsequent years of maintenance. Details of potential treatment models were shared with SFDs of concerned States seeking feedback for appropriate finalization. 27 models were selected and incorporated in the present DPR. Altogether, 13 models selected for Natural Landscape were numbered from BS/HP/NL/01 to BS/HP/NL/13 in the hilly region of Himachal Pradesh while 02 models for Natural Landscape in alluvial plains of Punjab State, numbered from BS/PB/NL/01 to BS/PB/NL/02 were included. Details of these models in Natural Landscape relevant to hills and alluvial plains along with incorporated abbreviations/ code are summarized in Table 5.1.

In all, 13 models for Natural Landscape in the hills of Himachal Pradesh are proposed for treatment and forestry interventions. The model BS/HP/NL/01 specific to moist alpine and sub-alpine areas at 3,600 - 4,500 m amsl, and is mostly snow bound while one model specific to sub-alpine area (2,900 - 3,600 m) are proposed. The model: BS/HP/NL/02 deals with enrichment and development of sub-alpine areas. Ten different models (BS/HP/NL/03 to BS/HP/NL/12) are proposed for lower, middle and upper temperate forested tracts in the Himalayan Mountains of Himachal Pradesh. All these 13 models prescribed for the Natural Landscape will be implemented by the SFD, Himachal Pradesh. Model BS/HP/NL/13 will be implemented by the Eco-Task Force in varied sub-tropical to temperate regions including inhospitable topography and refractory conditions.

In the vast area of alluvial plains of Punjab, altogether two different treatment models are proposed and included in the DPR. The treatment model BS/PB/NL/01 will be specifically applied in degraded areas in protected forests or vacant areas in village common lands or community lands. One model (BS/PB/NL/02) has been designed and proposed for plantations along roadsides, railway tracks, and canals, respectively in alluvial plains of Punjab.

Table 5. 1 – Proposed Plantation/ Treatment Models in Different Landscapes and States

Sr. No.	Model Type	Model Number
I	Natural Landscape (NL)	
A	Hills - Himachal Pradesh	
1	Sub-Alpine Conservation	BS/HP/NL/01
2	Sub-Alpine Enrichment	BS/HP/NL/02
3	Temperate Conifer Forest	BS/HP/NL/03
4	Temperate Mixed Forest	BS/HP/NL/04
5	Pasture and Grazing land Development	BS/HP/NL/05
6	Himalayan Chir Pine Forest	BS/HP/NL/06
7	Himalayan Mixed Forest	BS/HP/NL/07
8	Sub-Tropical Dry Deciduous Forest	BS/HP/NL/08
9	Control of Lantana	BS/HP/NL/09
10	Control/ Removal of Invasive Alien Species or <50% Lantana	BS/HP/NL/10
11	Protection Model for Natural Regeneration	BS/HP/NL/11
12	Fire Protection Model	BS/HP/NL/12
13	Plantation by Eco-Task Force in Temperate region	BS/HP/NL/13
B	Alluvial Plains – Punjab	
14	Restoration of Degraded Forest	BS/PB/NL/01
15	Road Side Plantation	BS/PB/NL/02
II	Agriculture Landscape (AL)	
A	Hills – Himachal Pradesh	
16	Boundary Plantation Model	BS/HP/AL/01
17	Block Plantation Model	BS/HP/AL/02
B	Alluvial Plains – Punjab	
18	Boundary Plantation Model	BS/PB/AL/01
19	High Density Block Plantation	BS/PB/AL/02
III	Urban Landscape (UL)	
A	Hills – Himachal Pradesh	
20	Bio-remediation and Bio-filtration	BS/HP/UL/01
21	Riverfront Development	BS/HP/UL/02
22	Institutional and Industrial Estate Plantation	BS/HP/UL/03
23	Eco-Park Development	BS/HP/UL/04
	Alluvial Plains – Punjab	
24	Bio-remediation and Bio-filtration	BS/PB/UL/01
25	Riverfront Development	BS/PB/UL/02
26	Institutional and Industrial Estate Plantation	BS/PB/UL/03
27	Eco-Park Development	BS/PB/UL/04

(b) Agriculture Landscape (AL)

The second largest lower order zone within the Beas Riverscape in terms of extent was the Agriculture Landscape, as it covered 35.29% area of the Riverscape, and was widely distributed firstly, along the altitudinal gradient in Himachal Pradesh, and secondly, in the vast expanse of alluvial plains of Punjab along the main channel. The Agriculture Landscape largely in the rural environment in hills/plains constitutes the ‘Matrix’ of the riverscape. The primary activity in this zone is agriculture and horticulture production. A wide range of agricultural and horticulture crops are being undertaken by farmers on their private lands. The purpose of this lower order zone (Agriculture Landscape) is to enhance productivity of

agricultural lands by appropriate soil and moisture conservation measures and planting of economic and fruit trees so as to support the overall conservation values and other expected ecological functions and ecosystem services. Two models for the Agriculture Landscape in the hill state of Himachal Pradesh are proposed. They are: (a) model BS/HP/AL/01, and (b) model BS/HP/AL/02 relevant to boundary plantations and block plantations, respectively. In case of alluvial plains of Punjab, two models (BS/PB/AL/01 and BS/PB/AL/02) specifically designed for plantations along the boundaries of crop fields and plantations in blocks, respectively have been proposed.

(c) Urban Landscape (UL)

The built-up environment represented by the land use and land cover category of ‘settlement’ covered about 1.85% area of the riverscape. This category of land use and land cover was widely distributed throughout the riverscape, predominantly all along the main channel and its tributaries and formed the third lower order zone, altogether four models (BS/HP/UL/01 to BS/HP/UL/04) focusing on bioremediation and bio-filter, riverfront development, plantations in institutional and industrial estates, ecopark development, and avenue plantations have been proposed in the mountainous tract of Himachal Pradesh. Likewise, four models in urban landscapes within the alluvial plains of Punjab *viz.*, bio-remediation and bio-filters (BS/PB/UL/01), riverfront Development (BS/PB/UL/02), institutional plantations (BS/PB/UL/03), and ecopark development (BS/PB/UL/04) are proposed.

Wetlands/ water bodies including rivers, lakes, streams, etc., particularly in the urban environment of alluvial plains of Punjab have been severely impacted due to anthropogenic activities including large scale pollution originating from extensive use of fertilizers and other chemicals in crop fields and orchards, industrial effluents, and urban sewage and waste disposal. Hence, a small number of pilot demonstrations sites adopting model BS/HP/UL/01 and BS/PB/UL/01 on bio-remediation and bio-filtration have been proposed in the mountainous tract of Himachal Pradesh and alluvial plains of Punjab. The proposed model BS/PB/UL/01 pertaining to river front development has been included with the primary intention to plant avenue trees and shrubs along the river bank so as to prevent the erosion of soil and banks. The proposed model would help in stabilizing the banks of the river. In addition, the area so developed would provide the aesthetic environment to the visitors. Two separate models BS/HP/UL/03 and BS/PB/UL/03 in two consecutive States specific to the institutional and industrial estates have been proposed in the urban landscape. Under these models, mainly ornamental, shade and fruit trees will be encouraged for planting. Likewise, two models BS/HP/UL/04 and BS/PB/UL/04 in two consecutive States pertain to the development of Eco-Parks. Eco-Parks would have both vegetation and non-vegetation components so as to provide better equipped facilities to visitors.

5.5.2 Model-Wise Treatment Plans under Three Lower Order Zones

The treatment plans for proposed 27 models (Natural-15; Agriculture-04; and Urban-8) meant for above described three lower order zones or landscapes within the riverscape are

elaborated below one by one. In case of each model, the treatment plan includes the details on site characteristics, recommended species for plantations, specific activities and cost norms.

In general, following guidelines would be applicable to all proposed plantation models meant for three different zones/ landscapes within the riverscape:

- a. All the models/ interventions are prescribed which comes under forestry interventions for various landscapes for proposed DPR of Rivers.
- b. Native species of trees, shrubs, herbs and grasses would only be selected for proposed treatment models/ plantations in consultation with stakeholders of the respective states/UT. Traditional and prominent horticultural and ornamental species those have been in cultivation in the region for quite some time are proposed in the agriculture and urban landscapes. Mixed plantations are proposed as far as possible instead of monoculture for enhancing plant diversity and greater ecosystem services. The species are proposed as per zone however implementing agencies may plant site specific species also.
- c. Suitable native species suggested for different plantation models are finalized after due consultation with forest department and other stake holders of concerned States/UT. Native species proposed for planting under each of the proposed treatment models are provided in the following section. In addition, landscape-wise model description provided below has been further supplemented with the species-wise attributes and model-wise listing in Annexure 3 and Annexure 4, respectively
- d. The necessary preparations for planting works including digging of pits would be completed two-three months before the onset of monsoon or planting season. However, the period between pit digging and scheduled planting time would not be more than four months so that run-off of soil by wind and water would be low.
- e. Appropriate quantity of farmyard or organic manure or VAM would be applied to boost plant growth in nurseries and plantation sites. Eco-friendly measures (e.g. physical or mechanical methods, use of natural products, etc.) for weed and pest control would be adopted without resorting to the use of synthetic chemicals
- f. Plantation sites would be protected against all types of biotic disturbances and abiotic stresses so as to effectively safeguard planted material for three years through fence, watch and ward, as well as local public awareness programmes and their active involvement..
- g. The implementing agency should either develop modern and centralized nurseries or identify various certified Research Institutes, Universities, NGOs, Institutions and progressive farmers for supply of best quality planting material.
- h. The schedule of rates (SoR) is adopted from prevailing SoR of respective States/UT. For Himachal Pradesh SoR of Shimla Forest circle for the year 2012-13 @ wage rate of Rs.150/ with increase of 66.66% i.e., Rs. 250/-, for Punjab SoR of PUNCAMPA @ wage rate Rs. 342/-, for J&K UT SoR of 2017 @ Rs. 225/- has been applied. Also

an increase of 7% has been added each year i.e. 2nd year onwards to compensate inflation.

- i. The budget will be provided after submission of Annual Plan Operations (APO) for each year. So the prevailing wage rate will be applicable whenever DPR is implemented. Also site can be changed as per the site available at the time of implementation wherever required.
- j. In Himachal Pradesh, further 25% hike in wage rates would be applied for Tribal Areas.
- k. The fencing cost has been calculated on average basis of enclosure of area to the extent of 5 hectare and average carriage lead is taken as 1 km (up & down).
- l. The nursery time for plants in multitier model is taken on average basis i.e. 1.5 – 4.5 year so average is 3 years, for calculating the norm. Also the plant cost is taken from the norm prescribed by the Forest Department of respective States.
- m. These cost Norms indicate the upper limits. The expenditure will be booked under various items shown in the detailed models as per actual work done in the field as per Schedule of Labour rates of the respective States/UT and will not exceed these/departmental norms.
- n. The suggestive cost models are to create multistoried forest cover for improving the bio-diversity of the area which in turn conserves the water and soil in-situ.
- o. In Lantana eradication models or wherever Lantana removal is involved, the Cut Root Stock (CRS) method should be adopted.
- p. The fencing work includes the 4-strands of barbed wire with interlacing of thorny bushes.
- q. In fire protection model as area is virtually targeted, hence implementing agency should rotate fire protection operations in areas of the division so that each selected area takes operations after 3 years.
- r. In agriculture models the guidelines of Sub-Mission on Agroforestry (SMAF) of Central Government should be considered as being adopted in States and UT.
- s. Under Urban Landscape, the Seechewal Model (Punjab) for bio-remediation and bio-filtration may be taken into consideration.
- t. Also in Urban landscape, Ecopark Development, Institutional Plantation and Riverfront Development models can be converged with Nagar Van Yozna as launched by GoI.
- u. In Soil and water conservation models, the watershed approach and techniques should be adopted for desired results. For this intervention the Annual Plan Operation (APO) should be submitted each year with the proposal of microplan of specific sites with detailed estimates.

- v. In Riverine and Riparian Management and Wetland Management models, areas shown in budgetary provisions are virtual and concerned Implementing Agency (IA) should clearly mention the proposed activities in Annual Plan operation (APO) to be taken up in particular area with detailed microplan and estimates.
- w. Plantation models are for the general areas as proposed by the Territorial Divisions but for the protected areas, two models under conservation Intervention viz. Riverine and Riparian management and Wetland Management.

a. Treatment Models for Natural Landscape

Proposed treatment models in Natural Landscape are broadly grouped in two categories: (a) in the mountainous tract/hills of Himachal Pradesh, and (b) in alluvial plains of Punjab. Elaborate details on various treatment models are presented in the following section.

(A) Treatment Models for Natural Landscape in Hills

As already stated, various natural land use and land cover categories together constitute the largest area of the Beas Riverscape and it is represented by diverse forests, alpine pastures, scrub, snow cover/glaciers, rivers, wetlands, etc. Thus, the maximum number of treatment models has been proposed in the mountainous/ hill portion of the riverscape. Various forestry interventions are proposed to be implemented in the entire upper basin of the Beas River and its tributaries through following models. Primarily, these models would be applied on forest lands under the control of SFD. The proposed treatment sites would mainly include areas under open forest, scrub, grasslands, and alpine pastures or along the river and its tributaries. One of the models BS/HP/NL/13 pertaining to plantation in temperate forests, particularly in higher reaches and difficult areas is proposed to be executed by the Eco Task Force. Details of each of the 15 treatment models prescribed in the natural landscape are presented below one by one.

Model - BS/HP/NL/01

Sub Alpine Conservation

Zone

Sub Alpine and Moist Alpine Areas

The sub-alpine and moist alpine zones are at 3,600 m – 4,200 m altitude and are mostly snow-bound. The temperature remains below 5° C for 6 months in a year. The active plant growth season is of almost 4-6 months. This region is above the tree line with varied rock formations. Vegetation is dominated by grasses and herbs with scattered shrubs. A low deciduous scrub formation usually about 1 m high forms a dense cover in some patches.

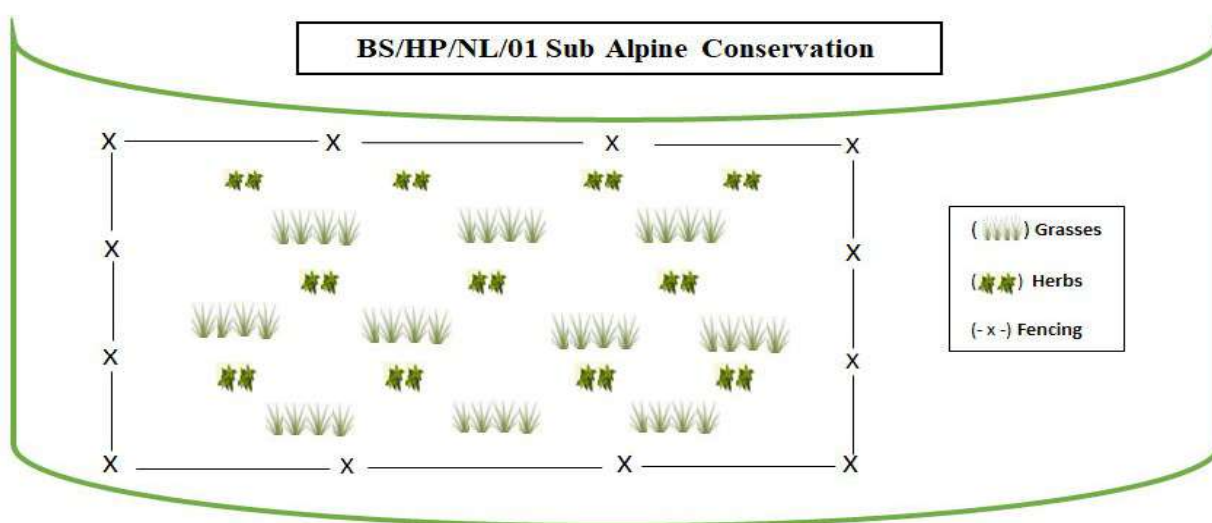
Under this model, it is proposed to conserve and augment vegetation of the alpine meadows. The major focus will be on conservation of native species and livelihood generation for local communities. The conservation practices as prescribed in the Working Plan of respective

territorial forest division and wildlife management plan of protected areas will be applicable. The collection of medicinal and aromatic plants species would be regulated as per the State's policy on the medicinal plants and accordingly the benefit will be shared with local communities. Under this model, medicinal plant species will be planted at the rate of 2,400 plants/ha in the blank areas. Root slips/ seeds of native grasses will be put in continuous contour strips immediately after melting of snow in 600/ha patches. The high altitude medicinal plants require two years nursery period and third year planting in the field along with grasses. For producing quality nursery stock of desired species, native zone soil will be used and VAM will be added in nursery to boost growth either species specific or as consortium. It will be followed by two years maintenance. Harvesting can be started after 5th year onwards in sustainable manner.

List of illustrative species for plantation

Herbs/Medicinal Plants: *Aconitum heterophyllum*, *Ainsliaea aptera*, *Arnebia benthamii*, *Dactylorhiza hatagirea*, *Heracleum candicans*, *Angelica glauca*, *Polygonatum verticillatum*, *Selinum wallichianum*, *Allium humile*, *Geranium wallichianum*, *Rheum australe*, *R. moorcroftianum*, *Podophyllum hexandrum*, *Saussurea costus*, etc.

Grasses and Forbs: *Festuca pratensis*, *F. valesiaca*, *Trifolium pratense*, *Poa pratensis*, *Poa annua*, *Dactylis glomerata*, *Erianthus* spp., *Agrostis gigantea*, *A. pilosula*, *A. munroana*, *Agropyron* spp., *Danthonia* spp., *Calamagrostis montanus*, *Koeleria* spp., *Brachypodium sylvaticum*, *Bromus himalaicus*, *B. ramosus*, *Danthonia cuminsii*, *Stipa roylei*, etc.



Herbs: Patch number - 600, Patch size (cm) - 30 x 30 x 5. Spacing (m) - 2 x 8, Plant per patch - 4, Spacing (cm) – 20 x 20 (planting in 3rd Year)

Grasses: Patch number - 600, Patch size (cm) – 100 x 30 x 5. Spacing (m) – 2 x 8, Seed/patch (gm) – 6gm, Spacing (cm) – 10 x 10

Fencing: Cement pole/ angle Iron pole Local material - wood/ Branches

***Labour Rate Rs 250 in 1st year and Annual Increase @ 7% in Subsequent Years**

Table 5. 2 – Cost Norms For Model BS/HP/NL/01

BS/HP/NL/01 (Sub Alpine Conservation)				
Year	Item	Detail of work	Amount (Rs)/ ha	Man days
	Number of Plants (No.)	2400 herbs + 600 patch of Grasses		
1 st Year	Advance Work Labour Cost	Establishment of Nursery	12,000	48
2 nd year	Advance Work Labour Cost	Maintenance of Nursery+ Establishment of plants for Ist year Maintenance	10,200	38
2 nd year	Advance Work Material	Cost of Seed, Farm yard manure (FYM), Barbed wire and Reinforced Cement Concrete (RCC) poles	55,600	0
2 nd year	Advance Work Labour Cost	Site Preparation, site preparation i/c survey & demarcation, Bush Cutting in strips , collection of debris, burning of debris, preparation of inspection path, Carriage of RCC poles, Digging of holes and Fixing for poles, Stretching & fixing of B/wire	54,910	205
3 rd year	Advance Work Labour Cost	Maintenance of Nursery for creation and maintenance work 1 st and 2 nd year plants in nursery	9,000	31
3 rd year	Creation	Carriage of Plants, Lay out of pits and patches, Pitting & Planting of Plants, Patches & Planting of Herbs, Preparation of strips including (i/c) sowing in strips, Weeding, mulching, etc.	25,087	88
	Total Establishment Cost		1,66,797	410
		MAINTENANCE		
4 th year	Maintenance Cost - I Year i/c Material	Nursery maintenance, Material cost, planting cost & other maintenance works	22,517	68
5 th year	Maintenance Cost - II Year	Nursery maintenance, Material cost, planting cost & other maintenance works	17,515	49
6 th year	Maintenance Cost - III Year	Nursery maintenance, Material cost, planting cost & other maintenance works	13,199	35
7 th year	Maintenance Cost -	Maintenance cost of fencing	582	2

BS/HP/NL/01 (Sub Alpine Conservation)				
Year	Item	Detail of work	Amount (Rs)/ ha	Man days
	IV Year			
	Total Maintenance Cost		53,813	154
		Total cost of Plantation	220610	564

Model No – BS/HP/NL/02
Sub Alpine Enrichment
Zone
Sub-alpine Zone

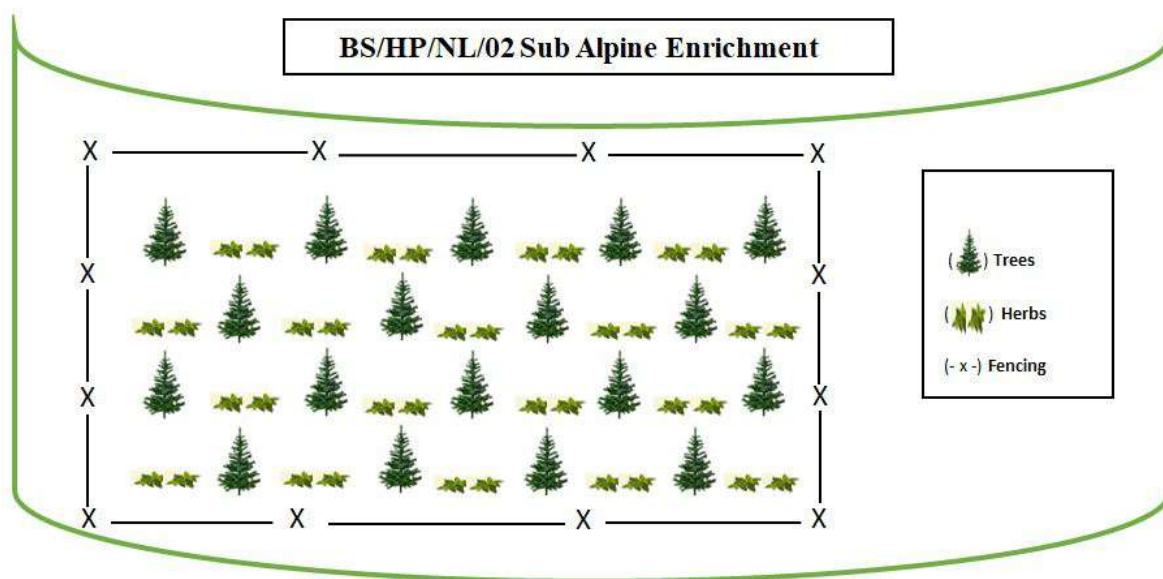
The Sub-alpine zone occurs at 2,900 m – 3,600 m altitude in the Beas Riverscape and is covered with snow for 4-5 months. The temperature remains below 5° C for around 4 months in a year. Vegetation in sub-alpine zone is dominated by herbs, grasses and shrubs of *Rhododendron* spp., and *Juniperus* spp., Area is sloppy and generally soil depth is very low.

Under this model, it is proposed to conserve and augment vegetation in sub-alpine zone by adopting specific interventions to enrich such areas. The major focus will be on conservation and enrichment of native species besides generation of sustainable livelihoods for local communities. Conservation and enrichment practices as prescribed in the Working Plan of respective territorial forest division /wildlife management plan of a protected area will be applicable. The collection of medicinal and aromatic plant species would be regulated as per the State's policy on medicinal plants and accordingly the accrued benefit will be shared with local communities. In this model, native trees @ 200 plants/ha at 6 m x 8 m spacing and medicinal plant species @ 800 plants/ha at 6 m x 8 m spacing in 200/ha patches will be planted in blank areas. The high altitude tree species requires around 3 years nursery period and planting will be done in the 4th year. For producing quality nursery stock of desired species, native zone soil will be used in conifer species and VAM will be added in other forestry species either species specific or as consortium. To synchronize planting of trees and medicinal plants in the 4th year, nursery of high attitude medicinal plants will be raised 2nd year onwards. The plants will be maintained in the field during 5th, 6th and 7th year of project implementation.

List of species for plantation:

Trees: *Betula utilis*, *Pinus wallichiana*, *Picea smithiana*, *Acer caesium*, *A. pictum*, *Corylus jacquemontii*, *Prunus cornuta*, *Quercus semecarpifolia*, etc.

Herbs/Medicinal Plants: *Aconitum heterophyllum*, *Arnebia benthamii*, *Dactylorhiza hatagirea*, *Heracleum candicans*, *Polygonatum verticillatum*, *Selinum wallichianum*, *Allium humile*, *Geranium wallichianum*, *Bergenia stracheyi*, *Phytolacca acinosa*, *Angelica glauca*, *Picrorhiza kurrooa*, etc.



.Shrubs: Plants: 200/ha., Spacing (m) - 6 x 8, Pit size (cm) – 30 x 30 x 30
 Herbs: Plants: 800/ha, Patch no – 200/ha, Patch size (cm) - 30 x 30 x 5. Spacing (m) - 6 x 8, plant/ patch - 4, Spacing (cm) – 20 x 20
 Fencing: Cement pole/ angle Iron pole/local material Wood/ Branches

Table 5.3 – Cost Norms for Model BS/HP/NL/02

BS/HP/NL/02 (Sub Alpine Enrichment)				
Year	Item	Detail of works	Amount	Man days
	Number of Plants (No.)	Shrubs: 200, herbs- 800		
1 st Year	Advance Work Labour Cost (Rs.)	Establishment of Nursery	400	2
2 nd year	Advance Work Labour Cost (Rs.)	Establishment of plants for 1st year maintenance of plantation	3,746	14
3 rd year	N-Advance Work Labour Cost (Rs.)	Maintenance of Nursery of herbs+ 1st and 2nd year maintenance of plant in nursery	10,650	37
4 th year	A-Advance Work Labour Cost (Rs.)	Nursery 1st year of herbs+ 1st, 2nd and 3 rd year maintenance of trees nursery	17,787	12
4 th year	Advance Work Material (Rs.)	Cost of Seed, Farm yard Manure (FYM), Barbed wire and Reinforced Cement Concrete (RCC) poles	55,000	0
4 th year	Advance Work Labour Cost (Rs.)	Site Preparation,- site preparation i/c survey & demarcation, Bush Cutting in strips, collection of debris, burning of debris, preparation of inspection path, Carriage of	62,867	205

BS/HP/NL/02 (Sub Alpine Enrichment)				
Year	Item	Detail of works	Amount	Man days
		fence RCC pole and RCC poles, Digging of holes and Fixing for poles, Stretching & fixing of B/wire		
5 th year	Advance Work Labour Cost (Rs.)	Maintenance of Nursery for creation and maint. works 1 st and 2 nd year plants of nursery	12,805	39
5 th year	Creation (Rs.)	Carriage of Plants, Lay out of pits and patches, Pitting & Planting of Plants, Patches & Planting of Herbs, Preparation of strips including (i/c) sowing in strips, Weeding, mulching, etc.	7,659	23
	Total Establishment Cost (Rs.)		1,70,914	332
		MAINTENANCE		
6 th year	Maintenance Cost - I Year i/c Material (Rs.)	Nursery maintenance, Material cost, planting cost & other maintenance works	13,793	35
7 th year	Maintenance Cost - II Year (Rs.)	Nursery maintenance, Material cost, planting cost & other maintenance works	8,993	20
8 th year	Maintenance Cost - III Year (Rs.)	Nursery maintenance, Material cost, planting cost & other maintenance works	3,305	6
	Total Maintenance Cost (Rs.)		26,091	61
Total cost of Plantation			1,97,005	394

Model No – BS/HP/NL/03

Temperate Conifer Forest

Zone

Moist Temperate Area

The moist temperate area lies at 1,700 m to 3,500 m altitude. This zone is characterized by dense forests, mainly of conifer species. However, blank patches too occur at several places which will be taken up for proposed treatment. In some areas, especially in fir and spruce forests, soil is covered with a thick layer of humus as the decomposition rate is very slow in these areas. The suggested treatment model for these areas is being referred as the Temperate Conifer Forest Model.

Planting of 300/ha plants of various tree species and 300/ha shrub species will be carried out per ha. In addition, 300/ha patches of medicinal plants with 1200 plants/ha will also be planted out in the treatment site. The small stream or *Nallah* facing side of the treatment area

will be planted with two rows of hill bamboo at 2 m x 2 m spacing with 200/ha plants of hill bamboo. The major focus will be on the conservation and development of native species and livelihood generation for local communities. The collection of medicinal and aromatic plants species in protected areas would be regulated as per the State's policy on medicinal plants and in accordance with the rights of local communities. Most of conifer plants require around 3 years of nursery period and planting will be done in the 4th year. For producing quality nursery stock of desired species, native zone soil will be used in conifer species and VAM will be added in shrubs and herb either species specific or as consortium To synchronize planting of trees, medicinal herbs and shrubs in 4th year, the nursery for selected herbs and shrubs will be raised 2nd year onwards. The plants will be maintained in the field during 5th, 6th and 7th year of the project implementation.

List of species for plantation:

Trees: *Cedrus deodara*, *Pinus wallichiana*, *Picea smithiana*, *Taxus wallichiana*, *Cupressus torulosa*, etc.

Shrubs: *Drepanostachyum falcatum*, *Daphne papyracea*, *Principia utilis*, *Rosa sericea*, *R. moschata*, *Debregeasia hypoleuca*, *Cotoneaster bacillaris*, *Viburnum cotinifolium*, *V. grandiflorum*, *Cornus oblonga*, *Syringa emodi*, *Indigofera heterantha*, *Desmodium elegans*, *Hypericum oblongifolium*, etc.

Herbs: *Aconitum heterophyllum*, *Picrorhiza kurrooa*, *Heracleum candicans*, *Angelica glauca*, *Geranium wallichianum*, *Podophyllum hexandrum*, *Polygonatum verticillatum*, *P. cirrhifolium*, *Bergenia stracheyi*, *Bergenia ciliata*, *Viola pilosa*, *Trillium govanianum*, *Phytolacca acinosa*, *Valeriana jatamansi*, etc.



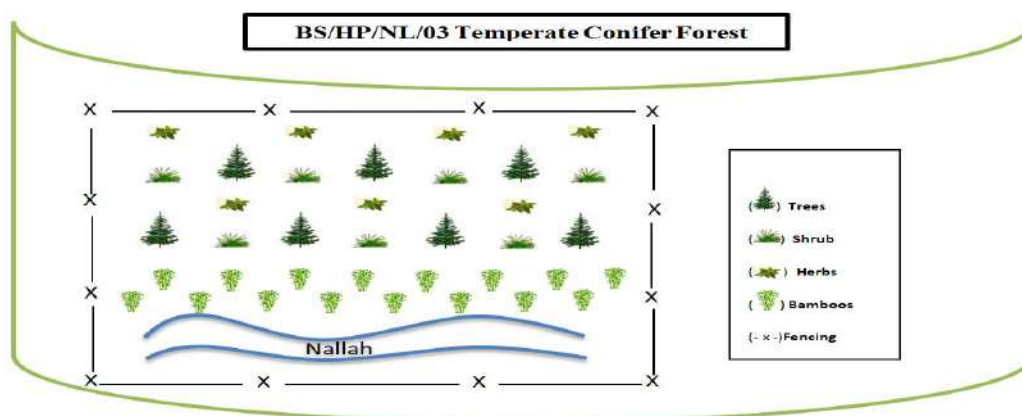
*Polygonatum
verticillatum*



Bergenia ciliata



Trillium govanianum



Trees = 300/ha, Spacing (m) – 5 x 5, Pit size (cm) – 45 x 45 x 45

Bamboo (hill): 200/ha, Spacing (m)-2 x 2, Pit size (cm) – 45 x 45 x 45 (along *Nallah*)

Shrubs: Plants: 300/ha., No. of Pit - 300, Spacing (m) - 5 x 5, Pit size (cm) – 30 x 30 x 30 (gap filling)

Herbs: Plants: 1200/ha, Patch no – 300/ha, Patch size (cm) - 30 x 30 x 5. Spacing (m) – 5 x 5, Plant/patch - 4, Spacing (cm) – 20 x 20

Fencing: Cement pole/ angle Iron pole /local material wood/ Branches

Table 5. 4 – Cost Norms for Model BS/HP/NL/03

BS/HP/NL/03 (Temperate Conifer Forest)				
Year	Item	Detail of work	Amount/ha	Man days
	Number of Plants (No.)	Plants- 300 No., Bamboo-200, Shrubs-300 no., Herbs- 1200 no (300 no. patches)		
1 st Year	Advance Work Labour Cost (Rs.)	Establishment of Nursery	10,000	40
2 nd year	Advance Work Labour Cost (Rs.)	Maintenance of Nursery + Establishment of plants for 1st year maintenance	38,879	145
2 nd year	Advance Work Material (Rs.)	Cost of Seed, Farm yard manure (FYM), Barbed wire and Reinforced Cement Concrete (RCC) poles	52,000	0
2 nd year	Advance Work Labour Cost (Rs.)	Site Preparation,- site preparation i/c survey & demarcation, Bush Cutting in strips, collection of debris, burning of debris, preparation of inspection path, Carriage of RCC poles, Digging of holes and Fixing for poles, Stretching & fixing of B/wire	54,910	205
3 rd year	Advance Work Labour Cost (Rs.)	Maintenance of Nursery for creation and maintenance works 1 st and 2 nd year plantation in nursery	28,603	100

BS/HP/NL/03 (Temperate Conifer Forest)				
Year	Item	Detail of work	Amount/ha	Man days
3 rd year	Creation (Rs.)	Carriage of Plants, Lay out of pits and patches, Pitting & Planting of Plants, Patches & Planting of Herbs, Preparation of strips including (i/c) sowing in strips, Weeding, mulching, etc.	45,157	158
	Total Establishment Cost (Rs.)		2,29,549	648
		MAINTENANCE		
4 th year	Maintenance Cost - I Year i/c Material (Rs.)	Nursery maintenance, Material cost, planting cost & other maintenance works	37,034	118
5 th year	Maintenance Cost - II Year (Rs.)	Nursery maintenance, Material cost, planting cost & other maintenance works	20,711	61
6 th year	Maintenance Cost - III Year (Rs.)	Nursery maintenance, Material cost, planting cost & other maintenance works	16,107	44
7 th year	Maintenance Cost - IV Year (Rs.)	Maintenance cost of fencing	582	2
	Total Maintenance Cost (Rs.)		74,434	225
Total cost of Plantation			303983	873

Model No – BS/HP/NL/04

Temperate Mixed Forest

Zone

Moist Temperate Area

The moist temperate forest area occurs at 1,700 m to 3,500 m altitude. Dominant species of the area are: *Betula utilis*, *B. alnoides*, *Aesculus indica*, *Quercus oblongata*, *Q. floribunda*, *Q. semecarpifolia*, *Alnus nitida*, *Acer caesium*, *A. pictum*, *A. cappadocicum*, *Ulmus wallichiana*, *Pinus wallichiana*, *Cedrus deodara*, *Picea smithiana*, *Abies pindrow*, *A. spectabilis* and *Cupressus torulosa*. Sometime, one species may occur in form of pure stands. This zone is often characterized by degraded stretches along the river banks running close to the area of dense temperate forests, mainly of conifers. This zone experiences snowfall and rainfall several times during winter months and enjoys a cool climate with plenty of monsoon rains.

Annual precipitation in this zone is around 1,000 mm to 1500 mm. In some areas, snow lasts till spring season. The soil in many places is shallow, exposed and prone to erosion. This zone is heavily grazed by domestic animals and cause huge damage to the vegetation.

Besides this, road construction and other developmental activities also cause severe soil erosion, resulting in damage to vegetation. There is heavy dependence of local communities on Oak fodder within Beas Riverscape. Further, owing to several famous tourist spots viz., Manali, Kullu, Manikaran, Parashar Lake, etc. and the enhanced tourism activities in such zones within the riverscape cause damage to vegetation and disturbance to wild fauna.

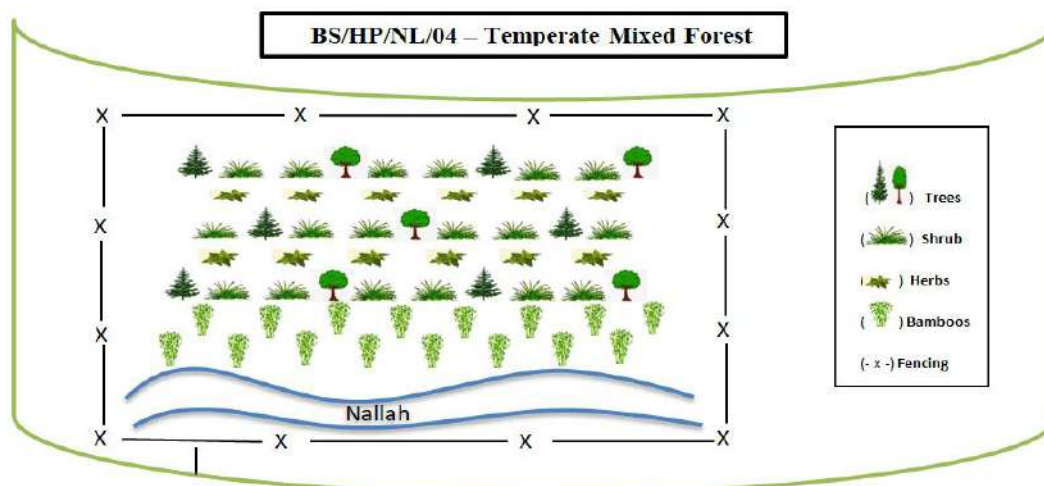
Temperate mixed forest treatment model has been proposed specifically for the blank and degraded patches within the temperate zone. Planting of trees @300/ha belonging to conifers and broadleaved species will be carried out in the blank and degraded patches. In this model preferably broadleaved plant will be planted in general and conifer plants can be planted on the ridges and shallow soil depth area. The native shrubs @300 plants/ha will be carried out in between the tree planted. The medicinal plants species will also be planted in patches @ 4 plants/ patch and that means planting of total of 1,200 medicinal plants/ ha. The small stream or *Nallah* facing side of the treatment site will be planted with two rows of hill bamboo @ 200/ha at 2 m x 2 m spacing. The major focus of the proposed treatment model will be on the conservation and propagation of native species alongside improved livelihoods for local communities. Most of conifer plants require around 3 years of nursery period and planting will be done in the 4th year. For producing quality nursery stock of desired species, native zone soil will be used in conifer species and VAM will be added in shrubs and herb either species specific or as consortium. To synchronize planting of trees, medicinal herbs and shrubs in 4th year, the nursery for selected herbs and shrubs will be raised 2nd year onwards. The plants will be maintained in the field during 5th, 6th and 7th year of the project implementation. The collection of medicinal and aromatic plant species in protected areas would be regulated as per the State's policy on medicinal plants and in accordance with the rights of local communities.

List of species for plantation:

Trees: *Cedrus deodara*, *Pinus wallichiana*, *Picea smithiana*, *Taxus wallichiana*, *Aesculus indica*, *Prunus cornuta*, *P. cerasoides*, *Acer caesium*, *A. pictum*, *Betula alnoides*, *Alnus nitida*, *Ulmus wallichiana*, *Quercus glauca*, *Q. oblongata*, *Q. floribunda*, *Q. semecarpifolia*, *Cornus capitata*, etc.

Shrubs: *Drepanostachyum falcatum*, *Daphne papyracea*, *Prinsepia utilis*, *Rosa moschata*, *Debregeasia saeneb*, *Cotoneaster bacillaris*, *Viburnum grandiflorum*, *V. mullaha*, *Elaeagnus conferta*, *Hypericum oblongifolium*, *Rubus biflorus*, *R. niveus*, *R. ellipticus*, *Zanthoxylum armatum*, *Deutzia staminea*, *D. corymbosa*, etc.

Herbs: *Aconitum heterophyllum*, *Heracleum candicans*, *Angelica glauca*, *Geranium wallichianum*, *Polygonatum verticillatum*, *P. cirrhifolium*, *Podophyllum hexandrum*, *Bergenia ciliata*, *Viola pilosa*, *Valeriana jatamansi*, *Hedychium spicatum*, etc.



Trees = 300 /ha, Spacing (m) - 5 x 5, Pit size (cm) – 45 x 45 x 45 (50;50 of B/L & Conifer)
 Bamboo (hill): 200/ha,, Spacing (m) -5 x 5, Pit size (cm) – 45 x 45 x 45 (along *Nallah*)
 Shrubs: Plants: 300/ha, No. of Pit - 300, Spacing (m) - 2 x 5, Pit size (cm) – 30 x 30 x 30
 Herbs: Plants: 1200/ha, Patch no – 300, Patch size (cm) - 30 x 30 x 5. Spacing (m) - 3 x 5, plant / patch - 4, Spacing (cm) - 20 x 20
 Fencing: Cement pole/ angle Iron polelocal material wood/ Branches

Table 5. 5 – Cost Norms for Model BS/HP/NL/04

BS/HP/NL/04 (Temperate Mixed Forest)				
Year	Item	Detail of works	Amount/ha	Man days
	Number of Plants (No.)	Plants- 300 No., Bamboo-200, Shrubs-300 no., Herbs- 1200 no (300 no. patches)		
1 st Year	Advance Work Labour Cost (Rs.)	Establishment of Nursery	14,491	58
2 nd year	Advance Work Labour Cost (Rs.)	Maintenance of Nursery+ Establishment of plants for 1st year maintenance	33,045	124
2 nd year	Advance Work Material (Rs.)	Cost of Seed, Farm yard manure (FYM), Barbed wire and Reinforced Cement Concrete (RCC) poles	52,000	0
2 nd year	Advance Work Labour Cost (Rs.)	Site Preparation,- site preparation i/c survey & demarcation, Bush Cutting in strips, collection of debris, burning of debris, preparation of inspection path, Carriage of fence RCC poleand RCC poles, Digging of holes and Fixing for poles, Stretching & fixing of B/wire	54,910	205
3 rd year	Advance Work Labour Cost (Rs.)	Maintenance of Nursery for creation and maintenance works 1 st and 2 nd year	28,925	101

BS/HP/NL/04 (Temperate Mixed Forest)				
Year	Item	Detail of works	Amount/ha	Man days
		plantaion in nursery		
3 rd year	Creation (Rs.)	Carriage of Plants, Lay out of pits and patches, Pitting & Planting of Plants, Patches & Planting of Herbs, Preparation of strips including (i/c) sowing in strips, Weeding, mulching, etc.	45,157	158
	Total Establishment Cost (Rs.)		2,28,528	646
MAINTENANCE				
4 th year	Maintenance Cost - I Year i/c Material (Rs.)	Nursery maintenance, Material cost, planting cost & other maintenance works	38,815	117
5 th year	Maintenance Cost - II Year (Rs.)	Nursery maintenance, Material cost, planting cost & other maintenance works	20,711	61
6 th year	Maintenance Cost - III Year (Rs.)	Nursery maintenance, Material cost, planting cost & other maintenance works	16,107	44
7 th year	Maintenance Cost - IV Year (Rs.)	Maintenance cost of fencing	582	2
	Total Maintenance Cost (Rs.)		76,215	224
Total cost of Plantation			304743	870

Model No – BS/HP/NL/05

Pasture and Grazing Land Development

Zone

Sub- Tropical to Temperate Areas

The moist temperate areas located at altitude between 600 m to 3,200 m, particularly on southern slope and around habitations are characterized by pasture and grazing lands. This zone experiences snowfall and rainfall several times during winter months and enjoys a cool climate with plenty of monsoon rains. Annual precipitation is around 1,000 mm to 2,000 mm. In some areas, snow lasts till spring season. The soil is shallow, exposed and prone to erosion, particularly in moderate to steep slopes. This zone is heavily grazed by livestock and cause huge damage to the vegetation and results into heavy soil erosion. Besides disturbance by livestock, road construction and other developmental activities also cause significant soil degradation and damage to native flora by proliferation of invasive alien species. The local communities are heavily dependent on these grasslands in the Beas Riverscape. This zone

also severely suffers on account of enhanced tourism activities in several popular tourist destinations viz., Kullu, Manali, Manikaran, Rohtang, Dharamshala etc. causing damage to flora and disturbance to fauna.

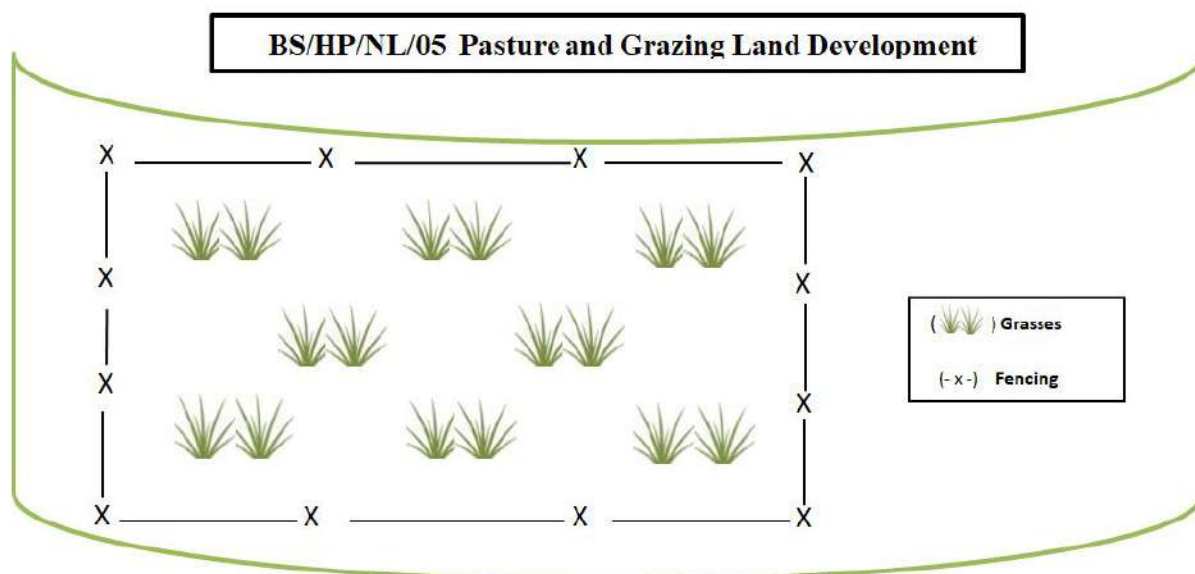
Under this model, pasture and grazing land development are proposed by protection, development and enrichment of areas within this zone. Suitable grass species will be planted/ sowing of seeds after carrying out necessary land development works like trenching/ terracing/ moisture conservation measures, etc. besides removal of weeds and unpalatable grasses. The proposed treatment model mainly includes plantation of native and nutritionally important grass species. In this model, grass sowing in furrows/ strips of 100 cm x 30 cm x 5 cm along contours at interval of 2 m apart is proposed. Selected species will be raised / maintained in the nursery during 1st year and planting will be done in the second year. The grasses will be replenished in the field during 3rd and 4th year.

List of species for plantation:

Grasses/Forbs: *Festuca pratensis*, *Trifolium pratense*, *Poa pratensis*, *P. annua*, *Dactylis glomerata*, *Erianthus* spp., *Agrostis* spp., *Agropyron* spp., *Danthonia* spp., *Calamagrostis* spp., *Koeleria* spp., *Saccharum spontaneum*, *Chrysopogon gryllus*, *Arundinella nepalensis*, *A. pumia*, *Themeda anathera*, *Drepanostachyum falcatum*, *Cymbopogon distans*, *Setaria glauca*, *Alopecurus aequalis*, *A. nepalensis*, *Bothriochloa pertusa*, *B. parviflora*, etc.



Hill Bamboo in plantation



Grasses: Patch no -2000, Patch size (cm) – 100 x 30 x 5. Spacing (m) – 2 x 2, Seed/patch (gm) – 6, seed, Spacing (cm) – 10 x 10, Type - Staggered

Fencing: Cement pole/ angle Iron pole/local material wood/ Branches/ Brushwood fencing

Table 5. 6 – Cost Norms for Model BS/HP/NL/05

BS/HP/NL/05 (Pasture and Grazing Land Development)				
Year	Item	Detail of works	Amount/ha	Man days
	Number of Plants (No.)	Grasses-2000 no. patches		
1 st Year	Advance Work Material (Rs.)	Cost of Seed, Farm yard manure (FYM), Barbed wire and Reinforced Cement Concrete (RCC) poles	66,400	0
1 st Year	Advance Work Labour Cost (Rs.)	Site Preparation,- site preparation i/c survey & demarcation, Bush Cutting in strips, collection of debris, burning of debris, preparation of inspection path, Carriage of RCC Poles and RCC poles, Digging of holes and Fixing for poles, Stretching & fixing of B/wire	54,910	205
2 nd year	Creation (Rs.)	Carriage of Plants, Lay out of pits and patches, Pitting & Planting of Plants, Patches & Planting of Herbs, Preparation of strips including (i/c) sowing in strips, Weeding, mulching etc.	40,850	143
	Total Establishment Cost (Rs.)		1,62,160	348

BS/HP/NL/05 (Pasture and Grazing Land Development)				
Year	Item	Detail of works	Amount/ha	Man days
		MAINTENANCE		
3 rd year	Maintenance Cost - I Year i/c Material (Rs.)	Material cost, planting cost & other maintenance work	27,994	67
4 th year	Maintenance Cost - II Year (Rs.)	Material cost, planting cost & other maintenance works	20,711	61
5 th year	Maintenance Cost - III Year (Rs.)	Material cost, planting cost & other maintenance works	16,107	44
6 th year	Maintenance Cost - IV Year (Rs.)	Maintenance cost of fencing	582	2
Total Maintenance Cost (Rs.)			65394	224
Total cost of Plantation			227554	572

Model No – BS/HP/NL/06

Himalayan Chir Pine Forest

Zone

Sub-Tropical to Lower Temperate Area

This zone occurs in mid hill region of Himachal Pradesh on southern aspect and is dominated by Chir pine. The altitude range of this zone is between 800 m–1,800 m and annual rainfall varies from 1,000 mm to 1,700 mm. In these areas, high temperatures and humidity conditions prevail during summer. Ground is densely covered with pine needles during winter to summer season and such areas are prone to forest fires. Grasses flush during monsoon season. Heavy rains in monsoon lead into severe soil erosion in this zone, ultimately results into high rate of sedimentation in Beas and its tributaries. This is one of the major causes of siltation of dams and floods in Punjab plains. Open and degraded forests on southern aspect with sparse vegetation coupled with agriculture on steep slopes, construction and developmental activities are prominent reasons behind large scale soil erosion in this zone. These areas experience heavy rainfall during monsoon season and modest rainfall during the winter season. Snowfall occurs in cooler aspects of higher reaches but the snow stays for a few days only. Most of the rainwater flows down the streams washing away top soil especially on sloppy sites. The soil is acidic in nature and shallow on steep slopes while valleys have deep soil. The biotic pressure in terms of livestock grazing, fuel wood and fodder collection from the forest area is conspicuous. Suitable forestry interventions in this zone can immensely help in improvement of pastures and grazing lands besides checking soil erosion and siltation into Beas and its tributaries.

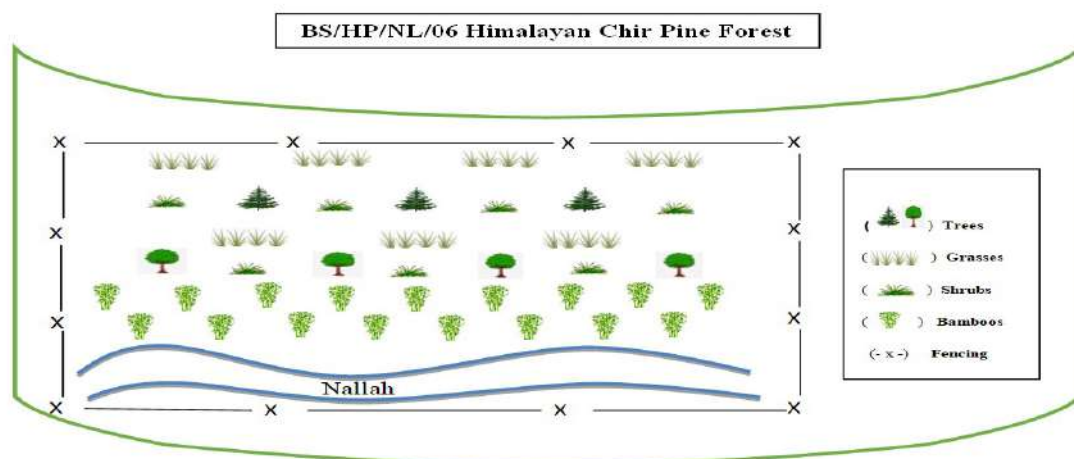
For such areas in this zone, the Himalayan Chir Pine Forest Model is proposed. Grass species such as *Heteropogon contortus*, *Chrysopogon fulvus*, etc. are proposed to be sown in the treatment site, particularly towards the river or *nallah* side. The area will be planted with *Pinus roxburghii* mainly in drier sites with shallow soil depth whereas broadleaved species like *Quercus oblongata*, *Lyonia ovalifolia*, Bamboo spp., etc. on moist sites are proposed to be planted at 5 m x 5 m spacing. A total of 300 plants of tree/ha, 100 bamboo species /ha along with 300 plants of shrubs/ha and 800 patches of grasses will be planted 2m apart in staggered fashion. Chir pine and associated broadleaved species require around 2 years nursery period and planting will be done in the 3rd year. For producing quality nursery stock of desired species, native zone soil will be used in conifer species and VAM will be added in shrubs and herb either species specific or as consortium. The plants will be maintained in the field during 4th, 5th and 6th year. The fire line of width 5m both side along the fencing of the plantation area be maintained twice a year.

List of species for plantation:

Tree: *Pinus roxburghii*, *Quercus oblongata*, *Lyonia ovalifolia*, *Dendrocalamus strictus*, *D. hamiltonii*, *Bambusa* spp., *Holoptelia integrifolia*, *Ficus bengalensis*, *F. racemosa*, *F. rumphii*, *Phyllanthus embellica*, *Diospyros montana*, *Bauhinia variegata*, *Grewia optiva*, *Pyrus pashia*, *Mallotus phillipensis*, etc.

Shrubs: *Desmodium elegans*, *Tephrosia purpurea*, *Justicia adathoda*, *Murraya koenigii*, *M. paniculatus*, *Ricinus communis*, *Cinnamomum tamala*, *Tinospora cordifolia*, *Woodfordia fruticosa*, *Maesa indica*, *Nyctanthes arbor-tristis*, *Vitex negundo*, *Carissa carandas*, *Berberis lycium*, *B. aristata*, *Ziziphus nummularia*, *Z. jujuba*, etc.

Grasses/Forbs: *Heteropogon contortus*, *Chrysopogon fulvus*, *C. serrulatus*, *Boerhavia diffusa*, *Festuca pratensis*, *F. arundinacea*, *Poa pratensis*, *Erianthus filifolius*, *E. rufipilus*, *Agrostis gigantea*, *Agropyron* spp., *Phleum pratense*, *Themeda anathera*, *Arundo donax*, *Cymbopogon martinii*, *Phragmites karka*, *Bothriochloa pertusa*, *B. intermedia*, *Eulaliopsis binata*, *Calamograstis* spp., *Thysanolaena maxima*, etc.



Trees: 300/ha, Spacing (m) - 5 x 5, Pit size (cm) – 45 x 45 x 45

Bamboo : 100/ha, Spacing (m) - 5 x 5, Pit size (cm) – 45 x 45 x 45 along *Nallah* (if available)

Shrubs: Plants: 300/ha, No. of Pit - 300, Spacing (m) - 5 x 5, Pit size (cm) – 30 x 30 x 30

Grasses: Patch no - 800, Patch size (cm) – 100 x 30 x 5. Spacing (m) – 2 x 5, Seed/ patch (gm) – 6gm, Spacing (cm) - 10 x 10, Type – Staggered

Fencing: Cement pole/ angle Iron pole local material wood/ Branches /Brushwood fencing

Table 5. 7 – Cost Norms for Model BS/HP/NL/06

BS/HP/NL/06 (Himalayan Chir Pine Forest)				
Year	Item	Detail of works	Amount/ha	Man days
	Number of Plants (No.)	Plants- 300 No., Bamboo-100, Shrubs-300 no., Grasses- 800 no. patches		
1 st Year	Advance Work Labour Cost (Rs.)	Establishment of Nursery	8,397	34
2 nd year	Advance Work Labour Cost (Rs.)	Maintenance of Nursery+ Establishment of plants for 1st year maintenance	11,861	44
2 nd year	Advance Work Material (Rs.)	Cost of Seed, Farm yard manure (FYM), Barbed wire and Reinforced Cement Concrete (RCC) poles	58,000	0
2 nd year	Advance Work Labour Cost (Rs.)	Site Preparation,- site preparation i/c survey & demarcation, Bush Cutting in strips, collection of debris, burning of debris, preparation of inspection path, Carriage of RCC poles, Digging of holes and Fixing for poles, Stretching & fixing of B/wire	54,910	205
3 rd year	Advance Work Labour Cost (Rs.)	Maintenance of Nursery for creation and maintenance works 1 st and 2 nd year plantation in nursery	11,890	42

BS/HP/NL/06 (Himalayan Chir Pine Forest)				
Year	Item	Detail of works	Amount/ha	Man days
3 rd year	Creation (Rs.)	Carriage of Plants, Lay out of pits and patches, Pitting & Planting of Plants, Patches & Planting of Herbs, Preparation of strips including (i/c) sowing in strips, Weeding, mulching, etc.	52,006	182
Total Establishment Cost (Rs.)			1,96,344	507
		MAINTENANCE		
4 th year	Maintenance Cost - I Year i/c Material (Rs.)	Nursery maintenance, Material cost, planting cost & other maintenance works	39,786	118
5 th year	Maintenance Cost - II Year (Rs.)	Nursery maintenance, Material cost, planting cost & other maintenance works	31,875	90
6 th year	Maintenance Cost - III Year (Rs.)	Nursery maintenance, Material cost, planting cost & other maintenance works	26,144	70
7 th year	Maintenance Cost - IV Year (Rs.)	Maintenance cost of fencing	8588	24
	Total Maintenance Cost (Rs.)		106,393	302
Total cost of Plantation			3,02,737	809

Model No – BS/HP/NL/07
Himalayan Mixed Forest
Zone
Sub-Tropical to Lower Temperate Area

This zone occurs in mid hill region on the northern aspect and is dominated by broadleaved species with some Chir pine in exposed areas. The altitudinal variation in this zone is between 800 m–1,800 m and the zone receives annual rainfall ranging from 1,000 mm to 1,700 mm. The zone experiences high temperatures and humidity prevails during the summer season. In areas wherein Chir pine species is around 50%, the ground is mostly covered with pine needles and area is prone to forest fires. Grasses in slopes flush during the monsoon season. Heavy rains in the monsoon season cause severe soil erosion and sedimentation in Beas River or its tributaries. Moderately dense to open forests on the northern aspect coupled with agriculture on terraces along moderately steep slopes, and construction and development activities are primary reasons for large scale soil erosion in this zone. These areas experience heavy rainfall during the monsoon season and modest rainfall during the winter season.

Snowfall occurs on cooler aspects of higher reaches but the snow stays for a short duration of few days. Most of the rainwater flows down the streams washing away top soil especially on sloppy sites. The soil is neutral to acidic in nature and shallow on slopes while valleys have deep soils. The biotic pressure (livestock grazing, and collection of fuel wood & tree fodder) is severe. Appropriate forestry interventions in this zone can immensely help in improvement of the zone and also river flow.

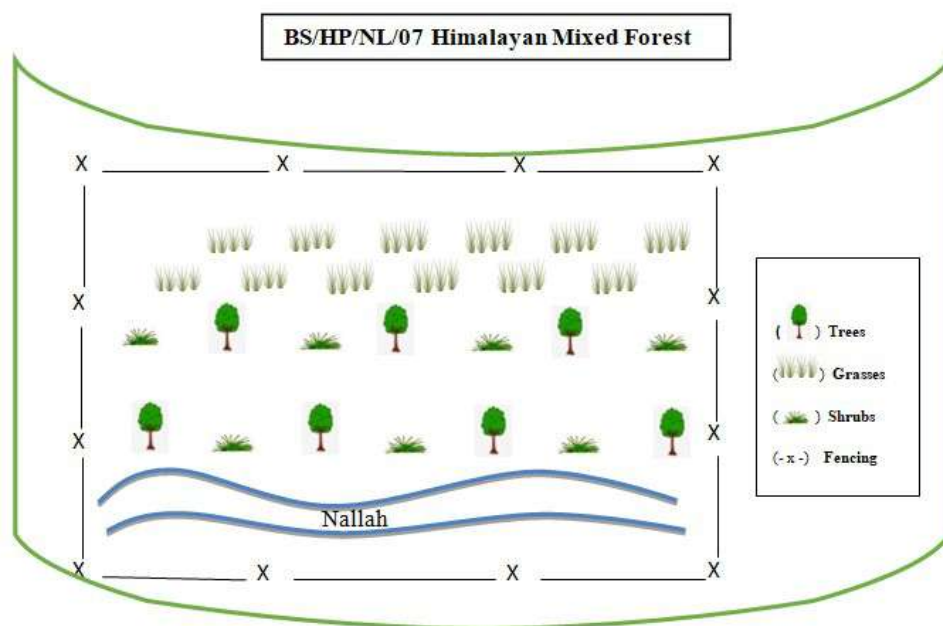
The Himalayan Mixed Forest Model is recommended for this zone. Grass species such as *Heteropogon contortus*, *Chrysopogon fulvus*, etc. will be sown or planted in the part of treatment site, particularly on the ridges. The treatment area will be planted with broadleaved species like *Quercus leucotricophora*, *Lyonia ovalifolia*, *Toona ciliata*, *Syzygium cumini*, *Grewia optiva*, *Pyrus pashia*, *Albizia* spp., *Phyllanthus emblica*, *Holoptelia integrifolia*, *Ficus* spp., *Punica granatum*, *Bauhinia variegata*, etc. Plants will be planted at 5 m x 5 m spacing. A total of 300 plants of tree/ha., 300 plants of shrubs/ha and 200 patches of 2x2 m apart grasses on the ridges/degraded sites will be planted. Broad leaved species of this zone require around one and half year to two years of nursery period and planting will be done in the 3rd year. For producing quality nursery stock of desired species VAM will be added either species specific or as consortium. The plants will be maintained in the 4th to 6th year. The fire line of width 5m both side along the fencing of the plantation area be maintained twice a year.

List of species for plantation:

Trees: *Quercus leucotricophora*, *Lyonia ovalifolia*, *Holoptelia integrifolia*, *Ficus racemosa*, *F. rumphii*, *Albizia* spp., *Phyllanthus embellica*, *Bauhinia variegata*, *Grewia optiva*, *Pyrus pashia*, *Toona ciliata*, *Morus alba*, *Syzygium cumini*, *Punica granatum*, *Terminalia* spp., etc.

Shrubs: *Rosa moschata*, *Debregeasia hypoleuca*, *Elaeagnus* spp., *Zanthoxylum armatum*, *Berberis lycium*, *B. aristata*, *Ziziphus nummularia*, *Z. jujuba*, *Carissa carandas*, *Murraya koenigii*, *Desmodium gangeticum*, *Tephrosia purpurea*, *Justicia adathoda*, *Murraya paniculatus*, *Ricinus communis*, *Cinnamomum tamala*, *Tinospora cordifolia*, *Woodfordia fruticosa*, *Maesa indica*, *Nyctanthes arbor-tristis*, *Vitex negundo*, etc.

Grasses/Forbs: *Heteropogon contortus*, *Chrysopogon fulvus*, *C. serrulatus*, *Boerhavia diffusa*, *Festuca pratensis*, *F. arundinacea*, *Poa pratensis*, *Erianthus filifolius*, *E. rufipilus*, *Agrostis gigantea*, *Agropyron* spp., *Phleum pratense*, *Themeda anathera*, *Arundo donax*, *Cymbopogon martinii*, *Phragmites karka*, *Bothriochloa pertusa*, *B. intermedia*, *Eulaliopsis binata*, *Calamograstis* spp., *Thysanolaena maxima*, etc.



Trees: 300/ha, Spacing (m) – 5 x 5, Pit size (cm) – 45 x 45 x 45

Shrubs: 300 /ha, spacing (m) – 5 x 5, Pit size (cm) – 30 x 30 x 5,.

Grasses: Patch number – 200, Patch size (cm) – 100 x 30 x 5. Spacing (m) – 2 x 2, Seed/ patch (gm) – 6gm, Spacing (cm) – 10 x 10, Type –Staggered,

Fencing: Cement pole/ angle Iron pole local material wood/ Branches /Brushwood fencing

Table 5. 8 – Cost Norms for Model BS/HP/NL/07

BS/HP/NL/07 (Himalayan Mixed Forest)				
Year	Item	Detail of works	Amount/ha	Man days
	Number of Plants (No.)	Plants- 300 No., Shrubs-300 no., Grasses-200 no. patches		
1 st Year	Advance Work Labour Cost (Rs.)	Establishment of Nursery	8397	34
2 nd year	Advance Work Labour Cost (Rs.)	Maintenance of Nursery+ Establishment of plants for 1st year maintenance	11861	44
2 nd year	Advance Work Material (Rs.)	Cost of Seed, Farm yard manure (FYM), Barbed wire and Reinforced Cement Concrete (RCC) poles	52600	0
2 nd year	Advance Work Labour Cost (Rs.)	Site Preparation,- site preparation i/c survey & demarcation, Bush Cutting in strips, collection of debris, burning of debris, preparation of inspection path, Carriage of RCC poles, Digging of holes and Fixing for poles, Stretching & fixing of B/wire	54910	205
3 rd year	Advance Work Labour Cost (Rs.)	Maint. of Nursery for creation and maint. Works, 1 st and 2 nd year plants in nursery	11890	42

BS/HP/NL/07 (Himalayan Mixed Forest)				
Year	Item	Detail of works	Amount/ha	Man days
3 rd year	Creation (Rs.)	Carriage of Plants, Lay out of pits and patches, Pitting & Planting of Plants, Patches & Planting of Herbs, Preparation of strips including (i/c) sowing in strips, Weeding, mulching	39849	139
Total Establishment Cost (Rs.)			1,79,507	464
MAINTENANCE				
4 th year	Maintenance Cost - I Year i/c Material (Rs.)	Nursery maintenance, Material cost, planting cost & other maintenance works	34,284	108
5 th year	Maintenance Cost - II Year (Rs.)	Nursery maintenance, Material cost, planting cost & other maintenance works	27,652	81
6 th year	Maintenance Cost - III Year (Rs.)	Nursery maintenance, Material cost, planting cost & other maintenance works	22,920	63
7 th year	Maintenance Cost - IV Year (Rs.)	Maintenance cost of fencing	8,588	23
	Total Maintenance Cost (Rs.)		93,444	275
Total cost of Plantation			2,72,951	739

Model No – BS/HP/NL/08

Sub-Tropical Dry Deciduous Forest

Zone

Sub-Tropical Area

This zone occurs in low hill region of Himachal Pradesh and dominated by broadleaved deciduous species. The altitudinal range in this zone is between 300 m and 900 m and the zone experiences annual rainfall varying from 1,000 mm to 1500 mm. Several broadleaved species grow in this zone which shed their leaves during summer months. The zone is represented by deep soil and moderate slope and experiences heavy rainfall during the monsoon season and modest rainfall during the winter season. Heavy rains during the monsoon season transport silt from these areas through number of seasonal water channels, *Nallahs*, rivulets, etc. to the Beas River causing siltation and floods in downstream areas. Besides this, agriculture on slopes and construction and developmental activities are the main reasons for soil erosion from these areas. A large part of rainwater flows down the streams within a few hours of rainfall as surface run off. The soil is shallow on slopes while valleys have deep soil depth. The biotic pressure (livestock grazing, fuel wood and tree fodder

collection) is significant in this zone. Appropriate forestry interventions in this zone would not only check soil erosion and improve vegetation but would also help in improvement in the e-flow of the Beas River and its tributaries.

The Sub-Tropical Dry Deciduous Forest Model is recommended in this zone. Under this model, it is proposed to plant 300 trees of broadleaved species or bamboos. 300 shrubs at 5 m x 5 m in between the tree rows. Strong soil binding grasses like *Arundinella nepalensis*, *Apluda mutica*, *Chrysopogon fulvus* and sedges like *Carex obscura* will be planted on the river or *nallah* facing side of the treatment site. In case of trees, a mixture of timber species like *Dalbergia sissoo*, *Acacia catechu*, *Adina cordifolia*, etc. along with medicinal trees like *Terminalia* spp, *Phyllanthus emblica*, *Oroxylum indicum*, *Sapindus mukrossi*, etc. will be planted at 5 m x 5 m spacing. Management practices and conservation measures as prescribed in the Working Plan of the respective territorial forest division or the wildlife management plan of the protected area will be applicable. Collection of medicinal plants and other NTFP's along with sharing of accrued benefits to local communities would be regulated as per the State's policy on medicinal plants. Nursery of selected trees/shrubs etc. will be established during 1st year and 2nd year and planting will be done in 3rd year. For producing quality nursery stock of desired species VAM will be added either species specific or as consortium. Subsequently, the plantation will be managed during next three years. The fire line of width 5m both side along the fencing of the plantation area be maintained twice a year.



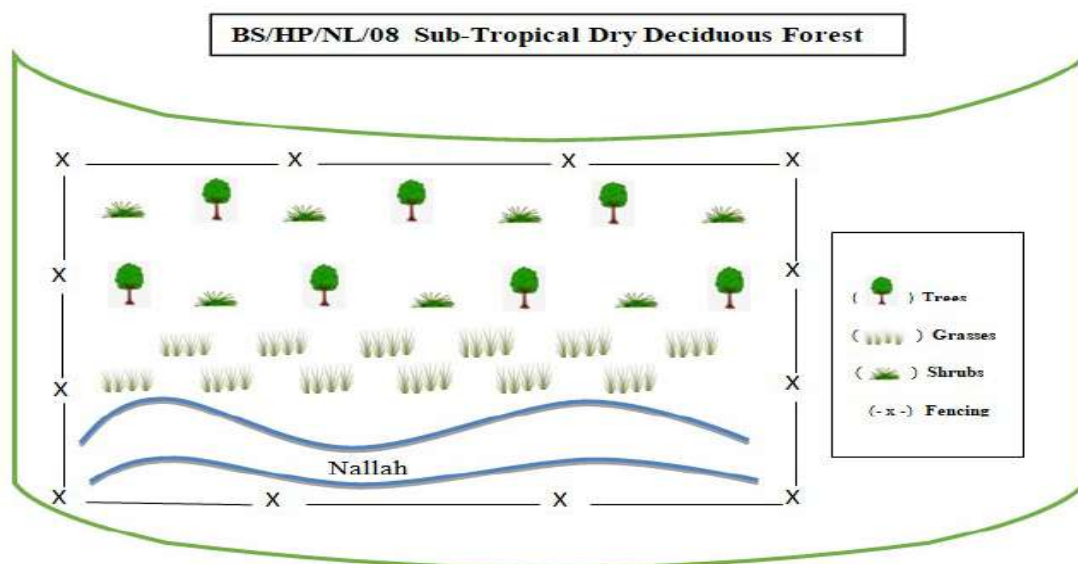
***Oroxylum indicum* – An important NTFP**

List of species for plantation:

Trees: *Dalbergia sissoo*, *Acacia catechu*, *Adina cordifolia*, *Aegle marmelos*, *Terminalia bellirica*, *T. chebula*, *T. arjuna*, *Mallotus philippensis*, *Syzygium cuminii*, *Oroxylum indicum*, *Sapindus mukorossi*, *Dendrocalamus* spp., *Bambusa* spp., *Holoptelia integrifolia*, *Ficus bengalensis*, *F. racemosa*, *F. rumphii*, *Albizia lebbeck*, *A. procera*, *Celtis australis*, *Pyrus pashia*, *Phyllanthus embellica*, *Diospyros montana*, *Bauhinia variegata*, *Grewia optiva*, *Azadirachta indica*, *Myrsine africana*, etc.

Shrubs: *Rosa moschata*, *Debregeasia saeneb*, *Zanthoxylum armatum*, *Berberis lycium*, *Ziziphus nummularia*, *Z. jujuba*, *Carissa carandas*, *Desmodium gangeticum*, *Tephrosia purpurea*, *Justicia adathoda*, *Murraya koenigii*, *M. paniculatus*, *Ricinus communis*, *Cinnamomum tamala*, *Tinospora cordifolia*, *Woodfordia fruticosa*, *Maesa indica*, *Nyctanthes arbor-tristis*, *Vitex negundo*, etc.

Grasses/Forbs: *Heteropogon contortus*, *Chrysopogon fulvus*, *C. serrulatus*, *Boerhavia diffusa*, *Festuca pratensis*, *F. arundinacea*, *Poa pratensis*, *Erianthus filifolius*, *E. rufipilus*, *Agrostis gigantea*, *Agropyron* spp., *Phleum pratense*, *Themeda anathera*, *Arundo donax*, *Cymbopogon martinii*, *Phragmites karka*, *Bothriochloa pertusa*, *B. intermedia*, *Eulaliopsis binata*, *Calamograstis* spp., *Thysanolaena maxima*, etc.



Trees: 300/ha, Spacing (m) - 5 x 5, Pit size (cm) – 45 x 45 x 45

Shrubs: 300/ha spacing (m) - 5 x 5, Pit size (cm) – 30 x 30 x 30

Grasses: Patch no - 200, Patch size (cm) - 100 x 30 x 5. Spacing (m) - 2 x 2, Seed/ patch (gm) – 6gm, Spacing (cm)-10 x 10, Type –Staggered, along *Nallah*/depressions(if available)

Fencing: Cement pole/ angle Iron pole local material wood/ Branches /Brushwood fencing

Table 5. 9 – Cost Norms for Model BS/HP/NL/08

BS/HP/NL/08 (Sub-Tropical Dry Deciduous Forest)				
Year	Item	Detail of works	Amount/ha	Man days
	Number of Plants (No.)	Plants- 300 No., Shrubs-300 no., Grasses-200 no. patches		
1 st Year	Advance Work Labour Cost (Rs.)	Establishment of Nursery	7,940	32
2 nd year	Advance Work Labour Cost (Rs.)	Maintenance of Nursery+ Establishment of plants for 1st year maintenance	11,657	44
2 nd year	Advance Work Material (Rs.)	Cost of Seed, Farm yard manure (FYM), Barbed wire and Reinforced Cement Concrete (RCC) poles	52,600	0

2 nd year	Advance Work Labour Cost (Rs.)	Site Preparation,- site preparation i/c survey & demarcation, Bush Cutting in strips, collection of debris, burning of debris, preparation of inspection path, Carriage of RCC poles, Digging of holes and Fixing for poles, Stretching & fixing of B/wire	54,910	205
3 rd year	Advance Work Labour Cost (Rs.)	Maintenance of Nursery for creation and maintenance work 1 st and 2 nd year plants in nursery	9,544	33
3 rd year	Creation (Rs.)	Carriage of Plants, Lay out of pits and patches, Pitting & Planting of Plants, Patches & Planting of Herbs, Preparation of strips including (i/c) sowing in strips, Weeding, mulching, etc.	39,849	139
	Total Establishment Cost (Rs.)		1,76,500	453
		MAINTENANCE		
4 th year	Maintenance Cost - I Year i/c Material (Rs.)	Nursery maintenance, Material cost, planting cost & other maintenance works	33,563	105
5 th year	Maintenance Cost - II Year (Rs.)	Nursery maintenance, Material cost, planting cost & other maintenance works	27,154	80
6 th year	Maintenance Cost - III Year (Rs.)	Nursery maintenance, Material cost, planting cost & other maintenance works	22,521	62
7 th year	Maintenance Cost - IV Year (Rs.)	Maintenance cost of fencing	8,588	23
	Total Maintenance Cost (Rs.)		91,826	270
Total cost of Plantation			2,68,326	723

Model No – BS/HP/NL/09

Control of Lantana (> 50%)

Zone

Lower Temperate to Sub-Tropical Areas

Invasive alien species are plants which hamper natural regeneration and growth of native species, thereby replacement of native plant species coupled with loss of biodiversity, forage, habitat, aesthetics and productivity of native species in lower temperate and sub-tropical areas. Owing to considerable area of this zone under the influence of *Lantana camara*,

tangible and intangible benefits from lower temperate to sub-tropical forests within the Beas Riverscape have been adversely affected.

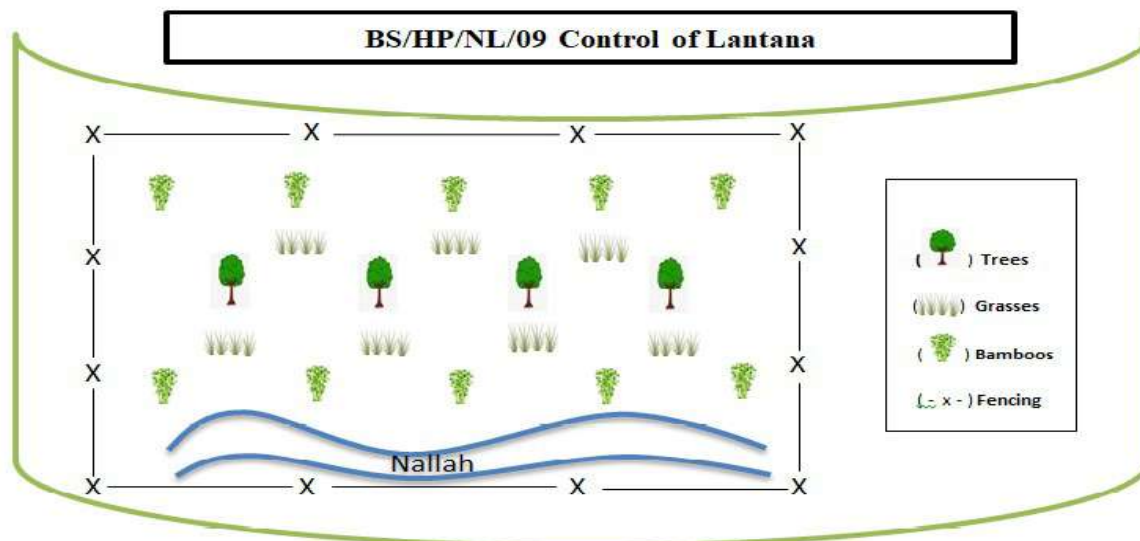
The area for the proposed model referred as Control of Lantana (>50%) covers forest sites between 300 m to 1,200 m wherein the topography is with gentle slopes. Such areas have sub-tropical to lower-temperate climate with around 1,000 mm to 1,500 mm annual rainfall. Soils are generally fertile and moderately deep. The proposed treatment area for this model usually has open or moderately dense forest or scrub vegetation. Luxuriant growth of *Lantana camara* forms dense undergrowth in the forest suppressing the native vegetation of that area.

It is proposed to cut and manually uproot above stated invasive species in treatment sites as per the prescription of CRS (Cut Root Stock) method for complete control of this obnoxious weed. These areas after *Lantana* control will be planted in the third year of project implementation. Grass species such as *Heteropogon contortus*, *Chrysopogon fulvus*, etc. will be sown in the part of treatment site. The treatment area will be planted with broadleaved species like *Toona ciliata*, *Syzygium cumini*, *Grewia optiva*, *Pyrus pashia*, *Albizia* spp., *Phyllanthus emblica*, *Holoptelia integrifolia*, *Ficus* spp., *Punica granatum*, *Bauhinia variegata*, *Dendrocalamus* spp., and *Bambusa* spp., etc. Plants will be planted at 4 m x 4 m spacing. A total of 600 plants of tree and bamboos /ha along with 600 patches of 4x4 m apart grasses on sites will be planted. Alternate rows of bamboo and Broadleaved species will be planted throughout the treatment area. Broadleaved species of this zone require around two and half years of nursery period to produce sturdy plants and planting will be done in the 3rd year. For producing quality nursery stock of desired species VAM will be added either species specific or as consortium. The plants will be maintained in the 4th to 6th years.

List of species for plantation:

Trees: *Dalbergia sissoo*, *Acacia catechu*, *Toona ciliata*, *Adina cordifolia*, *Aegle marmelos*, *Terminalia bellirica*, *T. chebula*, *T. arjuna*, *Mallotus philippensis*, *Syzygium cumini*, *Sapindus mukorossi*, *Dendrocalamus strictus*, *D. hamiltonii*, *Bambusa* spp., *Holoptelia integrifolia*, *Albizia* spp., *Myrica esculenta*, *Celtis australis*, *Pyrus pashia*, *Alstonia scholaris*, *Phyllanthus embellica*, *Diospyros montana*, *Bauhinia variegata*, *Grewia optiva*, etc.

Grasses/Forbs: *Arundinella nepalensis*, *Apluda mutica*, *Chrysopogon fulvus*, *Boerhavia diffusa*, *Heteropogon contortus*, *Trifolium repens*, *Eragrostis nigra*, *Deschamsia* spp., *Panicum maximum*, *Phleum pratense*, *Cymbopogon citrullus*, *Arundo donax*, *Phragmites karka*, *Themeda arundinacea*, *Eulaliopsis binata*, *Dichanthium annulatum*, *Sporobolus diander*, *Thysanolaena maxima*, *Hierochloa laxa*, etc.



Trees/Bamboo: 600/ha, Spacing (m) - 4 x 4, Pit size (cm) – 45 x 45 x 45

Grasses: Patch no - 600, Patch size (cm) - 100 x 30 x 5. Spacing (m) - 4 x 4, Seed/patch (gm) – 6gm, Spacing (cm) - 10 x 10, Type –Staggered

Fencing: Cement pole/ angle Iron pole local material wood/ Branches /Brushwood fencing

Table 5. 10 – Cost Norms for Model BS/HP/NL/09

BS/HP/NL/09 (Control of Lantana (> 50%))				
Year	Item	Detail of works	Amount/ha (Rs)	Man days
	Number of Plants (No.)	Plants/ Bamboo- 600 No., Grasses- 600 no. patches		
1 st Year	Advance Labour Cost	Work Establishment of Nursery	5,955	24
1 st Year	Advance Labour Cost	Work Lantana by Cut Root Stock method and Cleaning of lantana(sprouts) and seedlings, one times (100%) and @15% one cut in Ist year	31501	126
2 nd year	Advance Labour Cost	Work Maintenance of Nursery+ Establishment of plants for Ist year maintenance	8,743	33
2 nd year	Advance Material	Work Cost of Seed, Farm yard mannure (FYM), Barbed wire and Reinforced Cement Concrete (RCC) poles	55,600	0
2 nd year	Advance Labour Cost	Work Site Preparation includes Lantana by Cut Root Stock method and Cleaning of lantana(sprouts) and seedlings 3 times a year @15% in 2 nd year @ 15% of unit cost (Establishment) preparation inspection path, Carriage of RCC poles, Digging of	62609	234

BS/HP/NL/09 (Control of Lantana (> 50%))				
Year	Item	Detail of works	Amount/ha (Rs)	Man days
		holes and Fixing for poles, Stretching & fixing of B/wire		
3 rd year	Advance Work Labour Cost	Maintenance of Nursery for creation and maintenance work 1 st and 2 nd year	7,158	25
3 rd year	Creation	Carriage of Plants, Lay out of pits and patches, Pitting & Planting of Plants, Patches & Planting of Herbs, Preparation of strips including (i/c) sowing in strips, Weeding, mulching, Lantana by Cut Root Stock method and Cleaning of lantana(sprouts) and seedlings in 2 times in 3 rd year @ 15% of unit cost (Establishment).	49258	172
	Total Establishment Cost		220,824	614
		MAINTENANCE		
4 th year	Maintenance Cost - I Year i/c Material	Nursery maintenance, Material cost, planting cost & other maintenance works, Clearing of Fire line along fencing, Lantana by Cut Root Stock method and Cleaning of lantana(sprouts) and seedlings in 2 times in 4 th year @ 15% of unit cost (Establishment)	41842	128
5 th year	Maintenance Cost - II Year	Nursery maintenance, Material cost, planting cost & other maintenance works, Clearing of Fire line along fencing	26028	74
6 th year	Maintenance Cost - III Year	Nursery maintenance, Material cost, planting cost & other maintenance works Clearing of Fire line along fencing	21812	59
7 th year	Maintenance Cost - IV Year	Maintenance cost of fencing, Clearing of Fire line along fencing	8588	23
	Total Maintenance Cost		98270	284
		Total cost of Plantation	319094	898

Model No – BS/HP/NL/10

**Control/ Removal of Invasive Species or
<50% Lantana**

Zone

Lower Temperate to Sub-Tropical Areas

Invasive alien species are plants those hamper regeneration and growth of native species, thereby replacement of native plant species coupled with loss of biodiversity, forage, habitat, aesthetics and productivity of native species. Owing to considerable area of this zone under the influence of invasive alien or weed species, tangible and intangible benefits from sub-temperate to sub-tropical forests within the Beas Riverscape have been adversely affected.

The area for the proposed model referred as ‘Control/ Removal of Invasive Species’ covers forest sites between 300 m to 1,200 m wherein the topography is with gentle slopes. Such areas have sub-tropical to lower-temperate climate with 1,000 mm to 1,500 mm annual rainfall. Soils are generally fertile and moderately deep. The proposed treatment area for this model usually has open or moderately dense forest or scrub vegetation. Luxuriant growth of weed species including *Lantana camara* (<50%) forms considerably dense undergrowth in the forest suppressing the native vegetation of that area. *Ageratum conyzoides* and *Parthenium hysterophorus* also cause considerable hazard especially near agriculture fields and settlements.

It is proposed to cut and manually uproot above stated invasive species in treatment sites prior to their flowering, and immediately to be followed by planting of native plant species. In case of *Lantana* infested areas, CRS (Cut Root Stock) method will be used for complete control of this obnoxious weed. In case of other weeds, cuttings and removal of infested plants will be done at such a time and such a way as to cause least disturbance to soil and provide opportunity to the nearby economically important plants to occupy the space vacated by weeds. These areas after plantation will be intensively managed subsequently for two years to minimize the chances of their re-growth. For controlling herbaceous weeds like *Ageratum conyzoides* and *Parthenium hysterophorus*, eco-friendly measures (e.g. physical or mechanical methods, use of natural products, etc.) will be adopted without resorting to the use of synthetic chemicals. These areas after *lantana* eradication will be planted in the third year of project implementation. Grass species such as *Heteropogon contortus*, *Chrysopogon fulvus*, etc. will be sown in the part of treatment site. The treatment area will be planted with broadleaved species like *Toona ciliata*, *Syzygium cumini*, *Grewia optiva*, *Pyrus pashia*, *Albizia* spp., *Phyllanthus emblica*, *Holoptelia integrifolia*, *Ficus* spp., *Punica granatum*, *Bauhinia variegata*, *Dendrocalamus* spp., and *Bambusa* spp., etc. Plants will be planted at 5 m x 5 m spacing. A total of 400 plants of trees and bamboo/ha- a mixture of broad leaved species and bamboos will be planted. In additions, 400 patches of grasses 5x5 m apart will be planted on the proposed sites. The rows of trees and grasses will be planted alternatively. Broadleaved species of this zone require around two and half year of nursery period to produce sturdy plants and planting will be done in the 3rd year. For producing quality nursery stock of desired species VAM will be added either species specific or as consortium in the potting media. The plants will be maintained in the 4th to 6th year.

List of species for plantation:

Trees: *Toona ciliata*, *Dalbergia sissoo*, *Acacia catechu*, *Adina cordifolia*, *Aegle marmelos*, *Terminalia bellirica*, *T. chebula*, *T. arjuna*, *Mallotus philippensis*, *Syzygium cumini*, *Sapindus mukorossi*, *Dendrocalamus* spp., *Bambusa* spp., *Holoptelia integrifolia*, *Albizia* spp., *Celtis australis*, *Pyrus pashia*, *Alstonia scholaris*, *Phyllanthus embellica*, *Diospyros montana*, *Bauhinia variegata*, *Grewia optiva*, *Morus alba*, etc.

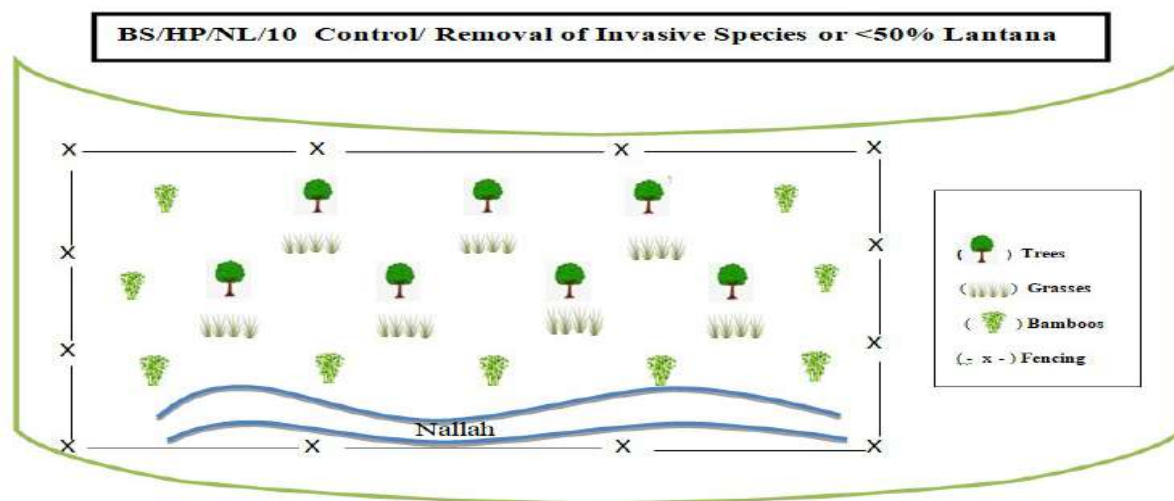
Grasses/Forbs: *Arundinella nepalensis*, *Apluda mutica*, *Chrysopogon fulvus*, *Boerhavia diffusa*, *Heteropogon contortus*, *Trifolium repens*, *Eragrostis nigra*, *Deschamsia* spp., *Panicum maximum*, *Phleum pratense*, *Cymbopogon citratus*, *Arundo donax*, *Phragmites karka*, *Themeda arundinacea*, *Eulaliopsis binata*, *Dichanthium annulatum*, *Sporobolus diander*, *Thysanolaena maxima*, *Hierochloa laxa*, etc.



Bauhinia variegata



Pyrus pashia



Trees/Bamboo: 400/ha, Spacing (m) - 5 x 5, Pit size (cm) – 45 x 45 x 45

Grasses: Patch no - 400, Patch size (cm) - 100 x 30 x 5. Spacing (m) - 5 x 5, Seed/ patch (gm) – 6gm, Spacing (cm) - 10 x 10, Type – Staggered

Fencing: Cement pole/ angle Iron pole/ local material wood/ Branches /Brushwood fencing

Table 5. 11 – Cost Norms for Model BS/HP/NL/10

BS/HP/NL/10 (Control/ Removal of Invasive Species or Lantana (<50%))				
Year	Item	Detail of works	Amount/ha (Rs)	Man days
	Number of Plants (No.)	Plants/ Bamboo- 400 No., Grasses- 400 no. patches		
1 st Year	Advance Work Labour Cost	Establishment of Nursery	3970	16
1 st Year	Advance Work Labour Cost	Lantana by Cut Root Stock method and Cleaning of lantana(sprouts) and seedlings, one times (100%) and @15% one cut in Ist year	31501	126
2 nd year	Advance Work Labour Cost	Maintenance of Nursery+ Establishment of plants for Ist year maintenance	5829	22
2 nd year	Advance Work Material	Cost of Seed, Farm yard mannure (FYM), Barbed wire and Reinforced Cement Concrete (RCC) poles	54400	0
2 nd year	Advance Work Labour Cost	Site Preparation includes Lantana by Cut Root Stock method and Cleaning of lantana(sprouts) and seedlings 3 times a year @15% in 2 nd year @ 15% of unit cost (Establishment) preparation inspection path, Carriage of RCC poles, Digging of holes and Fixing for poles, Stretching & fixing of B/wire	62609	234
3 rd year	Advance Work Labour Cost	Maintenance of Nursery for creation and maint. work 1 st and 2 nd year	4772	17
3 rd year	Creation	Carriage of Plants, Lay out of pits and patches, Pitting & Planting of Plants, Patches & Planting of Herbs, Preparation of strips including (i/c) sowing in strips, Weeding, mulching, Lantana by Cut Root Stock method and Cleaning of lantana(sprouts) and seedlings in 2 times in 3 rd year @ 15% of unit cost (Establishment)	49258	172
	Total Establishment Cost		212339	587
		MAINTENANCE		
4 th year	Maintenance Cost - I Year i/c Material	Nursery maintenance, Material cost, planting cost & other maintenance works, Clearing of Fire line along fencing, Lantana by Cut Root Stock method and	39675	123

BS/HP/NL/10 (Control/ Removal of Invasive Species or Lantana (<50%))				
Year	Item	Detail of works	Amount/ha (Rs)	Man days
		Cleaning of lantana(sprouts) and seedlings in 2 times in 4 th year @ 15% of unit cost (Establishment)		
5 th year	Maintenance Cost - II Year	Nursery Maintenance, Material cost, planting cost & other maintenance works, Clearing of Fire line along fencing	25046	72
6 th year	Maintenance Cost - III Year	Nursery Maintenance, Material cost, planting cost & other maintenance works, Clearing of Fire line along fencing	21372	58
7 th year	Maintenance Cost - IV Year	Maintenance cost of fencing, Clearing of Fire line along fencing	8588	23
	Total Maintenance Cost		94681	276
		Total cost of Plantation	307020	863

Model No – BS/HP/NL/11	Protection Model for Natural Regeneration
Zone	All Hill Areas

All the hill areas between 1,300 m to 4,200 m altitude is characterized by dense forests, mainly conifers and Oak forests, Sub Alpine vegetation i.e. herbs, grasses, shrubs and scattered small trees and Alpine pastures. However, blank patches too occur at several locations that can be taken up for the proposed treatment. In selected areas, especially in Deodar, Blue pine, Fir, Spruce, Oaks forests and even the Sub Alpine & Alpine areas, adequate regeneration can be observed under favorable conditions. Owing to varied disturbances by human and livestock in such areas, establishment of natural regeneration is generally poor and need immediate attention. Often, a thick layer of humus is typically present and the soil is generally moist and conducive for natural regeneration.

Under this treatment model, it is proposed to protect and conserve vegetation so as to promote ample establishment and recruitment of natural regeneration. The major focus will be on protection of special areas like patches of good natural regeneration of various conifers, broadleaved species shrubs etc. and thereby conserving native plant species, particularly herbs. In Natural regeneration areas cleaning operation twice a year in the month of September and March be carried out *viz* climber cutting, obnoxious weeds, unwanted species, pruning of plants, removing dead and dying trees. The broadcasting of desired seed is done in the closed area to supplement the natural regeneration

List of species for plantation:**Trees:** No plantation proposed**Shrubs:** No plantation proposed**Herbs:** No plantation proposed

Cleaning Operations: Cleaning and un-saleable thinning (noncommercial) in regeneration areas, Climber cutting in the forests/ plantation area, Debris collection and burning

Seed broadcasting: Seed (2 kg for conifer and 15 kg for Broad leaved/ha)

Fencing: Cement pole/ angle Iron pole local material wood/ Branches /Brushwood fencing

Table 5. 12 – Cost Norms for Model BS/HP/NL/11

BS/HP/NL/11 Protection Model for Natural Regeneration				
Year	Item	Detail of works	Amount/ha (Rs)	Man days
	Number of Plants (No.)	Seed Broadcasting - (2 kg for conifer and 15 kg for Broad leave)		
1 st Year	I-Advance Work Material (Rs.)	Cost of Seed, Farm yard manure (FYM), Barbed wire and Reinforced Cement Concrete (RCC) poles	0	0
1 st Year	II-Advance Work Labour Cost (Rs.)	Site Preparation,- site preparation i/c survey & demarcation, Debris collection and burning, preparation of inspection path, Carriage of RCC poles, Digging of holes and Fixing for poles, Stretching & fixing of B/wire	0	0
1 st Year	III-Creation (Rs.)	Cleaning and un-saleable thinning (noncommercial) in regeneration areas, Climber cutting in the forests/ plantation area, Broadcasting sowing in plantation/ Regeneration area, Preparation of fire lines 2.5 m wide, Pruning of established saplings in plantation/regeneration 1/3 portion, Burning/maintenance of lines 2.5	1,28,301	306

BS/HP/NL/11 Protection Model for Natural Regeneration				
Year	Item	Detail of works	Amount/ha (Rs)	Man days
		mt around the fencing		
	Total Establishment Cost (Rs.)		1,28,301	306
		MAINTENANCE		
2 nd year	Maintenance Cost - I Year i/c Material (Rs.)	Cleaning and un-saleable thinning (noncommercial) in regeneration areas, Climber cutting in the forests/ plantation area (50%), Broadcasting sowing in plantation/Regeneration area (50%), Pruning of established saplings in plantation/ regeneration 1/12 portion, Burning/ maintenance of lines 2.5 mt around the fencing (2 times)	15,389	50
3 rd year	Maintenance Cost - II Year (Rs.)	Cleaning and un-saleable thinning (noncommercial) in regeneration areas, Climber cutting in the forests/ plantation area (30%), Broadcasting sowing in plantation/Regeneration area (30%), Pruning of established saplings in plantation/ regeneration 1/15 portion, Burning/maintenance of lines 2.5 mt around the fencing (2 times)	14,216	44
4 th year	Maintenance Cost - III Year (Rs.)	Cleaning and un-saleable thinning (noncommercial) in regeneration areas, Climber cutting in the forests/ plantation area (20%), Broadcasting sowing in plantation/Regeneration area (20%), Pruning of established saplings in plantation/ regeneration 1/18 portion, Burning/maintenance of lines 2.5 mt around the fencing (2 times)	13,174	39
5 th	Maintenance	Cleaning and un-saleable thinning (noncommercial) in regeneration areas,	8,146	23

BS/HP/NL/11 Protection Model for Natural Regeneration				
Year	Item	Detail of works	Amount/ha (Rs)	Man days
year	Cost - IV Year (Rs.)	Climber cutting in the forests/ plantation area (15%), Broadcasting sowing in plantation/Regeneration area (15%), Burning/maintenance of lines 2.5 mt around the fencing (2 times)		
	Total Maintenance Cost (Rs.)		50,925	156
		Total Cost of Plantation	1,79,226	462

Model No – BS/HP/NL/12
Fire Protection Model
Zone
Sub-Tropical Area to Lower Temperate Area

This zone occurs in sub-tropical i.e. from foot hills to mid hill region of Himachal Pradesh. It is dominated by Chir pine in southern aspects and mixed vegetation in other aspects. The altitude is 800 m – 1800 m and annual rainfall is 1000mm – 15,00 mm and mostly during monsoon and some portion in winter months. This zone experiences 7-8 dry months every year making these forests highly vulnerable to fires. Even a small negligence during dry months in Chir pine dominated areas carries the great risk of igniting forest fires that spread very fast riding on the wind. Damage caused by the forest fire during 2015-16 was in 5734 ha forest in Himachal Pradesh with loss to regeneration, pole crop, and productivity and Ecosystem services, Wildlife etc. Heavy monsoon rains in the burnt out areas transport huge quantities of silt to Beas river carrying siltation of dams and floods in Punjab plains. Effective fire control measures can help significantly in reducing the silt load in Beas and its tributaries.

For these fire prone forest area, ‘Fire Protection Model’ is recommended. In this model, existing fire lines are cleared of vegetation and maintained all around the forest in such a way that a compact block or area is separated from adjoining areas. These fire lines are usually cleared before the start of the fire seasons in order to avoid the spread of fires from one forest to another. Engagement of fire watchers in fire sensitive beats, Procurement of fire fighting equipments and use of elide fire extinguishing balls. Construction of water harvesting and storage structure with locally available materials will be done e.g. Ponds, Khals etc. Besides these, awareness campaign among rural masses particularly about overall damage by forest

fires to nature flora and fauna, soil and other ecosystem services of the forest such as hydrological functions, moderation of local climate etc. influencing horticulture/ agriculture productivity of farmlands. Role of local communities in bringing down the forest fire incidences in Chir-pine zone and is very important and need to be highlighted at various levels.

Cleaning of Fire lines

Control burning

Engagement of fire watchers

Procurement of fire fighting equipments/ Elide fire extinguishing balls

Constructions of Ponds/ water harvesting structures

Awareness campaign, Community awareness.

Table 5. 13 – Cost Norms for Model BS/HP/NL/12

BS/HP/NL/12 Fire Protection Model				
Year	Item	Detail of work	Amount (Rs) /ha	Man days
1 st Year	Establishment Cost	Cleaning of Fire lines (2.5 mt width), Control burning, Engagement of fire watchers, Constructions of Ponds/ water harvesting structures, Procurement of firefighting equipment's / Elide fire extinguishing balls and maintenance, Awareness campaign, Community awareness	32,863	307
2 nd year	Maintenance Cost - I Year i/c Material	Cleaning of Fire lines (2.5 mt width), Control burning, Engagement of fire watchers, Procurement of firefighting equipment's / Elide fire extinguishing balls and maintenance, Awareness campaign, Community awareness	24,462	78
3 rd year	Maintenance Cost - II Year	Cleaning of Fire lines (2.5 mt width), Control burning, Engagement of fire watchers, Procurement of firefighting equipment's / Elide fire extinguishing balls and maintenance, Awareness campaign, Community awareness	24,265	71
4 th year	Maintenance Cost - III Year	Cleaning of Fire lines (2.5 mt width), Control burning, Engagement of fire watchers, Procurement of firefighting equipment's / Elide fire extinguishing	23,922	0

BS/HP/NL/12 Fire Protection Model				
Year	Item	Detail of work	Amount (Rs) /ha	Man days
		balls and maintenance, Awareness campaign, Community awareness		
5 th year	Maintenance Cost - IV Year (Rs.)	Cleaning of Fire lines (2.5 mt width), Control burning, Engagement of fire watchers, Procurement of firefighting equipment's / Elide fire extinguishing balls and maintenance, Awareness campaign, Community awareness	23,411	0
Total Maintenance Cost (Rs.)			96,060	149
Total cost of model			1,28,923	456

Model No – BS/HP/NL//13

Plantation by Eco Task Force in Temperate Forests

Zone

Temperate to Sub-Tropical Areas

Some sites in the upper Beas Basin have rugged topography, harsh conditions, shallow soils with low moisture content, etc. Such areas are mostly located on the southern slopes. These sites require continued presence and close supervision by planting and maintenance teams. The Eco Task Force (ETF) in the past has exhibited great success in regeneration of such harsh sites. It is proposed to utilize this unique ability of ETF in planting on such difficult sites under this DPR. A total of 1,000 ha land in such areas will be identified in the Beas Riverscape in liaison with Himachal Pradesh State Forest Department. The selected areas may not necessarily be contiguous. The task of establishment and maintenance of proposed plantations will be carried out by the existing unit of ETF at Aut in Mandi district in close coordination with HPFD. One or more of the proposed plantation models amongst suggested models (BS/HP/NL/1 to BS/HP/NS/10) will be selected for replication by the ETF under this model.

Table 5. 14 – Cost Norms for Model BS/HP/NL/13

Model No – BS/HP/NL/13 - Plantation by Eco Task Force		
Year	Item	Amount (Rs)
1st	Establishment of cost of Eco Task Force, Cost of Vehicle, Equipment for Plantation, firefighting	7 00 00 000

Model No – BS/HP/NL/13 - Plantation by Eco Task Force		
Year	Item	Amount (Rs)
	& Protection	
2 nd	Material cost of Plantation (ha) and Petrol and Vehicle maintenance per year	60 00 000
2 nd	Cost of Salary and maintenance of E.T. Force per year	3 00 00 000
3 rd	Material cost for Plantation (ha), maintenance of Plantation and Carriage of planting material	66 00 000
3 rd	Cost of Salary and maintenance of E.T. Force	3 15 00 000
4 th	Material cost for Plantation (ha), maintenance of Plantation and Carriage of planting material	72 00 000
4 th	Cost of Salary and maintenance of E.T. Force	3 20 00 000
5 th	Material cost for Plantation (ha), maintenance of Plantation and Carriage of planting material	80 00 000
5 th	Cost of Salary and maintenance of E.T. Force	3 30 00 000
6 th	Material cost for Plantation (ha), maintenance of Plantation and Carriage of planting material	90 00 000
6 th	Cost of Salary and maintenance of E.T. Force	3 40 00 000
7 th	Material cost for Plantation (ha), maintenance of Plantation and Carriage of planting material	24 00 000
7 th	Cost of Salary and maintenance of E.T. Force	3 50 00 000
8 th	Material cost for Plantation (ha), maintenance of Plantation and Carriage of planting material	18 00 000
8 th	Cost of Salary and maintenance of E.T. Force	3 50 00 000
9 th	Material cost for Plantation (ha), maintenance of Plantation and Carriage of planting material	8 00 000
9 th	Cost of Salary and maintenance of E.T. Force	3 50 00 000

Model No – BS/HP/NL/13 - Plantation by Eco Task Force		
Year	Item	Amount (Rs)
10 th	Material cost for Plantation (ha), maintenance of Plantation and Carriage of planting material	4 00 000
10 th	Cost of Salary and maintenance of E.T. Force	3 50 00 000
	Grand Total	41 27 00 000
Total	Material cost including carriage	4 22 00 000
Total	Cost of Salary and maintenance of E.T. Force	37 05 00 000

Table 5. 15 – Nursery Rate in Himachal Pradesh and rate after including inflation factor

Nursery rate				Year	Rate per day (Rs)	Factor after inflation of 7% each year
Ban	(BL+ Conifer)	Tree/Shrub (avg)	Herbs		150	
11	10	10.5	5	1 st	250	1.667
6	6	5.7	3	2 nd	267.5	1.784
6	3	4.3	2	3 rd	286	1.909
				4 th	306	2.042
				5 th	327.7	2,185
				6 th	350.7	2.338
				7 th	375,3	2,502
				8 th	401.5	2.677
				9 th	450	2.864

(B) Treatment Models for Natural Landscape in Punjab

The Chapter on river and its environment has highlighted the existing situation of forests in the alluvial plains of Punjab and also elaborated on challenges faced by extremely small extent of forests owing to the fact that the entire tract is heavily populated as well as

extensively cultivated. In view of this, the following forestry interventions by way of different treatment models are proposed.

Model No – BS/PB/NL/01	Restoration of Degraded Forests Model
Zone	Tropical Areas

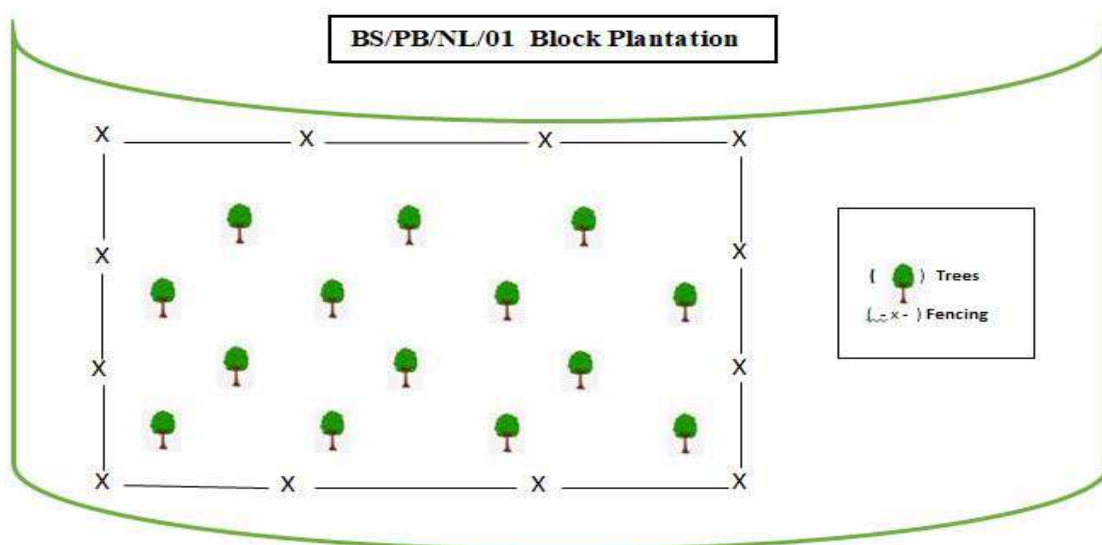
This model is specifically proposed for restoration of degraded protected forests or plantation in village common lands or community lands. Proposed sites are mostly flat and covered either with shrubs/ herbs/ grasses or invasive alien species. Often such areas are inhabited by Nilgai or wild pig and locally abundant populations of these two herbivore species could be a menace to propose plantation activities. Moreover, such sites also face severe biotic pressure by way of livestock grazing, and collection of fodder and fuel wood. Hence, effective fencing of sites selected for proposed forestry interventions is a pre-requisite so as to ensure full protection to young plantation. Heavy monsoon rains cause severe siltation in Beas and resultant flooding in larger tracts of Punjab Plains.

Suitable and effective forestry interventions in above sites can immensely help in improvement of vegetation cover, checking soil erosion, and enhancing groundwater recharge. Block plantations of native broadleaved species are proposed for such areas. Trees will be planted at the rate of 1000 plants ha⁻¹ at 3 m x 3 m spacing. Pit size of 50 cm x 50 cm x 40 cm will be used for proposed plantations under this model.

After land development, pit digging, etc. plants mainly of broadleaved species like *Acacia nilotica*, *A. catechu*, *Dalbergia sissoo*, *Melia composita*, *Ailanthus excelsa*, *Toona ciliata*, *Morus alba*, *Tectona grandis*, *Azadirachta indica*, etc. will be planted. Conservation and other management practices as prescribed in the forest working plan of the respective forest division would be applicable. Nursery of selected tree species will be established during first year and planting will be done in the second year. For producing quality nursery stock of desired species VAM will be added either species specific or as consortium in the potting media. Subsequently, the plantation will be managed during next three year of the project.

List of species for plantation:

Trees: *Acacia nilotica*, *A. catechu*, *Dalbergia sissoo*, *Melia composita*, *Ailanthus excelsa*, *Toona ciliata*, *Tectona grandis*, *Azadirachta indica*, *Cordia myxa*, *Morus alba*, *Pongamia pinnata*, *Tecomella undulata*, *Capparis decidua*, *Prosopis cineraria*, *Bombax ceiba*, *Sesbania sesban*, *Aegle marmelos*, *Pterocarpus marsupium*, *Grewia elastica*, *Cassia fistula*, etc.



Trees: 1,000/ha, Spacing (m) – 3 x 3, Pit size (cm) – 50 x 50 x 40

Fencing: Cement pole/ angle Iron pole local material wood/ Branches /Brushwood fencing

Table 5. 16 – Cost Norms for Model BS/PB/NL/01

Labour Rate Rs 342/day in 1st year and Annual Increase @ 7% in Subsequent Years				
BS/PB/NL/01 Restoration of Degraded Forests Model				
Year	Item	Detail of work	Amount Rs./ha	Man days
	Number of Plants (No.)	Plants- 1000 No.		
1 st Year	Nursery Advance Work Labour Cost (Rs.)	Cost of seedlings including (a) Original planting =1000 per ha (b) Replacement 10%= 100 per ha Total 1100 No. in Bio-degradable polybag	16,115	47
2 nd year	Advance Work Labour Cost (Rs.)	Cutting of Lantana/Mallah etc, Kana stubbing, Survey and alignment Earth work i.e.digging of pit of size a) 1000 no x .5m x0.5mx 0.40m, Refilling of pits, Fencing (5% of plantation cost)	25,100	70
3 rd Year	Creation (Rs.)	Carriage of Plants, Lay out of pits and patches, Pitting & Planting of Plants, Weeding hoeing (twice), Application of insecticides, Application of FYM/ fertilizers (twice), Providing thorny protection to plants against Porcupine attack, Covering and uncovering of frost tender plant species (25%), Preparation of inspection path, Watch and ward for every 10	1,10,424	305

Labour Rate Rs 342/day in Ist year and Annual Increase @ 7% in Subsequent Years				
BS/PB/NL/01 Restoration of Degraded Forests Model				
Year	Item	Detail of work	Amount Rs./ha	Man days
		ha. of plantation, Cutting of lantana/mallah IInd and IIIrd times, Spot Irrigation (8+1 times), Reopening of Trenches and pits, Insecticides including carriage, Fertilizers i.e. urea etc. including carriage, Overhead charges (10% of planation cost) POL, OE, Misc.		
Total Establishment Cost (Rs.)			1,51,639	422
MAINTENANCE				
4 th year	Maintenance Cost - I Year i/c Material (Rs.)	Cost of seedlings (25%), Cutting of Lantana/Mallah etc, Kana stubbing, Earth work i.e.re digging of pit Refilling of pits,(25%) Fencing (5% of plantation cost), Carriage of Plants, Weeding hoeing (twice), Application of insecticides, Application of FYM/ fertilizers(twice), Providing thorny protection to plants against Porcupine attack, Covering and uncovering of frost tender plant species (25%), Maintenance of inspection path, Watch and ward for every 10 ha. of plantation, Spot Irrigation (8+1 times), Reopening of Trenches and pits, Insecticides including carriage, Fertilizers i.e. urea etc. including carriage, Overhead charges (10% of maintenance of planation cost) POL, OE, Misc.	51,534	118
5 th year	Maintenance Cost - II Year (Rs.)	Earth work i.e.re digging of pit Refilling of pits,(15%) Fencing (5% of plantation cost), Carriage of Plants, Weeding hoeing (twice), Application of insecticides, Application of FYM/ fertilizers(twice), Providing thorny protection to plants against Porcupine attack, Covering and uncovering of frost tender plant species (25%), Maintenance of inspection path, Watch and ward for every 10 ha. of plantation, Spot Irrigation (8+1 times), Reopening of Trenches and pits, Insecticides including carriage, Fertilizers i.e. urea etc. including carriage, Overhead charges (10% of maintenance of planation cost) POL, OE, Misc.	21,346	41
6 th year	Maintenance Cost - III Year (Rs.)	Weeding hoeing (twice), Application of insecticides, Application of FYM/ fertilizers	7394	10

Labour Rate Rs 342/day in Ist year and Annual Increase @ 7% in Subsequent Years				
BS/PB/NL/01 Restoration of Degraded Forests Model				
Year	Item	Detail of work	Amount Rs./ha	Man days
		(twice), Providing thorny protection to plants against Porcupine attack, Watch and ward for every 10 ha. of plantation, Fertilizers i.e. urea etc. including carriage, Overhead charges (10% of maintenance of planation cost) POL, OE, Misc.		
Total Maintenance Cost (Rs.)			80,274	169
Total cost of Plantation			231913	591

Model No – BS/PB/NL/02

Road Side Plantation

Zone

Tropical Areas

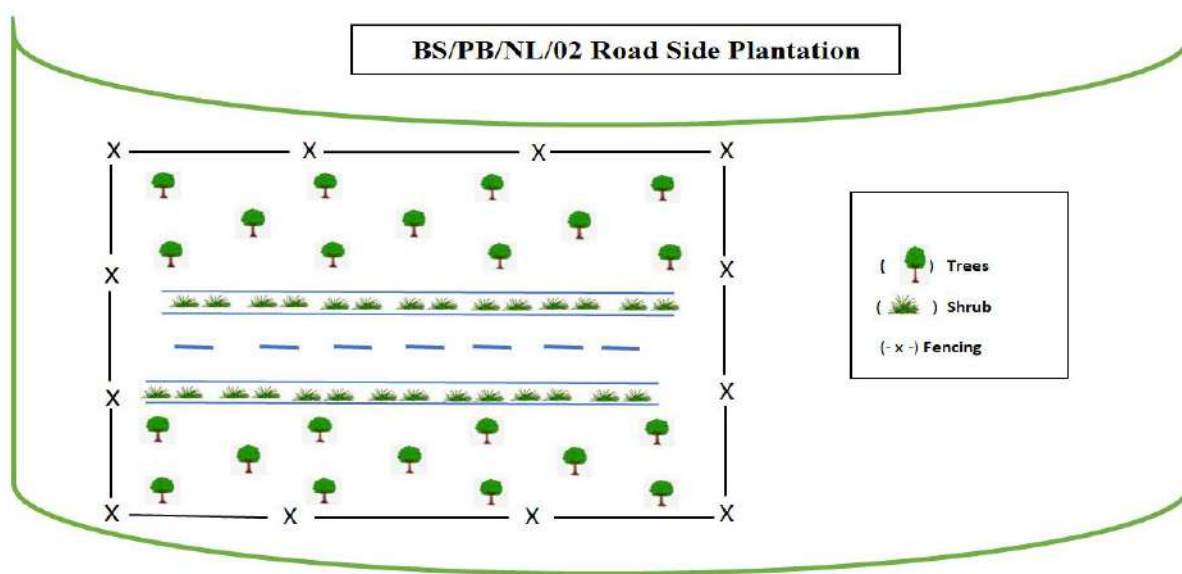
This model is specifically proposed for the purpose of road side plantations. Hence, proposed plantations will be in narrow strips along the roads. Generally, proposed sites along the roads are either sparsely covered by native vegetation or select invasive alien species or often blank. Stray cattle as well as wild animals like Nilgai and wild pig could be a menace to proposed plantations. Hence, effective fencing of sites proposed for plantation is a pre-requisite. The proposed road side plantations would help in enhancing the forest cover in a State which is otherwise deficient in natural vegetative cover besides checking soil erosion and runoff.

Strip plantations on both sides of the road are proposed. The planting area will be cleaned and one row of shrubs is proposed at 1 m x 1 m spacing towards the road side. Fast growing ornamental shrub species are proposed. Two rows of native broadleaved tree species is recommended under this road side plantation model at 3 m x 2 m spacing. Pit size of 45 cm x 45 cm x 45 cm will be used for plantation. After land development, pit digging, etc. plants mainly of broadleaved species viz., *Dalbergia sissoo*, *Terminalia bellirica*, *T. chebula*, *T. arjuna*, *Melia azedarach*, *M. composita*, *Acacia nilotica*, *Azadirachta indica*, *Anthocephalus kadamba*, *Ailanthus excelsa*, *Toona ciliata*, etc. will be planted. Nursery of selected tree species will be established during first year and planting will be done in the second year. For producing quality nursery stock of desired species VAM will be added either species specific or as consortium in the potting media. Subsequently, the plantation will be managed during next three year of the project.

List of species for plantation:

Trees: *Dalbergia sissoo*, *Terminalia bellirica*, *T. chebula*, *T. arjuna*, *Melia azedarach*, *M. composita*, *Acacia nilotica*, *Albizia lebbek*, *A. procera*, *Butea monosperma*, *Azadirachta indica*, *Anthocephalus kadamba*, *Ailanthus excelsa*, *Toona ciliata*, *Jacaranda mimosifolia*, *Grevillea robusta*, *Salix alba*, etc.

Shrubs: *Nerium oleander*, *Bougainvillea* spp., *Nyctanthes arbor-tritis*, *Spiraea* spp., *Rosa* spp., etc.



Trees: 1,000 No, Spacing (m) - 3 x 3, Pit size (cm) – 50 x 50 x 40

Shrubs: 2,500 No, Spacing (m) - 2 x 2, Pit size (cm) – 30 x 30 x 30

Fencing: Cement pole/ angle Iron pole/local material wood/ Branches/ Brushwood fencing

Table 5. 17 – Cost Norms for Model BS/PB/NL/02

BS/PB/NL/02 Road Side Plantation				
Year	Item	Detail of works	Amount/ha (Rs)	Man days
	Number of Plants (No.)	Plants- 1000 No., Herbs- 2500		
1 st Year	Nursery Advance Work Labour Cost (Rs.)	Cost of seedlings including (a) Original planting =3500 per ha (b) Replacement 10%= 350 per ha Total 1100 No. in Bio-degradable polybag Cost of Herbs - (a) Original planting =2500 per ha (b) Replacement 10%= 250 per ha	38115	111

BS/PB/NL/02 Road Side Plantation				
Year	Item	Detail of works	Amount/ha (Rs)	Man days
		Total 2750 No. in Bio-degradable polybag (Ist year)		
2 nd year	Advance Work Labour Cost (Rs.)	Cutting of Lantana/Mallah etc, Kana stubbing, Survey and alignment Earth work i.e. digging of pit of size a) 1000 no x .5m x 0.5mx 0.40m, b) 2500 no. Spacing (m) - 2 x 2, Pit size (cm) – 30 x 30 x 30, Refilling of pits, Fencing (5% of plantation cost)	52361	119
3 rd Year	Creation (Rs.)	Carriage of Plants, Lay out of pits and patches, Pitting & Planting of Plants, Weeding hoeing (twice), Application of insecticides, Application of FYM/ fertilizers(twice), Providing thorny protection to plants against Porcupine attack, Covering and uncovering of frost tender plant species (25%), Preparation of inspection path, Watch and ward for every 10 ha. of plantation, Cutting of lantana/mallah IInd and IIIrd times, Spot Irrigation (8+1 times), Reopening of Trenches and pits, Insecticides including carriage, Fertilizers i.e. urea etc. including carriage, Overhead charges (10% of plantation cost) POL, OE, Misc.	180376	442
Total Establishment Cost (Rs.)			2,70,852	672
MAINTENANCE				
4 th year	Maintenance Cost - I Year i/c Material (Rs.)	Cost of seedlings (25%), Cutting of Lantana/Mallah etc, Kana stubbing, Earth work i.e.re digging of pit Refilling of pits, (25%) Fencing (5% of plantation cost), Carriage of Plants, Weeding hoeing (twice), Application of insecticides, Application of FYM/ fertilizers(twice), Providing thorny protection to plants against Porcupine attack, Covering and uncovering of frost tender plant species (25%), Maintenance of inspection path, Watch and ward for every 10 ha. of plantation, Spot Irrigation (8+1 times), Reopening of Trenches and pits, Insecticides including carriage, Fertilizers i.e. urea etc. including carriage, Overhead	125712	311

BS/PB/NL/02 Road Side Plantation				
Year	Item	Detail of works	Amount/ha (Rs)	Man days
		charges (10% of maintenance of plantation cost) POL, OE, Misc.		
5 th year	Maintenance Cost - II Year (Rs.)	Earth work i.e. re-digging of pit Refilling of pits,(15%) Fencing (5% of plantation cost), Carriage of Plants, Weeding hoeing (twice), Application of insecticides, Application of FYM/fertilizers (twice), Providing thorny protection to plants against Porcupine attack, Covering and uncovering of frost tender plant species (25%), Maintenance of inspection path, Watch and ward for every 10 ha. of plantation, Spot Irrigation (8+1 times), Reopening of Trenches and pits, Insecticides including carriage, Fertilizers i.e. urea etc. including carriage, Overhead charges (10% of maintenance of plantation cost) POL, OE, Misc.	47220	114
6 th year	Maintenance Cost - III Year (Rs.)	Weeding hoeing (twice), Application of insecticides, Application of FYM/fertilizers (twice), Providing thorny protection to plants against Porcupine attack, Watch and ward for every 10 ha. of plantation, Fertilizers i.e. urea etc. including carriage, Overhead charges (10% of maintenance of plantation cost) POL, OE, Misc.	5863	10
Total Maintenance Cost (Rs.)			178795	435
Total cost of Plantation			449647	1107

Table 5. 18 – Rate after including inflation factor in Punjab

Year	Rupess per Manday	Factor of 7% increase each year
I	342	1.000
II	366	1.070

III	392	1.145
IV	419	1.225

b. Treatment Models for Agriculture Landscape

The tree cover outside recorded forest area, particularly on farm lands is of vital importance from ecological functions of agro-ecosystems (e.g. pollinators, soil and moisture conservation regime, carbon sequestration (CS), environmental amelioration etc.). As per the strategies given in the foregoing description, 'Agriculture Landscapes' have been recognized as one of the zones within the Beas/ Beas Riverscape. Comprehensive afforestation/ plantations on private farm lands in agriculture landscape have been proposed in DPR. The Forest Survey of India (FSI) in the biennial 'India State of Forest Report (ISFR)' also includes information on Forest cover outside green wash area, tree cover and 'Trees Outside Forests (TOFs)' for the entire country/ state-wise to distinguish it from actual pure forest cover of the country as the digitalized information on public and private land is lacking in most of the states. The proportion of TOFs and tree cover is on increase in several states as per past two ISFRs. According to the FSI, 2019 report, the agricultural landscape which accounts for forest cover outside green wash area plus tree cover accounts for 10.10% and 5.28% of the total geographical area of the Himachal Pradesh and Punjab respectively. The growing stock in TOF which is 25.19 m cum in case of Himachal Pradesh and 18.56 m cum in case of Punjab accounts for 1.53% and 1.13% contribution to the country's growing stock (See Table below).

Table 5. 19 – Forest Cover, Tree Cover and TOF Growing Stock in Himachal Pradesh and Punjab

Sr. No.	Forest Cover, Tree Cover and TOF Growing Stock	Himachal Pradesh	Punjab
1	Forest Cover Outside Green Wash Area (in Sq Km)		
	VDF	342	1
	MDF	2178	350
	OF	2276	714
	TOTAL	4796	1065
2	Tree Cover Area (in Sq Km)	829	1592
	Total of Forest Cover and Tree Cover Area (in Sq Km)	5625	2657
3	Growing Stock in TOF	25.19 m cum	18.56m cum

Thus, it is evident that farmers/ villagers do recognize significance of trees on farm/private lands and they come forward for availing saplings of economic and fruit trees for plantations not only to augment their income but they also do recognize ecological merits of such plantations. The current DPR, therefore, also proposes plantation activities in agriculture landscapes by adopting four models (BS/HP/AL/01, BS/HP/AL/02, BS/PB/AL/01 and BS/PB/AL/02).



Paddy crop in lower Himalaya of Himachal Pradesh

NYKS, *Mahila Mandals*, clubs and other NGOs/CBOs may play an important role in awareness campaigns about Forestry interventions which have also been included in the DPR. It is widely assumed and accepted that farmers usually do not indulge in cutting of such economic and fruits trees except those are solely planted as agro-forestry plantations of fast growing species as they do recognize multiple values obtained from such tree plantations on farmlands. Moreover incentives in the form of maintenance cost to be provided to the farmer at the rate of Rs. 70/-, 35/-, 35/- and 35/- per plant for first, second, third and fourth year, respectively will motivate them to protect and retain these planted tree species on their private land. The monetary aid proposed for the plantation will ensure sustainability of proposed plantations (maximum 150 trees/ ha) in agriculture landscapes and thus adding ecological benefits. Further, though the ownership of the plantation raised under the agriculture landscapes is vested with farmers but the felling, removal, and transportation of such plantation material are regulated under the framework of various acts and procedures, (e.g. State Felling and Transit Regulations, Land Preservation Act, etc.) and other relevant regulations enforced from time to time by the concerned states.

The proposed agricultural models will be implemented in private farmland and community/Panchayat land in rural areas. Availability of land will be ascertained by local officials of State Forest Department based upon proposals from local farmers and communities. Plants will be supplied to farmers and local communities who will carry out planting in their farmland. Maintenance cost will be given to the land owners based upon

plant survival at the end of first, second, third and fourth years. Nehru Yuvak Kendra may play a pivotal role in facilitating coordination between State Forest Department and farmers/communities. The cost models are based on the guidelines given by Central Govt. under Sub-mission on Agro-forestry which implemented in all the states.

(A) Treatment Models for Agriculture Landscape in Himachal Pradesh

Model No. – BS/HP/AL/01	Boundary Plantation Model
Zone	Agriculture/Horticulture land in Himachal Pradesh

This model will be implemented in agricultural land in temperate and sub-tropical zones in Himachal Pradesh. The area is mostly hilly for most of this zone with moderate to steep slopes. The sites proposed for this model are agricultural or horticultural lands where off season vegetables and fruit crops are grown; hence these sites possess better soil fertility and managerial care with occasional subsistence irrigation mostly available water judiciously divided among local communities collectively by them.

The farmers/ orchardists will decide the species and number of plants per unit area of economically important tree species (including hill bamboo) keeping in view their requirements; they may freely grow agricultural/horticultural crops of their own choice with the trees in any planting geometry mostly tree planting will be done on vacant areas around farms/ orchard and near settlements. Hill bamboo will be planted on boundaries and will also act as live fencing for farm/ orchard in future. Quality Planting Material will be supplied to the local communities through HPSFD. Planting and maintenance of the plants will be done by farmers/ orchardist. Financial incentive to the growers will be provided keeping in view the performance of the plantation especially survival. The local communities/ beneficiaries would be provided technical knowledge for the purpose through institutes or universities etc.

The methodology for deciding physical targets have been finalized after consultation with stakeholders. A simple methodology has been adopted based on number of farmers and their landholdings. Distribution of 150 plants per farmer would be taken as virtual one hectare area for Budgetary provisions.

List of species for plantation

Tree: *Prunus armeniaca*, *P. mira*, *P. cerasifera*, *P. domestica*, *P. persica*, *Malus pumila*, *Myrica esculenta*, *Citrus limon*, *Psidium guajava*, *Diospyros lotus*, *D. edulis*, *D. kaki*, *Phyllanthus emblica*, *Mangifera indica*, *Eriobotrya japonica*, *Terminalia arjuna*, *T. bellirica*, etc.

Shrubs: *Drepanostachyum falcatum*, *Thamnocalamus spathiflorus*, *Vitex negundo*, *Berberis* spp., *Zanthoxylum armatum*, *Hippophae rhamnoides*, *H. salicifolia*, etc.

Cost Sharing: The Govt will share cost Material i.e. plant cost Rs.@ 70/- , 35/-, 35/-, 35/- for Ist to IVth year and maximum of 150 trees per ha.

Table 5. 20 – Cost Norms and Pattern of Assistance for Peripheral and Boundary Plantation (PBP)

S. No	Type of Interventions	Indicative Unit cost per plant (Rs.)
1	Pre-Plant activities/Land clearing/maintenance etc	20
2	Digging /Planting etc	12
3	Single unit Planting material etc	30
4	Transportation charges	3
5	Critical inputs viz., FYM, Fertilizer., seed treatment, Vesicular Arbuscular Mycorrhizae (VAM) etc.	20
6	Planting cost	5
7	Fencing	20
	Maintenance (weeding+ watering etc.)	40
	Total	150
Note: (i) The activity wise cost indicated above are tentative and states have the flexibility to formulate their own estimate based on local requirements subject to a maximum of Rs. 150/- per plant (ii) The assistance will be given in the year wise proportion of 40:20:20:20		

Table 5. 21 – Cost Norms for Model BS/HP/AL/01

Year	Amount (RS)/ha	Man days
Ist year Establishment	9000	36
Maintenance Ist	4815	18
Maintenance IInd	5152	18
Maintenance IIRD	5513	18

	24480	90

Model No. – BS/HP/AL/02	Block Plantation Model
Zone	Agriculture/ Horticulture land in Himachal Pradesh

This model will be implemented in Agricultural/ Horticultural land in temperate to sub-tropical zones in Himachal Pradesh. The area is hilly and the slope is moderate to gentle. The sites proposed for this model are agricultural/ horticultural/ grassland where grains, off season vegetables, stone fruit crops, grasses etc. are grown, hence these sites possess better soil fertility and managerial care with occasional subsistence irrigation mostly available water judiciously divided among local communities collectively by them.

The zone experiences heavy rainfall during monsoon season and modest rainfall during winter months. Heavy rains during monsoon transport silt from these areas through no of seasonal water channels, *Nallahs*, rivulets etc to Beas causing siltation and floods down streams. Besides this, agriculture, construction and developmental activities are the main reasons behind soil erosion from these areas. A large part of rainwater flows down the streams within a few hours of rainfall as surface run-off causing lot of soil erosion. The pressure for grazing, fuel wood and tree fodder collection is considerable. Effective forestry interventions in this zone in agricultural/ horticultural/ grassland areas can help significantly in improvement of the flow of Beas and its tributaries.

For these areas, Planting of Economic Trees in hills is recommended for this zone. The farmer/ orchardist will decide the species and no of plants of per unit area of economically important tree species i.e. Harad (*Terminalia chebula*), Bahera (*Terminalia bellirica*), Amla (*Phyllanthus emblica*), Reetha (*Sapindus mukorossi*), Chandan (*Santalum album*) etc. Block plantation in vacant and fallow lands can be taken up by the farmers to increase their income as well as judiciously utilising the fallow lands and other grass lands also.

Similarly as in model BS/HP/AL/01, for deciding Physical Targets, Enlist the number of farmers District/ Division wise whose land holdings comes under small farmers and above (as described category) by Agriculture Department of the respective states to be considered under the proposed model. About 5% of total such farmers enlisted in the Beas riverscape would be included division wise in the proposed treatment model. Block plantation per farmer would be taken as virtual one hectare area for Budgetary provisions and no. of plants/ha can vary from 500 to > 1500 as per the requirements of species specific high density plantations.

List of species for plantation

Tree: *Prunus armeniaca*, *P. mira*, *P. cerasifera*, *P. domestica*, *P. persica*, *Myrica esculenta*,

Diospyros lotus, *D. edulis*, *D. kaki*, *Phyllanthus embellica*, *Terminalia arjuna*, *T. bellirica*, *Sapindus mukorossi*, *Santalum album*, etc.

Shrubs: *Drepanostachyum falcatum*, *Thamnocalamus spathiflorus*, *Embelia ribes*, *Gymnema sylvestre*, *Mucuna pruriens*, *Tinospora cordifolia*, etc.

Table 5. 22 – Cost Norms and Pattern of Assistance for High Density Block Plantation (HDBP)

Sl. No.	Magnitude of block Plantations (no of plants/block of 1 ha)	Total cost (Max.) (Rs) for the block ((or in proportion to planting intensity)			
		1 st Year	2 nd year	3 rd Year	4 th Year
1	500 to 1000 (spacing 3.5mx3.5m)	20,000	10,000	10,000	10,000
2	>1000 to 1200< (spacing 3mx3m)	24,000	12,000	12,000	12,000
3	>1200 to 1500< (spacing 2.5mx2.5m)	30,000	15,000	15,000	15,000
4	>1500(spacing less than 2.5mx2.5m))	36,000	18,000	18,000	18,000

Table 5. 23 – Cost Norms for Model BS/HP/AL/02

Sl. No.	Magnitude of block Plantations (no of plants/block of 1 ha)	Total cost (Max.) (Rs) for the block ((or in proportion to planting intensity)				Total
		1 st Year	2 nd year	3 rd Year	4 th Year	
1	1200	48,000	25,680	27,478	29,401	1,30,559
	Mandays	192	96	96	96	480

(B) Treatment Models for Agriculture Landscape in Punjab

Model No. - BS/PB/AL/01

Boundary Plantation Model

Zone

Agriculture/ Horticulture Land in Punjab

The model will be applied in agriculture fields in the plains of Punjab. These fields are intensively cultivated with wheat, rice, sugarcane, etc. and open to soil erosion especially during flood irrigation.

Heavy monsoon rains in this zone transport huge quantities of silt to Beas causing siltation and floods in adjoining plains. Intensive cultivation in this zone makes these areas vulnerable to soil erosion. Effective forestry interventions in these sites can help significantly in improvement of the flow of Beas and its tributaries.

The sites proposed for this model are agricultural lands where selected clones of Poplar, Dek, Neem, Chandan, Shisham etc., will be planted at 4m x 4m spacing. Pit size of 50cm x 50cm 40cm will be used for plantation. Selected plants will be distributed to farmers for planting on their agricultural land. Planting will be done by the farmers. The farmers will place requirement for plants to local forest officials who will supply the plants to the farmers at the start of the planting season.

The methodology for deciding physical targets have been finalized after consultation with stakeholders. A simple methodology has been adopted based on number of farmers and their landholdings. For boundary plantation model, out of total farmers of the various forest divisions in the Beas riverscape, 10% farmers have been included under this treatment model irrespective of their landholdings. Distribution of 150 plants per farmer would be taken as virtual one hectare area for Budgetary provisions.

List of species for plantation

Tree: *Populus deltoides*, *Melia composita*, *Phyllanthus emblica*, *Aegle marmelos*, *Albizia lebbeck*, *Azadirachta indica*, *Syzygium cumini*, *Gmelina arborea*, *Holarrhena antidysenterica*, *Santalum album*, *Tamarindus indica*, *Terminalia arjuna*, *T. bellirica*, etc.

Cost Sharing: The Govt will share cost Material i.e plant cost Rs. @ 70/- , 35/-, 35/-, 35/- for Ist to IV year and maximum of 150 trees per ha.

Table 5. 24 – Cost Norms for Model BS/PB/AL/01

Year	Amount (RS)/ha	Man days
Ist year Establishment	9000	26
Maintenance Ist	4815	13
Maintenance IInd	5513	14
Maintenance IIRD	5899	14
Total	25227	67

Model BS/PB/AL/02

Block Plantation Model

Zone

Agriculture/ Horticulture land in Punjab

This model will be applied in agriculture fields in the plains of Punjab. These fields are intensively cultivated with wheat, rice, sugarcane, etc. and open to soil erosion especially during flood irrigation.

Heavy monsoon rains in this zone transport huge quantities of silt to Beas causing siltation and floods in adjoining plains. Intensive cultivation in this zone makes these areas vulnerable to soil erosion. Effective forestry interventions in these sites can help significantly in improvement of the flow of Beas and its tributaries.

The sites proposed for this model are agricultural lands where selected tree species will be planted at 4m x 4m spacing – Pit size of 50 cm x 50 cm x 40 cm will be used for plantation. This is a practice of growing tree in rectangular or square planting pattern throughout the field as mostly adopted by farmers having large land holding. Poplar, Shisham, Dek etc. are the important tree species for block planting. Wheat, potato, mustard, berseem, turmeric, sugarcane etc., can be profitably raised intermixed with block plantation of trees. Planting will be done by the farmers. The farmers will place requisition for desired plants species to local forest officials who will supply the quality nursery stock to the farmers at the start of the planting season.

Similarly as in model BS/PB/AL/01, for deciding Physical Targets, Enlist the number of farmers District/ Division wise whose land holdings comes under small farmers and above (as described category) by Agriculture Department of the respective states to be considered under the proposed model. About 5% of total such farmers enlisted in the Beas riverscape would be included division wise in the proposed treatment model. Block plantation per farmer would be taken as virtual one hectare area for Budgetary provisions and no. of plants/ha can vary from 500 to > 1500 as per the requirements of species specific high density plantations.

List of species for plantation

Trees: *Populus deltoides*, *Melia composita*, *Phyllanthus emblica*, *Aegle marmelos*, *Azadirachta indica*, *Syzygium cumini*, *Gmelina arborea*, *Holarrharunena antidysenterica*, *Santalum album*, *Cinnamomum tamala*, *Tamarindus indica*, *Terminalia arjuna*, *T. bellirica*, *T. chebula*, *Sapindus mukorossi*, etc.

Shrubs: *Dendrocalamus strictus*, *D. hamiltonii*, *Bambusa bambos*, *Cinnamomum verum*, *Justicia adhatoda*, *Asparagus racemosus*, *Embelia ribes*, *Ficus hispida*, *Gymnema sylvestre*, *Mucuna pruriens*, *Murraya koenigii*, *Carissa opaca*, *Tinospora cordifolia*, etc.

Table 5. 25 – Cost Norms and Pattern of Assistance for High Density Block Plantation (HDBP)

Sl. No.	Magnitude of block Plantations (no of plants/block of 1 ha)	Total cost (Rs) for the block			
		1 st Year	2 nd year	3 rd Year	4 th Year

1	500 to 1000 (spacing 3.5mX3.5m)	28,000	14,000	14,000	14,000
2	>1000 to 1200 (spacing 3mX3m)	33,600	16,800	16,800	16,800
3	>1200 to 1500 (spacing 2.5mX2.5m)	48,000	24,000	24,000	24,000
4	>1500 (spacing less than 2.5mX2.5m))	52,000	26,000	26,000	26,000

Table 5. 26 – Cost Norms for Model BS/PB/AL/02

Sl. No.	Magnitude of block Plantations (no of plants/block of 1 ha)	Total cost (Max.) (Rs) for the block ((or in proportion to planting intensity)				Total
		1 st Year	2 nd year	3 rd Year	4 th Year	
1	1200	48,000	25,680	27,478	29,401	1,30,559
	Mandays	140	70	70	70	350

c. Treatment Models for Urban Landscape

Five treatment models viz., bioremediation and biofiltration, riverfront development, institutional and industrial estate plantation, ecopark development, and avenue plantation are proposed in the mountainous State of Himachal Pradesh. Likewise, four models except avenue plantations are proposed in alluvial plains of Punjab.

(A) Treatment Models for Urban Landscape in Himachal Pradesh

Model No. - BS/ HP/UL/01	Bio-remediation and Bio-filtration
Zone	Polluted Water Bodies and Wetlands

Under the Urban Landscape models, Bioremediation and biofiltration is one of the important forestry intervention activity proposed for rejuvenation of rivers/tributaries.

Varied anthropogenic activities and ever burgeoning population have resulted in deterioration of river ecosystems making them unfit for survival of indigenous biological forms. Rampant industrialization, improper agricultural methods, unchecked discharge of pollutants both

organic and inorganic into water bodies, drains, *Nallahs*, hillsides, rivulets and streams ultimately leads to the contamination of the river systems. Heavy metal effluents from the processing units of industrial agglomerations situated in the towns are drained into the river systems which degrade the quality of water, rendering of little or no use in the downstream.

Water bodies including rivers, lakes and streams have been heavily impacted due to the indiscriminate human activities and sometimes natural calamities and there is a great loss to their biodiversity or utility.

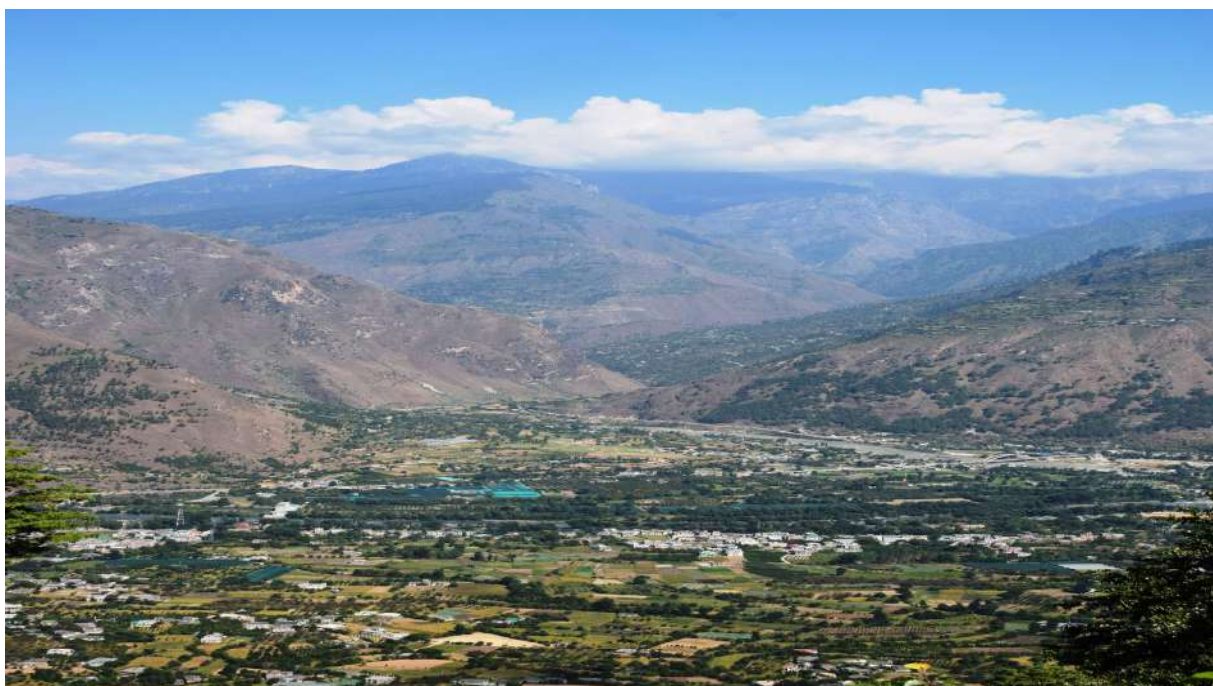
In this dismal scenario, cleaning of water bodies and removal of toxic pollutants from the river ecosystems to rejuvenate fresh water bodies by making them free of contaminants is urgently required.

In comparison to the conventional methods like physical, chemical and thermal processes, bioremediation techniques involving biological systems such as microorganisms or their products and plants are sustainable, cost effective options for abatement of pollution of the water bodies. In bioremediation, biological systems are applied for reclamation of the contaminated water by transformation of toxic pollutants into less hazardous or completely non-hazardous forms. The bioremediation technology includes use of microorganisms or their enzymatic machineries, phyto-remediation (plants) and rhizo-remediation (plant and microbe interactions) techniques. Thus, bioremediation is an effective and eco-friendly technique for removing toxic pollutants from aquatic environment.

Water pollution from untreated municipal wastewater is an enormous problem in urban agglomerations. Low-cost, decentralized, wetland-based bio-filters have strong potential to dramatically improve the water quality. Well-designed bio-treatment systems with inclusion of appropriate native species are ideal for removing pollutants from municipal wastewater. They can be applied extensively in rural areas, small towns, peri-urban areas of large cities, industrial townships or institutional campuses, as well as for certain types of industries such as agro-food/beverage etc. The biofilters are simple to construct, easy to operate, and cost effective. Major advantage of this method is that the pollutant is converted into biodegradable waste which can decompose within a moderate time frame, thus producing no secondary pollutants.

Broadly, in this technique plants and microbes associated with plant root systems are used to remove the pollutants in the form of inorganic and organic wastes. Selection criteria of plants for achieving high efficiency are always important. Plants such as *Tecoma stans*, *Actinoscirpus grossus*, *Eichhornia crassipes* (water hyacinth) and *Spirodela polyrrhiza* (aquatic plant) have been found good for dye degradation.

Organic and inorganic substances released from various sources into the existing natural water bodies cause their contamination. Among various water pollutants, nitrogen compounds form a significant role in wastewater contamination due to increase in anthropogenic sources like agriculture. Release of nitrate into fresh water poses severe problems including eutrophication. Biological denitrification is one of the more versatile and promising methods for the treatment of nitrate contaminated waters.



Urban pollutant pressures on water bodies

The plants in bio-filters played a great role in removing phosphates, nitrates, nitrites and ammonia. Many substances harmful to people and animals are conducive to plant growth. Plants require ammonia, phosphates and nitrates, and most synthetic fertilizers. Duckweed, nut grass and water lilies are known to absorb these substances.

The pollution control board already released the list of Urban/ Semi Urban area which are polluting the Rivers or their tributaries, so the areas are identified in the riverscape accordingly, and one site can be termed as 1 hectare (virtually) and where possible Seechewal model of Punjab or its modification can also be adopted

List of species for plantation

Tecoma stans, *Actinoscirpus grossus*, *Spirodela polyrhiza*, *Lemna minor*, *Cyperus rotundus*, *Nymphaea* spp., *Trapa natans*, *Cyperus* spp., *Typha* spp., *Phragmites* spp., etc.

Model No. – BS/HP/ UL/02

Riverfront Development

Zone

Along Beas River and Tributaries

Many cities, towns and semi-urban areas are located along the river Beas and its tributaries. Urban and peri-urban area along the river may be developed to attract residents and visitors and provide them a grand sight of the river along with fresh air, mental peace, solace and spiritual fulfillment that would connect them with the river.

River front development envisages riverbank plantation to stabilize it by protecting it from soil erosion. This involves covering the entire ground by intercepting the sunlight at various heights of canopy through multiple layers of vegetations. At the ground surface, the grasses

or surface growers are allowed to cover and to bind the surface soil and control the surface soil erosion like sheet erosion, splash erosion and rill erosion. It also promotes the rain water percolation and minimizes the surface runoff. At the second layer of vegetation, small to medium sized herbs and shrubs are accommodated to intercept some amount of sunlight and slow down the speed and reduce the erosive force of rain drops falling directly from sky and/or upper layers of canopy thereby reducing soil erosion (splash erosion). At the third layer of canopy above the ground surface, small to medium sized trees or larger shrubs are accommodated to provide a dense crown cover. This comprises light loving plants having good timber value and multipurpose benefits like fodder, fuel etc. Scattered taller strong light demander trees may make one or two higher layers of canopy. Strong root binders are promoted on this type of site. Multi-tier planting methods are preferred. A basic support system may also be developed for the convenience of visitors.

The riverfront of Beas and tributaries has different owners: farmers, Municipal Corporations, Panchayat, Irrigation department, Institutions, Forests department etc. and substantial portion are under private ownership. Suitable steps will be taken to ensure smooth coordination of the activities among different agencies.

In this model the river team has identified the major areas around district Headquarters or any other prominent places of religious importance in consultation with various stakeholders and area be decided as per availability at those places

One model for riverfront development has been proposed. Site-specific activities will be carried out at different places commensurate with the local site conditions available for riverfront development. Description of the model is given below:

Model – BS/HP/ UL/02 Riverfront Development

The proposed model of riverfront development would involve plantation of avenue shrubs and trees along the riverbank to stabilize the soil and protect the bank from erosion. It would also have beds of annual flowering plants and patches of grasses. The area is so developed that would provide a pleasing and relaxing environment to the visitors. It would be a typical landscaping area comprised of vegetation and non-vegetation components.

According to requirements following components need to be created for Riverfront development:

1. Vegetation Part: Grove consisting of shade trees, ornamental trees & bamboos, small herbal garden, climbers, hedges, grasses for lawn, etc.
2. Non-vegetation part: Stairs, pathways, walking trails, stone pitching, benches, rain shelters, e-public utilities, parking area, information centre, refreshment area etc. as per the site specific requirements.

The vegetation and non-vegetation components will be arranged in such a way to enhance the aesthetic beauty of riverfront. Ornamental species will be planted according to their recommended spacing and site specific suitability.

For using the available space economically and efficiently multi-tier planting methods will be used. Soil binding and water loving ornamental tree and shrub species are ideal choice for riverbank planting. To bind the surface soil, grasses and surface growers will be allowed to cover the surface and protect soil from erosion especially during rainy season or river flooding. It will minimise soil loss through sheet erosion, splash erosion and rill erosion. It will also improve rain water percolation or absorption. Besides this, small to medium sized herbs and shrubs will be accommodated at the second layer of vegetation to intercept some amount of sunlight and stop the fast/forceful falling of rain drops directly from sky in turn which stop soil erosion (splash erosion). Small to medium sized ornamental trees or larger shrubs i.e. mainly light demanding plants will be accommodated at the third layer of canopy to cover the crown area. This layer will provide small timber, fuel, fodder and intangible benefits. The top canopy will be occupied by the strong light demanding species which are ultimately the dominant species on riversides.

In this model the river team has identified the major areas around district Headquarters or any other prominent places of religions important with consultation of various stakeholders and area be decided as availability at those places.

List of species for plantation

Tree: *Jacaranda mimosifolia*, *Grevillea robusta*, *Albizia chinensis*, *A. procera*, *Butea monosperma*, *Kigelia pinnata*, *Dalbergia sissoo*, *Salix babylonica*, *Saraca asoca*, *Polyalthia longifolia*, *Callistemon citrinus*, *Syzygium cumini*, *Terminalia arjuna*, *Ehretia laevis*, etc.

Shrubs: *Bougainvillea* spp., *Rosa* spp., *Nerium oleander*, *Nyctanthes arbor-tristis*, and *Spiraea* spp.



Kalibein River at Sultanpur Lodhi, Kapurthala, Punjab

Model No. – BS/HP/ UL/03	Institution Plantation
Zone	Institutes and Industrial Estate

Number of Educational institutes, Hospitals, Government and Private Sector Offices, Factories, religious places, historical places, hotels, Guesthouses etc are located in the whole stretch on the bank of Beas and its tributaries. Many of such institutions and industries may have possibility to accommodate no. of trees of different sizes for beautifying the overall landscape. Tree/shrub/climber plantations will be encouraged on such lands within the project area. This would improve aesthetics, provide shade, produce non-wood and wood produce, reduce air, noise and dust pollution, harbour birds, reduce erosion, and create awareness about importance of trees. Some of the trees may serve religious purpose too and could be developed as small sacred grooves with the approval of management of such institutions.

The river team has consulted the secondary data of District wise/ Block wise in riverscape regarding schools (Universities, Collages, Corporate/Factory, Big hotels, Corporations, other NGO's, the Railways). Total numbers be worked out and 20% of those can be taken in this component and individual institution would be taken as one hectare (virtual) for calculating Budgetary provision. The forest department and commissioner of the district can be taken on board for providing the land for institutions for establishing plantations under this model. The Budgetary provision for those institutions can be distributed in three years in equal proportion or in the ratio of 30:30:40 in each year.

One model has been proposed for institutional and industrial estate plantation. Site-specific activities will be carried out according to the site conditions. Description of the model is given below:

Model –BS/HP/ UL/03 Institution Plantation

Under this model mainly ornamental, shade and fruit plants will be encouraged for planting. Evergreen plants especially Silver oak (*Grevillea robusta*) will be preferred so that the leaves do not shed during winter months when air pollution is usually high in plains. Plantation of forest species will be raised near the vicinity of various institutions and industries at 3m x 3m. Pit size of 45 cm x 45 cm x 45 cm will be used for plantation. After land development, pit digging etc. 1100 plants mainly of broadleaved species *Syzygium cumini*, *Anthocephalus kadamba*, *Dalbergia sissoo*, *Melia composita*, *Pongamia pinnata*, *Holoptelia integrifolia*, *Acacia nilotica*, etc. will be planted with tree guard protection. The initiative will beautify the area, create awareness among people associated with institution and industries and promote environmental services, besides providing economic returns from under-utilized land.

List of species for plantation

Tree: *Cedrus deodara*, *Aesculus indica*, *Prunus* spp., *Quercus* spp., *Bambusa* spp., *Dendrocalamus* spp., *Syzygium cumini*, *Anthocephalus kadamba*, *Dalbergia sissoo*, *Melia composita*, *Pongamia pinnata*, *Thuja* spp., *Cryptomeria japonica*, *Araucaria araucana*, *Cupressus torulosa*, *C. sempervirens*, *Jacaranda mimosifolia*, *Grevillea robusta*, *Albizia chinensis*, *A. procera*, *Delonix regia*, *Salix alba*, *Saraca asoca*, *Polyalthia longifolia*, *Callistemon viminalis*, *Kigelia pinnata*, etc.

Model No. – BS/ HP/UL/04

Ecopark Development

Zone

Along the Course of River or its Tributaries in the Great, Lesser, and Outer Himalayas

Development of some sites of urban landscape into Ecopark is an important activity keeping in view the growing population and settlements in urban areas. Actually, landscaping and beautification is proposed to be done for urban and peri-urban landscapes of frequent public visitation to bring forth aesthetics and entertainment coupled with natural awareness. The natural layout of the land will be manoeuvred in such a way that the aesthetic beauty will be enhanced without much investment by greening the blank areas. Landscaped area will be designed to afford good soil, moisture and biodiversity conservation, in addition to improvement in aesthetic values.

The River team has consulted various stakeholders having land for developing Eco park development which can be near any urban/semi urban area. The availability of land should be taken after consultation with respective stakeholders that can be anything from 0.5 ha. – 2 ha.

One model has been proposed for ecopark development. Site-specific activities will be carried out at different places in harmony with the selected site conditions. Description of the model is given below:

Model – BS/ HP/UL/04 Ecopark Development

An ecopark will be better equipped than riverfront development to facilitate visitors. An ecopark will have both vegetation and non vegetation components. Even in the Ecoparks the proportion of ornamental plants will be relatively more than in the riverfront development model.

According to requirement list of components to be created under this model

1. Vegetation part: Miscellaneous ornamental plant species e.g. trees, shrubs, herbs, creepers, hanging plants etc.
2. Non-vegetation part: Fencing, stairs, pathways, walking trails, stone pitching, rain shelter, e-public utilities, benches parking area, information centre, children playing area, pond beautification, lands scaping etc as per site-specific requirements.

List of species for plantation

Cedrus deodara, Aesculus indica, Platanus orientalis, P. occidentalis. Magnolia grandiflora, Jacaranda mimosifolia, Grevillea robusta, Albizzia chinensis, A. procera, Delonix regia, Butea monosperma, Thuja spp., Cryptomeria japonica, Araucaria araucana, Cupressus torulosa, C. sempervirens, Dalbergia sissoo, Salix spp., Saraca asoca, Polyalthia longifolia, Callistemon viminalis, Syzygium cumini, etc.

Shrubs: *Bougainvillea spp., Rosa spp., Nerium oleander, Nyctanthes arbor-tristis, Spiraea spp., etc.*

Table 5. 27 – Treatment Models for Urban Landscape in Himachal Pradesh

Sr. No	Model No.	Amount Rs/Ha	Man days	Amount Rs/Ha	Man days	Amount Rs/Ha	Man days	Amount Rs/Ha	Man days
		Estt.		1 st year Maint		2 nd year Maint		3 rd year Maint.	
1	BS/HP/UL/01 Bioremediation and Bio filtration	15,00,000	1800	4,50,000	540	3,00,000	360	2,25,000	270
2	BS/HP/UL/02 Riverfront Development	15,00,000	18000	4,50,000	5400	3,00,000	3600	2,25,000	2700
3	BS/HP/UL/03 Institution Plantation	2,60,000	312	78,000	94	52,000	62	39,000	47

4	BS/HP/UL /04 Eco-Park Development	1,50,00,000	18000	45,00,000	5400	30,00,000	3600	22,50,000	2700

(B) Treatment Models for Urban Landscape in Punjab

Model No. - BS/PB/UL/01	Bio-remediation and Bio-filtration
Zone	Polluted Water Bodies and Wetlands

The pollution control board already released the list of Urban/Semi Urban area which are polluting the Rivers or their tributaries, so the areas are identified in the riverscape accordingly, and one site can be termed as 1 hectare (virtually) and where possible Seechewal model of Punjab or its modification can also be adopted

The State Forest Department, municipal or Panchayat bodies have to adopt the suitable approach for bio-filter suiting to the specific requirements and site characteristics. The model will include the following activities.

1. Waste water treatment through mechanical measures as per the site requirement.
2. Drainage line treatment by planting grasses, herbaceous vegetation and shrubs.
3. Biofilters: Biofilters may be of different types: Free floating macrophyte biofilter, emergent macrophyte biofilter, sub-merged macrophyte biofilter, multispecies algal biofilter.

List of species for plantation

Tecoma stans, *Actinoscirpus grossus* , *Eichhornia crassipes*, *Spirodela polyrrhiza*, etc.

Model No. – BS/ PB / UL/02	Riverfront Development
Zone	Along River Course and Tributaries

The proposed model of riverfront development would involve plantation of avenue shrubs and trees along the riverbank to stabilize the soil and protect the bank from erosion. It would also have beds of annual flowering plants and patches of grasses. The area is so developed that would provide a pleasing and relaxing environment to the visitors. It would be a typical landscaping area comprised of vegetation and non-vegetation components.

According to requirements following components need to be created for Riverfront development:

1. Vegetation Part: Grove consisting of shade trees, ornamental trees and bamboos, small herbal garden, climbers, hedges, grasses for lawn, etc.
2. Non-vegetation part: Stairs, pathways, walking trails, stone pitching, benches, rain shelters, e-public utilities, parking area, information centre, refreshment area etc. as per the site specific requirements.

The vegetation and non-vegetation components will be arranged in such a way to enhance the aesthetic beauty of riverfront. Ornamental species will be planted according to their recommended spacing and site specific suitability.

For using the available space economically and efficiently multi-tier planting methods will be used. Soil binding and water loving ornamental tree and shrub species are ideal choice for riverbank planting. To bind the surface soil, grasses and surface growers will be allowed to cover the surface and protect soil from erosion especially during rainy season or river flooding. It will minimise soil loss through sheet erosion, splash erosion and rill erosion. It will also improve rain water per collation or absorption. Besides this, small to medium sized herbs and shrubs will be accommodated at the second layer of vegetation to intercept some amount of sunlight and stop the fast/ forceful falling of rain drops directly from sky in turn which stop soil erosion (splash erosion). Small to medium sized ornamental trees or larger shrubs i.e. mainly light demanding plants will be accommodated at the third layer of canopy to cover the crown area. This layer will provide small timber, fuel, fodder and intangible benefits. The top canopy will be occupied by the strong light demanding species which are ultimately the dominant species on riversides.

List of species for plantation

Tree: *Jacaranda mimosifolia*, *Grevillea robusta*, *Albizia* spp., *Butea monosperma*, *Kigelia pinnata*, *Dalbergia sissoo*, *Eucalyptus* spp., *Salix* spp., *Saraca asoca*, *Polyalthia longifolia*, *Callistemon citrinus*, etc.

Shrubs: *Bougainvillea* spp., *Rosa* spp., *Nerium oleander*, *Nyctanthes arbor-tristis*, *Spiraea* spp., etc.

Model No. – BS/ PB / UL/03

**Institution and Industrial Estates
Plantation**

Zone

Institutions and Industrial Estates

Under this model mainly ornamental, shade and fruit plants will be encouraged for planting. Evergreen plants especially Silver oak (*Grevillea robusta*) will be preferred so that the leaves do not shed during winter months when air pollution is usually high in plains. Plantation of forest species will be raised near the vicinity of various institutions and industries at 3m x 3m. Pit size of 45 cm x 45 cm x 45 cm will be used for plantation. Pit size of 45 cm x 45 cm x 45 cm will be used for plantation. After land development, pit digging etc. plants mainly of

broadleaved species *Syzygium cumini*, *Anthocephalus kadamba*, *Dalbergia sissoo*, *Melia composita*, *Pongamia pinnata*, *Holoptelia integrifolia*, *Acacia nilotica*, etc. will be planted. The initiative will beautify the area, create awareness among people associated with institution and industries and promote environmental services, besides providing economic returns from under-utilized land.

The river team has consulted the secondary data of District wise/ Block wise in riverscape regarding schools (Universities, Collages, Corporate/ Factory, Big hotels, Corporations, other NGO's, the Railways). Total numbers be worked out 20% of these can be taken in this component and the institution taken as one hectare. The forest department and commissioner of the district can be taken on board for providing the land for institutions for plantations. The 20% of number can be distributed in these years in equal proportion or in the ratio of 30:30:40 in each year

List of species for plantation

Tree: *Syzygium cumini*, *Anthocephalus kadamba*, *Dalbergia sissoo*, *Melia composita*, *Pongamia pinnata*, *Thuja* spp., *Cryptomeria japonica*, *Araucaria araucana*, *Jacaranda mimosifolia*, *Grevillea robusta*, *Albizia* spp., *Delonix regia*, *Salix alba*, *Saraca asoca*, *Polyalthia longifolia*, *Callistemon viminalis*, *Kigelia pinnata*, etc.

Model No. – BS/ PB/ UL/04

Ecopark Development

Zone

Riverfront

An ecopark will be better equipped than riverfront development to facilitate visitors. An ecopark will have both vegetation and non vegetation components. Even in the Ecoparks the proportion of ornamental plants will be relatively more than in the riverfront development model.

According to requirement list of components to be created under this model

1. Vegetation part: Miscellaneous ornamental plant species e.g. trees, shrubs, herbs, creepers, hanging plants etc.
2. Non-vegetation part: Fencing, stairs, pathways, walking trails, stone pitching, rain shelter, e-public utilities, benches parking area, information centre, children playing area, pond beautification, lands scaping etc. as per site-specific requirements.

The River team has consulted various stakeholders having land for developing Eco park development which can be near any urban/ semi urban area. The availability of land should

be taken after consultation with respective stakeholders that can be anything from 0.5 hact – 2 hact.

List of species for plantation

Trees: *Jacaranda mimosifolia*, *Grevillea robusta*, *Thuja* spp., *Cryptomeria japonica*, *Araucaria araucana*, *Albizia* spp., *Delonix regia*, *Butea monosperma*, *Kigelia pinnata*, *Dalbergia sissoo*, *Pongamia pinnata*, *Salix* spp., *Saraca asoca*, *Polyalthia longifolia*, *Callistemon viminalis*, etc.

Shrubs: *Bougainvillea* spp., *Rosa* spp., *Nerium oleander*, *Nyctanthes arbor-tristis*, *Spiraea* spp., etc.

Table 5. 28 – Treatment Models for Urban Landscape in Punjab

Sr. No	Model No.	Amount Rs/Ha	Man days	Amount Rs/Ha	Man days	Amount Rs/Ha	Man days	Amount Rs/Ha	Man days
		Estt.		1 st year Maint		2 nd year Maint		3 rd year Maint.	
1	BS/PB/UL/01 Bioremediation and Biofiltration	15,00,000	1,316	4,50,000	395	3,00,000	263	2,25,000	197
2	BS/PB/UL/02 Riverfront Development	150.00,000	3,115.8	45.00000	394.7	30.00000	263.2	2,25,000	197.4
3	BS/PB/UL/03 Institution Plantation	2,60,000	228	78,000	68	52,000	46	39,000	34
4	BS/PB/UL/04 Eco-Park Development	1,50,00,000	1,315.8	45,00,000	394.7	30,00,000	263.2	22,50,000	197.4

5.5.3 Projected Targets – Model-wise Extent and Cost

The foregoing description has provided details on the potential treatment models under different landscapes within the riverscape. It is evident that the model-wise cost ranged from Rs. 0.11 Crore to Rs. 84.77 Crore. The proposed extent under different models during the Phase I and Phase II i.e., during the 5-years Project Implementation and 5-years Maintenance Phase would range from 5 ha to 4730 ha. The projected targets of proposed forestry interventions under three types of landscapes are summarized in Table 5.29.

Table 5. 29 – Cost Norms and Pattern of Assistance for High Density Block Plantation (HDBP)

Sr. No.	Landscape	Plantation Extent (ha)		Total Number of Plants to be Planted	Total Cost
		Himachal Pradesh	Punjab		
1	Natural	8361	1065	4061300	24393.78
2	Agriculture	1671	1845	1137450	3516
3	Urban	138.5	274	2230339	412.5
Total		10170.5	3184	7429089	28322.28

(a) Cost Norms

Cost norms for each proposed treatment model under three different landscapes and conservation interventions were computed in great detail in taking into account labour work and cost aspects on preparation of sites, establishment of nurseries and raising of plants, cost of material, plantation cost, and maintenance cost. Cost norms were worked out on year-wise basis and they are discussed and presented in section 1.6 and 2.6 of Vol. II. However, a summary of cost norms in the context of proposed treatment models in three different landscapes within the riverscape are summarized in Table 5.30.

Table 5. 30 – Summary of Cost Norms in Context of Different Proposed Treatment Models in Three Landscapes within the Beas Riverscape

Sr. No.	Proposed Treatment Model		Establishment Cost (Rs.)	Maintenance Cost (Rs.)	Total Cost (Rs.)
Natural Landscape					
Hills – Himachal Pradesh					
1	BS/HP/NL/01	Sub-Alpine Conservation	8.34	2.69	11.03
2	BS/HP/NL/02	Sub-Alpine Enrichment	145.28	22.18	167.46
3	BS/HP/NL/03	Temperate Conifer Forest	486.64	157.8	644.44
4	BS/HP/NL/04	Temperate Mixed Forest	3542.18	1181.33	4723.51
5	BS/HP/NL/05	Pasture and Grazing land Development	56.76	22.89	79.65
6	BS/HP/NL/06	Himalayan Chir Pine Forest	1708.54	922.43	2630.97
7	BS/HP/NL/07	Himalayan Mixed Forest	2796.72	1455.86	4252.58

8	BS/HP/NL/08	Sub-Tropical Dry Deciduous Forest	1228.44	639.11	1867.55
9	BS/HP/NL/09	Control of Lantana	2181.74	970.91	3152.65
10	BS/HP/NL/10	Control/ Removal of Invasive Alien Species or <50% Lantana	2760.41	1230.85	3991.26
11	BS/HP/NL/11	Protection Model for Natural Regeneration	6068.59	2408.35	8476.94
12	BS/HP/NL/12	Fire Protection Model	519.25	1517.73	2036.98
13	BS/HP/NL/13	Plantation by Eco-Task Force in Temperate region	2243	1884	4127
Alluvial Plains – Punjab					
14	BS/PB/NL/01	Restoration of Degraded Forest	1334.42	706.41	2040.83
15	BS/PB/NL/02	Road Side Plantation	501.08	330.78	831.86
Agriculture Landscape					
Hills – Himachal Pradesh					
16	BS/HP/AL/01	Boundary Plantation Model	116.55	200.55	317.1
17	BS/HP/AL/02	Block Plantation Model	180.48	310.49	490.97
Alluvial Plains – Punjab					
18	BS/PB/AL/01	Boundary Plantation Model	147.6	266.17	413.77
19	BS/PB/AL/02	High Density Block Plantation	98.4	169.3	267.7
Urban Landscape					
Hills – Himachal Pradesh					
20	BS/HP/UL/01	Bio-remediation and Bio-filtration	232.5	151.17	383.67
21	BS/HP/UL/02	Riverfront Development	825	536.25	1361.25
22	BS/HP/UL/03	Institutional and Industrial Estate Plantation	278.2	180.83	459.03
23	BS/HP/UL/04	Eco-Park Development	1575	1023.75	2598.75
Alluvial Plains – Punjab					
24	BS/PB/UL/01	Bio-remediation and Bio-filtration	120	78.04	198.04
25	BS/PB/UL/03	Institutional and Industrial Estate Plantation	645.06	419.29	1064.35
26	BS/PB/UL/04	Eco-Park Development	1185	770.25	1955.25

(b) Proposed Intervention Sites

Intervention sites for proposed interventions were carefully selected by the frontline staff of Forest Department and concerned DFOs have furnished details on geographical coordinates of these field sites. Accordingly, these coordinates were superimposed on relevant satellite imageries. Details on geographical coordinates, thus, obtained and presented in Fig. 1.12-1.13 and 2.15 to 2.16 of Himachal Pradesh and Punjab in Vol. II.

5.5.4 Theme Plans

As stated earlier, ‘Conservation Interventions’ and ‘Supporting Activities’ those are common to two or more lower order sub-zones or three type of landscapes described above, referred as ‘Theme Plans’ are also being proposed. Details of proposed conservation interventions and supporting activities are provided below:

a. Conservation Interventions

Three types of conservation interventions viz., (a) soil and water conservation, (b) riparian wildlife management, and (c) wetland management are being proposed for implementation by two State level IAs. Proposed conservation interventions will be implemented at the State and local field levels. Details of three type of conservation interventions proposed are presented below:

(1) Soil and Water Conservation Measures

The description on physical sub-environment provided earlier in the context of Beas Riverscape has highlighted that the catchment of the river, particularly in the mountainous tract of Himachal Pradesh suffers on account of landslides, bank erosion, habitat loss, construction activities and other unsustainable human activities resulting into severe problem of soil erosion and sedimentation. Conservation interventions by way of appropriate soil and water conservation measures are of paramount importance in order to ensure *Aviral Dhara*, *Nirmal Dhara* and ecological integrity of the river. Accordingly, bioengineering as well as mechanical measures are envisaged for the purpose of soil and water conservation. Potential bioengineering and mechanical measures are described below one by one.

(A) Bioengineering Measures - A Homeopathy of Environmental Restoration

Bioengineering is the designed use of grasses, shrubs and trees to improve and protect the land. The hydrological and mechanical effects of the plant community are used to fulfill an engineering function. Vegetation can be used alone or in conjunction with engineering structures in which case it can be termed as biotechnical engineering. Bioengineering techniques have emerged as an effective method to prevent soil erosion and to assist re-vegetation of disturbed sites such as hill slopes and stream banks. Living plant material is used to construct live structures along the low cost engineering structures so that not only stabilization of hill slope takes place but also stimulate growth as well as provide a permanent solution to unstable hill slope. The vegetative conservation technology covers the set of

biological measures often planned and designed in conjunction with engineering/mechanical measures to conserve soil and water resources for sustainable biomass production.

(i) Special Characteristics of Conservation Flora

The plant species providing dense ground cover during rainy season like Bhabar grass (*Eulaliopsis binata*), *Saccharum munja* and *Phragmites* spp., are considered as erosion resistant crops. There are some plant species which are preferred because of their special characteristics as summarized below:

- The selected plant species should be generally evergreen.
- The species should be adapted to local climate, soil and site conditions.
- They must have a dense, fibrous and strong root system for soil binding.
- They should have a genetic ability to thrive on poor/impoverished/marginal lands.
- They must be fast growing and of primary colonizing nature.
- Such plants may not be attacked by termites/insects/pests and damaged by frost.
- Such plant species should multiply very fast by profuse tillering or through suckers.
- Such plants should have social and some economic value to local population.
- Such plants should profusely grow during monsoon when soil erosion is highest.
- Their architecture should be such that plants bend with currents of water and erect again when flow stops.

(ii) Vegetative Measures for Soil and Water Conservation

The vegetative measures are cost effective and play important role in conserving soil and water and are included in any watershed management plan. These bioengineering measures are different for arable and non-arable lands and generally divided into five categories viz., (a) land slope management, (b) drainage line treatment, (c) stream bank protection, (d) landslide stabilization, and (e) land-fill, mine spoiled and other problem areas.

(iii) Bio-engineering Measures for Land Slope Management

- Barriers of suitable and compatible grasses, shrubs and trees are established against over land slope on contour to intercept soil and water.
- The species vary according to agro-climatic conditions.
- There is considerable variation in soil working, planting techniques and planting material.
- In general, the soil excavated from contour trenches/V-ditches/contour furrows is deposited on the down-slope side leaving a 15 cm berm to form a parallel contour bund along the contour trench having breaks at regular interval.
- Rooted slips of grasses are planted at a spacing of 10 cm to 15 cm on bunds and fodder trees are planted in/ along the trenches.
- On the lower side of the bunds, a row of grasses are raised to form complete barrier.
- The vertical interval between the rows varies usually with slope and tree rows spacing which may vary from 3 m to 6 m.

- The contour trenches get partly filled with eroded soil and store rainwater which in turn provide sufficient moisture to the vegetative strips.
- Once established, the closely growing hedges along with dense roots reduce soil erosion by breaking the slope length, reduce velocity of water and increase infiltration to the soil, induce deposition of the eroded soil and help in establishing trees raised on trenches by improving moisture regime.



Navgrah Vatika, Eco Park at Nurpur, Kangra

The grass barriers are established during rainy season and when planted during drizzling establish very quickly. *Chrysopogon zizanioides* grass performs well only on wet/moist areas in non-arable lands, but suffers high mortality and then termite attack on drier slopes. Bhabar grass (*Eulaliopsis binata*) performs well when planted properly during light showers and particularly in association with trees having light/ thin canopy like khair (*Acacia catechu*). Napier grass (*Pennisetum purpureum*) is most liked by the farmers and provides forage for livestock. These hedges take 2 to 3 years to establish and over a period of time eroded soil accumulate above the hedges and this would tend to form terraces by breaking the slope into series of terraces.

(iv) Bio-engineering Measures for Drainage Line Treatment

A wide range of measures are available for the drainage line treatment. These are described below one by one:

Live Check Dams: Live check dams are the barriers created by planting available grasses and shrubs across the first order gullies to check soil erosion, retain fine soil and moisture. These are also raised to check extension of gully heads to upper slopes. To prolong the life of

water storage structures, live check dams in drainage lines above the water storage structures and in between the silt detention dams assumes significance.

Construction of Live Check Dams - Live check dams are constructed using locally available plant species such as *Vitex negundo*, *Arundo donax*, *Ipomoea carnea*, and *Agave sisalana*. Two rows of grasses like Vetiver (*Chrysopogon zizanioides*), Guinea grass (*Panicum maximum*) and Napier (*Pennisetum purpureum*), etc. are planted at 10cm interval from plant to plant and 20 cm row to row spacing. On the down side of grass row, two rows of shrubs like *Vitex negundo*, *Arundo donax* and *Ipomoea carnea* are planted at close spacing of 30cm from plant to plant and 50cm from row to row across the *Nallah* bed. In case sand/debris load is large then series of live check dams are constructed above and below the crate/dry stone check dams.

Brush Wood Check Dams: Brush wood check dams are constructed using locally available brush wood material and wooden poles from the forest. They are feasible where such material is available. They are constructed in small gullies not deeper than one meter depth. They are of two types, viz., (a) single row post brush wood dams, and (b) double row post brush wood dams.

Single Row Post Brush Wood Dams: These are made of wooden stakes to which long branches of trees and shrubs are tied in a zigzag manner across the small gully. The site is first eased to slope of 1:1 and bottom of the gully excavated by about 25 cm. Then, the wooden stakes of about 10 cm in diameter are driven about 0.75 m to 0.90 m deep and 0.60 m to 0.90 m apart along the dam axis. Their tops are kept in such a way that a depression is formed in the centre for disposal of excess water. In order to control termite attack, the wooden stakes are treated with coal tar. The height may vary from 30 cm to 60 cm. On the lower side, the brush wood is laid in such a way that cut end side half is placed inside the structure and remaining half extended downward as a mat to act as apron which may protect the base against erosion.

Double Row Post Brush Wood Dam: When the size of gully increases from 1-2.5 m depth and 5-6 m wide, then double row post brush wood dams are more appropriate. The construction is same as that of single row dam except that the brush wood is laid across the gully in between of two rows of poles spaced about 0.9 m apart. At the base, some branches are laid along the slope of gully with cut ends laid upside and branches extending to lower side to form an apron of branches. A row of live hedge is planted both on the upstream and downstream side of brush wood check dam which may become functional when brush wood decay after some time (Fig. 5.1).

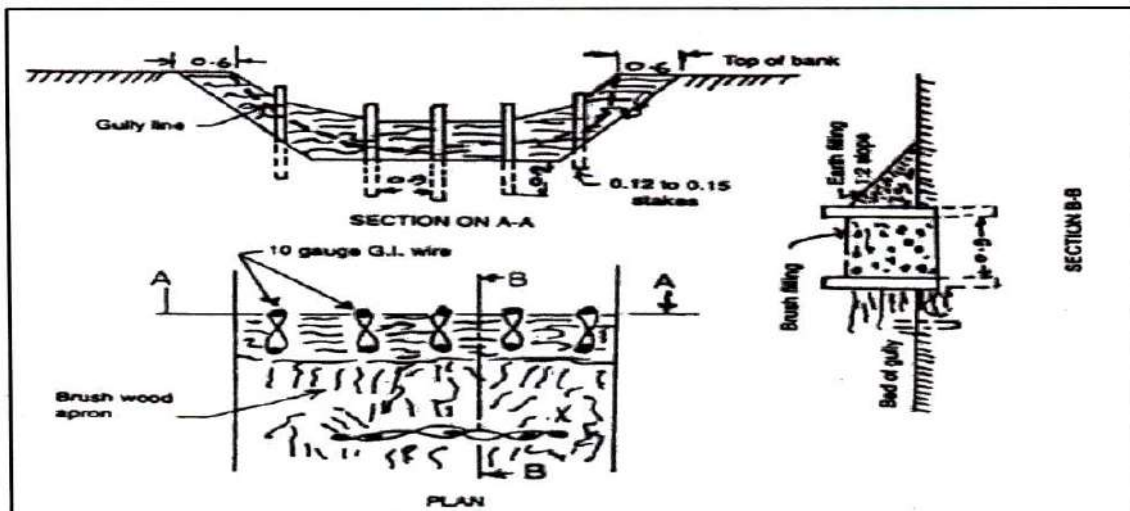
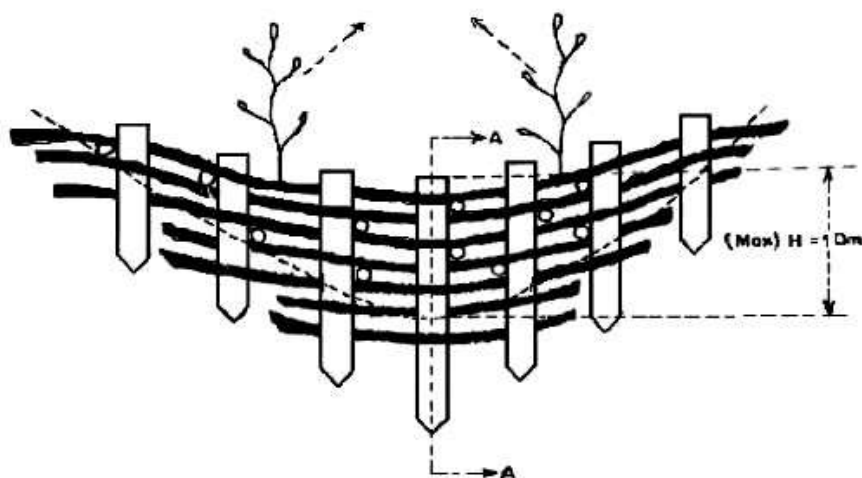


Fig. 5. 1- Design of Double Row Post Brush Wood Dam

Another method is to lay branches of trees horizontally between the wooden poles and tie those with wire to wooden poles and fill the central portion with some brush wood at the base and place heavy stones to press the brush wood. Because of serious termite problem, brushwood is decomposed very quickly and hence live hedge are preferred (Fig 5.2).



a: Front view
A. Seedlings

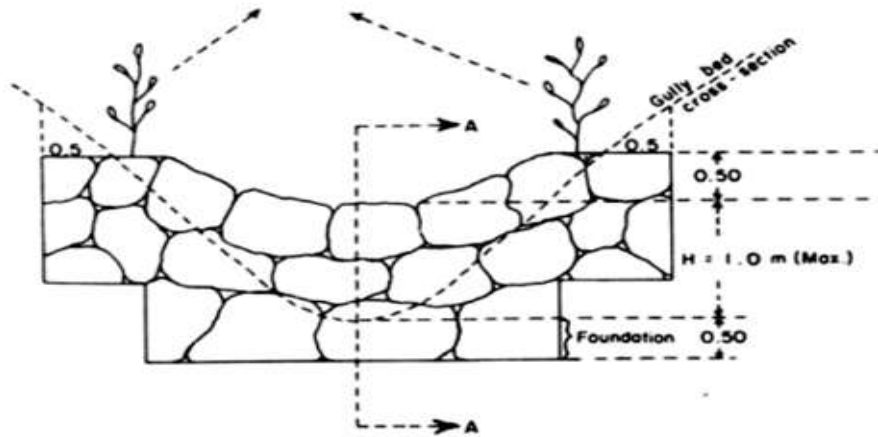


Fig. 5. 2- Alternative Construction Design of Double Row Post Brush Wood Dam

Contour Wattling: Contour wattling is a method of breaking the length of slope into shorter portions by providing contour wattles at 3-5 m interval. It is normally used on portions of the side which is easily accessible. The advantage is that it holds the downward movement of earth and reduces the raindrop impact. Wattles are laid out at a vertical interval of 3m up to 66% slope and 5-7 m up to 33% slope. Trenches of 0.3m wide and 0.3-0.5 m deep are dug up on contour and filled with brush wood bundles of 5-6 cm diameter branches laid horizontally. The poles of 8 -12 cm diameter and around 1.5m length of plant species which sprout on planting are embedded about half the length at about one meter interval on the lower side of the trenches. Some self-sprouting species are: *Ficus racemosa*, *Lansea coromandelica*, *Erythrina suberosa*, *Vitex negundo*, *Hymenodictyon orixense*, *Salix tetrasperma* (willow), *Spermadictyon suaveolens*, *Cassia fistula*, etc. The inter-space between the wattles is protected by mulching with a thick layer of locally available grass and tied with a thin wire or rope to avoid its displacement by water or wind. The inter-space area should be planted by soil binding grasses/shrubs. The wattling should be preferred on fragile slopes where soil working is difficult and mulching material should be locally available. The live contour wattles obstruct the movement of debris and allow the run off to pass through.

Contour Live Hedges: Contour live hedges serve the purpose of vegetative barriers and created by planting suitable erosion resistant grass/herb species on lower side of contour trenches which form a dense hedge to intercept soil and water (Fig.5.3)

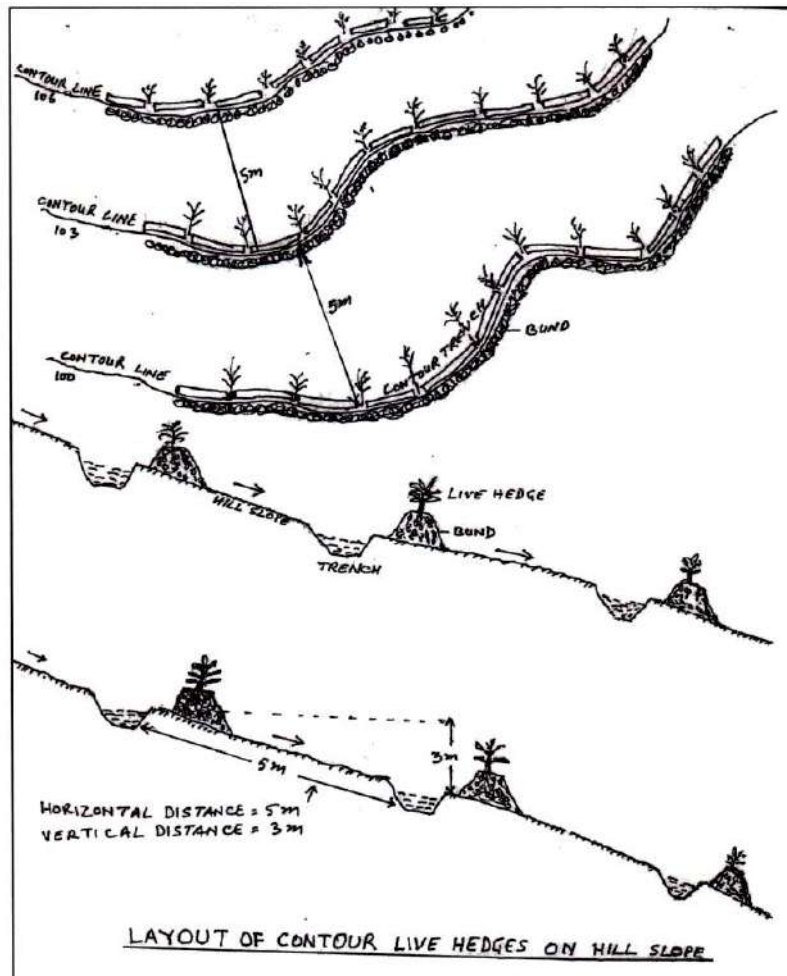


Fig. 5. 3- Design of Contour Live Hedge

(v) Bio-engineering Vegetative Measures for Stream Bank Protection

When drainage lines meander like a snake on relatively steep slopes the problem of stream bank erosion becomes quite serious. Generally, the *khad* cut the bank on the outer side on a curve because of higher velocity and deposit the eroded debris on the inner side of the curve. The protection of the banks is necessary particularly when infrastructure and costly farm lands are at risk of bank cutting. With the retards and revetments, vegetative reinforcement is always considered essential. When flow discharges are low, the *khad* do not meander much, the vegetation alone can serve the purpose of bank protection.

Two lines of *Ipomoea carnea*, *Arundo donax*, *Phragmites* spp., or other similar plant species are planted along the eroded bank at one meter apart. Along with this, on cutting side, repelling type spurs are raised in double rows at 15 - 20 m apart and extending only up to 1/4th length of active flow. In between the spurs, seeding of fast growing plant species is carried out. In these vegetative spurs, mixing of *Ipomoea carnea* and *Arundo donax* provides better results. If possible, brush wood of Ber (*Ziziphus mauritiana*), Karonda (*Carissa opaca*), or any thorny shrub may be imbedded which not only protect the vegetation from

under cutting by reducing the velocity of water, but also induce sediment deposition. In the subsequent year, bamboo may be planted on sand deposited moist bank sides to provide the additional strength to the spurs.

Such live hedges are used extensively for stream bank protection both alone and in conjunction with mechanical spurs and retaining walls. It is recommended that suitable shrub species like *Ipomoea carnea* should be planted in between the spurs along the gully banks and also along the spurs and particularly at its nose. These hedges break the velocity of water and induce deposition along the banks and near the structures. Once the land reclamation process starts, a row of bamboo is planted along the gully banks behind the live hedges. Bamboo as such is the most suitable plant for stream bank protection. On the reclaimed beds of the gullies, tree species like Khair (*Acacia catechu*), *Cassia fistula*, and Shisham (*Dalbergia sissoo*) are planted during second and third rainy season.

Where live spurs and hedge rows of *Ipomoea carnea* were planted for stream bank protection, the silt deposition along the bank takes place. In case, *Arundo donax* and *Ipomoea carnea* are mixed together, the stability is further enhanced. The best time for planting these vegetative structures is mid July to mid August when there is sufficient moisture in the soil. Most plants are vegetatively propagated.

(vi) Bio-engineering Measures for Landslide Control

The Himalayan Mountains are vulnerable to landslides where debris flow and other forms of mass wasting are common. The problem is pronounced in the Himalayas with high energy environment due to active tectonics, rugged topography with very high relief and highly concentrated monsoon precipitation. Moreover, high densities of both human and livestock populations and consequent changes in land use and land cover have caused further intensification of the processes of landslide and debris flow. The loss of life and properties from landslides, debris flow and flood has been increasing and the livelihood options of mountain people have been threatening. The causative factors responsible for enhanced landslides in the State of Himachal Pradesh along with the extent have been summarized in the Chapter on the riverscape and its environment.

Measures for Control of Landslides: As stated above, the cause for landslide could be multiple. Depending upon the reason for landslide, different treatments would be applicable. These are described below one by one:

Landslides Caused by Excessive Wetness/Over Saturation of Slip Zone – In order to treat landslides caused by excessive wetness/ over saturation of slip zone, the proposed mitigation measure involves the following five steps:

(a) **Step 1:** The foremost requirement is to locate the source of water entering from upper areas. In case water is entering from some leaking irrigation channel, the control of such a leak by suitable technique would be necessary. The channel may have to be lined or water is allowed to pass through a pipeline in that particular stretch. In case of runoff water, the

construction of a diversion channel would be necessary to divert the runoff and dispose it off at non-erosive velocity to a side drainage way. The diversion channel on gentle gradient may be protected by stone laid bed and sides supported by vegetation.

(b) **Step 2:** As a second step, drainage of excess water in the soil mass would require cross drainage works which may be carried out by installing perforated pipes, filter drains of stones/rubble (wire bolsters) and /or simple open drains converging to main pipe drain as shown in the Fig. 5.4.

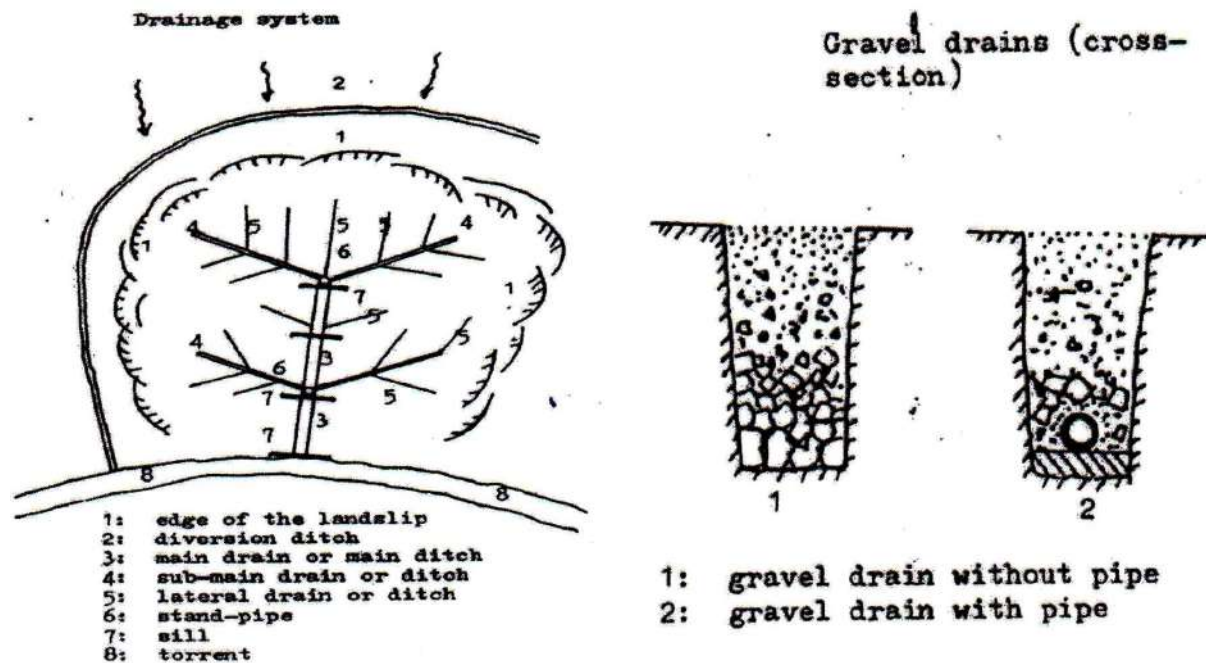


Fig. 5. 4- Drainage System of a Typical Landslip Site

Note: In Fig 5.4., The legends are: (1) The landslide area is shown by outer hachuring; (2) A diversion ditch is provided to carry away the water from top for safe disposal; (3) A main drain of perforated pipes or gravel filter is provided in the centre along the slope; (4) Four sub-drains are provided as laterals to carry seepage/ surface water to the main drain; (5) In each sub- drain, few lateral drains are provided to drain water from the wet/ moist land; (6) At each junction, vertical stand pipes are provided in which sub-pipes discharge water; (7) The main pipe at the end is placed over a wall of check dam or retaining wall for support and water fall over this wall/structure without causing scouring at the base; and (8) All the drained water is ultimately drained into the main torrent or drainage system.

(c) **Step 3:** The next most important part is the construction of gabion/masonry/dry stone retaining walls. One major retaining wall at the base of the landslide/slip zone to hold back the entire soil mass is necessary. The site should be selected carefully where maximum load can be retained with minimum length. The height of the retaining wall may vary from 1.5 - 4 m depending upon the height of the soil mass at site. The base width of 2 m and top width of 1 m is often suggested. The retaining wall is constructed either straight with steps or slanting at an angle of 75° to 80° from the base. Weep holes of 7.5cm must be made at regular interval and one hole for every 6 m² area. Back of the wall is filled with boulders for ensuring quick drainage. A toe drain in the foot of the wall may be required to carry the overflow to the nearby *khad*.

(d) **Step 4:** The fourth is the construction of series of staggered retaining walls on the slope. In addition to the main retaining wall at the base, series of staggered dry stone retaining walls are often required over the slipped land mass to retain the debris *in situ*. The local slate type stones are preferred for better stability. The number should not be too large as it would increase the weight of soil mass. More reliance has to be placed on vegetative measures.

Step 5: The final step relates to the live hedges as part of bio-engineering measures. The live hedges of selected tree and shrub species are planted almost on contour and soil binding grasses are planted between the rows of hedges. Close growing plant types forming mat and showing spreading and creeping habit hold promise. Hardy and xerophytic plants are ideal for dry areas. *Woodfordia fruticosa* shrub has great potential because of deep root system and *Mimosa himalayana* a shrub is also a good colonizer. *Alnus nepalensis*, *Debregeasia saeneb* and *Populus ciliata* are considered as potential soil conserving tree species. *Alnus nepalensis*, *Populus ciliata*, *Pyracantha crenulata*, and *Pennisetum clandestinum* grass on forest slopes damaged by landslides are also recommended.

Species for the bio-engineering have been recommended along the altitudinal gradients of Beas River Basin according to their occurrence. Three tiers plantation of species i.e., (i) Herbs, grasses and sedges; (ii) Shrubs; and (iii) Trees have been suggested as happens in natural succession. The altitudinal zone wise recommended species are given below, which can be considered as per the site conditions. The HFRI expert team, based on their vast working experience in the field, on forestry systems and plant diversity in Himachal Pradesh, has suggested the altitude wise species for bio-engineering applications are given in Table 5.31.

Table 5. 31 – Plant Species Recommended for Bioengineering Works in Himachal Pradesh

Altitudinal Zone <1000m	Trees <i>Acacia catechu</i>, <i>Aegle marmelos</i>, <i>Bixa orellana</i>, <i>Bombax ceiba</i>, <i>Casearia tomentosa</i>, <i>Cassia javanica</i>, <i>Dalbergia sissoo</i>, <i>Delonix regia</i>, <i>Elaeodendron glaucum</i>, <i>Eucalyptus tereticornis</i>, <i>Ficus benghalensis</i>, <i>F. hispida</i>, <i>F. semicordata</i>, <i>F. rumphii</i>, <i>F. racemose</i>, <i>Flacourtia indica</i>, <i>Holarrhena pubescens</i>, <i>Lagerstroemia parviflora</i>, <i>L. speciosa</i>, <i>Limonia acidissima</i>, <i>Mallotus philippensis</i>, <i>Magnolia grandiflora</i>, <i>Michelia champaca</i>, <i>Mimusops elengi</i>, <i>Oroxylum indicum</i>, <i>Peltophorum pterocarpum</i>, <i>Populus deltoides</i>, <i>Prosopis cineraria</i>, <i>Salix tetrasperma</i>, <i>Syzygium cumini</i>, <i>Cassia fistula</i>, <i>Terminalia</i> spp., <i>Albizia</i> spp., <i>Azadarachta indica</i>, <i>Tamarindus indica</i>, <i>Alstonia scholaris</i>, <i>Syzygium frondosum</i>, <i>Butea monosperma</i>, <i>Camellia sinensis</i>, <i>Boehmeria rugulosa</i>, <i>Dendrocalamus hamiltonii</i>, <i>D. strictus</i>, etc. Shrubs <i>Buddleja asiatica</i>, <i>Bambusa bambos</i>, <i>Berberis asiatica</i>, <i>Celastrus paniculatus</i>, <i>Cotinus coggygia</i>, <i>Justicia adhatoda</i>, <i>Rhus parviflora</i>, <i>Duranta repens</i>, <i>Flemingia semialata</i>, <i>Clerodendron</i> spp., <i>Murraya koenigii</i>, <i>M. paniculata</i>, <i>Meizotropis buteiformis</i>, <i>Senna tora</i>, <i>Thysanolaena latifolia</i>, <i>Vitex negundo</i>, <i>Nyctanthes arbour-tristis</i>,

	<i>Corchorus aestuans</i>, <i>C. olitorius</i>, <i>Woodfordia fruticosa</i>, <i>Carissa opaca</i>, <i>Maesa indica</i>, <i>Tinospora cordifolia</i>, etc. Herbs, Grasses and Sedges <i>Arundo donax</i>, <i>Alocasia macrorrhizos</i>, <i>Calendula officinalis</i>, <i>Cardiospermum halicacabum</i>, <i>Carthamus oxyacantha</i>, <i>Centella asiatica</i>, <i>Chamaecrista pumila</i>, <i>Cichorium intybus</i>, <i>Citrullus colocynthis</i>, <i>Desmodium triflorum</i>, <i>Eclipta prostrata</i>, <i>Hyptis suaveolens</i>, <i>Malva parviflora</i>, <i>Malvastrum coromandelianum</i>, <i>Medicago polymorpha</i>, <i>Chrysopogon zizanioides</i>, <i>Cymbopogon citratus</i>, <i>C. microthecus</i>, <i>Saccharum munja</i>, <i>Phragmites</i> spp., <i>Polygonum</i> spp., <i>Heteropogon contortus</i>, <i>Chrysopogon serrulatus</i>, <i>Fimbristylis</i> spp., <i>Polypogon fugax</i>, <i>Bothriochloa</i> spp., <i>Carex</i> spp., <i>Cyperus</i> spp., <i>Neyraudia reynaudiana</i>, <i>Eulaliopsis binata</i>, etc.
Altitudinal Zone 1001-2000m	Trees <i>Albizia julibrissin</i>, <i>A. chinensis</i>, <i>Alangium chinense</i>, <i>Alnus nitida</i>, <i>Bauhinia variegata</i>, <i>Carpinus viminea</i>, <i>Cornus capitata</i>, <i>Cinnamomum tamala</i>, <i>Cupressus torulosa</i>, <i>Dalbergia sissoo</i>, <i>Debregeasia saeneb</i>, <i>Dendrocalamus hamiltonii</i>, <i>D. strictus</i>, <i>Ficus semicordata</i>, <i>Fraxinus micrantha</i>, <i>Grewia optiva</i>, <i>Melia azedarach</i>, <i>Pistacia chinensis</i> subsp. <i>integerrima</i>, <i>Pinus roxburghii</i>, <i>Populus ciliata</i>, <i>Pyrus pashia</i>, <i>Salix babylonica</i>, <i>Symplocos paniculata</i>, <i>Toona ciliata</i>, <i>Quercus oblongata</i>, <i>Q. glauca</i>, <i>Wendlandia heynei</i>, <i>Myrica esculenta</i>, <i>Syzygium cumini</i>, <i>Cornus macrophylla</i>, <i>Cornus capitata</i>, <i>Prunus cerasoides</i>, <i>Neo-litsea paniculata</i>, <i>Rhododendron arboreum</i>, <i>Olea ferruginea</i>, etc. Shrubs <i>Berberis lycium</i>, <i>Cornus oblonga</i>, <i>Woodfordia fruticosa</i>, <i>Inula cuspidata</i>, <i>Colquhounia coccinea</i>, <i>Dodonaea viscosa</i>, <i>Duranta repens</i>, <i>Flemingia semialata</i>, <i>Myrsine africana</i>, <i>Drepanostachyum falcatum</i>, <i>Rubus ellipticus</i>, <i>Vitex negundo</i>, <i>Withania somnifera</i>, <i>Woodfordia fruticosa</i>, <i>Zanthoxylum armatum</i>, <i>Coriaria nepalensis</i>, <i>Hypericum oblongifolium</i>, <i>Rosa</i> spp., <i>Deutzia</i> spp., <i>Viburnum</i> spp., <i>Desmodium elegans</i>, <i>Indigofera heterantha</i>, <i>Sorbaria tomentosa</i>, <i>Cotoneaster</i> spp., <i>Pyracantha crenulata</i>, <i>Colebrookea oppositifolia</i>, <i>Justicia adhatoda</i>, etc. Herbs, Grasses and Sedges <i>Saccharum spontaneum</i>, <i>Bergenia ciliata</i>, <i>Heteropogon contortus</i>, <i>Hyptis suaveolens</i>, <i>Rumex hastatus</i>, <i>Cynodon dactylon</i>, <i>Melilotus officinalis</i>, <i>Mentha arevensis</i>, <i>Pennisetum purpureum</i>, <i>Trifolium repens</i>, <i>T. pratense</i>, <i>Valeriana jatamansi</i>, <i>Saccharum spontaneum</i>, <i>Eulaliopsis binata</i>, <i>Erianthus rufipilus</i>, <i>Themeda arundinacea</i>, <i>T. anathera</i>, <i>Cyperus</i> spp., <i>Carex</i> spp., <i>Fimbristylis</i> spp., <i>Arundinalla nepalensis</i>, <i>A. pumila</i>, <i>Apluda mutica</i>, <i>Cymbopogon distans</i>, <i>Chrysopogon gryllus</i>, <i>C. serrulatus</i>, <i>Polygonum</i> spp., <i>Heteropogon contortus</i>, <i>Polypogon fugax</i>, <i>Bothriochloa</i> spp., etc.
Altitudinal Zone 2001-3000m	Trees <i>Abies pindrow</i>, <i>Acer caesium</i>, <i>A. pictum</i>, <i>A. acuminatum</i>, <i>Aesculus indica</i>, <i>Alnus nitida</i>, <i>Quercus oblongata</i>, <i>Cedrus deodara</i>, <i>Corylus jacquemontii</i>, <i>Euonymus tingens</i>, <i>E. lucidus</i>, <i>Ilex dipyrena</i>, <i>Juglans regia</i>, <i>Lyonia ovalifolia</i>, <i>Myrica esculenta</i>, <i>Morus serrata</i>, <i>Pinus wallichiana</i>, <i>Picea smithiana</i>, <i>Prunus cerasoides</i>, <i>P. cornuta</i>, <i>Salix tetrasperma</i>, <i>S. daphnoides</i>, <i>Toona sinensis</i>, <i>Taxus wallichiana</i>, etc. Shrubs

	<i>Berberis aristata</i>, <i>B. lycium</i>, <i>Clematis buchananiana</i>, <i>C. montana</i>, <i>Cotoneaster bacillaris</i>, <i>Daphne papyracea</i>, <i>Desmodium elegans</i>, <i>Hypericum oblongifolium</i>, <i>Indigofera heterantha</i>, <i>Prinsepia utilis</i>, <i>Pyracantha crenulata</i>, <i>Rosa moschata</i>, <i>R. sericea</i>, <i>R. macrophylla</i>, <i>Salix elegans</i>, <i>S. denticulata</i>, <i>Drepanostachyum falcatum</i>, <i>Sorbaria tomentosa</i>, <i>Syringa emodi</i>, <i>Skimmia laureola</i>, <i>Thamnocalamus spathiflorus</i>, <i>Viburnum cotinifolium</i>, <i>V. grandiflorum</i>. <i>Sarcococca saligna</i>, <i>Lonicera</i> spp., <i>Asparagus</i> spp., etc. Herbs, Grasses and Sedges <i>Agrostis gigantea</i>, <i>A. pilosula</i>, <i>A. munroana</i>, <i>Anemone obtusiloba</i>, <i>Arundinella pumila</i>, <i>Ainsliaea aptera</i>, <i>Angelica glauca</i>, <i>Agropyron</i> spp., <i>Carex</i> spp., <i>Cyperus</i> spp., <i>Bergenia stracheyi</i>, <i>B. ciliata</i>, <i>Bromus himalaicus</i>, <i>B. ramosus</i>, <i>Brachypodium sylvaticum</i>, <i>Dactylorhiza hatagirea</i>, <i>Dactylis glomerata</i>, <i>Festuca pratensis</i>, <i>F. valesiaca</i>, <i>Geranium wallichianum</i>, <i>Koeleria</i> spp., <i>Poa pratensis</i>, <i>P. annua</i>, <i>Podophyllum hexandrum</i>, <i>Polygonatum verticillatum</i>, <i>P. cirrhifolium</i>, <i>Phytolacca acinosa</i>, <i>Potentilla argyrophylla</i>, <i>Stipa roylei</i>, <i>Trifolium pratense</i>, <i>Trillium govanianum</i>, <i>Viola biflora</i>, <i>Valeriana jatamansi</i>, <i>Verbascum Thapsus</i>, <i>Ajuga integrifolia</i>, etc.
Altitudinal Zone >3000m	Trees <i>Abies spectabilis</i>, <i>A. pindrow</i>, <i>Acer acuminatum</i>, <i>Betula utilis</i>, <i>Pinus wallichiana</i>, <i>Populus ciliata</i>, <i>Prunus cornuta</i>, <i>Quercus ilex</i>, <i>Q. semecarpifolia</i>, <i>Salix daphnoides</i>, etc. Shrubs <i>Colutea nepalensis</i>, <i>Cotoneaster bacillaris</i>, <i>C. acuminatus</i>, <i>Pyracantha crenulata</i>, <i>Daphne oleoides</i>, <i>Juniperus communis</i>, <i>J. indica</i>, <i>J. squamata</i>, <i>Rhododendron campanulatum</i>, <i>R. Anthopogon</i>, <i>Rosa sericea</i>, <i>Rosa macrophylla</i>, <i>Salix</i> spp., <i>Syringa emodi</i>, <i>Thamnocalamus spathiflorus</i>, <i>Skimmia laureola</i>, <i>Lonicera</i> spp., <i>Ribes</i> spp., <i>Spirea</i> spp., etc. Herbs, Grasses and Sedges <i>Aconitum heterophyllum</i>, <i>Anemone polyanthes</i>, <i>A. tetracephala</i>, <i>Arnebia benthamii</i>, <i>Artemisia</i> spp., <i>Dactylorhiza hatagirea</i>, <i>Danthonia cachemyriana</i>, <i>Heracleum candicans</i>, <i>H. wallichii</i>, <i>Polygonatum verticillatum</i>, <i>P. cirrhifolium</i>, <i>Selinum wallichianum</i>, <i>S. vaginatum</i>, <i>Allium humile</i>, <i>Geranium wallichianum</i>, <i>Bergenia stracheyi</i>, <i>Angelica glauca</i>, <i>Picrorhiza kurroa</i>, <i>Podophyllum hexandrum</i>, <i>Rheum australe</i>, <i>Rheum</i> spp., <i>Carex</i> spp., <i>Potentilla</i> spp., <i>Bromus</i> spp., <i>Bistorta</i> spp., etc.

(HFRI Team, pers. comm.)

The plant species suitable for bioengineering in Himalayas as reported by Agrawal 2006 are given in Table 5.32.

Table 5. 32 - Plant Species Suitable for Bioengineering Practices in Indian Himalayan Region

Species	Elevation (m)	Site Condition	Functions	Method of Propagation
Species Suitable for Entire Indian Himalayan Region				
<i>Alnus nepalensis</i>	900 m-2,700 m	Moist to Wet	Anchor, catch, armour, reinforce,	Seed

Species	Elevation (m)	Site Condition	Functions	Method of Propagation
			support, drainage	
<i>Amomum subulatum</i>	Upto 1,700 m	Swamp	-do-	Rhizome
<i>Camellia sinensis</i>	Upto 2,000 m	Varied and moist	Armour, catch, reinforce	Seed/cuttings
<i>Crotalaria tetragona</i>	Upto 1,600 m	Dry	-do-	Seed
<i>Dalbergia sissoo</i>	Upto 150 m	Dry	-do-	Seed
<i>Dendrocalamus hamiltonii</i>	Upto 1,300 m	Moist to Wet	Armour, catch, reinforce, support	Nodal segment
<i>Ficus semicordata</i>	Upto 2,000 m	Hot and dry, varied	Armour, catch, reinforce	Seeds/polypots
<i>Flemingia macrophylla</i>	300 m-2,000 m	Varied	-do-	Seeds
<i>Lagerstroemia parviflora</i>	Upto 1,200 m	Varied to dry	Anchor, catch, armour, support	Seeds/polypots
<i>Musa paradisiaca</i>	Upto 1,300 m	Varied to dry	-do-	Root suckers
<i>Thysanolaena maxima</i>	Upto 2,000 m	Moist	-do-	Rhizome
<i>Toona ciliata</i>	Upto 1,700 m	Moist, good soil	-do-	
Species Suitable for Western Himalaya				
<i>Adhatoda vasica</i>	Upto 1,000 m	Varied	Support, catch, reinforce	Hard wood cuttings
<i>Arundinaria falcata</i>	Above 1,600m	Moist	Catch, armour, reinforce, support	rhizome
<i>Bauhinia variegata</i>	Upto 1,200 m	Moist	-do-	Seed
<i>Boehmeria rugulosa</i>	300 m -1,200 m	Varied	-do-	Seed/cuttings
<i>Buddleja asiatica</i>	600 m -1,800 m	Dry, harsh	Catch, armour, reinforce	Seeds/hard wood cutting
<i>Dodonaea viscosa</i>	Upto 1,700 m	Varied, dry	-do-	Seeds
<i>Duranta repens</i>	Upto 1,500 m	Varied, dry	-do-	Seeds/cuttings
<i>Erythrina suberosa</i>	900 m -3,000 m	Varied	-do-	Seeds/cuttings
<i>Eulaliopsis binata</i>	Upto 1,500 m	Dry	Armour, catch, reinforcement	Slips
<i>Grewia oppositifolia</i>	Upto 2,100 m	Dry to moist	Anchor, catch, armour, drainage	Seed
<i>Heteropogon contortus</i>	Upto 2,100 m	Dry	-do-	Slips/seeds
<i>Juglans regia</i>	1,000 m -3,300 m	Dry to moist	-do-	Seed
<i>Melia azedarach</i>	Upto 1,800 m	-do-	-do-	Seed
<i>Morus alba</i>	Upto 3,300 m	-do-	-do-	Cutting, seed
<i>Pennisetum purpureum</i>	Upto 1,700 m	Dry	-do-	Rhizome/cutting
<i>Pyrus pashia</i>	1,500 m-2,500m	Varied	-do-	Seeds
<i>Quercus glauca</i>	600 m-2,000 m	Moist	-do-	Seed
<i>Saccharum spontaneum</i>	Upto 2,000 m	Hot, dry and moist	Armour, catch, reinforce	Slip/cutting/seeds
<i>Salix tetrasperma</i>	Upto 1,800 m	Moist	Support, catch, reinforce	Cutting
<i>Sapium insigne</i>	Upto 1,800 m	Dry	-do-	Cutting
<i>Vitex negundo</i>	Upto 1,500 m	Moist to dry	Support, catch, reinforce	Cutting
<i>Woodfordia fruticosa</i>	Upto 1,500 m	Dry	-do-	Seed

(Source: Agrawal, 2006)

A landslide generates a huge mass of debris (Plate 5.1) and hence, such areas need treatment including retaining wall at the base (Plate 5.2) and planting of live hedges across the slope.



Plate 5.1 – Landslide Generated Mass of Debris on the River Bank



Plate 5.2 – Retaining Wall at the Base of the Landslide to Protect the Road

The Pandoh landslide is famous and frequently blocks traffic to Kullu due to debris deposition on the road (Plate 5.3). The debris further slides up to the bank of Beas River (Plate 5.4). The complete treatment of upper area including diversion of flow, proper drainage and live hedges in series are required. The main cause is the weak geology, over saturation of slope and almost vertical cutting of the base along the road. The construction of new roads and widening of existing roads disregarding the rules and regulations on hill road construction is creating havoc with the ecology of sensitive hill slopes. Under cutting of hill slopes cause landslides which generate transportable loose mass and carried away with rain to silt the reservoirs.



Plate 5.3 – Pandoh Landslide Blocking the Road



Plate 5.4 – Sliding of Debris up to the River Bank

(vii) Protection of Landslide Areas Triggered by Faulty Road Construction

The road construction is important for the economic development of hitherto inaccessible remote areas. It is also important for defense point of view. The HEPs also need wider roads to take heavy machinery. But, ecological considerations are equally important. The road

construction and maintenance practices should be such that minimum disturbance is caused to the ecology of the fragile mountain ecosystem.



Plate 5.5 – Faulty Rock Cutting for Road Construction



Plate 5.6 - Faulty Rock Cutting Resulting into Collapse of Slope



Plate 5.7 – Use of Geo-Jute Mats as Bio-engineering Measure

The following steps are necessary for eco-friendly road construction:

- The cutting of rocks should not be vertical, but slanting at an angle of 60° so that slope does not collapse.
- All the debris generated should not be pushed along the slopes but properly dumped at pre-decided dump sites.
- The dumping sites should have proper retaining walls to check the debris from falling into *nallahs*.
- The dumping sites should be planted by suitable grasses, herbs, tree and shrub species.
- The seepage and runoff water should be carried by guide channels and disposed off safely by making culverts and cross drainage works. Vegetation should be established on the slip sites.
- The steep slopes can be vegetated by using geo-jute mats and or any other suitable bio-engineering technique.

Geo Jute: Geo-textile is a knitted structure made up of natural material or synthetic polymers. Use of natural geo-textiles (geo-jute) is preferred as they are less expensive, available from local resources and are environmental friendly due to their biodegradability. Geo-textile has been used in bank protection, establishment of steep hill slope, checking run-off etc. Geo-jute was used for erosion control in mine spoil on different slopes, ranging from 30°-70°. The geo-jute should be of the grade 500 g/ m² with strand thickness of 5 mm and open area 65%. In recent times, natural geo-textile product called geo-jute have entered the market and becoming popular for eco-restoration of disturbed sites. This is basically a mat made of jute with mesh size of 2-5 mm having aperture of 10 mm. This bio-degradable material was found highly effective when used to stabilize mine-spoiled sites, landslide/slip areas and specific slopes stabilizing of which is essential to maintain road/ railway network. The area to be treated is carefully measured and the length and width of sheet required is calculated. The surface to be covered is smoothened. The mat sheet is spread over the area and is secured by driving wooden stakes to a reasonable depth of 50-100cm. The sides of strips can be buried in a 30 cm deep trench. The sheets are overlapped with the adjoining sheet. The seeds/rooted slips/ cuttings of the selected plants are planted during rainy season through the openings at quite close spacing to have good cover in a short time. The jute mat does not allow the movement of eroded mass and allow undisturbed germination and establishment of plants. Geo-jute was found successful for initial establishment of vegetation on degraded slopes up to 60°-70°. The total estimated cost of jute and planting is around Rs.25/-per m².



Plate 5.8 – Use of Geo-Jute on Steep Degraded Slopes

Log Crib Structures: The log wood structures are generally constructed where stone check dams are not feasible because of steep slope. The log check dams are constructed as steps by nailing each of the horizontal cross poles of long lasting wood with 3 - 4 longitudinal poles. These poles are of 3-4 m length and 8-12 cm diameter. These are driven to a depth of 50-60 cm depth and erected in two parallel lines about a meter apart from pole to pole and one meter from line to line. The height may be kept about 1.5 m above the ground. The log wood crib structures are filled with stone/brush wood which can be used to stabilize slopes above 40°. The inter-space between paired lines is vegetated with suitable fast growing plant species. These are stable because horizontal poles can withstand the load of the earth above it and consequently hold the soil more effectively and provide the vegetation an opportunity to establish.

Gunny Bag Structures: The practice of using cement gunny bags for temporary protection is quite common by the PWD Department as they have plenty of bags available. These bags are filled with inert material like sand and gravel (not soil as it hastens decomposition of gunny bag), and used for bank protection, slope stabilization and temporary diversions. For more stability and durability, the cement and sand mixed in the ratio of 1 : 20 may be used. The filled gunny bags are laid in row over one another to gain the desired height. The back side is filled with earth and compacted.

(viii) Landslides Triggered by Snowmelt

The snow- covered upper areas experience very severe landslides when snowmelts. The oversaturated soil mass shaken by even slight seismic activity slips down and takes away even full-grown trees (Plate 5.9).



Plate 5.9 – Landslides Triggered by Snowmelt Carrying Away Full Grown Trees

(ix) Bio-engineering Measures for Mine Spoiled and Other Problem Areas

Broadly, there are two methods for rehabilitating mined areas: (a) engineering measures, and (b) biological measures. While rehabilitating an area where slope is steep, engineering measures should always precede biological measure. This is due to the fact that, in initial stages, biological measures are not able to give protection to the area due to their smaller size and tender nature. But, it should be borne in mind that, with the passage of time, the biological measures prove to be more fruitful than engineering measures because engineering measures gets filled up with silt, etc., but the soil protection capacity of plants increases with the passage of time. Some of the engineering and biological measures applied in mined areas are discussed below.

(B) Mechanical Measures for Soil and Water Conservation

Various mechanical measures are used for soil and water conservation. These include various engineering techniques and structures aim at the following objectives.

- To divide a long slope of land into a series of shorter ones in order to reduce the velocity of runoff water.
- To retain the water in the land for long period so as to allow maximum water to be absorbed and held in the soil and less water flows down the slope of the land at non-erosive velocity.
- To protect the soil against erosion by water.

The important mechanical soil conservation measures are described below one by one.

(i) Engineering Measures for Landslide Control

In case of landslides when the overburden is pushed down slope and is compacted, it may cause a problem of mass movement of the overburden. In such cases, engineering measures

like constructing a toe wall of stone at a bottom of the overburden checks the sliding of the overburden. To avoid erosion and land slide through over flowing water from uphill side, a diversion channel of 1/2 mx1/2m is constructed. This not only avoids erosion but also prevents accumulation of water at the active mined site below it. Some have used gabion structure as mechanical measures in mined area to check soil erosion. They were of the view that concrete and brick masonry fails easily in areas which settle down. However, in such areas, gabion structures, owing to their inherent flexibility, ability to bend without breaking, permeability to water but not to soil and their reusable nature prove their success. For the construction of gabion, 12 gauge galvanized iron (GI) wires are used while 14 gauge GI wire is used for binding purpose. Gabion structure is a box type structure which is as follows.

For construction of gabion 2m x1 m x1 m dimensions, 4 meshes of 2m x 1m size and 2 meshes of 1m x 1m are constructed. They are then joined together and folded. The gabion structure is placed in the *Nallah*/channel, where *Nallah* is narrow and fairly level, with sufficient place in upstream, an apron is constructed to avoid under scoring of the gabion. To avoid the displacement of gabion, its foundation is dug to a depth of at least 0.3m and should be anchored through its sides to the backs of *Nallah*. In this structure, boulders/ rocks of large size are kept layer by layer with bigger size rock at the bottom and smaller on upper layer. After filling, the box is closed tightly. For effective control over soil erosion, gabion structure should be constructed at a horizontal interval of 10-20 m in 50°- 60° slope, 20-30 m in 20° - 30° slope and 30-50 m in foot hills.

Other soil and water conservation measures for erosion control are described below:

Dry Stone Check Dams - Dry stone check dams are porous checks constructed across the *Nallah* using loose boulders to check water velocity and arrest silt (Fig. 5.5 and Fig. 5.6). This is usable in all areas irrespective of soil and rainfall. They are effective for reducing run-off velocity in upper parts of the drainage lines having steep slopes. These are planned in shallow/first order gullies having stones of suitable quality and required quantity locally available in and around the drainage ways. When properly constructed by the trained masons and suitable sites are selected, such structures help in stabilizing bed gradient and establishment of vegetation in the silted up portions of the gullies. This is a semi-permanent mechanical measure. Slab type dressed stones are arranged with proper spillway in the center. At least half a meter anchorage to sides and half meter foundations are enough for a one meter high structure. The normal design specifications are given in Table 5.33.

Table 5. 33 – Design Specifications of Dry Stone Check Dams

Top width	0.5-1 m
Base width	1-2 m
Height above ground level	0.6-1.2 m
Depth of foundation	0.3-0.6 m
Side slopes	0.5:1.0

Anchorage to banks	0.45-0.75m
Spillway section	Length should be as per discharge or roughly 1/3 of <i>Nallah</i> width and bed over crest may be as per discharge or 0.3 m to 0.5 m.
Apron	Width 1-1.5 m x fall
Length	Entire section below spillway and side walls
Depth	Minimum 0.3m and should be below immediate ground level.

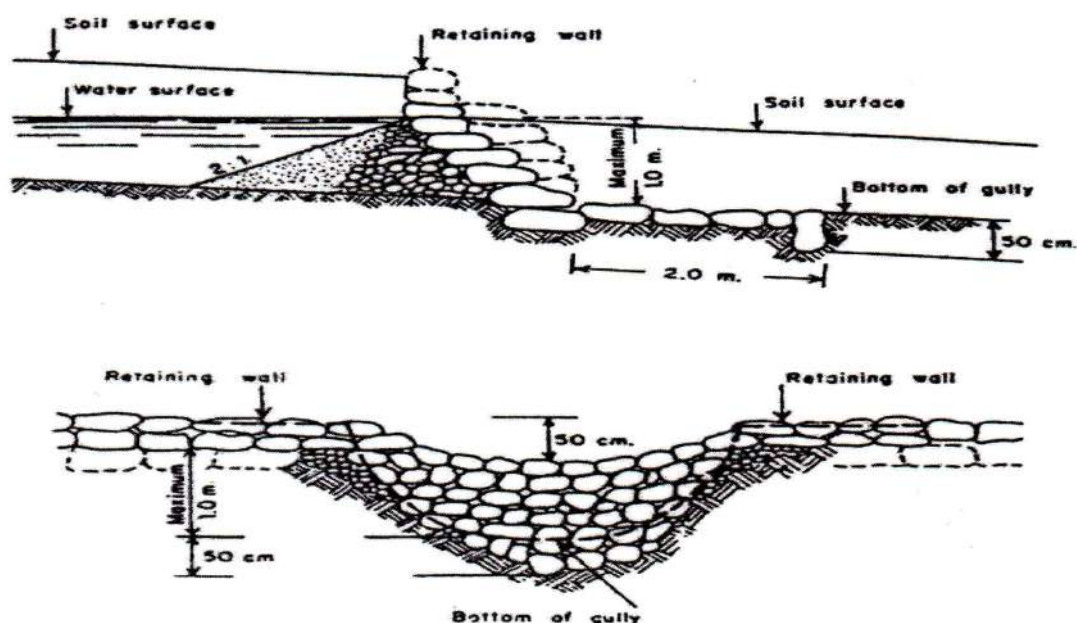


Fig. 5. 5- Design of Dry Stone Check Dams

Proper site selection is very important for all types of erosion control structures. These structures are constructed in series one after the other usually keeping head and toe relationship excluding the permissible stable bed gradient. The following safeguards may be considered in site selection:

- The gully should have narrower section at the dam axis.
- It should have bowl type wider section above the site for storage of water and silt.
- Preferably, the bed gradient in *Nallah* should be as low as possible above the site. This would ensure more storage of water/debris.
- Slab type/ flat stones should be available near the sites. No stones should be excavated from the actual *Nallah* bed.
- Construction with stones transported from longer distances to be avoided in view of high cost involved.

- In case *Nallah* bed is well covered with vegetation and no scouring is visible, then dry stone check dams may not be required.

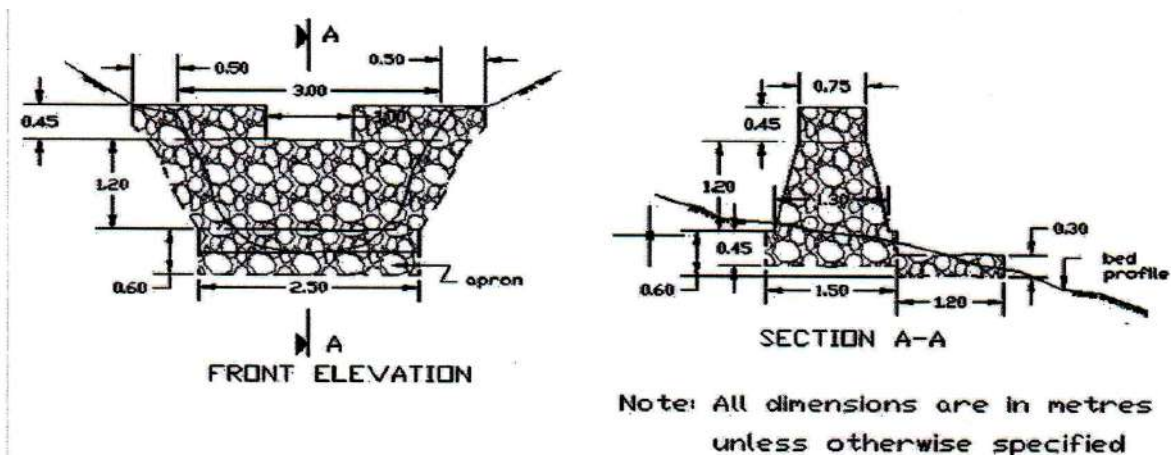
Construction of Dry Check Dams

The steps involved in construction of check dams are as follows:

- A copy of the approved plans and estimates should be obtained by the field staff executing the work.
- First of all, the proposed site is located on the ground.
- The slab type stones are collected at site in advance.
- The site is cleared of all vegetation including uprooting of trees, bushes, grasses and removal of all organic matter.
- The foundations are excavated to a uniform depth and dimensions as provided in the plans.
- Stones are laid properly by breaking the joints. Anchorage to sides is ensured.
- The stones of larger size are used in the central part of spillway portion because of more pressure of water.
- The slab type stones in each layer are made stable by inserting smaller broken stone pieces.
- The corners of stones are slightly dressed to maintain uniformity in size.
- The gaps are filled with smaller stones or broken pieces such that the holes between the stones are reduced to the minimum size.
- Slight curvature is given like half-moon to the main wall on the downstream side so as to provide the strength of an arc to the dam body.
- Each layer of stones is receded by about 5cm (slightly more from centre and less from sides) so that a cascading effect is generated when water falls from the spillway section over the apron.
- Round stones be avoided as they do not remain stable in constructed dams without mortar.
- Slabs of soft sandstone are not recommended because of their low structural strength.
- The apron should be lowered and embedded in the ground and its top should be 20-30 cm below the immediate ground level.
- Top level of wing walls/head wall extensions should be at the same level.
- Vegetative reinforcement above and below the structure is important for its functional success.



Plate 5.10 –Typical Dry Stone Structure Made of Slate Type Stones is More Stable



DRY STONE CHECK DAM (LENGTH=3.00m, HEIGHT=1.20m)

Fig. 5. 6- Design of Dry Stone Check Dams

The dry stone structures may fail when:

- Wing walls/extensions are not anchored sufficiently to the sides or into the banks.
- Less anchorage to the sides at the base results in leakage from the sides.
- Toe of the structure erodes if no head-toe relationship is maintained.
- Structure may tilt, sag or breach, if sufficient foundations are not provided.
- Structure constructed at a bend or curve in *Nallah* is more liable to fail.

Gabion Check Dams - Gabion structures are made with stones/boulders packed closely in wire mesh cages made with GI wire of 10 gauge thickness. Gabion structures are preferred in soil conservation works as they are: (a) flexible (i.e., bend without breaking), (b) porous (i.e., water can seep through them), (c) stable, and (d) economical as compared to cement concrete structures.

GI wire of 8-10 gauge thickness is used in the fabrication of wire nets and the mesh is generally kept 10-15 cm. Gabion structures have a long life (20 - 25 years) almost similar to cement masonry permanent structures (Fig. 5.7).

Suitability

The gabion check dams may be constructed in main gullies/channels for retention of debris and soil accumulation without pondage. The debris carrying capacity within the inter-structure reach reduces due to reduction in channel gradient. The check dams encourage good plant cover not only along the bank but also in the bed of the stream due to increased moisture regime. Cross barriers are suitable in the head water reaches in higher order streams/main drainage channels receiving relatively large quantities of runoff and debris flow.

Specifications

Top width	1m
Depth of foundation	0.3-0.5m
Height above Ground Level	1-3 m
Keying into banks	0.3-0.6 m into stable portion

Galvanized iron wire	10 gauge (3.14 mm dia)
Mesh size	15x 15 cm to 20x 20 cm

Construction of Gabion Check Dam

The steps involved in construction of gabion check dam are summarised below:

- The wire mesh is fabricated and boxes are made with a dimension of 2m x 1m x 1m or any other desired dimensions with a mesh opening size of 10-20 cm depending on the stone size.
- Clear the site.
- Excavate the foundation trench of required width and upto desired depth (normally a foundation depth of 0.3-0.5 m is sufficient). The trench is smoothened and compacted. The sides of gully are also excavated to about 0.3-0.6 m for keying of the structure to prevent undercutting.
- Place the GI wire mesh in the trench and start hand packing of stones. Larger size stones (>20 cm size) are used at the bottom portion and along the sides. The void space between the stones is filled with small size stones. The construction is carried till the desired height is obtained.
- The sides of the wire mesh are tied together with the protruding wires. If required next wires mesh cage is laid over/along it and the same procedure is repeated. The adjoining cages are again tied together with the wires.
- Provide the desired wire opening to the structure for safe disposal of peak runoff.
- On downstream side, provide 2-2.5m wide gabion/rubble soiling along the full length of the structure. This helps to prevent erosion of the downstream side of the structure.



Mechanical structures required for proper channelization of streams

DRAWING AND DESIGN OF GABION STRUCTURE

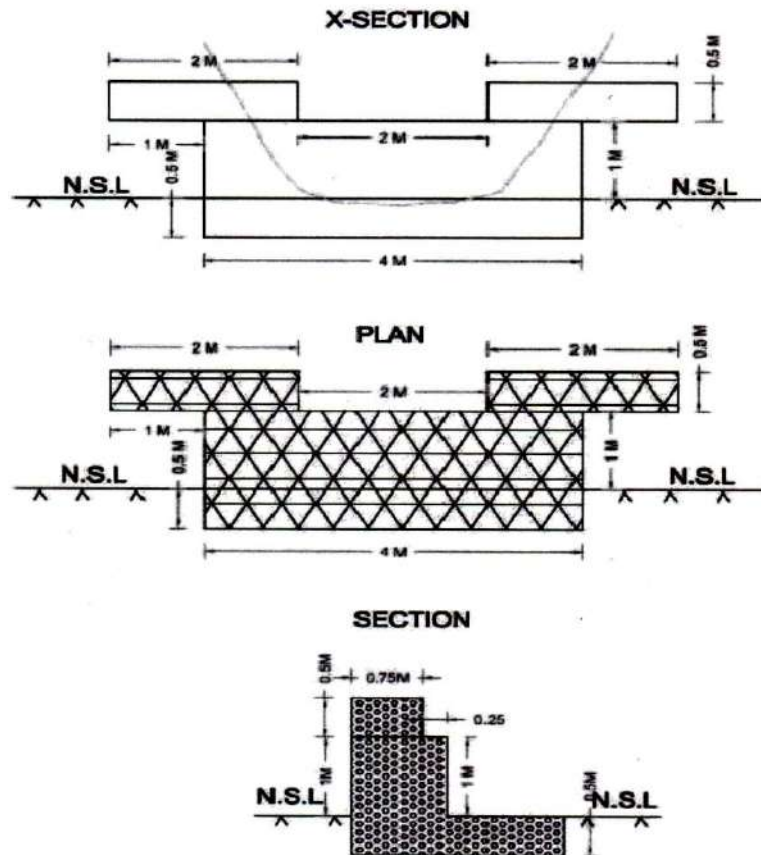


Fig. 5. 7- Drawing and Design of Gabion Structure

Gabion Structure with Ferro-Cement Impervious Barrier - A ferro-cement gabion has 2.5cm thick impervious wall of ferro-cement at the centre of the structure which goes below the ground level up to the hard strata. This ferro-cement partition supported by gabion is able to retain the water as well as withstands the force of runoff water. Use of G.I. wire of good quality for wire mesh fabrication is recommended to ensure durability and strength to the structure.

Construction of Ferro-Cement Impervious Barrier

The steps involved in construction of Ferro-cement impervious barrier is briefly described below:

- Clean the site first.
- Excavate the foundation trench up to the hard strata.
- Lay down the concrete in the proportion 1:3:6 and thickness of 15cm for the foundation of ferro-cement wall.
- Construct the ferro-cement wall at the centre of the foundation trench upto 7.5cm below GI Fill up the upstream and downstream sides of the ferro-cement wall with sand (about 15cm thick) and the remaining trench with available soil. The sand layers protect the ferro-cement from swelling action of the surrounding soil and also allows the water which is sprinkled on top for curing to go down to the bottom.
- Next, provide a 7.5 cm thick concrete bed of 1:2:4 proportion on the ferro-cement wall. Place on it, the GI wire mesh of size 15-15 cm of 10 gauge thickness. Lay the remaining 7.5cm thick concrete above the earlier layer so that the chain link gets fully embedded in the concrete. A ferro-cement wall upto the full supply level of the structure should then be built above the concrete.

- Construct a stone bund keeping the ferro-cement wall at the centre.
- The whole structure including ferro-cement core wall should go upto 0.3-0.6 m into the stable portion of the gully side to prevent end-cuttings.
- Raise the end portion of the structure to the level equal to the flood depth. Aim is to prevent scouring of the *Nallah* banks.
- On the downstream side, provide 2-2.5 m wide gabion/rubble soling along the full length of the structure. This helps to prevent erosion of the downstream side of the structure.

Permanent Structures for Gully Stabilization - Permanent soil conservation structures are often used for runoff and sediment control as well as storage of water for irrigation in arable and non-arable lands. These can be constructed of cement masonry or gabion. Their use becomes necessary when the runoff from the catchments is too large to be handled with vegetative measures/temporary structures or where high degree of safety is warranted against the loss of life and property. However, it should be ensured that the benefits from such structures are justifiable against the cost.

Design Criteria of permanent structures

Permanent structures in soil conservation are normally designed for a recurrence interval (RI) or frequency of 10 to 50 years which means that they are supposed to discharge maximally during the design period. The structure should be strong enough to withstand the forces exerted by water/ earth. A structure should, therefore, be designed with the following considerations.

- **Hydrologic design:** It involves computation of the peak discharge at the point of watershed where the structure is to be constructed. Generally, rational method is employed for the purpose.
- **Hydraulic design:** It involves calculation of the dimensions of the spillway which is able to carry the above peak discharge.
- **Structural design:** It involves calculation of the dimensions of each component of the structure which ensures its safety against water/ earth forces, the structure are to withstand.

Drop Spillways - Drop spillway is a weir structure. Flow passes through the weir opening, drops to an approximately level apron or stilling basin and then passes into the downstream channel. The different components of the drip spillway are; (a) head wall and head wall extension, (b) side walls, (c) wing walls, (d) apron, and (e) longitudinal sills. These are used for gully stabilization or sometimes as water storage structures where the drop is low. Drop inlet structures are used at appropriate locations in the gully for storage of water/sediment. Chute spillways are used at gully heads to convey the water safely to the gully bed. The drop spillway is an efficient structure for controlling low heads, normally up to 3 m.

Functional Uses of Drop Spillways

The functional uses of spillways are as follows.

- Gully and ravine stabilization.
- Erosion control structures for stabilization of landslides and mined areas.
- Protection of fields, roads and hutments, etc. from gullies.
- Grade control for stabilizing channels and waterways.
- Reservoir spillway where the total drop is relatively low.
- Control of irrigation water.
- Adaptability
- The drop spillway is an efficient structure for controlling low heads.

Site Selection for Drop Spillway

Following criteria needs to be considered for selection of site of a Drop Spillway.

- The site should be selected so that the spillway can be located on a reasonably straight section of the channel, with no upstream or downstream curves within at least 30 m of the structure. Poor alignment may result in reduction of the storage capacity and excessive scour of the embankment and channel banks.
- The site should provide an adequate foundation for the spillway. The foundation material must have the required supporting strength, resistance to sliding and piping and be reasonably homogenous so as to prevent unequal settlement of the structure.

Masonry Walls with Apron - In some of the forest areas, suitable stones are not available in the drainage lines and hence crate wire check dams cannot be constructed. In case, large size stones are transported from outside, this turns out to be quite expensive. As a substitute to crate wire structures, masonry drop structures constructed with locally available small sized stones and *bajri* turns out to be cheaper and hence constructed in series in the drainage lines of such areas. When constructed in series, head-toe relationship is maintained. The scouring of toe wall remains a problem when this relationship is not maintained (Fig. 5.8).

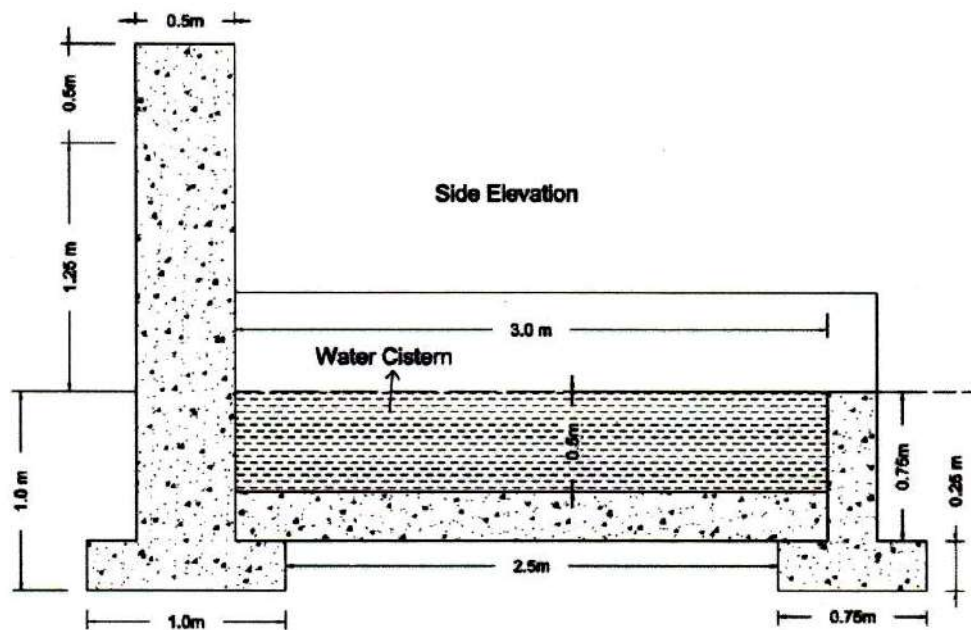


Fig. 5. 8- Masonry Drop Structures (1 - 1.5 m Height for Silt Control)

Silt Detention Structure - These check dams are constructed in *khads* to check the flow of silt. A cement concrete wall is constructed across the flow of water. On the downstream side the buttresses can be constructed, if the length of the check dam is more than 3.0 m. Such types of check dams need proper foundation, as well as sufficient embedment in the sides. A spillway is constructed on the top of the check dam. A cistern is constructed on the downstream side of the check dam. Apron of the proper length is constructed depending on site conditions and drop (Fig. 5.9).

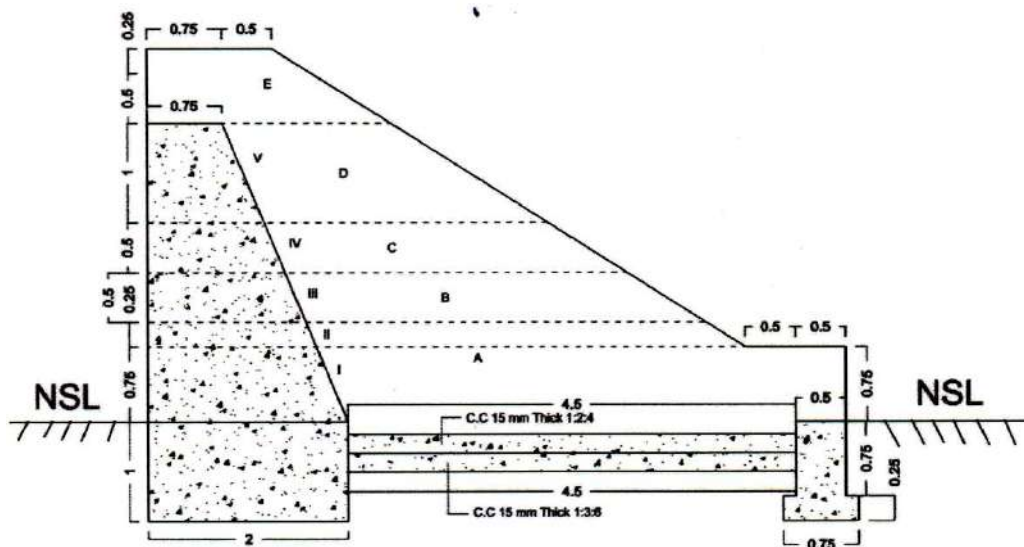


Fig. 5. 9- Silt Detention Structure

Stream Bank Erosion Control – Several mechanical measures can be used for the control of soil bank erosion. These are described below:

(a) Mechanical Spurs for Torrent Control

Torrents are causing vast area submergence and damage to life, property and infrastructure almost every year. This is the most common problem in foothills of Shivaliks, spread over the northern States of India. Study by Tiwari *et al.* (2006) based on remote sensing study reported that about 1500 km² area and the area affected can be up to 7,500 km² in the Shivaliks. This demands economically viable and appropriate measures to combat the menace of torrent in the region. Hill torrents (locally known as 'Rao' or 'Cho') cause extensive damage to life and property as a result of the frequent changes in their course and associated flash flows with heavy debris loads. However, when the streams reach the relatively flat valley, their debris carrying capacity diminishes due to drastic reduction in flow velocities and the debris gets deposited in the water courses in the form of gravel bars and islands. As a result, the flow tends to braid and migrate laterally overtopping and undermining the low erodible banks and affecting the adjoining forest/agriculture lands and utility services such as roads and bridges, etc. Spurs, retards and retaining walls are used at such downstream reaches for training the torrent flow along desired courses and prevent damage to natural resources, life and property.

Spurs are structures constructed transverse to river flow extending from one of the banks at an angle to the flow. These structures are known by different names, such as spur-dikes, groynes, transverse dikes, jetties, etc. Their main functions are to serve as a protection to the stream bank from erosion and to train the main stream along a desired alignment. A well designed series of spurs built along an eroding bank will, firstly, check the erosion, and secondly induce siltation in the quiet water between the spurs. As the silt beds so formed rise above normal low water level, vegetation may be planted on them to bind the silt and to catch more.

Function of Spurs

- The functions of a spur system may be one or a combination.
- Protection of river banks including land, road, building, bridge abutments and other structures along them.
- Reclamation of land along torrent beds, in excess of that required for the flow discharge.
- Narrowing of floodway to induce scouring along defined lines to create a narrow, deep and straightened channel instead of one which is more wide, shallow and wandering.
- Diversion of current in a desired direction.

Types of Spurs

The spurs may be classified according to: (a) method and material of construction – permeable and solid/impermeable type, (b) function served – attracting, deflecting and repelling type, (c) height of spur with respect to high water – submerged or un-submerged type, and (d) special type – T headed, hockey type, etc. Depending on the purpose, spurs can

be used singly or in series. River conditions affecting the choice of type and design of spurs may be:

- Grade and velocity of river
- Character of bed and material carried – shingle, sand mud, etc.
- Width of waterways and area of flood way.
- Depth of waterway, and height of flood rise.
- Availability of material and financial resources.

Spur Types According to Material of Construction: Wire created (gabion) and vegetative spurs are the commonly used permeable spurs in torrent control works. They have a dampening action on the velocity of approaching flow. Gabion spurs are ideally suited as they are flexible, porous, stable and economical. They are fabricated using 8-10 gauge G.I wire. Spurs constructed with vegetative materials (i.e., trees, brushwood, etc.) are also in vogue since olden times. Cement masonry or concrete structures come under the impermeable types.

Spur Types According to Function Served: According to the function served, spurs may be of the following types.

(a) Repelling type: The repelling type of spur projects towards upstream direction of the flow current. The spur angle is recommended to be 95° - 110° from the downstream (i.e. 5° to 20° with normal flow towards upstream). It has the property of repelling flow away from it.

(b) Attracting type: Attracting type of spur projects towards the downstream of flow direction, normally an angle of 30° to 60° from downstream. It attracts the river flow towards it, hence named so.

(c) Deflecting type: Deflecting type of spur is made projecting at right angle with the bank. It is usually of short length and gives local protection.

Design Specification of Spurs: Construction of spurs for river training is quite expensive. Hence, they are to be judiciously planned and executed optimally at the most crucial reaches along a river course. Some of the important factors that determine the use and design parameters of spurs are:

(a) Nature and Extent of the Problem: Use of spurs and other engineering structures is justifiable where the river damage is severe and poses a threat to the life and adjoining property.

(b) River Characteristics: Factor like river geometry (i.e., width, flow depth, bank height), flow velocity, flow pattern, bed slope, sediment – debris-boulder movement, river meandering and curvature, etc. are important parameters that may determine the design specifications of structures.

(c) Super Geometry: The length of spur, its alignment to flow, shape and permeability are important design considerations.

(d) Super Length: Construction of a spur causes constriction of river flow which should be limited so as not to affect the river regime adversely. This is represented by a 'Blockage Ratio' b/B , where b is projected length of spur and B is the river width. The Blockage Ratio should not exceed 0.3 i.e., the projected length of the spur should not exceed $1/3^{\text{rd}}$ of the width of river.

(e) **Alignment of Spur:** The spur alignment is defined by the angle of the spur made. Attracting (downstream pointing) spurs are normally used for flow diversion whereas short and closely spaced right angled deflecting spurs are recommended for quick sedimentation along banks.

(f) **Shape of Spur:** As is expected, stream lined shapes create fewer disturbances and hence produce less scour than blunt shapes. In oblique faced spurs, such as with trapezoidal cross section, the scour depth is lesser because some of the energy of the downward flow component of the principle vortex, which would otherwise erode the sediment bed is dissipated on the sloping wall. Simple rounding of corners and edges of spurs reduce the scour considerably. The upstream nose of the spur plays an important part in the phenomenon of scour and the rear of the spur has got no effect.

(g) **Permeability of Spur:** Permeable spurs are mostly used in torrent training works, yet very little information is available on them. Permeable spurs are less expensive and can be made by locally available material. Their stability is better than the solid ones due to lesser scour around them.

(h) **Spacing of Spur:** Obviously a spur will protect only a certain length of the bank. It is usual, therefore, to use spurs in series, spaced so as to give a continuous effect. A single spur can protect bank length between 3 - 5 times of the spur length. The recommended optimum spacing of spurs is 3 - 4 times the projected spur length. A larger spacing can be adopted for convex bank and a smaller one for concave bank i.e., 2 - 2.5 times the length of spur. The method to locate the spurs is shown in Fig.10.

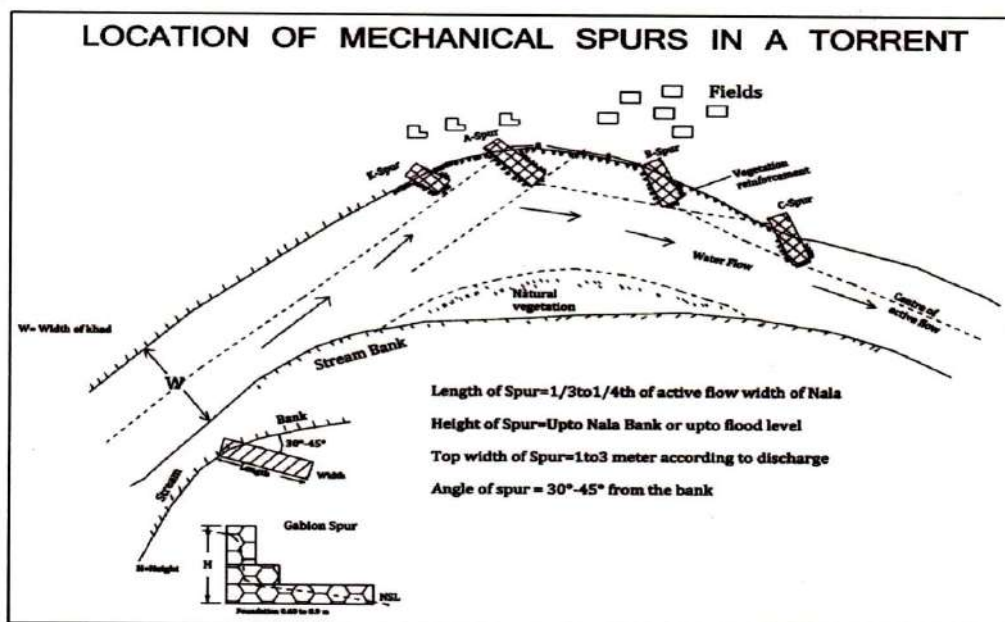


Fig. 5. 10- Location of Mechanical Spurs in a Torrent

Crate Wire Spurs - Cement masonry structures are impermeable, but they are not generally used in soil conservation works. Semi-permeable gabion structures are being used extensively for stream bank protection because they are flexible and economical. Gabion spurs are made of boulders packed closely in wire crates made of 10 gauge GI wires. The method to locate the spurs is shown in Fig. 5.11.

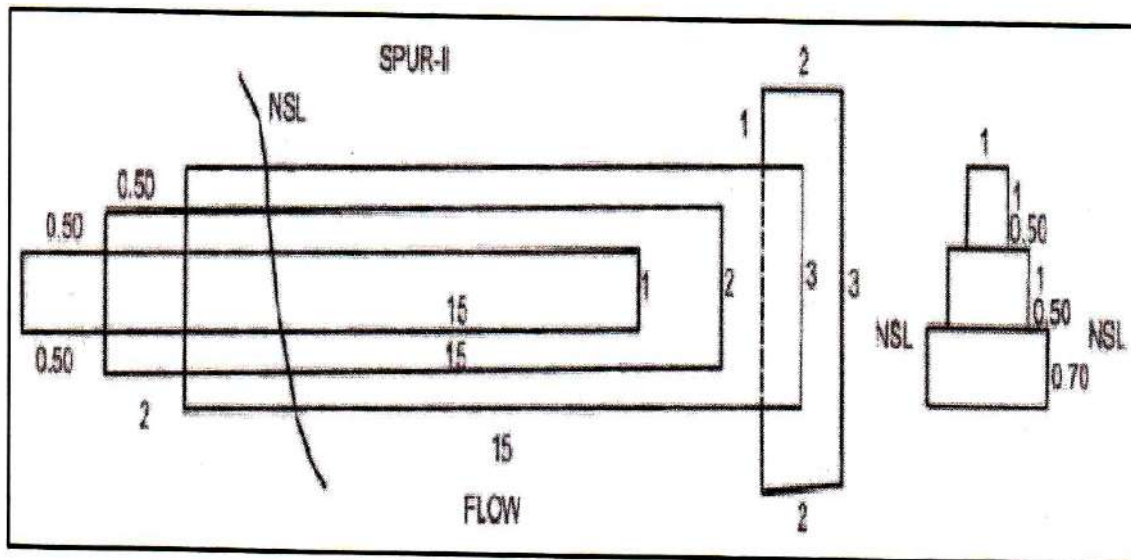


Fig. 5. 11- Crate Wire Spur

Masonry

Retaining Walls - The retaining walls are constructed to stabilize steep hill slopes and to provide stability to stream banks. In the hill roads, masonry or gabion retaining walls are constructed to retain the sliding debris from the hill sides. The retaining walls are also constructed to provide support to buildings made on steep but unstable slopes. In case *nallah/gullies* are cutting the banks and there is costly land, buildings or road near the top of the banks, then retaining walls are constructed to provide stability to the banks. In case slope length is small, then only one retaining wall may be sufficient. But, if slope length is more than series of retaining walls, one over the other are made to provide necessary protection. Generally, the bottom width of the retaining wall is kept as two-third of the height. The base width is reduced in steps to 1 m at the top if there is no surcharge in case of gabion structures. In case there is surcharge, 2 m top width may be adopted for gabion and one meter for masonry walls. The retaining walls are broadly classified as structures subjected to water pressure (i.e., dams and weirs) and earth pressure. In the later case, angle of repose of soil is considered in design and its value depends upon nature of earth and its wetness. The stability of gravity retaining walls is due to the self-weight of the wall which should be more than the pressure generated by the water or the earth mass. The method to locate the spurs is shown in Fig. 5.12.

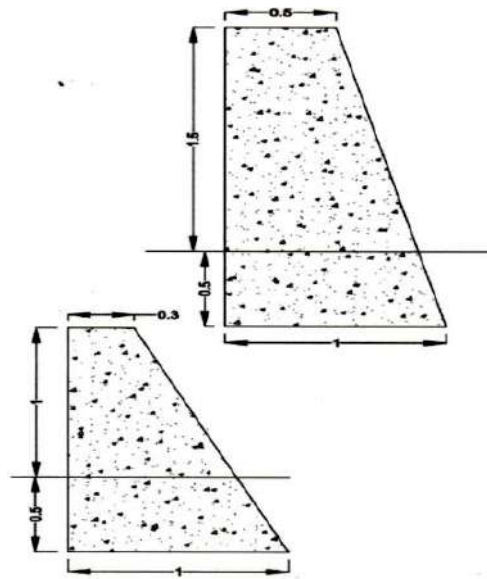


Fig. 5. 12- Masonry Retaining Walls

Crate Wire Retaining Walls – Often, river banks require retaining wall to protect them from soil erosion and also for the protection of adjacent vegetation (Plate 5.11). Retaining walls are essential around the muck sites to prevent erosion (Plate 5.12). In many of the khads, suitable sizes of stones are available and used for the construction of gabion retaining walls (Plate 5.13). The height is decided by the level of flood flow. The size is determined by the size of the khad and flood discharge. One meter foundation is provided.



Plate 5.11 - Need of Retaining Wall Construction to Protect the River Bank from Soil Erosion



Plate 5.12 - Muck Disposal Sites along the Banks of the Sainj River



Plate 5.13 - Retaining Walls Constructed Along the Banks of the Tirthan River for Soil Erosion Control

After consultation with the Riverscape Subject matter specialist following models are suggested:

a) Soil and Water Conservations

The soil and water conservation works are required in all landscapes viz. Natural Landscape, Urban Landscape and Agricultural Landscape. These soil and water conservation works are extremely important for protecting fertile soils of various landscapes, regulating stream flows and reducing silt load of river Beas and its tributaries. The following Models have been finalized for treatment of sites as soil and water conservation interventions in HP and Punjab:

In Himachal Pradesh

1. SL/HP/CI/01 - Brushwood Interventions
2. SL/HP/CI/02 - Dry Stone Interventions & Activities
3. SL/HP/CI/03 - Crate Wire Interventions & Activities
4. SL/HP/CI/04 - Water Ponds
5. SL/HP/CI/05 - Silt Detention Dams

The details of various activities under aforementioned Models are also given in Chapter V of Volume - I.

Table 5. 34 – Treatment Models for Soil and Water Conservation Interventions in Himachal Pradesh

Sr.No.	Model No.	Amount Rs/Cumt	Mandays
1	BS/HP/CI/01 Brushwood Interventions	300	2
2	BS/HP /CI /02 Dry stone activities	1800	8
3	BS/HP /CI /03 Crate wire activities	4500	15
4	BS/HP /CI/04 Water Ponds	65,000	288
5	BS/HP /CI /05 Silt Detention Dam Type Activities	80,000	248

In Punjab

1. SL/PB/CI/01 - Brushwood Interventions
2. SL/PB/CI/02 - Dry Stone Interventions & Activities
3. SL/PB/CI/03 - Crate Wire Interventions & Activities
4. SL/PB/CI/04 - Water Ponds
5. SL/PB/CI/05 - Silt Detention Dams

Table 5. 35 – Treatment Models for Soil and Water Conservation Interventions in Punjab

Sr.No.	Model No.	Amount Rs/Cumt	Mandays
1	BS/PB/CI/01 Brushwood Interventions	300	1
2	BS/PB/CI /02 Dry stone activities	1800	5
3	BS/PB/CI /03 Crate wire activities	4500	13
4	BS/PB/CI/04 Water Ponds	65,000	190
5	BS/PB/CI /05 Silt Detention Dam Type Activities	80,000	164

(2) Riparian and Riverine Wildlife Management

It is considered appropriate to firstly, differentiate between the two terms, 'Riparian' and 'Riverine', and secondly to understand the strong linkages between riparian zone and riverine habitats. Riparius is a Latin word meaning 'of or belonging to the bank of a river'. The term riparian has generally replaced the Latin Riparius and refers to biotic communities living on the shores of streams, rivers, ponds, lakes, and some wetlands (Naiman *et al.*, 1998). In short, 'Riparian' means relating to; living, growing or located on the banks of a stream (California State Parks, 2000). The riparian zone is an area between the upland zone and the shore line. It forms a corridor between land and water allowing animals to travel between different biomes. Riparian zones, as interfaces between terrestrial and aquatic ecosystems, encompass sharp gradients in environmental and community processes. Lining the border of the water, the riparian zone provides distinct rich, moist soils in which diverse plant communities can grow. A healthy riparian zone contains diverse plant species, aquatic and terrestrial wildlife. Riparian zones are an unusually diverse mosaic of landforms, communities, and environments within the larger landscape. The riparian area or corridor interacts with adjacent water body through reciprocal exchanges of materials and energy (NRC, 2002; Verry *et al.*, 2004; Naiman *et al.*, 2005; Stoffyn-Egli and Willison, 2011). As such, riparian areas strongly influence the ecological integrity of freshwater ecosystem.

In contrast, the term 'Riverine' means living in, growing in, or located in a river or stream (California State Parks, 2000). In other words, it refers to the aquatic wildlife. It could be plankton, macro invertebrates or chordates (i.e., fishes, amphibians, reptiles, water birds and aquatic mammals).

The phrase riparian forest refers to floodplain vegetation or vegetation directly adjacent to rivers and streams (Naiman *et al.*, 1998). The riparian forests extend laterally from the active channel to include the active floodplain and terraces. Forests contributing organic matter such as leaves, branches, and large woody debris directly to the active channel or the flood plain are included in this definition (Gregory *et al.*, 1991).

It is now well established that riparian vegetation particularly trees and soil perform various riparian functions including; (a) thermal regulation of the water, and more generally, establishment of unique micro-climates (i.e., wind, light, temperature, and humidity conditions); (b) the supply of coarse organic matter (e.g., leaves), a food source for many benthic invertebrates; (c) the supply of large woody debris that affect channel shape and water flow while providing refugia for fish and substrate for aquatic invertebrates; (d) water purification and regulation of nutrients inputs to streams and lakes; (e) dampening of floods and droughts by decreasing surface runoff and helping replenishment of groundwater by infiltration of precipitation; and (f) bank stabilization, control of erosion, and corresponding stream-bed sedimentation (Stoffyn-Egli and Willison, 2011). According to Dudgeon *et al.* (2006), riparian areas support high level of biodiversity on relatively small areas of the landscape.

It is now well established that forest and stream ecosystems exchange subsidies (Hjalte *et al.*, 2016). The exchange of lateral subsidies between forests and stream habitats make riparian environments key areas for landscape-scale biodiversity (Sabo *et al.*, 2005). According to Hjalte *et al.* (2016), aquatic communities depend on subsidies provided by riparian forests whose canopy cover, provision of leaf litter and large dead wood often increase with forest age. Large wood in streams has different effects on various aquatic populations. It can benefit big fish, whereas densities of young trout and bullhead are negatively correlated with the volume of large wood (Langford *et al.*, 2012). Leaf litter from riparian forests has strong influences on invertebrate communities in the aquatic environment, as well as top predators such as fish (Wallace *et al.*, 1997; Hagen *et al.*, 2012). Terrestrial subsidies clearly affect both the functional and structural attributes of aquatic ecosystems, but the quantities knowledge of these inputs and their impacts on stream biota is limited. Just as terrestrial matter and organisms contribute to aquatic communities, aquatic subsidies contribute to terrestrial environment. Organic matter disperse by streams add nutrients and structure to terrestrial soils (Xiong and Nilsson, 1997). Plants propagules dispersed by water eventually strand and can establish populations in riparian or even upland habitats (Nilsson *et al.*, 2010). Insects emerging from aquatic larval stage are an important food resource for several terrestrial predators viz., birds, bats, lizards, spiders and beetles (Baxter *et al.*, 2005).

The functioning of aquatic ecosystems depends on the exchange of subsidies but various human activities act as stressors and easily disrupt reciprocal flows. The clear felling of trees can increase the input of silt, nutrients, and pollutants to streams and influence assemblages of aquatic insects (Gundersen *et al.*, 2010). Changes in forest composition caused by forestry also influence terrestrial input to rivers. Planted coniferous forests, for instance, will produce fewer subsidies for fish growth than broad leaved forests (Inoue *et al.*, 2013). There is ample evidence that the use of exotic tree species in forestry, particularly Eucalyptus can reduce decomposition and nutrients levels, which in turn affect macro invertebrates as leaves of Eucalyptus are poor quality food for invertebrates owing to their oil and polyphenolic content, ultimately can also affect fish growth and survival (Richardson and Rejmanek, 2011; Larranaga *et al.*, 2014; Morrongiello *et al.*, 2013; Hjalte *et al.*, 2016). The presence of exotic tree and shrub species is likely to have a significant influence on forest-stream links. Flow regulation and stream channelization have profound impacts on aquatic and adjacent habitats.

The wildlife community within riparian zones is composed of obligate and generalist riparian species as well as introduced species. Riparian obligates are species considered so highly dependent on riparian and aquatic resources that they would disappear with the loss of this habitat from the drainage basin. Amphibian species dominate the list of riparian obligates when the proportion of obligates is compared to the total number of species present in a given situation. Species that utilize both riparian and upland forests are considered riparian generalists. Obligate riparian bird species require aquatic or riparian habitat for either breeding, nesting, roosting, or feeding, although several species do not require aquatic or riparian habitat at all times. Fishing eagle and some raptors are best examples of obligate

species as they depend for roosting/ nesting on large trees in the riparian zones while they depend exclusively on the aquatic/ riverine environment for feeding on fishes.

The enhanced extraction of forests and water resources has led to habitat degradation, biodiversity loss and decline in ecosystem services. As a consequence, ecological restoration has become a conservation priority. Restoration efforts to offset this trend, however, are not always effective owing to the fact that several restoration projects target single ecosystem and fail to acknowledge functional links between ecosystems. Despite the clear evidence of strong linkages between aquatic (riverine) and terrestrial (riparian) ecosystems, there are still few scientific studies evaluating and highlighting combined efforts jointly restore streams and forests (Hjälte *et al.*, 2016).

In the context of Beas Riverscape, the riparian forests as well as riverine ecosystem have been severely imperiled in the mountainous tract of Himachal Pradesh and the alluvial plains of Punjab due to enhanced human activities. It is very well established fact that riverscape and its environment, wild flora and fauna in the riparian zone as well as the aquatic environment have been adversely impacted due to various anthropogenic stressors. In the aquatic environment, fish fauna, particularly migratory species and the Indus River dolphin have been impacted while a wide range of species (e.g., otter, turtle, gharial, etc.) using the riparian zone as well as the lotic system have also been impacted. Thus, there is an urgency to protect, conserve, and rehabilitate species of concern. Several protected areas (Manali WLS, Inderkilla NP, Khokhan WLS, Khirganga NP, Kanawar WLS, GHNP, Tirthan WLS, Sainj WLS, Bandli WLS, Dhauladhar WLS, Nagru WLS, Shikari Devi WLS, Pong Dam Lake WLS, Beas River Conservation Reserve, and Harike WLS) are some of the prominent PAs along the main channel of Beas River and its tributaries and these PAs are repository of representative biodiversity of North-Western Himalaya and Western Himalaya biotic provinces and harbours several Rare, Endangered and Threatened (RET) species.

In view of the above enormous significance of riparian zones and riverine ecosystem, protected areas, and associated threatened biodiversity, it is vital to have appropriate conservation interventions to protect the wildlife habitat and associated wildlife. The following forestry interventions are proposed in the present DPR.

- Collection of baseline information – status, distribution and population dynamics
- Ecological research on select threatened taxa
- Protection and improved management of protected areas
- Protection and conservation measures for riparian and riverine wildlife
- Habitat improvement including control of invasive and alien species in the terrestrial and aquatic environment
- Conservation breeding and reintroduction of gharial, turtle, otter, etc.
- Awareness creation
- Capacity development
- Long term ecological monitoring

In view of the above proposed forestry interventions and allied activities, necessary Budget provisions for IAs in two concerned States within the riverscape have been made towards site

specific activities for the protection, management, restoration, and conservation of wildlife relevant to riparian zones and riverine (aquatic) ecosystem.

The River team have consulted the list of riverine riparian area and wildlife areas and made list of prominent or high prioritized area in consultation with stakeholders which can be taken under this component. The part of area the Riverine and Riparian area also can be taken up as this is package for the whole Protected Area concerned. The area taken for management can be taken up with the concerned stakeholder (Department as well as NGO or any other secondary sources).

The activities included in the proposed Models along with Nomenclature for Himachal Pradesh and Punjab is as follows:

- **In Himachal Pradesh**
- **BS/HP/CI /07**
- **In Punjab**
- **BS/PB/CI /07**

Table 5. 36 – Component-wise details of activities under Riverine and Riparian Management

Sr. No.	Components	Activities	Year				
			1	2	3	4	5
1	Protection	General Protection from illicit felling, illegal grazing, mining, poaching, etc.	√	√	√	√	√
		Survey and demarcation of boundaries and establishment and maintenance of permanent boundaries	√		√		√
		Physical Infrastructure (Watch Tower, Patrolling Path); Electric Vehicle;	√	√	√		
		Field Equipment - Tranquillization Gun, Night Vision with Binoculars, GPS, Surveillance equipment, Camera trap etc.	√	√	√		
		Communications equipment including laptops, wifi system etc.	√	√	√		
2	Habitat	Water ponds in every 2x2 km grid	√	√	√	√	

Sr. No.	Components	Activities	Year				
			1	2	3	4	5
	Management	Habitat enrichment plantations 1. Slopy area, 2. Riverine area (receded area broadcasting of lintels in strips 3. Riparian area 4. Grass land development	√	√	√	√	√
		Soil and Water Conservations Measures	√	√	√	√	√
		Control of Invasive and Alien Species	√	√	√	√	√
3	Wild Faunal Species Management	Conservative Breeding; Re-introduction of Species, etc.	√	√	√	√	√
4	Research and Development	Short Term Projects up to 1 year; Long Term Projects (5-Year)	√	√	√	√	√
		Essential Equipment and Field Infrastructure for facilitation of Research and Development and Monitoring					
5	Eco-development	Basic Infrastructure; Training to Tourist Guides of Peripheral Villages; Interpretation Centre for Nature Education	√	√	√	√	
6	Community Awareness and Participation	Creation of Self-help Groups (SHG), Provision of Revolving Fund for SHG; Alternate Income Generation Activities; Federation for Developing Entrepreneurship and Supply Management, etc.	√	√	√	√	√
7	Ecotourism	Provision of Essential Facilities; Regulation of Tourism Activities, with respect to carrying capacity of the area etc.	√	√	√	√	

(3) Wetland Management

Natural and manmade wetlands of Himachal Pradesh and Punjab states help in maintaining the ecological balance, serving the various needs of the society by recycling nutrients, purifying water, attenuating floods, maintaining stream flow, recharging groundwater, etc. Wetlands are not only one of the most productive ecosystems, but are also repository of rich and unique biodiversity. In addition, majority of wetlands in Himachal Pradesh and Punjab offer enormous opportunity of livelihood for local communities, and are major attraction centers for recreation and tourism activities. In the context of Beas Riverscape, the Brighu Lake, Prashar Lake, Rewalsar Lake, Pandoh Dam Lake, Pong Dam Lake, Largi dam and Harike Lake are some of the prominent wetlands of greater ecological, cultural and recreational importance. Most of them are IBA sites also while Pong Dam Lake and Harike Lake are the Ramsar sites. Majority of these wetlands on account of small size, large interface with urban/ rural environments, traditional resource dependence, and enhanced biotic activities are either deteriorated or in the process of degradation. In view of this, as a part of the proposed forestry interventions in two concerned States and as one of the strategies on conservation interventions, the present DPR focuses on wetland conservation and restoration efforts. The proposed strategy for conservation and restoration of wetlands is broadly two pronged. Firstly, the proposed strategy aims to protect, manage and restore priority wetlands within the Beas Riverscape. Secondly, the strategy also focuses on restoration and conservation of featured species and species of concern those are relevant to various wetlands. The following sections narrate the details of proposed strategy towards wetland conservation and restoration.

(a) Protection, Management and Restoration of Wetlands along the Beas River

In majority cases, the foremost requirement is to; ensure protection of various wetlands and facilitate their scientific management. The Space Application Center, Ahmadabad has provided the baseline information on various natural and manmade wetlands in two States by way of preparing the inventories and mapping. However, such information is more than 10 years old and there are large scale land use and land cover changes besides rapid development and enhanced biotic activities in both the States. Hence, it is of utmost importance that similar exercise is carried out/ repeated on a periodic interval of at least every five year so as to keep track on the current status of distribution and extent of wetlands. Being complex, fragile and dynamic ecosystems, majority wetlands require much desired protection and scientific management. This urgently calls for the preparation of comprehensive management plans adopting the landscape approach incorporating insights from research and monitoring activities. Majority wetland sites require creation of awareness, reduction in biotic pressure, and eliciting people support for conservation of wetlands through the execution of appropriate, site specific strategies on the eco-development. The conservation of wetlands and restoration of degraded wetlands require multidisciplinary insight and appropriate approaches. The officials and frontline staff involved in the protection and management of various wetlands require opportunities for capacity development and support of modern technologies and tools so as to implement prominent activities related to protection, habitat improvement, species management, control of invasive and alien species, eco-development,

tourism and visitor management, nature interpretation, and monitoring.

(b) Restoration and Conservation of Aquatic and Riparian Wildlife

The available published literature has revealed the declining state of several prominent and featured species (e.g., fishes – snow trout and mahseer; amphibians; reptiles– gharial, turtles; water birds; and aquatic mammals – otter and Indus River dolphin) and narrated recent efforts to restore/ conserve such species. The rediscovery of the Indus River dolphin after a considerable gap and efforts to create the Beas River Conservation Reserve in Punjab, awareness campaign, ecological research and population monitoring by the State Forest Department and WWF-India are laudable. However, the species like Indus River dolphin and associated faunal species in the riverine wetlands calls for comprehensive long term planning for their conservation and support at all levels so as to ensure the ecological integrity of the wetlands and sustainable management of various Rare, Endangered and Threatened (RET) species. The extremely small population size and narrow distribution range of dolphins that too just in one site make the population highly precarious and vulnerable to any type of adversity. The community led participatory approaches are thus, visualized so as to augment and strengthen populations of RET species. The foregoing review also revealed that there is conspicuous devoid of much desired scientific insight on most of the RET species with respect to their distribution and status, population dynamics, ecology, habitat preference, reproductive behavior, and their likely response to climate change. The Wildlife Wing, State Forest Department of two concerned States, need support for various above stated activities so as to ensure effective protection and management of wetland sites/ protected areas and conservation of threatened floral and faunal species. Much of the ongoing activities within various wetlands/protected areas along the river channel and its tributaries need augmentation and strengthening.

In view of the above, the following site specific activities are being proposed towards wetland management and conservation as a part of the present DPR and proposed forestry interventions.

- Protection of wetlands and associated floral and faunal species including survey and demarcation.
- Habitat improvement works – de-siltation, control/removal of invasive alien species, creation of mounts, protection of embankments, soil and moisture conservation works, and afforestation.
- Conservation of RET species.
- Ecological and management oriented research.
- Eco-development measures namely awareness, mitigation of people-PA/human-wildlife conflict, sustainable livelihoods, and participatory management.
- Nature interpretation and ecotourism.
- Long term ecological monitoring.

- The list is too high in the case of wetlands. So only more degraded or prominent should have been taken up with the consultation of stakeholders (Department/NGO/secondary services).
- The activities included in the proposed Model along with nomenclature for the states of Himachal Pradesh and Punjab is as follows:
- **In Himachal Pradesh**
- **BS/HP/CI /07**
- **In Punjab**
- **BS/PB/CI /07**

Table 5. 37 – Component-wise details of activities under Wetland Management (Natural and Artificial)

Sr. No.	Components	Activities	Year				
			1	2	3	4	5
1	Protection	General Protection from illicit felling, illegal grazing, mining, poaching, etc.	√	√	√	√	√
		Survey and demarcation of boundaries and establishment and maintenance of permanent boundaries	√		√		√
		Physical Infrastructure (Watch Tower, Patrolling Path); Electric Vehicle; Field Equipment - Tranquillization Gun, Night Vision with Binoculars, GPS, etc.	√	√	√		
		Communications	√	√	√		
2	Habitat Management	Habitat enrichment plantations 1. Sloppy area, 2. Riverine area (receded area broadcasting of lintels in strips 3. Riparian area 4. Grass land development	√	√	√	√	√
		Soil and Water Conservations Measures	√	√	√	√	√
		Control of Invasive and Alien Species	√	√	√	√	√

Sr. No.	Components	Activities	Year				
		Creations of Mounds/ Highlands	√	√	√	√	√
3	Wild Faunal Species Management	Conservative Breeding; Re-introduction of Species, etc.	√	√	√	√	√
4	Research and Development	Short Term Projects up to 1 year; Long Term Projects (5-Year)	√	√	√	√	√
		Essential Equipment and Field Infrastructure for facilitation of Research and Development and Monitoring					
5	Eco-development	Basic Infrastructure; Training to Tourist Guides of Peripheral Villages; Interpretation Centre for Nature Education	√	√	√	√	
6	Community Awareness and Participation	Creation of Self-help Groups (SHG), Provision of Revolving Fund for SHG; Alternate Income Generation Activities; Federation for Developing Entrepreneurship and Supply Management, etc.	√	√	√	√	√
7	Ecotourism	Provision of Essential Facilities; Regulation of Tourism Activities, etc.	√	√	√	√	

Table 5. 38 – Treatment Models for other Conservation Interventions in Himachal Pradesh

Sr. No	Year	BS/HP/CI /06 Riverine and Riparian Management		BS/HP/CI /07 Wetland Management	
		Amount Rs./ ha	Mandays	Amount Rs./ ha	Mandays
1	1 st year	3,20,000	512	2,80,000	448
2	2 nd year	2,80,000	448	2,50,000	400
3	3 rd year	1,90,000	304	1,60,000	256

4	4 th year	1,20,000	192	1,20,000	192
5	5 th year	90,000	144	90,000	144

Table 5. 39 – Treatment Models for other Conservation Interventions in Punjab

Sr. No	Year	BS/HP/CI /06 Riverine and Riparian Management		BS/HP/CI /07 Wetland Management	
		Amount Rs/ha	Mandays	Amount Rs/ha	Mandays
1	1 st year	3,20,000	374	2,80,000	327
2	2 nd year	2,80,000	306	2,50,000	273
3	3 rd year	1,90,000	194	1,60,000	163
4	4 th year	1,20,000	115	1,20,000	115
5	5 th year	90,000	80	90,000	80

Accordingly, necessary Budget provisions for concerned implementing agencies (SFDs) in two States have been made towards proposed activities for wetland management and conservation. (Table 5.40).

Table 5. 40 - Cost Norms for Conservation Interventions (in Lakhs)

Sr. No.	Soil and water Conversation Measures	Riverine and Riparian Wildlife	Wetland Management
Himachal Pradesh	12953.41	1750.00	495
Punjab	3145.60	490.00	270.00
Grand Total	16099.01	2240	765

b. Supporting Activities

In addition to the above stated proposed forestry interventions in three types of landscapes (i.e., Natural, Agriculture, and Urban) and three types of conservation interventions, execution of priority supporting activities is considered vital for the successful implementation of the present DPR and envisaged wide range of specific activities in the priority sites identified within the riverscape on the basis of geospatial analysis and inputs from the field.

(A) Policy Level Interventions

It is evident from the review that the complex and emerging subject of river conservation and restoration in country like India is backed up by numerous acts and policies. There is a growing concern about the plight of rivers in India at all levels. However, at the same time,

there have been several governmental and non-governmental initiatives towards river conservation including a large number of judgments and specific directives by the various Hon'ble Courts including NGT so as to safeguard the interests of river ecosystem, surrounding lands, dependent communities, and various user agencies. However, despite considerable progress in recent decades, there are gaps and several issues those continue to affect the river and associated biodiversity, production sectors, and even the human communities all along the main river channel and its tributaries. Undoubtedly, a wide range of stakeholders including numerous government agencies are involved in efforts towards river conservation and there are competing demands and conflicts. By and large, isolationist approaches are still being applied. In the absence of single agency overseen river conservation, there are serious issues of coordination and monitoring. In absence of appropriate alternatives, most concerned government agencies find difficult to effectively implement/ enforce various legislative acts and even the directives of the Hon'ble Courts. In general, the desired institutional framework and infrastructure is inadequate to tackle the complex nature of river ecosystem spread over large extent. Hence, augmentation and strengthening of existing policy and legal frameworks are desirable and much needs to be done so as to recover the past glory of the Beas River and its tributaries. In view of this, appropriate interventions related to improvement in the policy, law and institutional context are proposed as a part of the present DPR and to be implemented in the plan period. Necessary Budget provision for envisaged policy level interventions by way of reviews, seminars, workshops, visits, field level assessments and monitoring has been made. An amount of Rs. 4.20 Crore has been provisioned for this purpose for the Central Nodal Agency, 2.68 Crore for national level partner organization while at State level a provision of Rs. 0.23 Crore and 0.15 Crore have also been envisaged for Himachal Pradesh and Punjab respectively.

(B) Strategic Adaptive Research and Development

Certainly, the discipline of river ecology, management, restoration and conservation is relatively newer in the country and not much work has been done. Moreover, the approach has been largely piecemeal, fragmentary, and isolated in nature. Much of the information on various aspects of rivers come from different government agencies those are responsible for cryosphere, surface water, groundwater, pollution control, irrigation, hydropower, etc. Most of the researches by various scientific organizations, universities and individual efforts have focused so far on inventory of glaciers and wetlands, glacier retreat/ snowmelt, surface water, groundmap and development, water quality and impact of various developmental and biotic activities. Often, such initiatives are just one time efforts or in a project mode. In several instances, information is obsolete or specific to a particular tributary or stretch of a larger river. Only recently, first time effort has been made to carry out comprehensive study on cumulative impact of HEPs and carrying capacity. Ecological insight on threatened taxa in the riparian and riverine environments is generally poor. There have been hardly studies on the various aspects of socio-economics and human impacts on the river ecosystems. The subject of restoration of rivers in India is almost new. Hence, neither desired knowledge nor

essentially required tools and techniques are available those can be deployed in the socioeconomic milieu of the country. In view of this, priority action research is proposed during the plan period by concerned agencies and expert organizations. The experience towards proposed holistic forestry interventions for restoration of a major Himalayan river like Beas is relatively new, except little experience gained by the country in programme implementation in the context of rejuvenation of Ganga River. Thus, the present DPR seeks adoption of a holistic, integrated, multidisciplinary and multi-scale approach to forestry interventions by executing plantation activities, soil and water conservation measures, riparian and riverine wildlife management, and wetland management. As a part of the supporting activities, priority research as the concurrent activity is proposed by the national partner organization, SFDs and other concerned agencies. Research findings would immensely help the agencies ineffective implementation of the present DPR and in similar efforts on other rivers. Concurrent research is proposed to be taken up on the following priority thrust areas.

(a) Forest Hydrology Studies

It is a well-established fact that forests and water and highlighted that forests not only influence the hydrological cycle, but they also have a profound effect on water resources both quantitatively and qualitatively. The study of water in forests is termed *forest hydrology* and it includes the distribution, storage, movement, and quality of water; hydrological processes within forested areas; and the delivery of water from forested areas (NRC, 2008). Forest hydrological science is regarded as the foundation of modern integrated watershed management. Hence, the subject of forest hydrology has been of great interest for long to natural resource professionals and policy makers. As such, forest hydrology is an interdisciplinary science that evolved from the specialization of traditional hydrological science and forest ecosystem science during the past century and enormous literature exists on the subject, primarily from the western world. However, in spite of nearly 125-years old elaborate country-wide infrastructure exists on forestry research in India, the discipline of forest hydrology has been poorly addressed. All major rivers in the country and other freshwater resources are on decline. There is growing concern about the poor state of rivers and other freshwater resources. Hence, there is an urgency to initiate priority research in the field of forest hydrology in diverse forests of the country so as to understand how different forests are helping in distribution, storage, movement, supply and quality of water. Likewise, to answer the pertinent question that how forestry interventions, particularly plantations in different bio-geographic/ agro climatic zones.

(b) Screening of Suitable Species and Pilot Trials on Bio-remediation and Bio-filtration Bio-filtration

Most rivers in the country suffer on account of multitude of pollutants, waste and sewage originating from agricultural lands, industries and the urban environment. Both organic and inorganic contaminants find their way into rivers and other freshwater resources. Heavy metals are likely to be more in both municipal waste waters and industrial effluents.

Approaches like Phyto-remediation, Bio-remediation, and Bio-filters have been developed to treat pollutants in such waters. Removal of metals through phyto-remediation techniques and the subsequent recovery of the metals or their safe disposal are attracting research and commercial interests. Bio-remediation is being used as a method to treat waste water wherein biological organisms are used to convert the hazardous waste into non-toxic or less toxic substances. Usually, microorganisms are being used for bioremediation of sewage. Much work has been done in these emerging technologies, mainly in developed nations. However, in India these technologies are relatively emerging and thus, in infancy. Only handful sporadic efforts have been made so far in this direction and the success stories have been inadequately documented and disseminated. Nevertheless, these technologies have enormous potential to treat contaminated water prior to their release in the river or other wetlands. There is an urgency to initiate and support pilot trials in these priority fields in collaboration with potential scientific institutions and also to undertake researches on screening of suitable species for such purposes. The results obtained can be applied not only to Beas River, but also on its tributaries, other major river systems and water bodies of the country.

(c) Evaluation of Ecosystem Services Especially in Provisioning of Water Supplies

The concept of ecosystem services has become part of any approach towards conservation of biodiversity water, primary industries, human settlements, regional planning and climate change. There has been a growing public interest in the role and value of natural ecosystem and how they contribute to the quality of human life and human well-being. Ecosystem services and their continued provision underpin human existence, health and prosperity. Diverse natural ecosystems provide ecosystem services within four categories *viz.*, provisioning, regulating, supporting and cultural. Different forest ecosystems and forestry plantations provide a wide range of goods and services, both tangible and intangible in nature. Tangible benefits like timber, non-timber forest products (NTFPs) including medicinal plants, fuel wood, and fodder have been adequately quantified arising from various provisioning services. However, water supply under provisioning services, soil conservation under supporting services, and environmental amelioration under regulatory services are yet to be quantified. Likewise, river ecosystems also provide a wide array of ecosystem services. In general, researches in the context of services provided by forests as well as river ecosystems in the country are wanting. Hence, it is proposed to support priority researches in this field.



Fuelwood: An essential NTFP



Burans (*Rhododendron*) and Chilora (Lichen) – Important NTFPs

(d) Bio-engineering Methods for Soil Conservation and Stream/ River Bank Stabilization

The review on the riverscape and its environment highlighted that the Himalayan Rivers like Beas and its tributaries are severely impacted by soil erosion and eroding stream/ river banks owing to landslides, steep slopes, higher rates of runoff, and enhanced developmental/ biotic activities. Thus, soil and moisture conservation, and stabilization of stream/ river banks are amongst the priority activities towards river restoration. The use of biological and engineering measures in combination or biological interventions alone to control soil erosion and improve moisture conservation is referred as bio-engineering measures. Appropriate bio-engineering measures involving suitable cultural practices and plant species in addition to engineering structures have proven to be the cost-effective methods to check soil erosion and efficient soil moisture conservation strategy. Newer eco-friendly materials (e.g., geo-jute) are being extensively used in stabilizing steep slopes and checking soil erosion. However, researches in this emerging field need augmentation and strengthening, particularly in identification of newer eco-friendly materials, appropriate use of solid waste, screening of suitable plant species, and designing new bioengineering models. Hence, proposed research

activities in this emerging field with a focus on innovative and low-cost bio-engineering methods for riverbank stabilization and soil and moisture conservation are envisaged by the National Level Partner Organization in collaboration with SFDs and the Indian Institute of Soil and Water Conservation, Dehra Dun and its regional centers.

(e) Biodiversity, Forestry and Livelihoods

The world over, humanity is strongly intertwined with forests as they offer wide range of ecosystem services. Forests also provide habitat for wildlife, and are repository of biodiversity. Forests play a vital role in the rural economy. In India, it has been observed wherever there is a large concentration of forests, there is also high concentration of tribal people in particular and of the rural population in general. Rural people are dependent on forest resources for their livelihood. Forests not only provide resources for economic subsistence, but they are also a way of life socially and culturally. Sustainable livelihood is increasingly linked to the maintenance of 'Natural Capital' and environmental conservation at large. The Sustainable Forest Management (SFM) has been recognized as the pillar of biodiversity conservation and ensuring livelihood security of the local people. The United Nations adopted the Agenda 2030 with its core element, the 17 Sustainable Development Goals (SDGs) in September, 2015. Further, it has been realized that forests not only have a special role to just contribute to the Goal 15 (Life on Land), but forests have greater role to play in achieving several interconnected SDGs. Like most other natural ecosystems, the world over forests has also suffered due to enhanced human activities and face enormous challenges. In past five decades or so, country has made concerted efforts to protect and conserve diverse forests in different States/ UTs through appropriate innovations, policy and legal interventions, setting aside significant proportion of forest lands as protected areas, wildlife management and conservation of biodiversity, wetland management, integrated watershed management, adoption of participatory community led approaches, implementation of afforestation programmes, actions for recovery and conservation of RET floral and faunal species, research and monitoring, capacity development, etc. However, much needs to be done. A comprehensive research agenda on priority themes relevant to SFM, biodiversity conservation, management of NTFPs, fire management, eco-development and sustainable livelihoods needs to be planned and implemented. It is proposed that the national level partner organisation made responsible under this DPR for research, monitoring and capacity development will carry out researches on the above stated thrust areas in collaboration with SFDs and other National/State Level Scientific Organisation.

(f) Climate Change Mitigation and Adaptation

The Beas River originates in the Himalayan State of Himachal Pradesh, traverses through the steep mountains, and finally flows through the alluvial plains of Punjab. The fragile mountain environment of the riverscape in Himachal Pradesh is extremely sensitive to the changes in the global climate system, with widespread glacial retreat being one of the major signals of warming temperatures over the past century. The glacial retreat coupled with enhanced human activities by way of expansion of agriculture, infrastructural development, urban

growth, and other environmental pressures are considered as significant climate related threats to the river ecosystem, snow cover and high altitude wetlands, forests and biodiversity including aquatic biota, human lives, and livelihoods. The review on the riverscape and its environment has highlighted that one of the prominent/larger glaciers (Parbati Glacier) within the Beas Riverscape has shown signs of rapid retreat in the past two decades or so. Likely implications of climate change are expected to alter the structure and composition of forests and the distributional range of some of the featured floral and faunal species. Uncertain climatic events (i.e., avalanche, cloud burst, floods, droughts, etc.) are expected to impact the river, surrounding lands, and environmental flows besides local communities and their livelihoods. The State of Punjab is considered as the granary of the country due to its contribution towards the green revolution and production of food crops. The semi-arid State is over-developed in terms of its groundwater and prone to droughts and floods. Climatic perturbations arising due to global warming are recognised as serious threats to this economically important agriculture-horticulture belt and food security in the region. Thus, the slightest changes in the climate patterns can have large implications on the Beas River and its tributaries, not only for their own ecological values but also for larger humanity in two States. As of now, there is poor insight on the nature of impending impacts and the ways and mean to adapt and mitigate. Hence, it is proposed that the national level partner organisation undertakes the priority researches relevant to this important theme involving other State/ National Level Scientific Organizations.

(g) Support of Modern Technology in Natural Resource Management (NRM)

Degradation of natural resources is a growing concern that threatens the livelihoods of millions of people. Innovations by research and development organisation, and local communities themselves have produced several promising technologies and practices for making natural resource management more productive and sustainable. The advent of modern technologies in the fields viz., remote sensing and GIS, IT, biotechnology and genetics, waste management, forestry and agricultural operations, wildlife conservation, nano-technology, water use and efficiency etc. have opened several avenues for effective planning and managing of vital natural and manmade resources including cryosphere, forests, wetlands, wildlife, agriculture. However, the potential of advanced technological interventions in NRM is yet to be fully explored. Hence, collaborative researches with the aim to augment and strengthen advanced technological support in NRM are envisaged and proposed as part of the present DPR. The National Level Partner organisation is expected to play a lead role in this endeavor so as to encourage active involvement and partnership of related organisations. In addition to national level endeavors, the site specific researches in the aforementioned technology fields are proposed to be encouraged, supported, and facilitated by the state level organisations. As the subject of river conservation and restoration is relatively new for the country and very little experience exists at this juncture, it is proposed that the national level partner organisation would organize a research need analysis workshop involving all the probable research organisation so as to plan the research agenda for this priority field and to facilitate the cooperative research.

(C) Participatory Monitoring

The adverse impacts of past river use and developments have been widely recognized in recent decades (Malmqvist and Rundle, 2002; Tockner and Stanford, 2002; Woolsey *et al.*, 2007). Thus, elaborate restoration attempts are underway worldwide to return human impacted rivers to more natural states and to restore lost ecosystem services (Palmer *et al.*, 2004; Speed *et al.*, 2016, Johnson *et al.*, 2019). Off late, the Government of India has also decided to restore major rivers of the country and new initiatives have been launched. Assessing the outcome of river restoration projects is vital for adaptive management, evaluating project efficiency, optimizing future programmes and gaining public acceptance. Participation of the various stakeholders and the public in river restoration is increasingly prompted because it is expected to improve resource management and enable participants to engage freely and equally in management. The present DPR has earlier provided an overview on the diverse stakeholders associated with the river, its use, management, restoration, and those are impacted by the river. As a part of the preparation of this DPR, one of the key components was on the involvement of various stakeholders and following the process of extensive consultation at all levels. Concurrent, participatory, results based monitoring is envisaged while implementing the present DPR on forestry interventions.

(a) Monitoring: Monitoring, evaluation and adaptive management play vital roles in supporting effective river restoration. Monitoring against defined and measurable objectives is critical for assessing the effectiveness of river restoration measures and for guiding adaptive management. Monitoring describes the process of gathering qualitative or quantitative data at periodic intervals, using pre-determined indicators of progress towards project or programme objectives. The following regions dictate that the process of monitoring be made an integral part of the programme implementation on proposed forestry interventions in the Beas River.

- **Seasonal Activities and Timely Implementation:** Most proposed forestry interventions (i.e., soil and moisture conservation, planting and allied activities) are seasonal in nature. Moreover, the Himalayan mountainous tract in the upper part of the riverscape allows limited time for field activities owing to harsh climatic conditions and the larger extent of the riverscape is inaccessible during winter when areas are covered by snow. Timely implementation of proposed seasonal activities is vital for the success of the programme. Thus, regular monitoring of progress is essential so as to minimize any risk of failure.
- **Involvement of Multiple Agencies and Stakeholders:** Proposed forestry interventions so as to rejuvenate the Beas River would be spread across two States and it would involve multiple agencies and stakeholders in its implementation. Forestry interventions have been planned in Natural, Agriculture and Urban landscapes. Obviously, it would include a wide range of stakeholders and implementing partners. Hence, periodic monitoring of the progress of various works through appropriate mechanisms is considered essential.
- **Adaptive Management:** River conservation and restoration are complex activities and prone to several uncertainties. Moreover, river restoration programmes such as forestry interventions in the context of a river are relatively new and very little experience exists within the country. Thus, the adaptive management as an inbuilt programme is vital. Adaptive management is often used in generic sense to reflect the need for flexibility in

project and programme management in the light of evidence gathered through monitoring and evaluation programme. Adaptive management is a tool that can be used not only to change a system but also to learn about the system. Since adaptive management is based on practice and learning through monitoring, therefore, it improves long run management outcomes and builds adaptive capacity (Speed *et al.*, 2016).

- **Transparency and Accountability:** Increasingly, there is greater emphasis on transparency and accountability in the prevailing system of governance, particularly when the tax payer's money is involved. Regular and periodical monitoring ensures much desired transparency and accountability in the programme implementation at various levels.

(b) Monitoring Needs: Thorough review on the existing situation of the river and its environment in Part 1 of the present DPR has provided much desired insight about the varied monitoring activities (e.g., glaciers and snow cover; climate – rainfall, snowfall, temperature, wind, etc.; surface water and runoff; groundwater and aquifers; sedimentation; forest cover, growing stock, carbon sequestration and fire incidences; e-flow and water quality; wetlands and water birds; fish production; population monitoring of RET floral and faunal species; visitors to tourism sites; and demography), undertaken by different central/ state level departments and agencies. Some of these monitoring activities are well designed, planned, executed and supported by appropriate institutional mechanisms and carried out either on regular basis or for longer stretches. Definitely, to a great extent baseline information for several important themes, components and variables is available. Nevertheless, there is ample scope to strengthen and augment the current monitoring activities. The logical framework analysis provides a broad based insight on verifiable indicators. However, it is proposed to firm up the verifiable indicators, methods and periodicity besides monitoring sites, etc. so as to ensure a meaningful and diagnostic monitoring on regular basis for vital aspects of the river ecosystem. It is also proposed to plan for collection of baseline data wherever required during the first year itself. This can be facilitated by the national partner organization responsible for research, monitoring and capacity development.

(c) Concurrent Monitoring Mechanisms for Proposed Forestry Interventions: Considering the complex and dynamic nature of river ecosystem, and the fact that the vast area is covered within the riverscape and much of the area is in difficult terrain and inaccessible, it is essential to adopt various concurrent monitoring mechanisms and relevant tools for carrying out envisaged monitoring activities. Thus, concurrent monitoring mechanisms include: (a) IT enabled monitoring, (b) RS and GIS based monitoring, (c) Online monitoring through web portal, (d) on ground monitoring, and (e) participatory monitoring. In recent times, increasingly mobile app based monitoring on real time basis in a much more transparent manner is possible. Thus, it is proposed to incorporate IT/mobile app based monitoring. Since large, difficult and inaccessible areas form the major part of the river basin/ riverscape, optimal use of RS and GIS technologies, particularly for monitoring glaciers; sedimentation in reservoirs; and changes in channel morphology, land use and land cover, snow cover, forest cover, wetlands, cropping pattern, etc. The SFDs and other governmental agencies have established their state-of-the-art RS and GIS facilities which can be used effectively for the monitoring purpose. A financial assistance of Rs. 18.89 Lakh and 24.84 Lakh has been proposed at centre and national level organisations. However, single time financial assistance to the tune of Rs. 27.59 Lakh and Rs. 22.06 Lakh to the SFDs of Himachal Pradesh and Punjab is proposed for the upgradation of existing GIS facilities, procurement of desired hardware and software, and high resolution satellite data. The Forest Survey of India, Dehra Dun or its Regional Centers would play an important role in carrying

out RS based monitoring of forest cover. Online monitoring of the proposed interventions is being planned through Web Portal developed by the HFRI, Shimla during the process of preparation of DPR. The Portal would be able to incorporate and process all vital information like area and extent, geo-references and locations of each of the activity, financial expenditure, plantation survival status, maintenance works, and actual pictures of field sites at various stages of programme implementation and progress. This online web based monitoring shall not only facilitate the compilation of desired information for each of the type of landscape/ forest division/ State and even the entire riverscape on yearly basis, but would also facilitate instant query and report generation. In addition, on-ground monitoring by way of participatory monitoring at division level and third party monitoring are envisaged. The proposed monitoring would include physical as well as financial progress aspects at the local level and shall be monitored jointly by the field level staff of Forest Department and select Community Based Organizations. The monitoring reports shall be submitted by the Divisional Forest Officers (DFOs) to the Principal Chief Conservator of Forests. The scope of monitoring would include the extent treated, expenditure details, survival of plantations, performance of other activities, flow of tangible benefits to the community and adherence to time schedules. The SFDs may design performa for participatory monitoring based on local needs. Local level monitoring is proposed to be carried out annually while incorporating vital physical parameters such as e-flow/ discharge rate of streams and silt load at randomly selected field sites in each of the forest divisions. In addition, it is proposed to select at least ten points each on different streams/ tributaries contributing to the main channel and shall be randomly selected in different micro-watershed areas in each division. Monitoring of e-flow and siltation shall be carried out seasonally. Further, the DFOs will submit a quarterly progress report of physical and financial achievements. The quarterly reports so obtained from the divisions/ FDAs shall be compiled for analysis by the PMU under SFDA at the State level and submitted further to the PMU of the Central Nodal Ministry and the National Partner Organizations for consolidated monitoring purpose. The proposed multi-tiered monitoring mechanism for proposed forestry interventions in Beas Riverscape is depicted in Fig. 5.13.

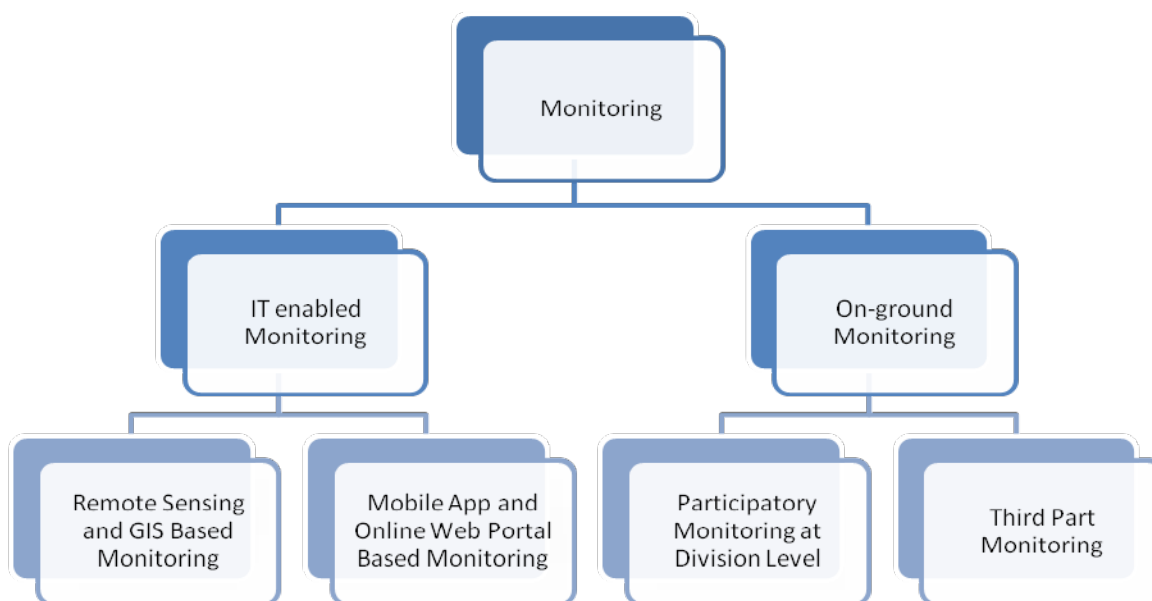


Fig. 5. 13– Multi-Tiered Monitoring Mechanism for Proposed Forestry Interventions in Beas Riverscape

In short, the implementation plan envisaged multi-tiered monitoring mechanism for monitoring progress of the project as well as achievements of objectives. The National Level Partner Organization (HFRI, Shimla) selected by the Central Nodal Ministry implementing the project will be responsible for comprehensive monitoring besides State/ Local site specific monitoring would be undertaken by the concerned SFD. The monitoring and evaluation of the program will be carried out as per the existing State norms. However, a Budgetary provision for developing a comprehensive monitoring programme as well as its implementation has been made which accounts for about 2 -2.5% of the total cost of the project.

(D) Capacity Development

The world over, the development agenda is being implemented for past several decades by various International/National/State/Local Governments with mixed success. Often, developmental projects are not yielding desired results and a reasonably high number of projects even fail. One of the primary reasons of failures of major developmental projects in spite of elaborate planning and huge investments is the inadequate capacity.

Capacity is Development: *Capacity* has been defined as the ability of people, organizations and society as a whole to manage their affairs successfully; whereas the capacity development has been defined as the process whereby people, organizations and society as a whole unleash, strengthen, create, adapt and maintain capacity over time (UNDG, 2008). Further, National and International Agencies engage in addressing global challenges (e.g., land degradation; water crisis; food insecurity; depleting ‘natural capital’ and loss of biodiversity; poverty; hunger; malnutrition; social issues – gender, equity and peace; and climate change) or contributing towards specific sector or the agenda of development increasingly emphasize on decentralized, bottom up, participatory, science-based, integrated approaches, essentially seeking building alliances, inter-agency cooperation and sectoral convergence. There is now emerging agreement in the community development that capacity development at all levels is of utmost importance and is the engine of human development. Capacity development starts from the principle that are best empowered to realize their full potential when the means of development are sustainable – home-grown, long-term, generated, and managed collectively by those who stand to benefit. According to UNDP (2009), the ‘Capacity is Development’ and the capacity development is about transformations that empower individuals, leaders, organizations and societies. Capacity development is aimed at effective and informed participation in decision making for implementation of any programme towards sustainable development. Capacity development initiatives go much beyond raising awareness of stakeholders and aim at developing the capacity of diverse stakeholder groups to appreciate the multifaceted issues, and their own role within a complex set of actors and dynamic environment. Most agencies aim to bring desired change in policy framework, mindsets, attitudes, perceptions, functional approaches, and foster an enabling environment in view of the emerging requirements. Diverse stakeholder groups at various hierarchical levels depending upon their interests, roles and responsibilities, needs, and expectations require different knowledge, ability, and skills for taking active part and to make

meaningful contributions in the participatory processes. In recent time, the concept of capacity development has undergone notable transformations, conceptually, operationally, and institutionally. Conceptually, efforts of capacity development seek an enlarged and broader scope beyond the capacity enhancement of individuals, instead now it also focuses on societal and organizational transformation. Thereby, creating appropriate space for and management of dialogues, relationships, collaborations, partnership, knowledge networks, and incentives for efficiency, performance, transparency, accountability, and sustainability. In past, the sole emphasis was on physical targets and outputs. However, in the changed scenario, the operational transformation of capacity development emphasizes on processes and mechanisms that lead to desired outcomes, and impact. Institutionally, capacity development initiatives are at the core of the work of the countries and national governments and they are embedded in the national development strategies as well as sub-national developmental plans. Capacity development is central for ensuring ownership of any development plan for effective resource management, empowering communities and civil society, scaling up, sustaining progress overtime.

River Conservation – Intricate Nature: Certainly, the agenda of river conservation and restoration for India is relatively new. Proposed forestry interventions for river restoration aiming *Aviral Dhara*, *Nirmal Dhara* and ecological integrity of the river lays emphasis on a holistic and integrated approach for achieving goals of sustainable land and river ecosystem management, increased forest/vegetation cover, improved livelihoods and build resilience for climate change. The envisaged thrust of the project is on ‘Multi-disciplinary’, ‘Multi-sectoral’, ‘Multi-stakeholder’ and ‘Multi-scale’ approach. In order to achieve project goals and objectives, SFDs of concerned States as Implementing Agencies would need cooperation and collaboration of various line agencies and local communities. Various measures *viz.*, plantations in different types of landscapes (i.e., natural, agriculture and urban), conservation interventions (i.e., soil and moisture conservation, riparian and riverine wildlife management, and wetland management) and supporting activities like policy level interventions, strategic adaptive research and development, participatory monitoring, capacity development, awareness, evaluation and project management have been planned. The project implementation would require partnering, collaboration and convergence. The intricate nature of river and of the above stated holistic approach towards river conservation and restoration essentially requires capacity development of various target groups.

Objectives of Capacity Development: The logical framework analysis has summarized the vision, goals, and objectives of river conservation and restoration along with envisioned outputs and outcomes. Accordingly, objectives of capacity development lay emphasize on participatory planning involving various line agencies and engaging communities at the grass roots level. Development of soft skills relevant to communication, advocacy, negotiation, conflict resolution, etc. is a prerequisite for varied stakeholders, particularly in case of professionals representing different line agencies, and local communities. Considering the intricate nature of river and associated measures for river restoration, it is proposed to build professional competence and develop skills for science and technology based backstopping. The agenda of capacity development would need to focus on sustainable livelihoods

alongside effectively managing and maintaining natural resources as the natural capital. Enhanced capacity for monitoring and evaluation is also proposed. A wide range of stakeholders are expected to be involved in proposed plantation activities in three types of landscapes besides implementation of different conservation interventions. Hence, one of the objectives of capacity development would be to enhance capacity in the field of forestry interventions. The holistic approach to river conservation essentially requires sectoral integration, convergence and sustainability. Thus, developing appropriate capacity in these specialized fields is envisaged as one of the objectives. Various objectives for capacity development are presented in Fig. 5.14.

Core Modules: The newer generation approaches towards river conservation and restoration emphasize on the basin or riverscape approach wherein the linkages between the upstream and downstream, riverine lotic system and the adjacent riparian zone, surface water and groundwater, and environmental flow and aquatic biota matter. The river ecosystem management efforts are regardless of administrative and legal boundaries and require application of different scales.

In view of the above, the capacity development efforts for river conservation and restoration envisage various core modules on: (a) river ecology and ecosystem management, (b) organizations and project management, (c) participatory approaches and sustainable livelihoods, (d) science and technology based backstopping, (e) cross-cutting issues, convergence and synergies, (f) climate change mitigation and adaptation, (g) forestry interventions, (h) monitoring, evaluation and learning documentation, and (i) sustainability (Fig. 5.15).



Fig. 5. 14- Objectives of Capacity Development

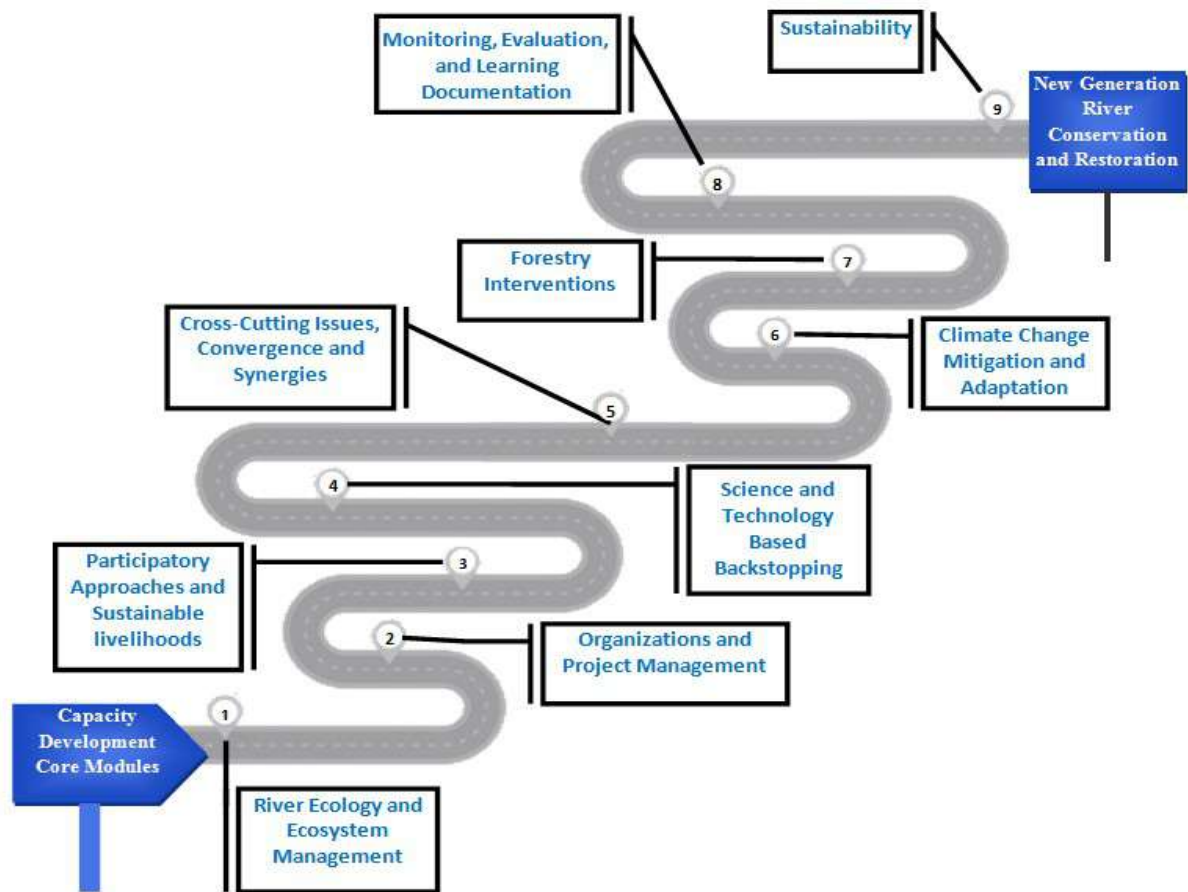


Fig. 5. 15- Capacity Development –Core Modules for River Conservation and Restoration

Target Groups: Broadly, the target audience for capacity development can be grouped at four hierarchical levels viz., national, state, division and community (Fig. 5.16). It is essential to target the right people for specific inputs towards capacity development. Potential target audience at different hierarchical levels includes:

- National Level – Policy and decision makers, and professionals of partner organizations
- State Level – Forest officials and professionals of various line agencies, partner Institutions
- District/Division Level – Forest frontline staff, and NGOs
- Community Level – CBOs, local communities, farmers, grazers, fishermen, etc.

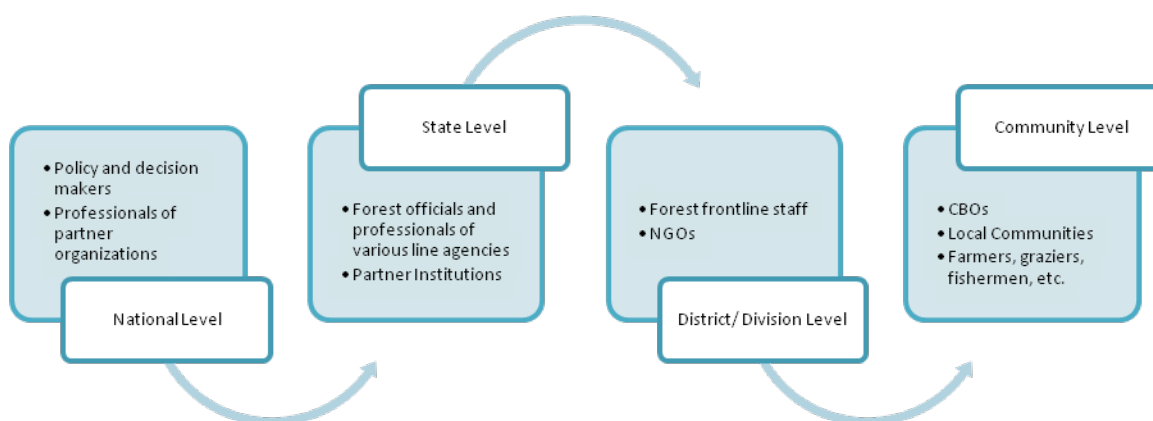


Fig. 5. 16- Capacity Development at Various Hierarchical Levels and Target Groups

Proposed capacity development is expected to improve the knowledge and skills of the professionals, partners, frontline staff of SFDs, local communities and specialized occupational groups.

Trainings, Workshops, Scientific Exchange and Engagement of National/International Experts: The knowledge and skill development of various target groups can be enhanced through trainings, seminars, workshops, scientific exchange, exposure visits, demonstrations and resource inputs by National And International Experts. Theme based short duration trainings (2-3 days) have been planned. Seminar/Workshops have also been planned. Exposure visits for professionals, frontline staff, local communities and other occupational groups have also been provisioned. The National Level Partner Organization responsible for capacity development would plan and organize for the National Level Capacity Enhancement by organizing trainings and orientation seminar/meetings, scientific exchange, field tours and overseas visits for professionals and decision makers. Considering the fact that the discipline of river restoration is relatively new for the country, the national level partner organization also plans to involve select reputed national and international experts, especially in the fields of river conservation and ecological restoration, bio-remediation and bio-engineering methods, climate change mitigation and adaptation, conservation breeding, policy interventions, and advanced technologies relevant to riverscape management so as to avail their resource inputs in endeavors towards knowledge management and national level capacity development. Necessary Budget provisions for such activities have been made in the Budget outlay meant for the purpose of capacity development, scientific exchange and management of national and international experts. The details of activities and costs of various activities pertaining to capacity development and knowledge management to be implemented by the concerned SFDs as the IA are provided in Table 5.41. The proposed expenditure norms include costs towards payment of honorarium to Resource Persons, training and learning material, travel and transportation, lodging and board, venue charges, and other contingent expenses. The trainings, workshops, meetings, exposure visits, etc. at

the State/ Division/ Community levels will be either conducted in house by the SFDs or outsourced to other relevant specialized organizations or technical agencies having expertise in the relevant field. The cost details towards various activities of capacity development by the National Partner Organizations are provided in Chapter 7.

Table 5. 41 - Cost of Capacity Building (Training, Workshops, Seminars and Exposure Trips)

Sr.No.	Activity	Norms Rs. in lakh	Phase I					Grand Total (Cost Rs. in lakh)
			Year					
			(Cost Rs. in lakh)					
			I	II	III	IV	V	
Himachal Pradesh	Local Level Training for Communities (Trainings; 2-3 days) 25	3.00	42.00	44.10	46.31	48.62	51.05	232.08
	Division Level Trainings for SFD Personnel, Line Departments and Other Partner Agencies (1 Training/Division/2-3 days) 25	3.00	42.00	44.10	46.31	48.62	51.05	232.08
	State Level Inception Workshop (2-3 days) 1	15.00	15.00	-	-	-	-	15.00
	State Level Seminar – Mid Term (2-3 days) 1	20.00	-	0.00	20	-	-	20.00
	Exposure Trip Within State (30 participants; 2 per year)	10.00	20.00	21.00	22.05	23.15	24.31	110.51
	Exposure Trip Outside State (15 participants; 1 per year)	20.00	20.00	21.00	22.05	23.15	24.31	110.51
	Total		139.00	130.20	156.71	143.55	150.72	720.18
Punjab	Local Level Training for Communities (Trainings; 2-3 days) 25	3.00	18.00	18.90	19.85	20.84	-	77.58
	Division Level Trainings for SFD Personnel, Line Departments and Other Partner Agencies (1 Training/Division/2-3 days) 25	3.00	18.00	18.90	19.85	20.84	-	77.58
	State Level Inception Workshop (2-3 days) 1	15.00	15.00	15.75	16.54	17.36	-	64.65
	State Level Seminar – Mid Term (2-3 days) 1 and Final year (1)	20.00	-	-	20.00	-	22.05	42.05
	Exposure Trip Within State (30 participants; 2 per year)	10.00	20.00	21.00	22.05	23.15	24.31	110.51
	Exposure Trip Outside State (15 participants;	20.00	20.00	21.00	22.05	23.15	24.31	110.51

Sr.No.	Activity	Norms Rs. in lakh	Phase I					Grand Total (Cost Rs. in lakh)
			Year					
			(Cost Rs. in lakh)					
			I	II	III	IV	V	
	1 per year)							
Total			91.00	95.55	120.33	105.34	70.67	482.89
Grand Total			230	225.75	277.04	248.89	221.39	1203.07

Capacity Enhancement through Technology Adoption: It is essential to incorporate appropriate modern technologies and innovations in an endeavor towards river restoration. Thus, capacity enhancement at the national level, national level partner organizations, and capabilities of field personnel of concerned SFDs is proposed by adopting innovations and modern technologies so as to facilitate efficient implementation of activities envisaged in the DPR. For facilitation of smooth field level operations, the concerned SFDs will require support of physical infrastructure. Accordingly, necessary Budget provision has been made to augment and strengthen physical infrastructure including office, computer, RS and GIS, IT and communication, and field equipment. The field staff of SFDs will be provided proper training in the use of GPS, mobile app, and other modern field tools relevant to analysis of water quality, sedimentation and runoff, animal monitoring, etc.

(E) Awareness

Despite rivers are lifelines; being worshipped; play an important role in the economic development; forms an integral part of the mythology; and reflect multicultural fabric of the Indian Society and ethos, all prominent rivers in the country and their tributaries are in the state of degradation due to the fact that the rural and urban populations living along the river course continue to exploit its resources, contaminate and neglect the ecological concerns of the river and contribute in some form of the disturbance or pollution. Thus, it has been lately realized that the public awareness campaign is a prerequisite for any planned efforts towards river restoration. In absence of such efforts, any amount of investments and diversity of interventions would not help in the restoration process of degraded rivers.

A public awareness campaign is an effort to build public recognition of a problem through media, messaging, and an organized set of communication tactics. These campaigns target masses and specific groups of people over a period of time so as to try and generate explicit outcomes or achieve predetermined goals. Public awareness campaigns are important as they can help to facilitate policy change and encourage the community to take action. Campaigns also help to inform the community about the declining condition of the river, factors responsible for the current state, and how they affect the overall environment, economy, livelihoods, ecological integrity of the river, and even the human health. Awareness campaigns can also help in drawing attention of the community in such a way that the information and education provided can elicit their support for river restoration and solicit

actions to make changes in current use patterns of river resources, lifestyle and behaviour those have been adversely impacting the river and its ecological functioning.

In view of the above, creating awareness and sensitizing the masses on the importance of restoration of river and the role public has to play in such efforts are the priority agenda envisaged as a part of the proposed forestry interventions. Awareness campaigns are proposed to be directed primarily towards two broad groups i.e., the general public, and the educational institutions, particularly targeting the youth. The SFDs as IAs in concerned States can adopt different approaches and tools for awareness campaigns and sensitizing the masses. These are: use of multimedia, awareness camps and rallies, posters, brochures, pamphlets, booklets, hoardings, mobile vans, audio visual shows, and celebration of important days (Water Day, Wetlands Day, Wildlife Week, World Environment Day, World Forestry Day, etc.). It is proposed that SFDs can organize awareness campaigns in educational institutions (i.e., schools, colleges, and universities) through the NYKS, Eco-clubs, NSS, NCC, Scout and Guide and other appropriate mechanisms approved by the educational authorities both in government and private institutions. The Civil Society Organizations (CSOs), NGOs and religious organizations are expected to play pivotal role in this priority endeavor. SFDs can prepare video documentaries highlighting ecosystem services offered by the river; declining state and its reasons; and how public can meaningfully contribute towards river restoration by way of planting trees, reducing biotic pressure and various contaminants and widely use them for awareness campaigns. Necessary Budget provisions for carrying out various activities by SFDs for awareness have been made (Table 5.42). Likewise, Budgetary provisions have also been made for various envisaged activities relevant to this priority agenda by the National Level Partner Organization.

Table 5. 42 - Cost of Awareness Programmes

State	Activity	Year					Grand Total (Cost Rs. in lakh)
		Phase I (Cost Rs. in lakh)					
		I	II	III	IV	V	
Himachal Pradesh	Awareness Campaigns@1	14.00	14.70	15.44	16.21	17.02	77
	Awareness Activities for General Public@2	28.00	29.40	30.87	32.41	34.03	155
	Awareness Material – Pamphlets, Brochures, Booklets, Signages, Boards and Hoardings @2	28.00	29.40	30.87	32.41	34.03	155
	Publicity Through Mass Media@3	42.00	44.10	46.31	48.62	51.05	232
Total		112	118	123	130	136	619
Punjab	Awareness Campaigns@1	6.00	6.30	6.62	6.95	7.29	33.15
	Awareness Activities for General Public@2	12.00	12.60	13.23	13.89	14.59	66.31
	Awareness Material – Pamphlets, Brochures, Booklets, Signages, Boards and Hoardings @2	12.00	12.60	13.23	13.89	14.59	66.31
	Publicity Through Mass	18.00	18.90	19.85	20.84	21.88	99.46

State	Activity	Year					Grand Total (Cost Rs. in lakh)
		Phase I (Cost Rs. in lakh)					
		I	II	III	IV	V	
	Media@3						
Total		48.00	50.40	52.92	55.57	58.34	265.23
		160	168.4	175.92	185.57	194.34	884.23

(F) Evaluation

A strong evaluation mechanism is a core element of a major, multifaceted project like the present one on proposed forestry interventions for restoration of a river so as to assess the project performance, collect evidence that indicates the extent to which the envisaged outcomes have been achieved, and document what has been the impact of the project to bring desired change. The logical framework matrix has earlier provided details on the range of activities, expected outputs and outcomes, performance and impact indicators along with their means of verification. This information forms the basis to assess the project's impact. The project envisages project evaluation, particularly appraisal of annual progress, Mid Term Review (MTR), and the Terminal Evaluation (TE).

Third Party External Evaluation: Third party or external evaluation is essential so as to get an independent view of the project activities, performance and impact. The MTR and TE are proposed as independent evaluation involving external experts other than those who have been neither the part of the project design and development nor of implementation. The independent evaluations would rely on the criteria developed by the third party involved in the process. However, they would also review the monitoring efforts made by the implementing agencies at the state and division levels, the National Partner Organization, and the Central Nodal Ministry at different stages of the project implementation. The MTR would specifically focus on mid-course corrections so as to accomplish the project goals while the TE is expected not only to focus on documentation of project performance, accomplished outcomes and impact, but also provide recommendations for future projects based on learning's. The aim of evaluation is also to share the knowledge gained in project implementation. The National Level Partner Organization is expected to facilitate project evaluation and would require an amount of Rs. 44.86 Crore, while funds for carrying out various activities related to field evaluation by concerned SFDs have been clubbed with the cost of monitoring and details are being provided in Chapter 7.

(G) Project Management

Efficient management of project activities is of utmost importance in achieving desired goals. This requires appropriate institutional arrangements at various hierarchical levels and a well-designed mechanism for effective implementation of the project, particularly smooth flow of required funds to state level implementation agencies, especially in view of the seasonal and time bound nature of majority proposed works. Accordingly, Project Steering Committees

(PSCs) at two hierarchical levels (National and State) have been visualized. The details on institutional arrangements and mechanism for programme implementation are provided in Chapter 6. In view of the much desired transparency and efficiency, the optimum use of IT-based mobile app is envisaged for documentation of project activities, progress, monitoring and evaluation.

6.1 Project Implementation – The Components and Partnership Arrangements

India needs to guarantee water security in terms of both quantity and quality through sustainable management of available water resources. In view of that, the country's important document 'Strategy for New India @75' envisaged that by 2022–23, India's strategy on management of water resources should facilitate and ensure water security by way of adequate availability of water for life, agriculture, economic development, ecology and environment (NITI Aayog, 2018). The broader vision is aimed to be achieved by attaining the various sectoral goals including a focus on *Aviral* and *Nirmal Dhara* of the National River as well as other major rivers along with their tributaries. Further, the commitment of the Government of India to realize its vision is amply evident from the D.O. Letter No. 11(1)/2017 – WR Vol.- I dated 06 June, 2018 issued by the CEO, NITI Aayog, New Delhi to all the Chief Secretaries/Administrators of all States/UTs conveying the GoI's decision to launch of a major mission which details how the revitalization of India's River Programme will be implemented on the ground utilizing the existing schemes and programmes of the government with community led efforts. The said letter stated that 'the programme would be led by the Department of Rural Development (DoRD) under the guidance of NITI Aayog and would target convergence of MGNREGS with other programmes of Central Ministries viz., MoEF, DoAC, MoWR, MoPR, DoLR, as well as the State Governments'.

Considering the significance of revitalization of major Indian rivers and their tributaries from the perspective of environmental stability and economic prosperity and also in the view of the above directives by the NITI Aayog, the NAEB under the MoEFCC has entrusted the major task to ICFRE and its institutes to prepare the present DPRs of five rivers along with other eight (08) major rivers (Yamuna, Brahmaputra, Narmada, Luni, Godavari, Mahanadi, Krishna, Kaveri), of the country and not only provided full financial support for the purpose (project formulation) but also advised to follow the pathway earlier adopted in the preparation of DPR on forestry interventions in the context of rejuvenation of river Ganga. In the case of Ganga, the Namami Gange Programme of the NMCG has provided the financial support for implementation of the programme. However, in the present case, the MoEFCC may either decide to implement the project formulated in the present DPR at its own or request the MoJS to provide required funds for execution or implement as a joint venture in collaboration with any other central ministry/ national or international agency. Alternatively, the MoEF&CC may decide to implement the specific component(s) of the project and implement the whole programme in partnership with other Ministries/Agencies. The Project envisages the following four Components of programme implementation (Fig. 6.1):

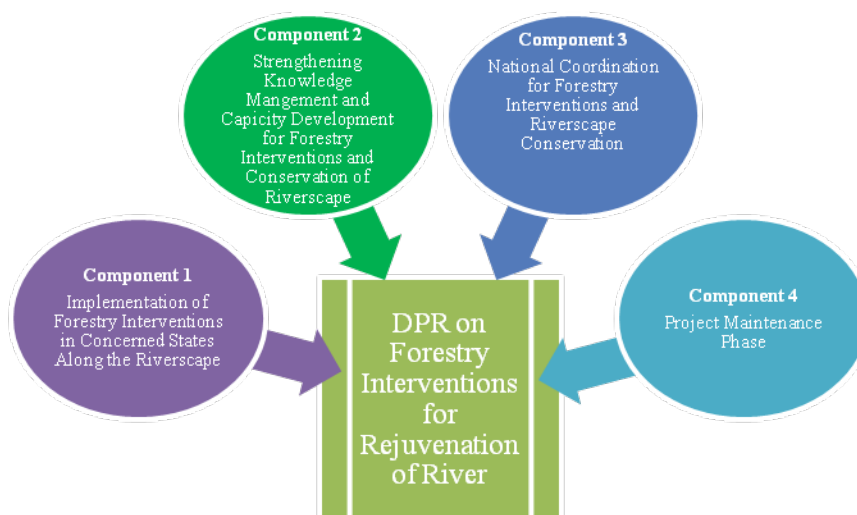


Fig. 6.1 - Four Components of the Project

Component 1: Implementation of Forestry Interventions in concerned States of Riverscape

The Component 1 of the Project specifically deals with the proposed forestry interventions in concerned States along the course of River. The Component 1 includes three sub-components: (i) the proposed ‘Forestry Interventions in three lower order sub-zones’ delineated within the riverscape viz., (a) Natural Landscape (NL), (b) Agriculture Landscape (AL), and (c) Urban Landscape (UL) adopting appropriate plantation treatment models; (ii) ‘Conservation Interventions’; and (iii) ‘Supporting Activities’. Besides proposed extensive plantations in three types of landscapes within the riverscape, the significant inputs under the sub-components on Conservation Interventions by way of soil and water conservation, riparian and riverine wildlife management, and wetland management have been envisaged. In addition, concerned participating States will carry out ‘Supporting Activities’ referred as ‘Themes’ at the state and local levels those are critical and supportive in nature for the overall success of major project on forestry interventions. Prominent proposed supporting activities include: (a) policy level interventions; (b) concurrent research and development; (c) participatory monitoring; (d) capacity development; (e) awareness; and (f) evaluation. Further, in order to ensure effective implementation, coordination, and monitoring of the state-wide project activities, support for the establishment and smooth running of the State level Project Management Units (SPMUs) in two concerned States is also provisioned as apart of this Component. The sub-components and various envisaged activities are summarized in Fig. 6.2.

The Project envisages that the State Forest Department (SFD) of concerned States will be responsible for implementation of the Component 1 that primarily includes plantation activities in three types of landscapes. Hence, the SFDs of concerned States would be the Implementing Agencies (IAs) for this major component. The Chapter 4 has already provided an insight on the organizational structure, mandate, functions and activities, schemes, past

experiences of SFDs in afforestation, forest management, protected area management, biodiversity conservation and improvement of rural livelihoods. Obviously, the SFDs is the relevant department related to proposed activities under the Component 1 as they offer most suitable organizational setup and institutional framework for execution of a major Project of this nature. The hierarchical organizational structure; well laid physical infrastructure and procedures for programme execution, communication, expenditure, accounting, and auditing; and monitoring are added characteristics of SFDs and thus, they make the right choice for effective implementation of the proposed programme. Often, the management units in the SFDs have been carved out on the basis of natural micro-watershed boundaries and such mechanism makes it convenient for planning, implementation, monitoring, and evaluation of the likely impacts of proposed activities at the micro-watershed levels. The Project also envisages that the SFDs may like to involve the Eco Task Force Battalion(s) of the Territorial Army and Civil Society Organizations (i.e. NYKS, NSS, Youth and Eco Clubs, *Mahila Mandals*, NGOs, etc.) as important partners in execution of proposed activities as planned in the DPR and also to replicate the reputed community led initiatives such as Seechewal's pioneer efforts in restoration of holy Kali Bein River in Punjab. Further, SFDs may like to involve the Agriculture Department, Pollution Control Board and Municipal Corporation/ Municipal Board for specific activities related to agriculture landscape and urban landscape, respectively.

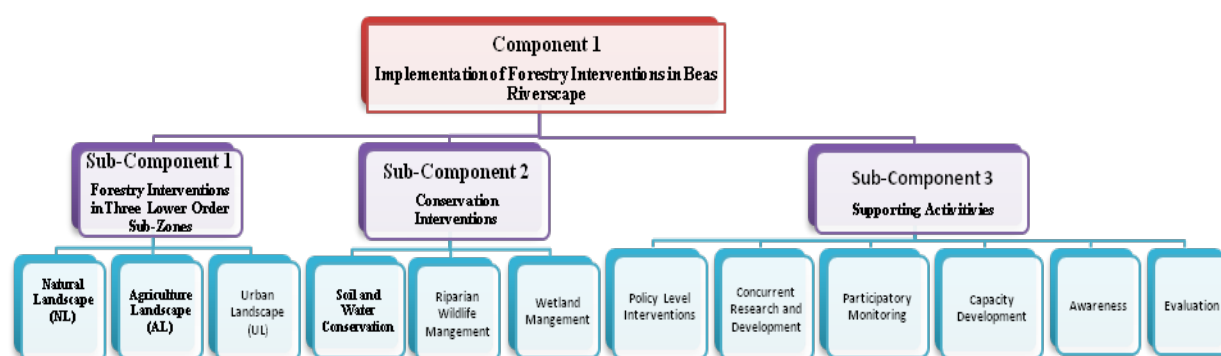


Fig. 6. 2 – Project Component on Forestry Interventions and Proposed Activities

Component 2: Strengthening Knowledge Management and Capacity Development for Forestry Interventions and Conservation of Riverscape

The preceding Chapters have highlighted the significance of rivers for human well-being, environmental stability and prosperity in the region/ country as well as elaborated on the complex and dynamic nature of rivers. The appropriate reviews also described strong linkages between forests and rivers, and four types of connectivity in the context of a river, and at the same time provided much desired clue that how enhanced biotic activities in a river basin have degraded the river ecosystem. Owing to degradation of the river environment and deterioration of water quality in the most rivers of the world, these natural renewable freshwater ecosystems now not only offer much reduced ecosystem services but are also a

major concern for poor health of human as well as his livestock. Such poor situation of river health is quite pertinent in human dominated country like India where all major rivers are facing enormous challenges for their sustainable management. As streams and rivers are among the most endangered ecosystems, there is a priority need for comprehensive approaches to evaluate the historic and current state of rivers and their environment, appreciate causative factors responsible for their present state and concerted efforts to restore them. There is an evident paradigm shift in management approaches of river ecosystems and it is fast changing. This has rapidly moved from the 'river development' to 'river conservation' and now to 'river restoration'. Obviously, India lacks desired experience in restoration of rivers as relatively it is a new discipline for the country. However, efforts are on in this direction. Positive outcomes from any such effort aiming towards river restoration or river conservation are unlikely unless evidence and science based holistic strategies are actively involved in planning, assessment, management and development of rivers and policies relevant to river conservation and restoration. Moreover, in the emerging scenario of transparency in public policy, and essential requirements of comprehensive environmental impact assessment, and integrated planning for conservation of water resources, there are several expectations from multidisciplinary sciences. The expected best available science in efforts towards river restoration should be based on six broad criteria: (a) relevance, (b) inclusiveness, (c) objectivity, (d) transparency and openness, (e) timeliness, and (f) peer review. In view of the above stated facts, the component two of the Project aims to incorporate science into policy, planning and management for informed decision making that can facilitate positive outcomes of concerted efforts towards sustainable management of rivers and river restoration in particular in India.

The HFRI, Shimla has taken a lead in the preparation of present DPR adopting a multistep approach involving active participation of stakeholders, exhaustive consultations, and following a scientific planning process using RS and GIS based geospatial analysis for the riverscape, multidisciplinary review on the riverscape environment, and extensive field level data collection by the concerned SFDs in the data formats prescribed by the institute. The HFRI is a reputed and established learning seat in the fields of natural resource management and forestry, Research and Education, particularly relevant to the Himalayan environment; those have direct relevance to the river ecosystems. Thus, it is of utmost importance that HFRI is not only involved as a National Level Partner Organization for facilitating monitoring, evaluation, and capacity development as proposed in the present DPR but also be entrusted the responsibility of major task to serve as the Knowledge Management/Learning Center and to undertake concurrent research related activities essential for conservation and restoration of the Himalayan Rivers. The HFRI will also play a pivotal role in building desired national capacity for demonstrating the strong linkages between diverse forests in the Himalaya and river ecosystems. The Component 2 specifically seeks to support the dissemination of improved knowledge by strengthening the Knowledge Management Center and capacity development required for conservation of Himalayan Riverscapes within the country by offering best practices for forestry interventions and varied conservation measures as envisaged in the DPR. In addition, the Knowledge Management Center (HFRI) is expected to contribute towards envisaged intervention and activities relevant to policy, advocacy,

outreach, monitoring, evaluation, and capacity development. In order to accomplish this, the national level partner organisation meant for the knowledge management and capacity development would need to establish a Project Facilitation Unit (PFU) for effective coordination with participating States and the Central Nodal Ministry supporting the implementation of the programme.

The knowledge management would require a range of strategies and practices so as to identify, create, represent, distribute, and enable adoption of insights and experiences. Such insight and experiences comprise knowledge, either embodied in individuals or embedded in organisational processes or practices. An organisation seeking to become a Knowledge Management Center would primarily require: People, Processes, Innovations and Technologies (Fig. 6.3). People are the key to the success of a Knowledge Management Programme in an organisation. The collective multidisciplinary knowledge in the organisation would play an important role in dealing with the complexities of Himalayan Rivers. It is essential that a culture of active experimentation through involvement of all concerned is encouraged, and trust and relationships among the members is build. The ‘institution building’ is complex and continuum process. It has to be holistic – have to go beyond organisation management and development, and involves the process of developing people, and streamlining various systems, improving style of functioning, developing a positive climate, and promote organisational culture of professional and non-hierarchical relationships. Innovations and technologies are enabler in a knowledge management programme. Remote Sensing and GIS tools, information technology (mobile apps, and web portals), automatic meteorological and hydrological equipment for measurement of river flow and rate of sedimentation, and applications of Unmanned Aerial Vehicles (UAVs), camera traps, satellite telemetry, etc. are some of the emerging technologies. These can be used for various proposes *viz.*, planning, management and monitoring. The internet and World Wide Web would not only connect people, but also connect them to various databases being maintained across the globe.

Component 3: Scaling Up, Replication in Additional Sites and Maintenance Phase

The present DPR focuses on the programme implementation on the select tributaries, particularly once the river descends in the plains. The Component 3 plans to support the scaling up and replication of planned efforts in additional sites / tributaries besides primarily, supporting the maintenance phase of various types of plantations raised in later years (3rd, 4th and 5th years) of the Phase I i.e., Implementation Phase.

Component 4: National Coordination for Forestry Interventions and Riverscape Conservations

In general, major Indian River systems involve two or more States as the basin of the river and its tributaries are spread over multiple States. Thus, programmes related to river management and restoration requires national level coordination for proposed forestry interventions and various conservation efforts among the participating States or located along the course of main channel and its tributaries. As such, the MoJS is the Central Nodal

Ministry for all aspects of management of water resources including river development and restoration of rivers. However, several other ministries are also involved for specific components/ needs. Thus, the Component 4 envisaged national level coordination for forestry interventions and river restoration and visualizes varied activities *viz.*, (a) establishment of the River Decision Support and Management Information System (RDS & MIS); (b) facilitating activities relevant to policy and legal interventions, riverscape level coordination, monitoring and impact evaluation; and (c) administering the implementation of major project on forestry interventions. In order to accomplish this, the Component 4 specifically envisages the establishment of a Project Management Unit (PMU) at the Nodal Ministry Level. The PMU at the Nodal Ministry would handle the programme implementation, coordination among participatory States, partner organisations at the national and State level besides extending support for the finances required for the project execution.

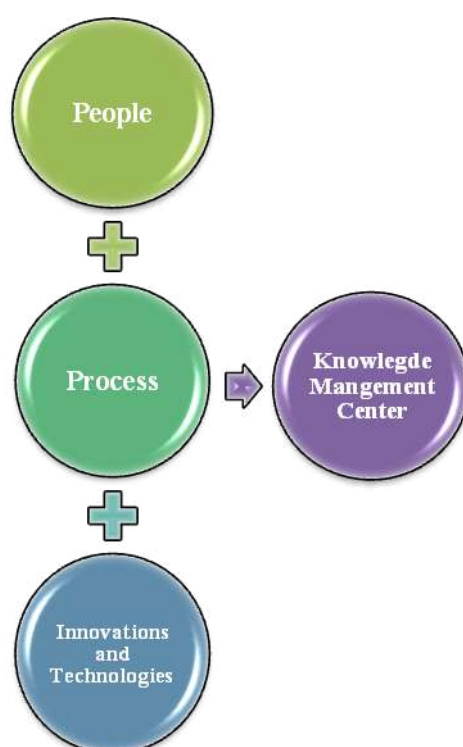


Fig. 6. 3 – Three Essential Elements for the Knowledge Management Center

6.2 Institutional and Implementation Arrangements

Basically, the project is proposed to be implemented at multiple hierarchical levels *viz.*, the National, State, Division and Local levels. Accordingly, institutional arrangements at these levels are envisaged for the effective and successful implementation of a major project of this kind. At the apex level, the identified Central Nodal Ministry will provide the overall policy guidance and the supervision of the project at the National or the Riverscape level. The PMU established at the central nodal ministry will not only ensure timely release of funds but would also be responsible for overseeing and coordinating the efforts at the national or riverscape level. The concerned SFDs of involved States within the riverscape will be the

primary Implementing Agencies (IAs) at the State, Division, and local levels. However, SFDs would be able to involve other partners (i.e., the Agriculture/ Urban Development Departments, Eco Task Force, NYKs, NSS, select NGOs, etc.) for programme implementation in different landscapes. Each SFD at the State level will establish the PMU for effective implementation of the project across the State/Divisions/Ranges and even at the *Panchayat*/Community levels. In addition, the National Level Partner Organization (HFRI, Shimla) responsible for facilitation, concurrent research, monitoring, evaluation, and capacity development would also be functioning and will have the support of Project Facilitation Unit (PFU). Details of institutional arrangements at different hierarchical levels are provided below:

6.2.1 Project Management Unit (PMU) at the Central Nodal Ministry

In all likelihood, the MoEFCC is expected to be the Central Nodal Ministry for implementation of project. However, if the GoI decides otherwise, one of the other related ministries (e.g., MoJS, MoRD) may also join and collaborate with the Central Nodal Ministry for the purpose and provide/arrange required financial resources. Once the GoI decides about the Central Nodal Ministry and entrusts the task to implement the project planned in the present DPR, then designated Central Nodal Ministry would require to establish the PMU, specifically for performing various functions relevant to project overseeing, advice, steering, coordination, programme approval, policy level interventions, Budget allocations, fund flow, monitoring, and evaluation.

The PMU at the central nodal ministry will be headed by an Addl. Secretary/Joint Secretary level officer who will be designated as the Project Director (PD). The PD will be supported by a small project management team of existing and project staff on contract to support various activities related to coordination, technical supervision, communication, project administration, procurement, financial control and management, report preparation, monitoring, and evaluation. The PD will be assisted by a Joint Secretary/Director level officer designated as the Project Coordinator (PC). The PC will be supported by two Senior Project Scientists (one each for Policy Intervention/Riverscape Conservation/Communication), two Junior Project Scientists (one each for Forestry/Riverscape Conservation/Monitoring and Evaluation), one Project Managers (one each for RDS & MIS/Administration/Procurement/Finance and Audit), two Project Assistants, three Office Assistants, and three Mutli-Tasking Staff (MTS) (Fig. 6.4). The PMU will carry out the following tasks relevant to the financial control and management:

- Annual Budgetary provision for the project and monitoring of project expenditure against allocated Budget.
- Approval of Annual Plan of Operations (APOs)/Work Plan and Budgets.
- Coordination and ensuring sufficient and timely fund flow to concerned State IAs and national partner organisation for activities at the riverscape level and for national capacity development activities, respectively.
- Regular financial reporting of the project at all levels and compilation of quarterly financial reports and annual financial statements of the project

- Ensuring internal audits and annual external audit of the project by the CAG

In order to make the PMU fully functional, necessary Budget provisions for its establishment, office equipment beside recurring costs on salary and wages, office expenses, travel, workshops/seminars, meetings, publications, dissemination, and miscellaneous expenditures and contingency have been made. Further, adequate Budget provisions for capacity development, planning and conduct of national level seminars/workshops, and coordination, review meetings, etc. have also been made so as to make the working of PMU effective in its mandate.

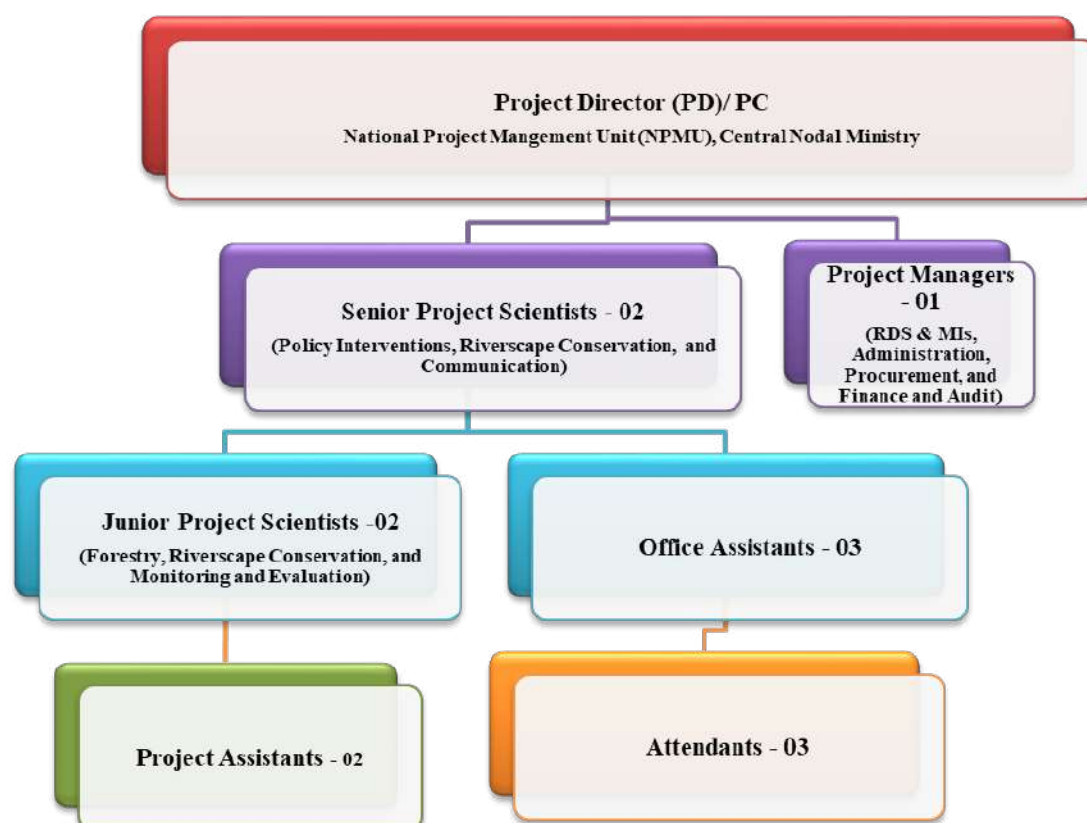


Fig. 6. 4– Proposed Organisation Structure of the Project Management Unit at the Central Nodal Ministry

6.2.2 Project Facilitation Unit at the National Level Partner Organization (HFRI, Shimla) for Knowledge Management and Enhancement of National Capacity for Forestry Interventions and Riverscape Conservation

The HFRI, Shimla, as one of the regional institutes of ICFRE owing to its expertise in the ecology of the Himalayan environment, natural resource management, and the Himalayan forestry besides its strategic location, multidisciplinary team, having long experience in dealing with cumulative environmental impact assessments of Himalayan Rivers, and well-laid infrastructure, has been proposed to undertake the major responsibility as the National Level Partner Organization for effective implementation of this priority project on river restoration (i.e., forestry and conservation interventions aiming for *Aviral Dhara* and *nirmal dhara*, ecological integrity and restoration of river health), liaisoning with Central Nodal

Ministry and Implementing Agencies at the State level, concurrent research and development, science and technology based back-stopping, capacity development, monitoring, and evaluation. For this purpose, the HFRI would need to establish a Project Facilitation Unit (PFU), headed by the Nodal Officer (NO) of the project at a senior level (Scientist – G or CCF level officer). He/ she will be supported by River Coordinator (RC). The NO and RC will be assisted in their functions by one Senior Project Scientist, two Junior Project Scientists (one each for Forest Biodiversity/ Bioremediation and Biofiltration/Aquatic Ecology/Remote Sensing and GIS/Agroforestry/SMC and Bioengineering), two Project Associate (one each for Forestry Research/Communication and Conservation Education/Ecosystem Monitoring/Forestry Training), one Project Managers (one each for IT and National River Database/Administration/ Procurement/Finance and Audit), two Project Assistants, two Office Assistants, and two MTS (Fig. 6.5). In order to make the PFU effective and fully functional, provisions for its establishment, engagement of contractual technical and office staff, recurrent expenses towards salary and wages, travel, procurement of office/computer, IT, and RS and GIS/laboratory/field equipment, research and monitoring, capacity development, development of learning material and dissemination, advocacy and outreach, and evaluation. In addition, Budget provisions for institutional charge and contingent expenses have also been made. Further, adequate Budgetary provisions for organisation and conduct of activities related to seminar/workshops/meetings, exposure visits to demonstration sites, scientific exchange and overseas visits, engagement of national and international experts on specific themes, impact evaluation, etc. have also been incorporated in the proposed Budget of the project so as to make the PFU, Knowledge Management Center at the national partner organisation fully functional and effective for the envisaged purpose.

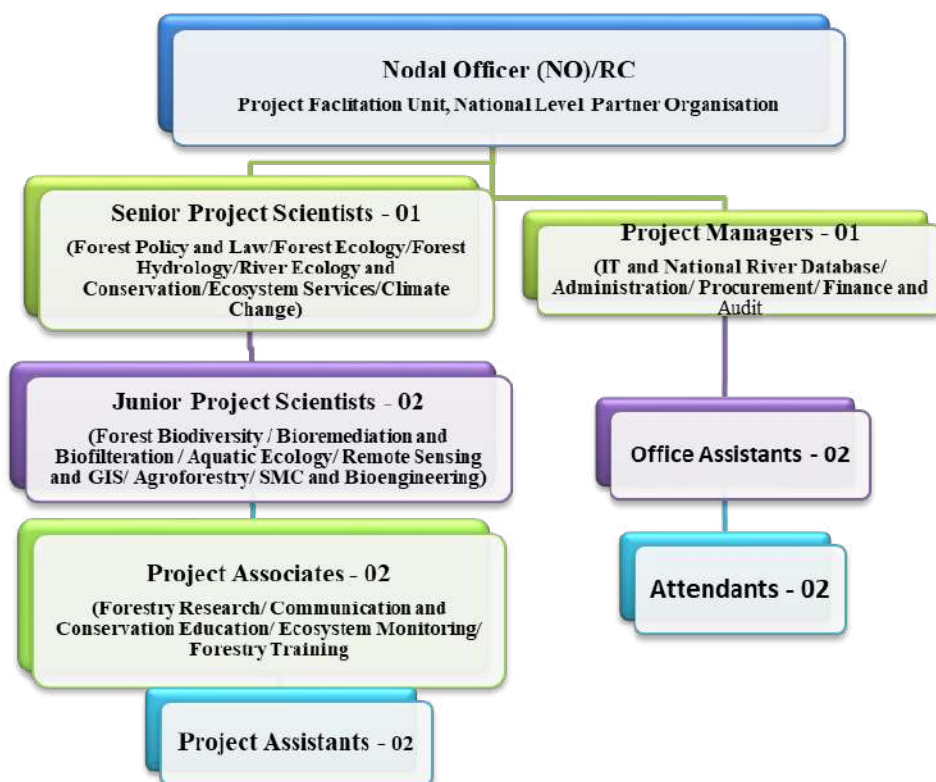


Fig. 6. 5– The Proposed Organisational Structure of the Project Facilitation Unit (PFU) at the National Level Partner Organisation on Knowledge Management and Capacity Development

6.2.3 Project Management Unit(s) at SFDs in Concerned States

The SFDs in concerned States along the course of river would be the primary IAs for proposed forestry interventions in the riverscape and they are expected to carry out extensive activities i.e., plantations, conservation interventions, and supporting activities at three hierarchical levels *viz.*, State, Division, and Local Communities. Thus, a provision of Project Management Unit (PMU) at each SFD has been made so as to facilitate, coordinate, and manage envisaged project activities through 20 Territorial Forest Divisions and 5 Wildlife Divisions within the State. The PMU in each of the participating State will be headed by the Addl. PCCF/CCF level officer and designated as the Project Executive Director (PED) while the CF level officer designated as Project Executive Officer (PEO) would assist the PED. The DFOs/DCFs of 20 Divisions will be responsible for actual implementation of proposed forestry interventions and other allied activities envisaged in the DPR. The existing Forest Development Agencies (FDAs) operating at Divisions/District level or any other appropriate suitable State specific mechanism could be utilized for implementation of the project at the field level while Joint Forest Management Committees (JFMCs)/Ecodevelopment Committees (ECs)/Biodiversity Management Committees (BMCs)/Gram Panchayats or other relevant bodies need to be involved in field level execution at the local/community level. Each State specific PMU will avail the existing government officers/staff besides select contractual employees for the project tenure. The contractual staff will include one Project Managers, one Senior Project Associates (Forestry/River Conservation), two Junior Project

Associates (Forestry/River Conservation/Capacity Development/Awareness and Outreach), two Project Assistants (Forest Management/RS and GIS/IT, Communication and Database), three Office Assistants and fifteen Data Operator would be engaged for the project duration (Fig. 6.6).

In case of Punjab State Forest Department the contractual staff will include two Project Managers, one Senior Project Associates (Forestry/River Conservation), one Junior Project Associates (Forestry/River Conservation/Capacity Development/Awareness and Outreach), two Project Assistants (Forest Management/RS and GIS/IT, Communication and Database), two Office Assistants and six Data Operator would be engaged for the project duration (Fig. 6.7).



Fig. 6. 6- Proposed Organisational Structure of Project Management Unit at the State Forest Department of

Himachal Pradesh

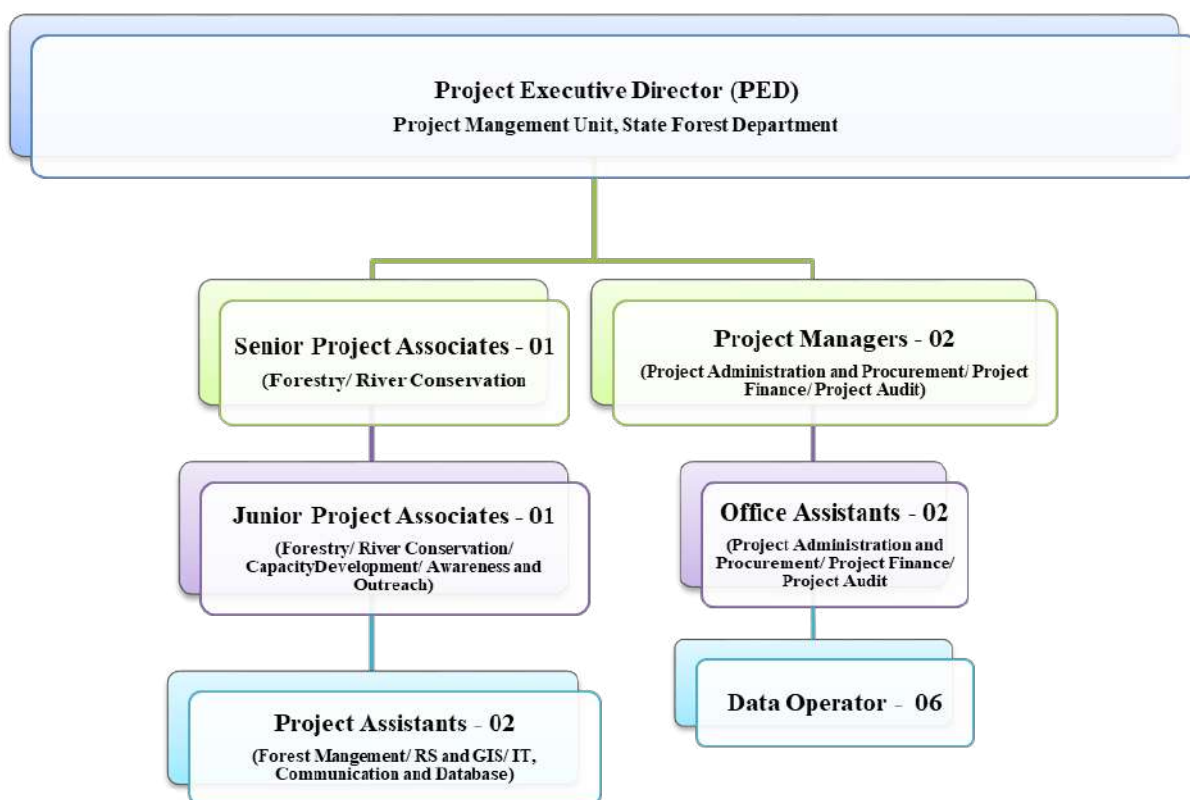


Fig. 6. 7- Proposed Organisational Structure of Project Management Unit at the State Forest Department of Punjab

6.3 Implementation and Fund Flow Mechanism

Considering the conservation significance of the river, multifaceted nature of the project design, diverse proposed activities, multiple agencies involved, and in order to ensure effective execution of the programme across the vast extent of riverscape, an efficient implementation mechanism is desirable. Thus, the project envisages constitution of two high level Project Steering Committees i.e., one at the National Level in the Central Nodal Ministry and referred as the ‘National Programme Steering Committee (NPSC)’, while other at the State level in concerned SFDs of the involved States within the riverscape to be named as the ‘State Programme Steering Committee (SPSC)’.

(i) National Level Programme Steering Committee (NPSC): The NPSC will be chaired by the Secretary of the concerned Central Nodal Ministry and the Member Secretary would be the NPD. The NPSC is expected to have multiple members represented by senior officials of the MoEF&CC; Ministries of Jal Shakti, Agriculture, AYUSH, Youth Affairs and Sports, Tribal Development, Rural Development, Urban Development, Panchayati Raj, and Tourism; PCCFs and HoFFs of concerned States or their representatives; Director/Nodal Officer of the National Partner Organisation (HFRI); and one representative each from ITBP and Eco Task Force. Thus, the NPSC is expected to have about 20 members or so. The NPSC shall meet at least twice in a year at appropriate time for considering and approving the APOs submitted by the concerned SFDs. The funds against the approved APOs of the States shall be

transferred by the NPMU to respective SFDs. The national level PFU will follow its own mechanism of governance and if required will have its Monitoring and Steering Committee for overseeing the project. Details on proposed institutional arrangements, implementation mechanism at the State and field levels, and constitution of SPSC in concerned States are presented in Fig. 6.8.

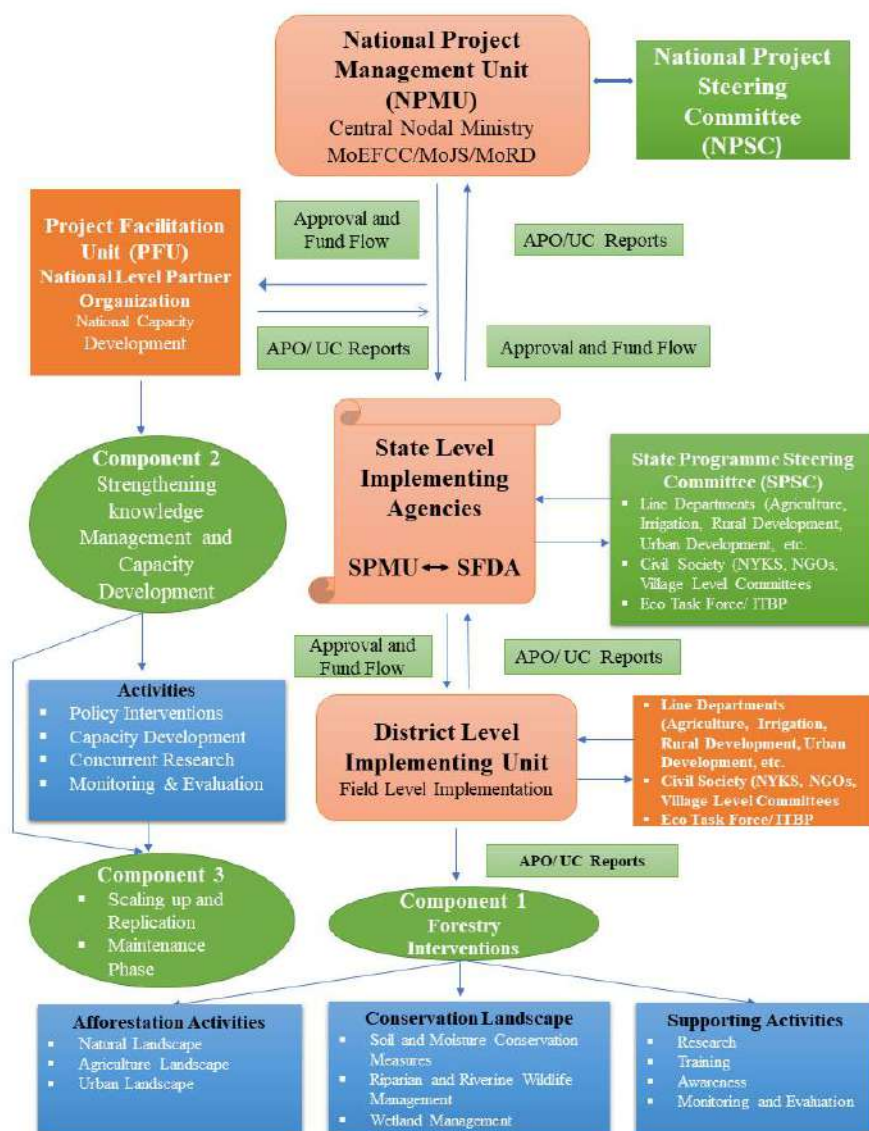


Fig. 6. 8– Proposed Hierarchical Institutional Arrangement and Mechanism for Project Implementation

(ii) State Level Programme Steering Committee (SPSC): On the lines of national level NPSC, each concerned SFD will also have the State level SPSC. The existing framework of the State Forest Development Agency (SFDA) at the State level or any other similar/equivalent agency will be used for transferring and parking of funds at the State level and to be released on the approval of the SPSCs. On approval by the SPSC, the matching funds will be transferred to SPMU, an exclusive State level PMU for further allocation to concerned Divisions as per the respective APOs, dully approved by the SPSC. At the

Circle/District Level, a Circle Project Implementation Committee (CPIC) will be constituted under the Chairpersonship of the Conservator of Forests (CF) with concerned DFO as the Member Secretary so as to ensure a transparent and accountable mechanism for implementation of activities as proposed in present DPR. Various work related to proposed forestry interventions in the riverscape could be implemented in close association and involvement of the Village *Panchayat*/ JFMC level setup. SPMU is proposed to perform in each of the implementing States. The SPMUs shall be responsible for all the directions, operations, and control of forestry interventions at the State level through SPSC. The SPSC shall be chaired the Principle Secretary Forest/PCCF and HoFF while at the State level Project Executive Director (PED) shall be the Member Secretary. The SPSC shall have equal level representative of various Line Agencies/ Departments, Civil Society, NGOs, Eco Task Force, ITBP, etc. The SPSC shall meet atleast twice a year at appropriate times for approving the APOs submitted by Divisions and steering the project implementation activities across the State.

(iii) Implementation at District/ Division Level: A Civil Society Organisation at the Division/District Level shall be involved for programme execution at the field level. The District Level Implementing Committee (DIC) shall be constituted for programme execution while having the CF as the Chairperson and the concerned DCF/ DFO as the Member Secretary along with the representation of District level Line Agencies/ Departments as well as the Civil Society. The concerned DFO as the Member Secretary who is also the Chief Executive Officer of this FDA wherever in existence and functional shall submit APOs for forestry interventions as envisaged in the project in consultations with the representatives of Line Departments, NGOs, Eco Task Force, and other Civil Societies who shall be invited by DFO and involve every time in the consultation process. The SPMU will scrutinise the APOs received from concerned DFOs and ensure timely approval by the SPSC, with or without necessary changes, for further submission to the NPSC at the Central Nodal Ministry. Upon approval of the APO by the NPSC, the funds shall be transferred against the APO to an account separately maintained by the respective SFDs for implementation of the project envisaged in the present DPR. Likewise, separate accounts shall be opened by each of the DFOs at the Division Level so as to exclusively operate planned forestry interventions as proposed/ envisaged in the DPR. DFOs will ensure that there is no mixing up of expenses/ accounts of any other nature with the account specifically opened for the purpose of present project. The SPSC shall authorise SFDA to transfer funds against approved APOs to accounts opened by Divisions specifically for the purpose. Financial expenses, creation and management of assets, incurring overhead expenditures, etc. shall be as per the provisions of GFR-2005 and/ or any rules/ guidelines framed by the Central and State Governments in this regard from time to time. The SFD or any other Implementing Partner Department/Agency as well as the Civil Societies shall be responsible for achieving the objectives, targets while maintaining proper documents and accounts, besides accountability and transparency. The Himalayan State will ensure active involvement of the Eco Task Force/ITBP in plantation and other related soil and water conservation measures, control of forest fires and protection of RET faunal species in the terrestrial as well as the riverine environments and other relevant

project activities. It is proposed that at least 10% plantation activities in the Himalayan State will be entrusted to the Eco Task Force and/ or ITBP. The PMUs of concerned SFDs will allocate funds to these agencies for actual implementation of areas under their command or arrange to allocate new areas. Further, setup under the Ministry of AYUSH will be involved for works related to afforestation/plantation, conservation and sustainable harvest of Medicinal and Aromatic Plants (MAPs). The State/District and Field Level formations under the NYKS of the Ministry of Youth Affairs and Sports, such as Youth Clubs/ Eco-Clubs/*Mahila Mandals* and other leading CSOs (e.g., Seechewal initiative, etc.) will also be actively involved not only in plantation works but also in awareness campaign and other activities relevant to this project. The concerned SFD/SPMU will work out the detailed mechanism as per the specific requirements and prevailing conditions and duly signed MoUs on record. Nearly, 30% to 40% Budget on awareness provisioned in the project for each of the State will be utilised through above stated State level and local level organisations/ formations. The SPMUs will invite proposal and APOs from AYUSH, NYKS, ITBP, Eco Task Force, and other CSOs for consideration by the concerned SPSC. On approval and signing of MoU, timely funds will be released to the concerned agency for the specific/set of activities.

Execution at Field Level: Once the APO submitted by the Division approved and works allotted, the respective work shall be executed with active involvement of JFMCs and/or other CSOs in the area. In case, the works are entrusted to JFMCs/CSOs for execution, the cashbook and account so maintained by them in turn shall be submitted to the concerned DFO who will ensure that the works have been done in accordance with the physical and financial parameters prescribed. The accounts as well as the bank account for the purpose of execution of the work project as per the present DPR shall be maintained separately. The Measurement Books (MBs) for such activities recorded through JFMCs or CSOs of the SFDs shall be maintained by the concerned officials of the SFDs while the JFMCs shall submit Utilization Certificate (UC) duly verified by RFOs and Completion Certificates (CCs) to the concerned DFO.

For the works to be executed by the other Line Departments, Eco Task Force, ITBP, NGOs, and other Community Based Organisations (CBOs), the DFOs shall convey the approved APOs to concerned officials of the respective Department/Agency, and also release corresponding funds to them. The responsibility of execution shall completely rest with the Line Department/Agency and they shall be maintaining MBs at their own level and submit account for the same to the DFO. These works shall be inspected jointly by the concerned field staff of SFDs with the executing Department/Agency and inspection report submitted to DFO. DFO who is the Member Secretary of District Level Implementing Agency (DIC) specifically constituted for implementation of the present project shall make electronic fund transfer to the executing agency to facilitate timely implementation of envisaged works. SFDs will maintain records for individual site with all the activities logged in immediately as and when carried out along with the expenditure incurred on the standard forms being used by respective SFD. The UCs and CCs compiled at State Level PMU shall be submitted to the NPMU at the Central Nodal Ministry for monitoring.

The SFD will form new JFMCs for programme implementation, if required and deemed fit. Concerned SPSCs, SPMUs and DFOs will ensure adequate involvement and participation of other recognized CSOs like, NYKS, NSS, NCC, NGOs, *Mahila Mandals*, Self Help Groups, (SSFs), etc. In areas where none of these CSOs exists or are not feasible for any justifiable reason, the DFO may opt for executing the works departmentally with the help of any other active Civil Society in the area.

The expenditure incurred is auditable as per the Government of India Rules/ Procedures and/ or as per the specifications provided by the Central Nodal Ministry or even the prominent financial agency supporting the project

(iv) Budget: The SFDs are mandatorily required to organize and undertake in-house/internal monitoring and necessary Budget provisions have been made in this regard. Twenty five per cent of the actual works carried out will have to be essentially monitored. The mechanism of such monitoring shall be finalized by the concerned SPSC which will also lay down the procedure for submission of UCs to the Central Nodal Ministry along with the approved APO for various works during the next year. Based on APO as well as UC for the amount released during the previous year, the Central Nodal Ministry/NPMU shall release the funds after obtaining the approval of the NPSC.

6.4 Risk Assessment

The introductory Chapter has attempted to highlight the strong linkages between forests and rivers and also intricate nature of both, forest ecosystem as well as river ecosystem. Likewise, two associated disciplines *viz.*, forestry and river conservation are likely to be influenced by a wide range of driving variables (i.e., solar radiation, precipitation, temperature, humidity, wind, etc.), biotic (human disturbances – deforestation, fragmentation and habitat loss, livestock grazing, forest fires, invasive and alien species, pests, agriculture expansion, developmental activities, etc.) and abiotic factors (e.g., soil erosion, landslides, etc.). While some of these factors (biotic and abiotic) can be managed to an extent, others (driving variables) are beyond the scope of human interventions. Hence, a degree of risks is involved in the implementation of planned activities of forestry interventions with the aim to restore the river from the perspective of water flow, water quality, ecological integrity, and sustainability of ecosystem services. Potential risks broadly grouped into biotic and abiotic categories based on the likely causes are summarized below:

Table 6. 1– Potential Risk Factors Relevant to Forestry Interventions and River Conservation

Sr. No.	Risk Factors	Risk Reduction Measures
A.	Biotic Risks	
1.	Illicit cutting of plantations - Plantations in remote areas as well as high human population areas are prone to illegal cutting of plantations or any other type of damage by human activities.	Effective fencing and protection measures (watch and ward and social fencing) so as to prevent any illegal activities and damage to plantations

Sr. No.	Risk Factors	Risk Reduction Measures
2.	Grazing of plantations by domestic livestock and wild herbivores – livestock grazing, particularly by migratory sheep and goat in harsh climatic conditions and upper reaches can adversely impact plantation efforts at any stage.	Proper fencing of plantation areas, watch and ward, social fencing, and awareness.
3.	Human induced forest fires – recurrent manmade annual forest fires are widespread and they can damage young plantations.	Adoption of comprehensive strategy towards prevention of forest fires. This would include awareness campaign, creation and maintenance of fire lines, watch and ward and efforts to control the fire in case it outbreaks.
4.	Pest and disease attacks	Little scope of management as use of chemical pesticides is discouraged due to toxic effect on water sources.
5.	Reduced e-flow and declining aquatic biota.	Ensure minimum e-flow and four dimensions of river connectivity; maintenance of riparian forests/buffer.
6.	Reduced water quality in streams, rivers and other wetlands owing to enhanced pollution.	Adoption of comprehensive strategy to deal with issues of water pollution including awareness, treatment of sewage prior to its flow to river/wetlands, bioremediation and bio-filters, etc.
B.	Abiotic Risks	
1.	Scarce and erratic rainfall –delayed rainfall, long dry spells and excessive rains can adversely impact planting activities	Timing of planting activities in consonance with rainfall is important for survival. Success of plantation depends on timely and optimum rainfall. Hence, prepare exigency plan – select hardy species those can withstand erratic rainfall pattern, ensure alternate methods for watering in the event of dry spells, select plant species those can also withstand impact of excessive rains/flooding.
2.	Climatic factors – Temperature: High temperature may lead to drying up of seedlings and root stock. Irrigation can be done in very few select areas especially in the riverfront development component, river parks and eco parks and agroforestry models; Low temperatures and frost in the alluvial plains are likely to cause mortality among plantations due to frost injury and desiccation.	The risk factor can be minimized by adopting planned adaptation in forest management practices. At the community level, planned adaptation may include diversification of forest based and non-forest based income sources, better local governance of forest resources and capacity development for monitoring. Industrial forest sector may involve the inclusion of bioenergy. At the stands level, planned adaptation may mean planting a larger diversity of species or provenances, or trees bread for resistance to accepted stresses. At the landscape level, planed adaptation may include measures to minimize the potential impact of fire, pests and diseases, increased afforestation and reforestation, and creation of biodiversity corridors. Science is essential to support planned

Sr. No.	Risk Factors	Risk Reduction Measures
		adaptation. The development of planting stock with desirable genetic traits may be a promising avenue to counter changes in the local climate. Intensive forest monitoring is key component of planned adaptation. The impetus for change in the forest sector and society primarily comes from socio-economic situation, not ecological crisis. Planned adaptation needs to link to local adaptation policies focussing on the importance of the social and behavioural sciences in the forest management. Awareness of actual and potential impacts from climate change is crucial.
3.	Edaphic factors – soil erosion and landslides: the Himalayan mountainous tract is prone to soil erosion and landslide due to fragility, steep slopes and enhanced human disturbances.	Adopt appropriate soil and water conservation measures (bioengineering and mechanical); species selection and use of quality nursery material is important to reduce the risk factor.

Any one or a combination of above stated potential risk factors can influence establishment, survival and desired growth of various proposed plantations as well as impact different conservation activities envisaged in the DPR. Hence, concerned SFDs, DFOs and other involved implementing agencies shall consider the following possible mechanisms to reduce above risks:

- The quality of planting stock, particularly age and size is an important aspect. In order to reduce above stated risks, IAs must ensure to use the quality planting stock. Tall nursery plants have proven to minimize several risk factors to a great extent.
- Time is essence for successful operation of plantation activities. Thus, timely establishment of nursery and supply of high quality planting materials well before the planting season are essential to minimize risk factors. Damage to planting materials in transit also needs to be prevented.
- Timely completion of planned advance works (fencing, cleaning of site, pit digging, etc.) and execution of actual plantation activities supplemented by use of bio-fertilizers, organic manure and composted, mulching, etc. can reduce risk levels drastically.
- Establishment of required fencing and protection of plantations from livestock and wild herbivores will ensure from the risk of grazing and browsing. Thus, awareness, sensitization, and involvement of local communities are essential so as to reduce the above stated biotic risks.

In spite of all possible attempts have been made to minimize the risk involved, much of the progress, growth and success of the plantations are left to nature. Vagaries of nature in the form of climatic and edaphic extremities pose the greatest threat to proposed forestry interventions.

6.5 Mid-Course Learning and Adaptation

Proposed forestry interventions for restoration of a river by way of enhanced e-flow and water quality are definitely an innovative and integrated approach. The preceding section has

highlighted the potential risks and vulnerability. Erratic climatic conditions and unpredictable external forces of nature tend to impact the field level activities as envisaged in the DPR. In view of the local conditions, activities and treatment models proposed in the DPR might need certain modifications to make them adaptable to micro-level conditions. The periodic monitoring, particularly the midterm review would allow the midcourse corrections and adaptation of new ideas and design. Such adaptive modifications in the design, criteria, specifications, timing of a particular activity, selection of sites and species, if any will have to be specifically mentioned in the APOs and executed by the DFOs/ Partner Organizations only after obtaining approval from the SPMU. If need be, special approval may be accorded by the State Level Project Executive Director in order to ensure timely execution keeping in view the seasonal nature of envisaged works.

6.6 Monitoring and Evaluation of Outcomes/ Results

The preceding Chapter has described details on various aspects of participatory monitoring as well as evaluation. Broadly, two types of monitoring have been envisaged during the project execution phase: (a) monitoring of project performance in terms of project goals/ objectives, activities, targets, outputs, outcomes and impact; and (b) ecological and socio economic monitoring in terrestrial as well as aquatic ecosystems. The set of measurable indicators elucidated will be monitored on a given timeline (Table 6.2).

Table 6. 2– Measurable Indicators for Monitoring and Review Mechanism

Sr. No.	Ecological Indicators	Socio-Economic Indicators
1	Area covered under plantations in different landscapes	Extent of employment generation
2	Stock quality of planting materials	Per capita income of the impacted population
3	Survival rates of plants	Forest based livelihood generation activities
4	Growth performance of plants viz., height and girth	Dependency of local population on forest resources
5	Biomass and productivity	Biotic pressure on forests/ grasslands/ wetlands and protected areas
6	Forest cover and tree cover	Availability of fodder to the affected population
7	Area under invasive and alien species	Availability of medicinal plants
8	Extent of soil and moisture conservation works	Number of awareness campaigns, development of publicity material (i.e., pamphlets, brochures, etc.)
9	Silt load/ rate of sedimentation in select locations in the implementation area	Access to safe drinking water
10	Water quality in the select locations	Health of people, enhanced crop productivity, improved well-being, and improved livelihood
11	Population estimates of select RET faunal species	Increased population and abundance of RET species

Plantation activities make the core activity of the proposed forestry interventions by adopting varied plantation/ treatment models in natural, agriculture, and urban landscapes within the riverscape and concerned states. Accordingly, a bulk amount of the total Budget outlay has been provisioned for this important activity. Considering the significance of plantation

activities for the overall success of the project, in house monitoring has been envisaged and to be carried out by the IAs i.e., the concerned SFDs. Thus, 25% of the actual works carried out will have to be mandatorily monitored. The DPR has made adequate provisions for the required Budget for monitoring of plantations as well as other interventions has envisaged in the project. Further, in order to ensure optimal success of the plantations, necessary Budgetary provisions have also been made for replacement of failed plants in the establishment year and gap filling (15% cost for first year, and 10% cost for second year) in subsequent years of maintenance. This is reflected in Table 5.29 and Table 5.31 under Chapter 5 of DPR. The DPR also envisions actual field level, and annual monitoring at three hierarchical levels of SFDs/ IAs by way of monitoring of 40-50% plantation sites by the concerned ACFs, 20-25% sites by DFOs, and 10-12% CFs. The SPMU in consultation with the SPSC shall finalize the mechanism for proposed 25% in house monitoring. The SPSC will also lay down the procedure for submission of UCs to the NPMU based at the Central Nodal Ministry along with the approved APO for the proposed works in the next year and the Budget estimates. The NPMU would release the funds for the next year after the NPSC has considered the UCs and APO and approved release of funds.

SFDs have provided preliminary information proposed sites for plantations in field data formats submitted to HFRI, Shimla along with GPS locations for the preparation of present DPR. Site details have been incorporated in GIS/ Google Earth maps. As per the old and well established traditional practice of documentation, SFDs are required to maintain 'Nursery Journal', 'Plantation Journals' and 'Journals for Other Interventions' meticulously. As per the existing system and laid procedures, these journals contain all requisite information on plantations, selected sites, geographical coordinates, site sketch and map, details of activities carried out and expenditure on plantations, weeding, tending, gap filling, and maintenance as well as the chronology of natural (i.e., flood, drought, etc.) and man-made (i.e., fire) events, if any impacting plantations adversely. As already stated, the DPR envisage actual monitoring of plantations at three hierarchical levels and proper recording of site level observations in the Plantation Journals. As a first step, SFDs are required to place a sign board at the plantation site indicating the name of the scheme, area covered, and other details on planted species and their numbers. Necessary Budget provisions for this purpose have been made in the cost norms under the head of contingency of various proposed forestry interventions.

The Logical Framework Analysis earlier presented incorporates important aspects of project monitoring and provides an insight on monitoring of project performance at various hierarchical levels (national/state/local levels). The logical framework has also provided details of verifiable indicators and appropriate means. The envisaged project outcomes (i.e., biological, socio economic and institutional) will assess the impact of project interventions against the baseline developed during the Year-1 of implementation. The national level partner organization (HFRI) will facilitate project monitoring and evaluation of outcomes/ results through consultative process with leading scientific organizations and effective coordination with the Central Nodal Ministry, State level IAs and CSOs.

Outcome indicators include: (a) creation of an enabling environment for climate resilient, sustainable terrestrial, aquatic (river and wetlands), and floodplain ecosystem management;

(b) enhanced levels for multi-sector convergence, alliances, integration, favorable national and state level policies.

The National Level Partner Organization in collaboration with concerned SFDs would involve concerned experts and organizations to develop an integrated, long-term ecological and socio economic monitoring programme during the first year of project implementation and generate the base line information for evaluation of project impact in future. The ecological and socio economic monitoring programme, thus, developed will be executed periodically as per the plan developed for the purpose. Additional priority researches and theme based studies would be supported for each of the landscape category, river and its tributaries so as to supplement the participatory impact monitoring programme. Local communities, scientific organizations, experts and CSOs will be involved in monitoring programme envisaged for the project.

In addition to the above stated project as well as ecological and socio economic monitoring, HFRI (National Partner Organization) will undertake and facilitate supervision missions in consultation and coordination with the NPMU based at the Central Nodal Ministry so as to review the progress made in execution of the Project besides the well-structured and designed Mid Term Review (in third year) and the Terminal Evaluation (last quarter of fifth year of project implementation) by the Third Party/ External Experts selected by the PMU of the Nodal Ministry.

6.7 Sustainability, Replication and Cost Effectiveness

For a multifaceted project on forestry interventions for restoration of river, three aspects *viz.*, sustainability, replication and cost effectiveness are of immense significance. These aspects are elaborated below:

6.7.1 Sustainability

The geo-spatial analysis of the riverscape was an important step towards the preparation of present DPR and that provided a valuable insight on priority sites (high, moderate and low) for proposed forestry interventions and execution of other conservation interventions etc. Availing this insight, forestry interventions have been proposed mainly in high and moderately priority sites identified on the basis of geospatial analysis. Hence, majority targeted sites are of great significance for protection, conservation and restoration. Proposed interventions in such sites are likely to generate global biodiversity benefits (enhanced forest cover and tree cover and diversity of species, carbon sequestration, and improved ecosystem services) besides improved rural livelihoods. The project relies on the ecosystem based approach to river conservation and targets towards forest – river linkages, conservation and development interventions at the riverscape level so as to contribute in a meaningful way towards three important goals (*Aviral Dhara*, *Nirmal Dhara* and ecological integrity). Hence, project itself aims to achieve the ecological sustainability. The project also lays emphasis on social sustainability as the project approach focuses on community driven strategy for forestry interventions and ecosystem management while ensures active involvement of CBOs/CSOs, line departments and various agencies. Project seeks to achieve objectives of

empowerment of local communities, livelihood support and plans to distill disseminate best practices for optimal use at elsewhere. The project is of utmost importance for the concerned States and the country, as the river contributes significantly towards water availability, agricultural sustainability particularly in the plains, economic development, biodiversity conservation, and the overall prosperity in the region.

6.7.2 Replication

The present project is yet another pilot effort after the first project of similar nature in the context of river Ganga which is being presently implemented in five States. Hence, the country has very little experience in implementing a major project in the entire riverscape on river restoration while specifically focusing on the theme of forestry intervention. Thus, the success of this yet another pilot project will help in developing capacity for replication of such efforts within the country and elsewhere. The project has an integral component to enhance the national capacity on river conservation and restoration. The project fits into the national priorities and is expected to contribute towards the wider goals of sustainable development. Since, it is the beginning of implementation of project of this nature in a vast country like India having nine major river systems, experiences and learnings in execution shall have enormous scope for their replication.

6.7.3 Cost Effectiveness

The project adopts newer, holistic, and participatory approaches towards river conservation and restoration and aims to develop best practices. The project promotes to enhance ecological integrity of the complex and dynamic river ecosystem. The cost norms for various proposed interventions have been computed on the basis of acceptable cost on the establishment of plantations in natural, agriculture and urban landscapes and the reasonable maintenance costs in the subsequent years. The project has also considered the norms of success rates of plantation in different States as well as the country as a whole. The project is expected to contribute a wide array of tangible and intangible values besides helping in the restoration of an important river ecosystem for the country. In general, cost effective norms and scientific basis to planning, management and conservation have been adopted. Project will be highly cost effective since it is not only expected to meaningfully contribute towards river conservation and restoration but also would help in development of national capacity in such endeavors and enhanced ecosystem services. In addition, the Chapter 8 provides a greater insight on the potential on successful implementation of this project of immense national importance.

7.1 Project Budget

The projected financial outlay of the Phase 1 on Project Implementation of five-year duration is Rs. 732.71 Crore. The projected budget outlay of Phase II (Maintenance Phase) of five-year duration is Rs. 136.67 Crore and Total budget outlay is Rs. 869.38 Crore. As mentioned above, the project includes four broad based components. Accordingly, financial cost of each of these four components is summarized below:

7.2 Project Outlay: Component and Activity Wise

The Principal Component-A: Implementation of Forestry Interventions in Beas Riverscape

An amount of Rs. 727.91 Crore, which is 83.73.50% of the overall project budget, is provisioned for principal component A. This includes total Rs. 727.91 Crore for forestry interventions in three landscapes and Conservation intervention (Sub-component A.1 and A.2) which include Rs. 443.08 Crores for component A.1, Rs.190.20 Crore for component A.2 and whereas, Rs. 44.09 Crore is provisioned for supporting activities (Sub-component A.3).

Component -A: the Sub-component (A.1) on plantations and various treatment models in three types of landscapes within the riverscape is the largest in terms of its spread, extent and quantum of funds provisioned. Rs. 443.08 Crore is provisioned for forestry interventions in three landscapes, which is 50.97% of total budget outlay of the project. Amongst three landscapes, the obvious emphasis is on Natural Landscapes, thus a sum of Rs. 307.91 Crore has been provisioned for proposed afforestation/reforestation activities in natural landscapes in Beas Riverscape. The projected budget outlay for proposed plantations in natural landscapes accounts for 69.49 % of the Sub-components. The projected budget outlays for Eco Task Force, agriculture and urban landscapes are of the tune of Rs. 22.43 Crore, Rs. 32.96 Crore and Rs. 79.78 Crore or 3.31%, 4.86 % and 11.78%, respectively of the envisaged cost of the Sub-component.

The second Sub-component on ‘Conservation Interventions’ (A.2) includes three major types of interventions/activities. These are: (a) soil and moisture conservation measures, (b) riverine and riparian wildlife management, and (c) wetland management. 190.20 Crore are provisioned for this subcomponent, which is 21.87% of total budget outlay. Of this, the budget outlay for SMC is Rs.160.99 Crore, which is 23.65% allocation of the funds provisioned for Component A. Budget outlay provisioned for Riverine and Riparian Wildlife Management and Wetland Management is 29.20 Crore, which is 4.31% of total budget of component A.

The third Sub-component (A.3) pertaining to ‘Supporting Activities’ is to be executed by concerned state level IAs. This Sub-component includes seven broad based activities viz., (a) policy and legal interventions, (b) participatory monitoring, (c) adaptive research, (d) capacity development, (e) awareness, (f) project management, and (g) evaluation. A budget of 44.09 Crore or 6.51% of the component A or 5.07% of total budget proposed to the

concerned states has been provisioned for carrying out various supporting activities for five-year period (**Table 7.1**).

The Component-B: ‘Strengthening Knowledge Management and enhancement of national capacity for forest hydrology, forestry interventions, and conservation and restoration of rivers would require a sum of Rs. 29.52 Crore or 3.39% of the overall project outlay. The highest budget amounting Rs. 7.79 Crore has been provisioned for cost of PFU, while budget of Rs. 6.27 Crore has been provisioned for Research and Development, 3.58 Crore, 2.69 Crore, 1.79 Crore, 1.46 Crore, 0.66 and 0.46 Crore have been envisaged for Scientific exchange, capacity development, policy level interventions, awareness, Monitoring and Evaluation respectively.

The Component – C on the Phase II of the project of five-year duration for maintenance of plantations raised during Phase I of the project has also been planned. The Phase II would also include limited activities related to replication of efforts in additional tributaries/areas and scaling up of the planned effort. A sum of Rs. 136.67 Crore or 15.72% of the total project financial outlay has been envisaged specifically for the Component – C on ‘Maintenance Phase’.

The Component – D pertains to project management at the national level which would include the establishment of National Project Management Unit (NPMU) at the Central Nodal Ministry with the responsibility to oversee, steer and manage this priority project. A sum of Rs. 25.82 Crore, representing 2.97% of the overall budget over a period of five-year during the Phase I has been provisioned. Thus, it is clear that the major portion of project budget outlay is meant for field level activities incorporating proposed forestry interventions, conservation interventions and supporting activities to be implemented in concerned States/UT.

A total of **20** Territorial Forest Divisions and **5** Wildlife Divisions in Beas Riverscape, will carry out proposed activities relevant to forestry interventions within the riverscape. A total of **24009.50** ha area of three landscapes (**Table 7.2**), **310** ha area of Riverine and Riparian wildlife management and wetland management and **926315.5m³** extent of soil and moisture conservation in Beas Riverscape is envisioned to be treated under the various forestry interventions (**Table 7.1 and Table 7.3**).

The consent for the availability of land for proposed forestry intervention have been obtained from PCCF & HoFF of Himachal Pradesh and Punjab (Annexure attached at Page No- 658 & 659 of Vol-I)

Table 7. 1- Project Budget Outlay - Component/ Activity Wise Budget allocation for Beas Riverscape

Sr. No.	Component/ Activity	Amount	Allocati on	Allocation
		(Rs. in Crore)	(%)	(%)
A.	Implementation of Forestry Interventions in Two States of Riverscape	727.91	83.73	86.43

A.1	Plantations and Treatment Models in Three Categories of Landscape	443.08	50.97	60.47
A.1.1	Natural Landscapes	307.91		
A.1.2	Eco Task Force	22.43		
A.1.3	Agriculture Landscapes	32.96		
A.1.4	Urban Landscapes	79.78		
A.2	Conservation Interventions	190.20	21.88	25.96
A.2.1	Soil and Moisture Conservation	160.99		
A.2.2	Riverine and Riparian Wildlife Management	21.83		
A.2.3	Wetland Management (Natural and Artificial)	7.38		
A.3	Supporting Activities	44.09	5.07	6.02
A.3.1	Policy Level Interventions	0.35		
A.3.2	Research Activities	3.27		
A.3.3	Capacity Development	12.03		
A.3.4	Awareness	8.84		
A.3.5	Participatory Monitoring	1.61		
A.3.6	Cost of PMUs of Two State Level Implementing Agencies	16.89		
A.3.7	Evaluation	1.01		
A.3.8	Contingency and Miscellaneous Activities	0.08		
Total Budget of Component A (A1+A2+A3)		677.37		
B.	Strengthening Knowledge Management and National Capacity for Forestry Interventions and Conservation of Riverscapes	29.52	3.4	4.03
C.	DPR – Phase II (Maintenance phase) Including Scaling Up and Replication of Successful Models of Forestry Interventions	136.67	15.72	
C.1	Maintenance Cost of A.1 and A.2 (Cost of Phase II)	62.97		
C.2	Maintenance Cost of A.3, B and D	42.04		
C.3	Scaling Up and Replication of Successful Models of Forestry Interventions (5% of A.1 & A.2)	31.66		
D.	National Coordination for Forestry Interventions and Riverscape Conservation	25.82	2.97	3.52
Total Phase I (A+B+D)		732.71		
Total Project Cost (Phase I+II) (A+B+C+D)		869.38		

C.1 Maintenance Cost in Crore [(NL)41.16+ (ETF) 17.94+ (Est. of Phase II ETF) 0.9 + (AL) 2.22+ (UL) 0.85 =63.07] + [(SMC) 0+ (Riparian & Wetland) 0.94] = 64.01]

Table 7. 2– Proposed Budget allocation for Various Plantations and Treatment Models in Three Types of Landscapes in Beas Riverscape

A. Natural Landscapes*						
State	No. of Sites	Area (ha)	Phase I (Project Implementation)		Phase II (Maintenance Phase)	Total Cost
			Establishment Cost (Rs. in Lakh)	Maintenance Cost (Rs. in Lakh)	Maintenance Cost (Rs. in Lakh)	(Rs. in Lakh)
Himachal Pradesh	465	13606	21502.89	6838.25	3694.29	32035.43
Punjab	140	1065	1835.50	614.56	422.62	2872.68
Total	605	14671	23338.39	7452.81	4116.91	34908.11
B. Agriculture Landscape						
State	No. of Sites	Area (ha)	Phase I (Project Implementation)		Phase II (Maintenance Phase)	Total Cost
			Establishment Cost (Rs. in Lakh)	Maintenance Cost (Rs. in Lakh)	Maintenance Cost (Rs. in Lakh)	(Rs. in Lakh)
Himachal Pradesh	73	1671	297.03	448.19	62.85	808.07
Punjab	36	7255	978.00	1572	159.12	2709.12
Total	109	8926	1275.03	2020.19	221.97	3517.19
C. Urban Landscape						
State	No. of Sites	Area (ha)	Phase I (Project Implementation)		Phase II (Maintenance Phase)	Total Cost
			Establishment Cost (Rs. in Lakh)	Maintenance Cost (Rs. in Lakh)	Maintenance Cost (Rs. in Lakh)	(Rs. in Lakh)
Himachal Pradesh	81	138.5	2910.7	1851.04	41.00	4802.74
Punjab	60	274	1976.06	1240.03	44.45	3260.54
Total	141	412.5	4886.76	3091.07	85.45	8063.28
Grand Total (A + B + C)	855	18599.5	28768.18	11374.50	4318.25	44460.93

**Natural landscape also includes area and cost of fire protection and natural regeneration models of natural landscape*

Table 7. 3– Budget allocation for Proposed Activities under the Sub-Component (A.2) on Conservation Interventions in Beas Riverscape

Activity	Himachal Pradesh	Punjab	Total

	No. of Sites	Extent	Total Cost (Rs. in Crore)	No. of Sites	Extent	Total Cost (Rs. in Crore)	No. of Sites	Extent	Total Cost (Rs. in Crore)
Soil and Moisture Conservation (Extent in m ³)	599	629262.5	129.53407	166	297053	31.455	765	926315.5	160.99
Riverine and Riparian Wildlife Management (Extent in ha)*	12	175	17.50	3	50	5.00	15	225	22.50
Wetland Management (Extent in ha)*	4	55	4.95	3	30	2.70	7	85	7.65
Total Cost on Proposed Conservation Interventions in Beas Riverscape									191.14

*Area is virtual considered for calculation of budgetary provisions

Table 7.4- Proposed Budget allocation under the Sub-Component (A.3) on Supporting Activities

Sr. No.	Activity	Phase I			Phase II			Grand Total (Rs. in Crore) Phase I+II
		States		Total	States		Total	
				(Rs. in Crore)			(Rs. in Crore)	
		Himachal Pradesh	Punjab	Phase I	Himachal Pradesh	Punjab	Phase II	
		(Rs. in Crore)	(Rs. in Crore)		(Rs. in Crore)	(Rs. in Crore)		
1	Policy Level Interventions	0.21	0.15	0.35	0.02	0.00	0.02	0.38
2	Research	2.64	0.63	3.27	1.68	0.37	2.06	5.33
3	Capacity Development	7.20	5.09	12.29	0.00	0.00	0.00	12.29
4	Awareness	6.19	2.65	8.84	0.00	0.00	0.00	8.84
5	Participatory Monitoring	0.98	0.63	1.61	0.58	0.37	0.95	2.56
6	Project Management	10.41	6.48	16.89	4.99	1.73	6.73	23.61
7	Evaluation	0.62	0.39	1.01	2.58	1.47	4.05	5.06
8	Contingency and other Expenses	0.05	0.03	0.08	0.02	0.01	0.03	0.12
Total Cost – Supporting Activities		28.30	16.05	44.35	9.88	3.96	13.84	58.19

Table 7. 5– Proposed Budget for Strengthening Knowledge Management and Capacity Enhancement by the National Level Partner Organization – HFRI, Shimla

Sr. No.	Item	Year (Rs. in Crore)											Total Phase II	Cost (Rs. in Crore) Phase I+II
		Phase I					Total Phase I	Phase II						
		I	II	III	IV	V		VI	VII	VIII	IX	X		
A.	Recurring Cost													
A.1	Cost of PFU - Salary and Wages, Equipment, Office Expenses and Management, Travel, Vehicle and POL, Audits, etc.,	1.62	1.45	1.51	1.57	1.64	7.79	0.55	0.52	0.49	0.46	0.43	2.45	10.24
A.2	Inputs for Policy Level Interventions	0.32	0.34	0.36	0.38	0.39	1.79	0.41	0.000	0.000	0.000	0.48	0.89	2.68
A.3	Strategic Adaptive Research and Development	1.13	1.19	1.25	1.31	1.38	6.27	0.69	0.72	0.76	0.80	0.84	3.81	10.07
A.4	Knowledge Management and Capacity Development	0.49	0.51	0.54	0.56	0.59	2.69	0.30	0.31	0.33	0.34	0.36	1.63	4.32
A.5	Scientific Exchange, Exposure Visits, and Engagement of International and National Consultants	0.65	0.68	0.71	0.75	0.79	3.58	0.39	0.41	0.43	0.46	0.48	2.18	5.76
A.6	Inputs for Awareness	0.49	0.24	0.24	0.24	0.24	1.46	0.06	0.00	0.02	0.00	0.00	0.08	1.54
A.7	Monitoring - Project, and Ecological and Socio-economic	0.16	0.15	0.13	0.12	0.11	0.66	0.10	0.09	0.08	0.07	0.06	0.39	1.06
A.8	Project Evaluation			0.46			0.46	0.78				1.02	1.80	2.26
	Sub Total Recurring Cost (A)	4.86	4.56	5.20	4.94	5.14	24.70	3.28	2.05	2.10	2.13	3.67	13.23	37.93
B.	Non-Recurring Cost													
B.1	Incorporation of Advance Technology	0.16	0.15	0.13	0.12	0.11	0.66	0.05	0.00	0.00	0.00	0.00	0.05	0.72
B.2	Permanent Equipment and Maint.	0.16	0.08	0.04	0.02	0.01	0.31	0.01	0.01	0.01	0.01	0.01	0.05	0.36
	Sub Total Non-Recurring Cost (B)	0.32	0.23	0.17	0.14	0.12	0.98	0.06	0.01	0.01	0.01	0.01	0.10	1.08
C.	Total (Recurring and Non- Recurring Costs) A+B	5.18	4.78	5.37	5.07	5.26	25.67	3.34	2.06	2.11	2.14	3.68	13.33	39.01
D.	Institutional Charge @ 15%	0.78	0.72	0.81	0.76	0.79	3.85	0.50	0.31	0.32	0.32	0.55	2.00	5.85
E.	Grand Total (C+D)	5.96	5.50	6.18	5.84	6.05	29.52	3.84	2.37	2.43	2.46	4.24	15.33	44.86

Table 7. 6– Proposed Budget for Project Management Unit at the Central Nodal Ministry

Sr. No.	Item	Year					Grand Total Cost (Rs. in
		Phase I		Total	Phase II		Total

		I	II	III	IV	V	Phase I	VI	VII	VIII	IX	X	Phase II	Creore) Phase I+II
A. Recurring Cost														
A.1	Cost of PMU - Salary and Wages, Equipment, Office Expenses and Management, Travel, Vehicle and POL, Audits, etc.,	1.76	1.36	1.41	1.48	1.55	7.57	0.49	0.46	0.44	0.41	0.39	2.19	9.76
A.2	Inputs for Policy Level Interventions	0.53	0.56	0.58	0.61	0.64	2.92	0.64	0.00	0.00	0.00	0.74	1.39	4.31
A.3	National Decision Support and Management Information System	0.70	0.74	0.78	0.82	0.86	3.89	0.45	0.40	0.36	0.33	0.30	1.84	5.74
A.4	Scientific Exchange, Exposure Visits, and Engagement of International and National Consultants	0.88	0.93	0.97	1.02	1.07	4.87	0.96	0.44	0.44	0.44	0.44	2.73	7.59
A.5	Inputs for National Level Awareness	0.53	0.56	0.58	0.61	0.64	2.92	0.58	0.55	0.52	0.49	0.46	2.59	5.51
A.6	Project Monitoring and Evaluation			0.45			0.45	0.76				0.98	1.73	2.19
Sub Total Recurring Cost (A)		4.41	4.14	4.78	4.54	4.77	22.63	3.88	1.85	1.76	1.67	3.31	12.47	35.10
B. Non-Recurring Cost														
B.1	Incorporation of Advance Technology	0.53	0.48	0.43	0.39	0.35	2.16	0.35	0.00	0.00	0.00	0.00	0.35	2.51
B.2	Permanent Equipment	0.53	0.26	0.13	0.07	0.03	1.02	0.01	0.01	0.01	0.01	0.01	0.05	1.07
Sub Total Non-Recurring Cost (B)		1.06	0.74	0.56	0.45	0.38	3.19	0.36	0.01	0.01	0.01	0.01	0.40	3.59
C.	Grand Total (Recurring and Non-Recurring Costs) A+B	5.46	4.88	5.34	4.99	5.15	25.82	4.24	1.86	1.77	1.68	3.32	12.87	38.69

Table 7. 7– Proposed Budget allocation for Beas River for two State Level Implementing Agencies under Three Landscapes, Conservation Interventions and Supporting Activities

Sr. No.	Activity	Phase I			Phase II			Grand Total (Rs. in Crores)
		States			States			
		Himachal Pradesh	Punjab	Total	Himachal Pradesh	Punjab	Total	
		(Rs. in Crores)	(Rs. in Crores)	(Rs. in Crores)	(Rs. in Crores)	(Rs. in Crores)	(Rs. in Crores)	
1	Natural Landscape	283.40	24.50	307.90	36.94	4.23	41.17	349.07
2	Eco Task Force	22.43	0.00	22.43	18.84	0.00	18.84	41.27
3	Agriculture Landscape	7.45	25.51	32.96	0.63	1.59	2.22	35.18
4	Urban Landscape	47.62	32.16	79.78	0.41	0.44	0.85	80.63
5	Soil and Moisture Conservation Measures	129.53	31.46	160.99	0.00	0.00	0	160.99
6	Other Intervention	21.77	7.43	29.20	0.67	0.27	0.94	30.14
7	Supporting Activities	28.30	15.79	44.09	0.10	3.96	4.06	48.15

Total Cost	540.5	136.85	677.35	57.59	10.49	68.08	745.43

Table 7. 8– Model/ Activity Wise Area and Cost for Forestry Interventions in Beas Riverscape

State	Landscape	Model/Activity	Area (Ha)	Cost (Rs. in Crore)
Himachal Pradesh	Natural	BS/HP/NL/01 – Sub-Alpine Conservation	5	0.11
		BS/HP/NL/02 – Sub-Alpine Enrichment	85	1.67
		BS/HP/NL/03 – Temperate Conifer Forest	212	6.44
		BS/HP/NL/04 – Temperate Mixed Forest	1550	47.23
		BS/HP/NL/05 – Pasture and Grazing Land Development	35	0.79
		BS/HP/NL/06 – Himalayan Chir Pine Forest	867	26.30
		BS/HP/NL/07 – Himalayan Mixed Forest	1558	42.52
		BS/HP/NL/08 – Sub-Tropical Dry Deciduous Forest	696	18.67
		BS/HP/NL/09 – Eradication of Lantana (> 50%)	988	31.52
		BS/HP/NL/10 – Control/Removal of Invasive Species or <50% Lantana	1300	39.91
		BS/HP/NL/11 – Protection Model for Natural Regeneration	4730	84.77
		BS/HP/NL/12 – Fire Protection Model	1580	20.36
	Agriculture	BS/HP/AL/01 – Boundary Plantation Model	1295	3.17
		BS/HP/AL/02 – Block Plantation Model	376	4.90
	Urban	BS/HP/UL/01 – Bioremediation and Bio-filtration	15.5	3.83
		BS/HP/UL/02 – Riverfront Development	5.5	13.61
		BS/HP/UL/03 – Institutional Plantation	107	4.59
		BS/HP/UL/04 – EcoPark Development	10.5	25.98
	Conservation Intervention	Soil and water Conservation	(m3)	
		BS/HP/CI/01 – Brushwood Interventions	137374	4.12
		BS/HP/CI/02 – Dry Stone Activities)	253994.5	45.71
		BS/HP/CI/03 – Crate Wire Activities	161235	72.55
		BS/HP/CI/04 – Water Ponds)	68774	2.40
		BS/HP/CI/05 – Silt Detention	7885	4.73

State	Landscape	Model/Activity	Area (Ha)	Cost (Rs. in Crore)
		Dam Type Activities		
		Other Interventions	Area (ha)	
		BS/HP/CI/06 – Riverine and Riparian Wildlife Management	175	17.50
		BS/HP/CI/07 – Wetland Management	55	4.95
		BS/HP/CI/08 – Moraine Management	-	-
		Sub Total	15645.5 ha. + 629262.5m³	528.33
Punjab	Natural	BS/PB/NL/01 – Restoration of Degraded Forest	880	20.40
		BS/PB/NL/02 – Road Side Plantation	185	8.31
	Agriculture	BS/PB/AL/01 – Boundary Plantation Model	6420	16.20
		BS/PB/AL/02 – Block Plantation	835	10.90
	Urban	BS/PB/UL/01 – Bioremediation and Bio-filtration	8	1.98
		BS/PB/UL/02 – River front development	-	-
		BS/PB/UL/03 – Institutional Plantation	258.1	11.07
		BS/PB/UL/04 – Eco Park Development	7.9	19.55
	Conservation Intervention	Soil and water Conservation	(m ³)	
		BS/PB/CI/01 – Brushwood Interventions	115050	3.45
		BS/PB/CI/02 – Dry Stone Activities	50690	9.12
		BS/PB/CI/03 – Crate Wire Activities	31030	13.96
		BS/ PB /CI/04 – Water Ponds	97793	3.42
		BS/PB/CI/05 – Silt Detention Dam Type Activities	2490	1.49
		Other Interventions	Area (ha)	
		BS/PB/CI/06 – Riverine and Riparian Wildlife Management	50	5.00
		BS/PB/CI/07 – Wetland Management	30	2.70
		Sub Total =	24319.5 hac + 297053	127.55
Grand Total =			18909.5 Hac + 926315.5	655.88

7.3 Budget Outlay- Forest Divisions

A total of 25 Forest Divisions falling in Beas Riverscape, will participate and carry out activities relating to forestry interventions including plantations, conservation interventions and supporting activities. Among these, 20 are territorial forest divisions and Five are wildlife divisions. Overall budget outlay for 20 Forest Divisions of Beas Riverscape has been given in

State summary of Himachal Pradesh and Punjab i.e., Vol II of the Beas River DPR. The range of budget allocation among 20 Forest Territorial Divisions varies from Rs. 0.12 Crore to Rs. 48.20 Crore over a period of five years of Establishment (Phase –I) and next five years of maintenance (Phase –II.) Whereas, the budget range for 5 wildlife divisions range from Rs 0.5 Crores to Rs 8.00 Crores over a period of 10 years (i.e., Phase I and II).

The execution period of five years in Phase I and five years of Phase II of the project has been designed and incorporated in the present DPR. Thus, the total duration for programme implementation including the maintenance phase is of 10-years. At this point of time, it is not clear when the project would start and which will be the first year of programme implementation during Phase I. The Government of India may take its own time to decide the Central Nodal Ministry responsible for the implementation of the project and to allocate required funds for the execution of plan. Various proposed activities have been proposed over five years of the Phase I. The experience illustrates that once the Government of India will accorded its approval for the project and will earmarked required funds, the first year by Implementing Agency (IA) would be largely devoted for project initiation, preparatory works, particularly the establishment of nurseries and commencement of various activities related to conservation interventions and supporting activities. The planting material meant for high altitude Himalayan part of the Beas riverscape would be ready in nurseries and earliest available by the end of second year of project implementation. Thus, the earliest effective establishment year of plantations would be the third year of Phase I in Beas Riverscape. Establishment of plantations is proposed in third, fourth and fifth year of Phase I. The Phase II of five-year duration is specifically designed and incorporated for the purpose of maintenance of plantations and other activities. Considering the fact that most proposed activities are time bound and seasonal in nature, ideally the project initiation after all approvals, budget allocation, etc. should commence in month of April–May so as to allow adequate time for preparatory works, establishment of nurseries, development of planting material for afforestation/ reforestation in lower reaches of the riverscape before the onset of monsoon season in month of July or so in the next year. Thus, careful scheduling of project commencement would be vital for the overall success and effective implementation of envisaged activities. The quantum of activities is expected to be at its peak in third or fourth year of Phase I. The Mid-Term Review (MTR) is proposed in the last quarter of third financial year of the project execution while the Terminal Evaluation (TE) is being envisaged in the third year of the Phase II.

Table 7. 9– Year-Wise Breakup of Extent Coverage of Proposed Forestry Interventions in Riverscape

Year	Period	Plantation and Treatment Models				Conservation Intervention		
		Natural Land-scape (ha)	Eco Task Force (ha)	Agriculture Landscape (ha)	Urban Landscap e (ha)	Soil and Moisture Conservation Measures (m³)	Riverine and Riparian Wildlife Management (ha)	Wetland Conserv ation (ha)
A. Phase I (Implementation Phase)								
I	Establishment	4045	0	3212	166.9	261864	150	55
II	Establishment	3077	200	3142.5	161.5	203010.5	75	30

Year	Period	Plantation and Treatment Models				Conservation Intervention		
		Natural Landscape (ha)	Eco Task Force (ha)	Agriculture Landscape (ha)	Urban Landscape (ha)	Soil and Moisture Conservation Measures (m ³)	Riverine and Riparian Wildlife Management (ha)	Wetland Conservation (ha)
	Maintenance	3690	0	3212	166.9		150	55
III	Establishment	3624	200	2571.5	84.1	224110	-	-
	Maintenance	6310	200	6354.5	328.4		225	85
IV	Establishment	3266	200	-		154473	-	-
	Maintenance	9924	400	8926	412.5		225	85
V	Establishment	1471	200	-	-	82858	-	-
	Maintenance	13200	600	5714	245.6		225	85
Total Phase I	Establishment	14671	800	8926	412.5	926315.5	225	85
	Maintenance	13200	600	8926	412.5	-	825	310
B. Phase II (Maintenance Phase)								
VI	Establishment	-	200	-	-	-	-	-
	Maintenance	10981	800	2571.5	84.1	-	75	30
VII	Establishment		0	-	-	-	-	-
	Maintenance	3946	800	-	-	-		
VIII	Establishment		0	-	-	-		
	Maintenance	4275	600	-	-	-		
IX	Establishment		0	-	-	--		
	Maintenance	1198	400	-	-	-		
X	Establishment	-	0	-	-	-		
	Maintenance	-	200	-	-	-		
Total Phase II	Establishment	-	200	-	-	-		
	Maintenance	20400	800	2571.5	84.1	-	75	30
Grand Total Phase I and Phase II	Establishment	14671	1000	8926	412.5	926315.5	225	85
	Maintenance	14671	1000	8926	412.5	-	825	310

*Natural landscape also includes area of fire protection and natural regeneration models of natural landscape;

**Area is virtual, considered for calculation of budgetary provisions

Table 7. 10– Year-Wise Breakup of Cost for Proposed Forestry Interventions in Riverscape

River Landscape								
Year	Period	Plantation and Treatment Models				Conservation Intervention		
		Natural Land-scape (Rs. in Lakhs)	Eco Task Force (Rs. in Lakhs)	Agriculture Land-scape (Rs. in Lakhs)	Urban Land-scape (Rs. in Lakhs)	Soil and Moisture Conservation Measures (Rs. in Lakhs)	Riverine and Riparian Wildlife Management (Rs. in Lakhs)	Wetland Conser-vation (Rs. in Lakhs)
B. Phase I (Implementation Phase)								
I	Establishment	3911.35	700.00	480.96	2195.6	4290.0765	480.00	154.00
II	Establishment	8215.02	60.00	443.7	2121.9	4040.4375	240.00	84.00
	Maintenance	711.22	300.00	257.33	658.68		420.00	137.5.00
III	Establishment	6284.55	66.00	350.97	569.26	3880.1225	-	-
	Maintenance	1086.54	315.00	521.02	1075.69		495.00	163.00
IV	Establishment	3906.35	72.00	-	-	2378.048	-	-

Year	Period	Plantation and Treatment Models				Conservation Intervention		
		Natural Landscape (Rs. in Lakhs)	Eco Task Force (Rs. in Lakhs)	Agriculture Landscape (Rs. in Lakhs)	Urban Landscape (Rs. in Lakhs)	Soil and Moisture Conservation Measures (Rs. in Lakhs)	Riverine and Riparian Wildlife Management (Rs. in Lakhs)	Wetland Conservation (Rs. in Lakhs)
	Maintenance	2453.01	320.00	753.67	924.54		322.50	114.00
V	Establishment	1021.13	80.00	-	-	1510.3185	-	-
	Maintenance	3202.04	330.00	488.2	432.16		225.00	85.5.00
Total Phase I	Establishment	23338.4	978.00	1275.63	4886.76	16099.002	720.00	238.00
	Maintenance	7452.81	1265.00	2020.00	3091.07	-	1462.50	500.00
B. Phase II (Maintenance Phase)								
VI	Establishment	-	90.00	-	-	-	-	-
	Maintenance	2375.49	340.00	221.97	85.41	-	67.50	27.00
VII	Establishment	-	-	-	-	-	-	-
	Maintenance	1214.19	374.00	-	-	-	-	-
VIII	Establishment		-	-	-	-	-	-
	Maintenance	448.76	368.00	-	-	-	-	-
IX	Establishment		-	-	-	-	-	-
	Maintenance	78.47	358.00	-	-	-	-	-
X	Establishment	-	-	-	-	-	-	-
	Maintenance	-	354.00	-	-	-	-	-
Total Phase II	Establishment	-	90.00	-	-	-	-	-
	Maintenance	4116.91	1794.00	221.97	85.41	-	67.50	27.00
Grand Total Phase I and Phase II	Establishment	23338.40	1068.00	1275.63	4886.76	16099.002	720.00	238.00
	Maintenance	11569.72	3059.00	2241.97	3176.48	-	1530.00	527.00

*Natural landscape also includes area of fire protection and natural regeneration models of natural landscape

Table 7. 11– Year-Wise Breakup of Extent Coverage of Proposed Forestry Interventions in Himachal Pradesh

Year	Period	Plantation and Treatment Models				Conservation Intervention		
		Natural Landscap e	Eco Task Force	Agricultur e Landscap e	Urban Landsc ape	Soil and Moisture Conservati on Measures	Riverine and Riparian Wildlife Management	Wetland Conservati on
		(ha)	(ha)	(ha)	(ha)	(m³)	(ha)	(ha)
A. Phase I (Implementation Phase)								
I	Establishment	3690	0	537	49.4	186365	110	45
II	Establishment	2620	200	542.5	55.1	143011.5	65	10
	Maintenance	3690	0	537	49.4	-	110	45
III	Establishment	3269	200	591.5	34	140613	-	-
	Maintenance	6310	200	1079.5	104.5	-	175	55

Year	Period	Plantation and Treatment Models				Conservation Intervention		
		Natural Landscape	Eco Task Force	Agriculture Landscape	Urban Landscape	Soil and Moisture Conservation Measures	Riverine and Riparian Wildlife Management	Wetland Conservation
		(ha)	(ha)	(ha)	(ha)	(m ³)	(ha)	(ha)
IV	Establishment	2809	200	-	-	98484	-	-
	Maintenance	9569	400	1671	138.5	-	175	55
V	Establishment	1218	200	-	-	60789	-	-
	Maintenance	12388	600	1134	89.1	-	175	55
Total Phase I	Establishment	13606	800	1671	138.5	629262.5	175	55
	Maintenance	12388	600	1671	138.5	-	175	55
B. Phase II (Maintenance Phase)								
VI	Establishment	-	200	-	-	-	-	-
	Maintenance	9916	800	591.5	34	-	65	10
VII	Establishment	-	-	-	-	-	-	-
	Maintenance	3236	800	-	-	-	-	-
VIII	Establishment	-	-	-	-	-	-	-
	Maintenance	4022	600	-	-	-	-	-
IX	Establishment	-	-	-	-	-	-	-
	Maintenance	1198	400	-	-	-	-	-
X	Establishment	-	-	-	-	-	-	-
	Maintenance	-	200	-	-	-	-	-
Total Phase II	Establishment	-	200	-	-	-	-	-
	Maintenance	18372	800	591.5	34	-	65	-
Grand Total Phase I and Phase II	Establishment	13606	1000	1671	138.5	629262.5	175	55
	Maintenance	13606	1000	1671	138.5	-	175	55

*Natural landscape also includes area of fire protection and natural regeneration models of natural landscape;

**Area is virtual, considered for calculation of budgetary provisions

Table 7. 12– Year-Wise Breakup of Cost for Proposed Forestry Interventions in Himachal Pradesh

Year	Period	Plantation and Treatment Models				Conservation Intervention		
		Natural Landscape	Eco Task Force	Agriculture Landscape	Urban Landscape	Soil and Moisture Conservation Measures	Riverine and Riparian Wildlife Management	Wetland Conservation
		(Rs. in Lakhs)	(Rs. in Lakhs)	(Rs. in Lakhs)	(Rs. in Lakhs)	(Rs. in Lakhs)	(Rs. in Lakhs)	(Rs. in Lakhs)
A. Phase I (Implementation Phase)								
I	Establishment	3846.44	700.00	93.96	1398.30	3581.33	352.00	126.00
II	Establishment	8017.43	60.00	100.50	1239.40	3208.41	208.00	28.00
	Maintenance	711.22	300.00	50.28	419.49	-	308.00	112.50
III	Establishment	5673.53	66.00	102.57	273.00	3085.13	-	-
	Maintenance	1086.54	315.00	107.57	651.48	-	391.00	97.00

Year	Period	Plantation and Treatment Models				Conservation Intervention		
		Natural Landscape	Eco Task Force	Agriculture Landscape	Urban Landscape	Soil and Moisture Conservation Measures	Riverine and Riparian Wildlife Management	Wetland Conservation
		(Rs. in Lakhs)	(Rs. in Lakhs)	(Rs. in Lakhs)	(Rs. in Lakhs)	(Rs. in Lakhs)	(Rs. in Lakhs)	(Rs. in Lakhs)
IV	Establishment	3248.22	72.00	-	-	1903.16	-	-
	Maintenance	2244.10	320.00	170.02	539.55	-	255.50	70.00
V	Establishment	717.27	80.00	-	-	1175.37	-	-
	Maintenance	2796.39	330.00	120.32	240.52	-	177.00	52.50
Total Phase I	Establishment	21502.90	978.00	297.03	2910.70	12953.40	560.00	154.00
	Maintenance	6838.25	1265.00	448.19	1851.04	-	1131.50	332.00
B. Phase II (Maintenance Phase)								
VI	Establishment	-	90.00	-	-	-	-	-
	Maintenance	2066.13	340.00	62.85	40.96	-	58.50	9.00
VII	Maintenance	1119.10	374.00	-	-	-	-	-
VIII	Maintenance	430.59	368.00	-	-	-	-	-
IX	Maintenance	78.47	358.00	-	-	-	-	-
X	Maintenance	-	354.00	-	-	-	-	-
Total Phase II	Establishment	-	90.00	-	-	-	-	-
	Maintenance	3694.29	1794.00	62.85	40.96	-	-	9.00
Grand Total Phase I and Phase II	Establishment	21502.90	1068.00	297.03	2910.70	12953.41	560.00	154.00
	Maintenance	10532.54	3059.00	511.04	1892.00	-	1190.00	341.00

*Natural landscape also includes cost of fire protection and natural regeneration models of natural landscape.

Table 7. 13– Year-Wise Breakup of Extent Coverage of Proposed Forestry Interventions in Punjab

Year	Period	Plantation and Treatment Models			Conservation Intervention		
		Natural Landscap e	Agricult ure Landscap e	Urban Landscape	Soil and Moisture Conservati on Measures	Riverine and Riparian Wildlife Management	Wetland Conserva tion
A. Phase I (Implementation Phase)							
		(ha)	(ha)	(ha)	(m ³)	(ha)	(ha)
I	Establishment	355	3212	117.5	75499	40	10
	Maintenance	-	-	-		-	-
II	Establishment	457	3142.5	106.4	59999	10	20
	Maintenance	-	3212	-		40	10
III	Establishment	253	2571.5	50.1	83497	-	-
	Maintenance	-	6354.5	223.9		50	30
IV	Establishment	-	-	-	55989	-	-
	Maintenance	355	8926	274		50	30
V	Establishment	-	-	-	22069	-	-

Year	Period	Plantation and Treatment Models			Conservation Intervention		
		Natural Landscape	Agriculture Landscape	Urban Landscape	Soil and Moisture Conservation Measures	Riverine and Riparian Wildlife Management	Wetland Conservation
	Maintenance	457	5714	156.5	-	50	30
Total Phase I	Establishment	1065	8926	274	297053	50	30
	Maintenance	812	8926	274	-	50	30
Phase II (Maintenance Phase)							
VI	Establishment	-	-	-	-	-	-
	Maintenance	1065	2571.5	50.1	-	10	20
VII	Establishment	-	-	-	-	-	-
	Maintenance	710	-	-	-	-	-
VIII	Establishment	-	-	-	-	-	-
	Maintenance	253	-	-	-	-	-
IX	Establishment	-	-	-	-	-	-
	Maintenance	-	-	-	-	-	-
X	Establishment	-	-	-	-	-	-
	Maintenance	-	-	-	-	-	-
Total Phase II	Establishment	-	-	-	-	-	-
	Maintenance	2028	2571.5	50.1	-	10	20
Grand Total Phase I and Phase II	Establishment	1065	8926	274	297053	50	30
	Maintenance	1065	8926	274	-	50	30

*Natural landscape also includes area of fire protection and natural regeneration models of natural landscape;

**Area is virtual, considered for calculation of budgetary provisions

Table 7. 14- Year-Wise Breakup of Cost for Proposed Forestry Interventions in Punjab

Year	Period	Plantation and Treatment Models			Conservation Intervention		
		Natural Landscap e	Agriculture Landscape	Urban Landscape	Soil and Moisture Conservation Measures	Riverine and Riparian Wildlife Management	Wetland Conservati on
		(Rs. in Lakhs)	(Rs. in Lakhs)	(Rs. in Lakhs)	(Rs. in Lakhs)	(Rs. in Lakhs)	(Rs. in Lakhs)
A. Phase I (Implementation Phase)							
I	Establishment	64.91	387.00	797.30	708.75	128.00	28.00
	Maintenance	-	-	-	-	-	-
II	Establishment	197.59	343.20	882.50	832.02	32.00	56.00
	Maintenance	-	207.05	239.19	-	112.00	25.00
III	Establishment	611.02	284.40	296.26	794.99	-	-
	Maintenance	-	413.45	424.21	-	104.00	66.00
IV	Establishment	658.13	-	-	474.88	-	-
	Maintenance	208.91	583.65	384.99	-	67.00	44.00
V	Establishment	303.86	-	-	334.95	-	-
	Maintenance	405.65	367.88	191.64	-	48.00	33.00
Total Phase I	Establishment	1835.51	978.60	1976.06	3145.60	160.00	84.00
	Maintenance	614.56	1572.00	1240.03	-	331.00	168.00
B. Phase II (Maintenance Phase)							

Year	Period	Plantation and Treatment Models			Conservation Intervention		
		Natural Landscape	Agriculture Landscape	Urban Landscape	Soil and Moisture Conservation Measures	Riverine and Riparian Wildlife Management	Wetland Conservation
		(Rs. in Lakhs)	(Rs. in Lakhs)	(Rs. in Lakhs)	(Rs. in Lakhs)	(Rs. in Lakhs)	(Rs. in Lakhs)
VI	Establishment	-	-	-	-	-	-
	Maintenance	309.36	159.12	44.45	-	9.00	18.00
VII	Establishment	-	-	-	-	-	-
	Maintenance	95.09	-	-	-	-	-
VIII	Establishment	-	-	-	-	-	-
	Maintenance	18.17	-	-	-	-	-
IX	Establishment	-	-	-	-	-	-
	Maintenance	-	-	-	-	-	-
X	Establishment	-	-	-	-	-	-
	Maintenance	-	-	-	-	-	-
Total Phase II	Establishment	-	-	-	-	-	-
	Maintenance	422.62	159.12	44.45	-	9.00	18.00
Grand Total Phase I and Phase II	Establishment	1835.51	978.6	1976.06	3145.60	160.00	84.00
	Maintenance	1036.98	1731.12	1284.48	-	340.00	186.00

*Natural landscape also includes cost of fire protection and natural regeneration models of natural landscape

Table 7.15– Year-Wise Breakup of Projected Cost on Supporting Activities in Beas Riverscape Phase I

Sr. No.	Activity	Year					
		(Rs. in lakh)					
		Phase I					Total
		I	II	III	IV	V	Phase I (Rs. in lakh)
1	Policy Level Interventions	12.56	7.64	5.89	5.11	4.35	35.54
2	Research Activities	63.68	64.54	65.67	67.08	68.74	329.70
3	Capacity Development	236.00	232.05	283.65	255.84	228.69	1236.22
4	Awareness	168.00	176.40	185.22	194.48	204.21	928.31
5	Participatory Monitoring	39.58	35.62	32.06	28.85	25.97	162.08
6	Cost of PMUs of Two State Level Implementing Agencies	395.80	302.83	317.65	333.21	349.54	1699.02
7	Evaluation	0.00	0.00	101.63	0.00	0.00	101.63
8	Contingency and Miscellaneous Activities	1.98	1.51	1.59	1.67	1.75	8.50
Total		917.59	820.59	993.35	886.23	883.23	4500.99

Table 7. 16– Year-Wise Breakup of Projected Cost on Supporting Activities in Beas

Riverscape Phase II

Sr. No.	Activity	Year					
		(Rs. in lakh)					
		Phase II					Total
		I	II	III	IV	V	Phase II (Rs. in lakh)
1	Policy Level Interventions	2.26	0.00	0.00	0.00	0.00	2.26
2	Research Activities	39.90	40.52	41.31	42.27	43.38	207.37
3	Capacity Development	0.00	0.00	0.00	0.00	0.00	0.00
4	Awareness	0.00	0.00	0.00	0.00	0.00	0.00
5	Participatory Monitoring	23.37	21.03	18.93	17.04	15.33	95.71
6	Cost of PMUs of Two State Level Implementing Agencies	153.62	143.05	134.66	126.77	119.34	677.44
7	Evaluation	169.90	0.00	0.00	0.00	237.65	407.55
8	Contingency and Miscellaneous Activities	0.77	0.72	0.67	0.63	0.60	3.39
Grand Total of Riverscape		389.81	205.32	195.58	186.71	416.30	1393.71

Table 7. 17– Year-Wise Breakup of Projected Cost on Supporting Activities in Himachal Pradesh

Sr. No.	Activity	Year												Grand Total (Cost Rs. in lakh) Phase I+II
		(Rs. in lakh)											Total I	
		Phase I					Total	Phase II					Phase II	
		I	II		IV	V	Phase I	I	II	III	IV	V		
1	Policy Level Interventions	4.77	3.73	3.91	4.10	4.31	20.83	2.23	0.00	0.00	0.00	0.00	2.23	23.06
2	Research Activities	47.73	50.12	52.62	55.25	58.02	263.75	30.46	31.98	33.58	35.26	37.02	168.31	432.05
3	Capacity Development	139.00	130.20	156.71	143.55	150.72	720.18	0.00	0.00	0.00	0.00	0.00	0.00	720.18
4	Awareness	112.00	117.60	123.48	129.65	136.14	618.87	0.00	0.00	0.00	0.00	0.00	0.00	618.87
5	Participatory Monitoring	23.87	21.48	19.33	17.40	15.66	97.73	14.09	12.68	11.41	10.27	9.25	57.71	155.44
6	Cost of PMUs of State Level Implementing Agencies	238.66	186.45	195.61	205.23	215.33	1041.28	111.74	105.52	99.57	93.95	88.66	499.44	1540.73
7	Evaluation	0.00	0.00	62.07	0.00	0.00	62.07	104.13	0.00	0.00	0.00	154.07	258.20	320.27
8	Contingency and Miscellaneous Activities	1.19	0.93	0.98	1.03	1.08	5.21	0.56	0.53	0.50	0.47	0.44	2.50	7.70
Grand Total		567.22	510.51	614.72	556.22	581.25	2829.91	263.21	150.72	145.06	139.96	289.44	988.39	3818.31

Table 7. 18– Year-Wise Breakup of Projected Cost on Supporting Activities in Punjab

Sr · N o.	Activities	Year											Total	Grand Total (Cost Rs. in lakh) Phase I+II
		(Cost Rs. in lakh)												
		Phase I					Total	Phase II					Phase II	
		I	II	III	IV	V	Phase I	VI	VII	VII I	IX	X		
1	Policy Level Interventions	7.74	3.87	1.94	0.97	0.00	14.52	0.0 0	0.0 0	0.0 0	0.0 0	0.00	0.00	14.52
2	Research	15.48	13.9 4	12.54	11.2 9	10.1 6	63.41	9.1 4	8.2 3	7.4 1	6.6 7	6.00	37.44	100.85
3	Capacity Developmen t	91.00	95.5 5	120.33	105. 34	70.6 7	482.89	0.0 0	0.0 0	0.0 0	0.0 0	0.00	0.00	482.89
4	Awareness	48.00	50.4 0	52.92	55.5 7	58.3 4	265.23	0.0 0	0.0 0	0.0 0	0.0 0	0.00	0.00	265.23
5	Participatory Monitoring	15.48	13.9 4	12.54	11.2 9	10.1 6	63.41	9.1 4	8.2 3	7.4 1	6.6 7	6.00	37.44	100.85
6	Project Management Unit	154.8 4	114. 55	120.12	125. 96	132. 10	647.56	40. 79	36. 50	34. 13	31. 91	29.8 3	173.16	820.72
7	Evaluation			38.95			38.95	64. 76				82.0 7	146.83	185.78
8	Contingency and Miscellaneous Expenses	0.77	0.57	0.60	0.63	0.66	3.24	0.2 0	0.1 8	0.1 7	0.1 6	0.15	0.87	4.10
Grand Total		333.3 2	292. 81	359.93	311. 04	282. 09	1579.2 0	124 .04	53. 14	49. 11	45. 40	124. 05	395.73	1974.9 3

8.1 Benefits of River Restoration

Healthy rivers offer a wide range of social and economic benefits besides performing various ecological functions. Social and economic benefits derived from healthy rivers can be expressed in terms of provisioning, regulatory, cultural or supporting ecosystem services (MEA, 2005). River restoration has become essential where river systems have degraded to the point that can no longer provide the services required of them. Increasingly, river restoration is now a common response to declining river health and its importance can only be expected to grow. Restoration is often triggered on account of ecological concerns, social and cultural factors, economic drivers, the need to protect infrastructure and assets from water related risks, and increasing water security concerns (Speed *et al.*, 2016). Restoration includes any action aimed at improving the health of the river, including improving ecosystem functions and any related ecosystem service. The benefits of well-designed river restoration projects will mainly be felt from the return of at least some services as a result of improvements in river health.

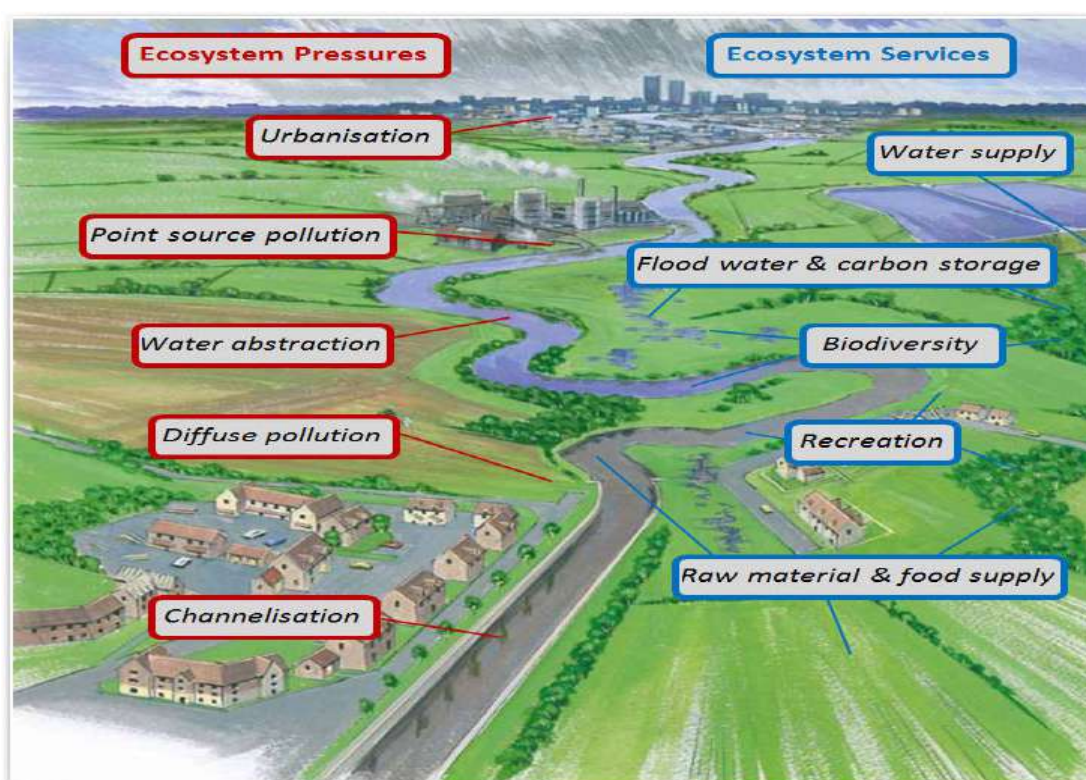


Fig. 8. 1 - Ecosystem Pressures on Rivers and Ecosystem Services Provided by Rivers

Thought process revolving around retrieval of enhancement of river environments originally began with the addressing of issues pertaining to severe water pollution and the conservation of target species. However, with the passage of time changes in attitude towards

environmental management eventually led to more integrated approaches including river restoration schemes with multiple benefits. It is beyond any doubt that these benefits will provide new dimensions to the management of river resources involving techniques like catchment management, floodplain reconnection, wetland recreation, river remaindering, in-stream enhancement, etc., with the ultimate object to use the resources in much better and sustainable way.

8.2 Need for River Restoration in the Context of Beas River

The need for river restoration in the context of Beas River has arisen as a consequence of primarily two main reasons: (a) the degradation of river ecosystem through the cumulative effect of deforestation in past, enhanced resource dependence on forests, expansion of agriculture and horticulture, increased developmental activities (road network, hydroelectric projects, urbanization and industrialization along the course of river and its tributaries), over-abstraction, diversion of water, pollution, and climate change; and (b) the loss of services historically provided by river are indicated by decreased water availability; decline of water quality; loss of biodiversity; reduced aesthetics; recreational and tourism values; increased floods; and the growing risks.

Based on the exhaustive review on the river and its environment, it can be safely stated that the current degraded state of the Beas River is a cumulative reflection of a number of anthropogenic activities occurred gradually in past one and a half centuries or so (Fig. 8.2). Resultant major environmental concerns or evident broad-based symptoms of river deterioration are: (i) degraded land and river ecosystem; (ii) excessive soil erosion, landslides and sedimentation; (iii) non-availability of water and reduced e-flow; and (iv) poor quality of water.

8.3 Strategy and Measures for River Restoration

As already spelled in Chapter 5, the present Plan has adopted a comprehensive, multipronged strategy to address above stated four broad-based symptoms of river degradation. Several potential measures have been planned for concurrent implementation. The proposed restoration strategy includes extensive plantation activities in natural, agriculture, and urban landscapes within the riverscape along with appropriate bioengineering and mechanical measures for soil and water conservation besides riparian and riverine wildlife management, and wetland conservation. Several supporting activities *viz.*, policy level interventions, concurrent research and development, awareness, capacity development, participatory monitoring, and evaluation vital for effective and successful execution of the implementation plan have also been envisaged.

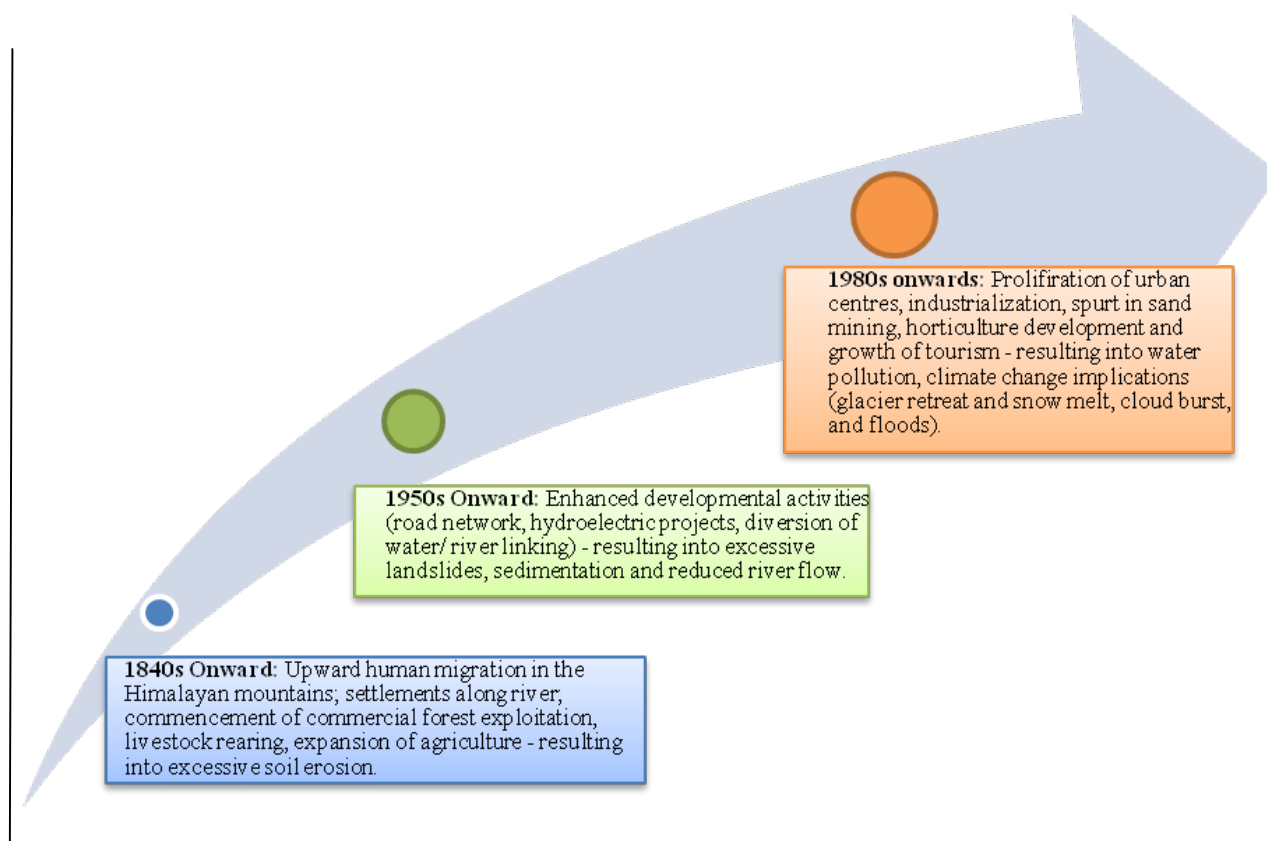


Fig. 8. 2 - Gradual Process of Degradation and Cumulative Impact on the River Ecosystem

8.4 Potential Benefits of Proposed Forestry Interventions

There are many complexities in forestry sector and some of their special characteristics are; **(i)** a very long production/gestation period i.e., a long period between investment and output; **(ii)** the tree acts both as the production unit and the product as well; **(iii)** there is great flexibility over the timing of harvest of a tree, but once it is harvested it again takes a long time to rebuild the stock for future harvests can be taken; **(iv)** involves biological production process, and accordingly is subjected to considerable variation in output, and uncertainty can be substantial; and **(v)** Forests and even individual trees, can have multiple uses. Thereby provide economy-raw material for industry, source of rural employment and income, environmental conservation, etc.

‘The proposed activities for Beas River restoration are confined exclusively to forestry interventions aiming for enhancement of forest cover, grassland and wetland management, reduction in soil erosion, riparian management and in-stream/aquatic habitat and species management’.

However, several other measures of engineering, hydrological, mechanical, agricultural and bio-technological nature aiming at channel and flow modification, dam removal or retrofitting, bank stabilization, storm water management and flood control, spring/aquifer management, floodplain reconnection and channelization, channel reconfiguration,

management of industrial effluents and urban waste and sewage, climate smart agriculture, management of toxins, etc. are out of purview of the present DPR. Various potential socio-economic benefits and improved ecological functions expected as a result of proposed wide-ranging forestry interventions in present DPR have been given briefly in **Table 8.1**.

Table 8. 1– Potential Socio-economic Benefits and Improved Ecological Functions as a Result of Proposed forestry Interventions

Element	Approach to Restoration	Ecosystem Services			
		Provisioning	Regulating	Cultural	Supporting
Catchment	Protection and conservation of natural forests; forest plantations in Natural Landscape, agroforestry models in Agriculture Landscapes and development of Eco-parks/ Avenue plantations in Urban Landscapes; and riparian management	Wood, NTFPs – fuelwood, fiber, fruits, medicinal plants for human consumption; grass, fodder, and grazing for livestock; increased population and enhanced abundance of native flora and fauna including Rare Endangered and Threatened (RET) species	Carbon sequestration by forest/plantation and other vegetation and carbon storage in soils; water storage by forests/plantations - function of ‘sponge’ and water purification; control water temperature; lessens soil erosion, sediment and nutrient run-off; control of invasive and alien species; enhanced fluvial processes, lateral connectivity; and environmental amelioration	Aesthetic value of natural forests and riparian zones; benefit to tourism, employment generation, and areas for public recreation	Increased and improved habitat for biodiversity on land and in stream/rivers; checking soil erosion, water conservation; and sediment changes
Flow regime	Water availability and e-flow	Increased availability of water and enhanced e-flow; affect fish diversity and population and other services that rely on presence and abundance of migratory fishes	Alter the timing and delivery of water; and improvement in water quality; enhanced longitudinal and vertical connectivity	Increased ecotourism and recreation	Important fish spawning habitat and benthic invertebrates
Habitat	Instream habitat improvement	Increase in availability of key fish and	Increased oxygenation and sediment flushing	Improved aesthetics and	Physical habitat heterogeneity;

Element	Approach to Restoration	Ecosystem Services			
		Provisioning	Regulating	Cultural	Supporting
	and bank stability	other featured aquatic fauna; improved fisheries, and conserve native species	of water; reduced diffuse and point source pollution	environment for recreation	enhanced biodiversity; Improves and stabilizes physical habitats for breeding; increased richness and abundance of macro-invertebrates; enhanced spawning, feeding and refugia habitats for native fishes
Water Quality	Improvement in water quality	Supports aquatic fauna and enhancement in native fish diversity	Improvement in instream water quality and reduces competition of native fishes species for resources	Enhances the economic and social amenity value; improves the quality of life	Reduces habitat inhabitation by invasive species and increase in population and abundance of RET species
Biodiversity	Species management	Increase in availability of native fish and other aquatic fauna	Improves water quality and resource competition among native fish species	Improves river health and recreational activities	Alter aquatic native species distribution and abundance

(Source: Adopted and Modified from Speed *et al.*, 2016)

8.5 Forests and Climate Change

8.5.1 Climate Change

Few global issues have received more attention than climate change in recent years. Amidst all the discussion about the greenhouse effect, one fact is certain i.e., atmospheric CO₂ levels are rising. The amount of anthropogenic carbon dioxide (CO₂) emitted to the atmosphere, primarily because of expanding use of fossil fuels for energy has risen from pre-industrial levels of 280 parts per million (ppm) to over 400 ppm. Intergovernmental Panel on Climate Change (IPCC) stated that, Human influence on the climate system is clear and recent anthropogenic emissions of Green House Gases (GHGs) are the highest in history. Recent climate changes have had widespread impacts on human and natural systems' (IPCC, 2014).

According to IPCC (2014), globally CO₂ emissions from fossil fuel combustion and industrial processes contributed about 78% of the total GHG emission increase from 1970 to 2010. An estimated 23% of total anthropogenic greenhouse gas emissions (2007-2016) derived from Agriculture, Forestry and Other Land Use (AFOLU) (IPCC, 2019). The IPCC report on the impacts of global warming of 1.5°C above pre-industrial levels (IPCC, 2018) has highlighted that average global earth's temperature has increased by about 1°C as compared to pre-industrial level due to anthropogenic activities. In line with increasing trends witnessed in global surface temperature, the average yearly temperature over India for the period 1901 to 2017 has shown significant rising trend of 0.66°C over 100 years. Extreme events like heat waves have risen in past 30 years (MoEF&CC, 2017).

8.5.2 Forests for Climate Change Mitigation

The impact of climate change has alarmed the global communities and attracted the interest of scientific communities towards various mitigation and adaptation measures. Forest ecosystem plays a significant role in reducing the impact of climate change. Intrinsically forests and climate change are directly linked to each other's. Forests are known as the sink as well as the source of carbon dioxide. Forest ecosystem during the process of photosynthesis, absorbs the carbon dioxide from the atmosphere and releases oxygen into the atmosphere. Role of forests has been increasingly recognized as most cost-effective option for climate change mitigation through carbon captured in biomass and soils. Forests are considered to provide a large climate change mitigation opportunity at relatively lower costs along with other significant co-benefits. Global forests cover around 30% of earth's surface, spread over about 4 billion hectares of land mass. Forestry mitigation options including reduced deforestation, forest management, afforestation, and agro-forestry are estimated to contribute 0.2-13.8 GtCO₂/year of economically viable abatement in 2030 (IPCC, 2014). Thus managing our forests for carbon storage will help to absorb atmospheric carbon dioxide. Expansion of land under vegetative cover through afforestation and reforestation programs is another important component of forestry activities that could store more and more atmospheric carbon. Forestation implies increasing the amount of carbon stored in vegetation both above and below ground, dead organic matter and medium and long-term wood products (Watson, 1996).

In forest ecosystem, the carbon is stored in the growing stock i.e., standing trees, herbs, shrubs etc. and in the soil. The cutting down of trees and removal of vegetation from the forest ecosystem for fuel wood, timber, fodder, etc. releases the stored carbon in the form of CO₂. Various anthropogenic activities like burning of fossil fuels, industrial as well as urban growth, deforestation and forest degradation are mainly responsible for increasing the concentration of CO₂ and other greenhouse gases into the atmosphere. The overall contribution from Agriculture, Forestry and Other Land Use (AFOLU) sector is around one quarter of the global anthropogenic GHGs emissions.

8.5.3 Carbon Services of Forests of India

India is a vast country with a rich biological diversity. Forest is the second-largest land use in India after agriculture. Approximately, 275 million rural people in India depend on forests for at least part of their subsistence and livelihood (World Bank, 2006). As per the India State of Forest Report (FSI, 2019), the forest cover of the country is 7,12,249 km², while it was 7,08,273 km² in 2015 (FSI, 2017), recording an increase of 3,976 km² with in two years. The total forest and tree cover of the country is 24.56% of its geographical area. However, National Forest Policy of India envisages 33% of its geographical area under forest and tree cover.

The Land Use Land Use Change and Forestry (LULUCF) sector was source of CO₂ in the year 1994 accounting for 1.16% of CO₂eq emissions when India submitted its first National Communication (NATCOM) to UNFCCC in 2000 (MoEF&CC, 2004). With its focus on sustainable management of forests, afforestation and regulating diversion of forest lands for non-forest purposes, India has been successful in improving carbon stock in its forests. In 2017, estimated carbon stock in forest was 7,124.68 million tonnes (FSI, 2019) while in 2015 it was 7,082 million tonnes (FSI, 2017) which is a net increase of 42 million tonnes in country's carbon stocks within two years. Various national programmes and policies have converted India's forests into net sink of CO₂. In its second National Communication, LULUCF sector was a net sink of 17% of total national emissions (MoEF&CC, 2012). India's first biennial update report to UNFCCC has reported that the LULUCF sector was a net carbon sink offsetting 252.5 million tonnes of CO₂e which is 12% of India's total GHG emission (MoEF&CC, 2015). LULUCF sector was a net sink of 301,193 million CO₂eq during 2014, registering an increase in the sink activity of the sector. Cropland dominates the CO₂ emissions/ removal estimates for India for the year 2014. Forest lands were net sinks and about 12% of India's GHGs emissions were offset by the LULUCF sector (MoEF&CC 2018a). Thus, forestry sector in India is making positive contribution for climate change mitigation.

8.5.4 Fulfilling International Commitments on Climate Change

Fulfilling emission reduction commitments under the United Nations Framework Convention on Climate Change (UNFCCC) and Paris Agreement on Climate Change, Government of India, launched India's National Action Plan on Climate Change (NAPCC) in 2008. In 2015 Government of India Nationally Determined Contributions (NDC) under Paris Agreement committed to create an additional carbon sink of 2.5 to 3 billion tonnes of CO₂ equivalent through additional forests and tree cover by 2030.

(i) National Mission for a Green India (GIM): India's National Action Plan on Climate Change (NAPCC) launched in June 2008, identifies several measures that simultaneously advance the country's development and climate change related objectives of adaptation and mitigation. The implementation of the NAPCC is designed to take place

through eight National Missions, which form the core of the National Action Plan on Climate Change and incorporate multi-pronged, long-term and integrated strategies for achieving India's key goals in the context of climate change. National Mission for a Green India also known as Green India Mission (GIM), is one of the key missions under NAPCC dealing with mitigation and adaptation of climate change in the forestry sector (MoEF&CC, 2014).

Green India Mission puts the “Greening” in the context of climate change adaptation and mitigation, meant to enhance ecosystem services like carbon sequestration and storage i.e., in forests and other ecosystems, hydrological services and biodiversity; along with provisioning services like fuel wood, fodder, small timber and Non-Timber Forest Products (NTFPs). The GIM aims at responding to climate change by a combination of adaptation and mitigation measures, which would help in;

- enhancing carbon sinks in sustainably managed forests and other ecosystems;
- adaptation of vulnerable species/ecosystems to the changing climate; and
- adaptation of forest dependent local communities in the face of climatic variability. In view of recent global climate negotiations and India NDC Commitments under agreeing to Paris Climate Agreement, government of India is in the process of revising the objectives and targets under Green India Mission.

(ii) India's Nationally Determined contribution (NDC) for Forestry Sector

Under Paris Climate Change Agreement, India has committed to meet its Nationally Determined Contribution (NDC). The Forestry sector goal of NDC beside other goals commits to create an additional carbon sink of 2.5 to 3 billion tonnes of CO₂ equivalent through additional forests and tree cover by 2030. To achieve this, India is determined to continue with its on-going interventions, enhance the existing policies and launch new initiatives in the priority areas inter alia full implementation of Green India Mission and other programmes of afforestation. Planned afforestation has been seen as a major mitigation strategy in forestry sector. India is one of the few countries, where forest and tree cover have increased in recent years transforming country's forests into a net sink owing to national policies aimed at conservation and sustainable management of forests.

India's efforts to increase the forests and tree cover have been further augmented by policies like National REDD-plus Strategy (2018a), National Agroforestry Policy (2014), Joint Forest Management Guidelines 1990; National Afforestation Programme, Namami Gange Programme and, Green Highways Mission and afforestation under Compensatory Afforestation Fund Management and Planning Authority Act (UNFCCC, 2015). The aforesaid actions are major drivers listed by India in its INDC submitted to UNFCCC to achieve the target of capturing 2.5 to 3 billion tonnes of additional CO₂ equivalent. The recent initiatives of afforestation along the major river basins of the country through forestry interventions will further contribute to additional carbon sequestration through afforestation activities.

8.6. Forest Carbon Assessment

8.6.1 Purposes of Carbon Measurement in Forest Ecosystem

Forests are both source and sink of carbon dioxide. A growing forest captures atmospheric carbon and this carbon is released into the atmosphere through activities like deforestation and forest degradation. The climate change mitigation benefit of afforestation/reforestation activities is one of the ecosystem services rendered by trees which are fully measurable, reportable and verifiable. Measurement of forest carbon stocks is a vital part of this unique Ecosystem Services because CO₂ emission reductions and removals by implementing various forestry activities are estimated by measuring changes in the amount of forest carbon and credits are also issued on the basis of carbon accrued through these actions.

8.6.2 Carbon Pools:

In a Forest Ecosystem, Carbon is stored in different **Carbon Pools**. A ‘Carbon Pool’ may be defined as a system that has the capacity to store or release carbon. For the estimation of carbon pools in a forested stand, IPCC (2003) identified five carbon pools as given in **Table 8.2**.

Table 8. 2- Definitions of Terrestrial Carbon Pools

Pool		Description
Living Biomass	Above Ground Biomass	All living biomass above the soil including stem, stump, branches, bark, seeds and foliage. Note: In cases where forest understory is a relatively small component of the above ground biomass carbon pool, it is acceptable for the methodologies and associated data used in some tiers to exclude it, provided the tiers are used in a consistent manner throughout the inventory time series.
	Below Ground Biomass	All living biomass of live roots. Fine roots of less than (suggested) 2 mm diameter are often excluded because these often cannot be distinguished empirically from soil organic matter or litter.
Dead Organic matter	Dead wood	Includes all non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. Dead wood includes wood lying on the surface, dead roots, and stumps larger than or equal to 10 cm in diameter or any other diameter used by the country.
	Litter	Includes all non-living biomass with a diameter less than a minimum diameter chosen by the country (for example 10 cm), lying dead, in various states of decomposition above the mineral or organic soil. This includes the litter, humic and fulvic layers. Live fine roots (of less than the suggested diameter limit for below-ground biomass) are included in litter where they cannot be distinguished from it empirically.
Soil	Soil Organic Matter	Includes organic carbon in mineral and organic soils (including peat) to a specified depth chosen by the country and applied consistently through the time series. Live fine roots (of less than the suggested diameter limit for below-ground biomass) are included with soil organic matter where they cannot be distinguished from it empirically.

Note: National circumstances may necessitate slight modifications to the pool definitions used here. Where modified definitions are used, it is good practice to report upon them clearly, to ensure that modified definitions are used consistently over time, and to demonstrate that pools are neither omitted nor double counted.

Forest carbon stocks in India's Forests and relative percentage proportion of carbon in different pools in forest riverscape state are given in **Table 8.3**. The Per ha stock (tonnes/ha) in different carbon pools of Himachal Pradesh and Punjab are given in **Table 8.4**

Table 8. 3- Forest Carbon Stock in the States of Himachal Pradesh and Punjab along with Different Carbon Pools (in Million Tonnes)

Sr. No	Carbon Pool	National	Himachal Pradesh	Punjab
1.	Above ground biomass	2,256.53	110.05	3.53
2.	Below ground biomass	700.82	30.75	1.37
3.	Litter	127.90	2.71	0.13
4.	Dead Wood	35.84	2.56	0.03
5.	Soil Organic Carbon	4,003.58	106.30	8.30
Total		7,124.68	252.36	13.34

Source: ISFR 2019

Table 8. 4 - Per Hectare Stock (tonnes/ha) in Different Carbon Pools of Himachal Pradesh and Punjab

Sr. No	Carbon Pool	National		Himachal Pradesh		Punjab	
		IFSR 2017	IFSR 2019	IFSR 2017	IFSR 2019	IFSR 2017	IFSR 2019
1.	Above ground biomass	31.59	31.68	46.79	71.30	27.74	19.09
2.	Below ground biomass	9.86	9.84	12.38	19.92	10.25	7.40
3.	Litter	0.43	0.50	1.66	1.76	87.31	71.18
4.	Dead Wood	1.92	1.80	0.49	1.66	0.14	0.14
5.	Soil Organic Carbon	56.19	56.21	55.09	68.87	48.84	44.89
Total		99.99	100.03	116.41	161.51	87.31	72.18

Source: ISFR, 2017 and 2019

8. 7 Carbon Sequestration Benefits of Forestry Interventions for Rejuvenation of Beas Riverscape

8.7.1 Potential of Production Forestry for Carbon Sequestration in India

The National Forest Policy 1988 envisages bringing one-third of the geographic area of the country under forest tree cover for maintaining ecological balance and environmental stability. India has been witnessing continuing improvement in existing policies and formulation of new policies and thus trying to keep pace with the activities and programmes to strive towards achievement of the country's national goal of 33% forest/tree cover as enunciated in National Forest Policy. To realize this goal, India has to bring about 109 million ha i.e., 33% of its total geographic area of 328 M ha of land under forest/tree cover.

An extent of 4.6 million ha i.e., 1.41% of scrub forests is also available in addition to the forest cover of 69.2 million ha. The difference in existing forest cover and the target area suggests that an additional 30 million ha has to be brought under the tree cover to achieve 33% tree cover as envisaged in National Forest Policy. This can be achieved by establishing plantations on non-forestland and through agro-ecosystems in existing agricultural lands. Forestry interventions in Beas Riverscape will further contribute to achieving national goal of 33% forest and tree cover.

8.7.2 Forest Productivity in India

The potential yield of natural forests in India is 6 m³/ha/year. Some of the plantation crops like Eucalyptus/poplars are fast growing species and are planted for maximum volume production. They are expected to yield much higher than the potential yield of natural forests. This has been exemplified in Brazil and South Africa, where actual yield are two and three times, respectively to the potential yields i.e., Brazil: 11 m³/ha/yr and Republic of South Africa: 7 m³/ha/yr. The comparison between actual Permanent Sample Plot (PSP) data and actual yield for some of the plantation species has been obtained almost in the range of potential yield (Pande, 1995). However, well managed plantations are expected to gain much higher than potential yield of natural forests. In India, it is expected that correct site and species matching, genetic improvement and adequate tending operations can improve the growth rate of plantations by at least 100 % (FAO, 1995). Newly planted or regenerating forests, in the absence of major disturbances, are likely to continue to uptake carbon for 20 to 50 years or more after establishment, depending on species, site conditions and objective of plantations.

8.7.3 Potential for Plant Biomass for Carbon Abatement

The current productivity of the forests is very poor and ranges between 0.7- 1.5 m³/ha/year as against the world average of 2.1 m³/ha/yr. The Mean Annual Increment (MAI) in India can vary between 3t/ha/year under degraded land conditions to 12 t/ha/year with genetic improvement and addition of fertilizers (Rawat, 1996). Increase in forest productivity directly indicates an increase in forest biomass and higher carbon sequestration. Despite commendable efforts made in the country towards improvement of planting stock material productivity of plantation is still much low much less (5-10 m³/ha/year). This is attributed to use of unimproved seed/clonal planting material, not matching species with site and poor management practices. The productivity of fast growing tree species of *Acacia*, *Casuarina*, *Eucalyptus* and *Populus* has increased from 10 m³/ha/year to more than 40 m³/ha/year by the use of improved clones, adoption of clonal technology site matching with clones and proper management practices (Kumar *et al.*, 2016). Kant (2005) has reported productivity of *Cryptomeria japonica* upto 39 m³/ha/year from Himalayan biogeographic zone and upto 35 m³/ha/year for *Gmelina arborea* from North-Eastern bio-geographic zone. Kant (2005) applied Paterson Productivity Index to the 10 bio-geographic zones in the country and gave potential ecosystem productivity (Table 8.5).

Table 8. 5- Potential Productivity of Different Biogeographic Zones of India

Sr. No.	Bio-geographic zone	Description	Potential Ecosystem Productivity (m ³ /ha/year)
1	Trans - Himalayan	Ladakh and high altitude zones abutting Tibet, very cold and arid, sparse alpine vegetation	Unproductive
2	Indian Desert	Thar and Kutch in western India, sandy deserts, seasonal marshes, sparse thorn forests	1-3
3	Semi-arid zone	Plains of Punjab, Haryana, Gujarat, Eastern Rajasthan, west-central UP, western MP. Most lands under agriculture, limited forested area	3-6
4	Himalayan bio-geographic zone	Four distinct biotic provinces of north, west, central and eastern Himalayas. Sharp altitudinal differences. Well forested and also degraded in places, rich biodiversity. Tea cultivation in eastern part.	6
5	Deccan Peninsula	Raised land covering 40% of India; bound by Satpura, western ghats and eastern ghats; elevation ranges from 300 to 1000 meters in east; covered by tropical dry and moist forests	6-9
6	Gangetic Plains	Plains of UP, Bihar, West Bengal; most fertile alluvial soils, mostly under crop; very little forest cover	6-9
7	North-Eastern bio-geographic zone	Brahmaputra and Barak river valleys and north eastern hills; evergreen and moist deciduous forests, heavily subjected to shifting cultivation	9-12
8	Coastal region	Coastal belts of west and east coasts, higher rainfall in west, exposure to cyclones in east, extensive casuarinas plantations on eastern coast	
		(i) West coast	>12
		(ii) East Coast	9-12
9	Western Ghats	Moderately high hill range along west coast, eastern side under rain shadow, very rich in bio-diversity and forest cover; large extent under tea, rubber, coffee, cardamom, tapioca; significant area under protected areas for wildlife	>12
		(i) Western Ghats	
		(iii) Eastern Ghats	9-12
10	Indian Islands	Group of 325 islands in Andaman sea and also Lakshadweep along west coast; heavy rainfall, warm and humid climate, extensive forest cover	>12

Source: Champion and Seth (1968), Kant (2004), Lal (1992), and WII (2000)

8.7.4 Carbon Sequestration from Carbon Forestry Projects

India is the leading country in carbon forestry in so far as carbon trading under Clean Development Mechanism (CDM) of UNFCCC is concerned. A total of 19 CDM Forestry Projects are registered from India under CDM. Average Reduction (Metric Tonnes CO₂/ha/year) by the Plantation activities under CDM project in India is in the region of 16

Metric Tonnes of CO₂/ha/year. However, the estimated carbon dioxide mitigation the CDM project registered in Himachal is expected to capture 10.34 Tonnes of CO₂/ha/year (Box 8.1). The low carbon mitigation from the project (10.34 tonnes of CO₂/ha/year) as compared to National average i.e., 16 metric tonnes of CO₂/ha/year is attributed to the nature of landscape where this project was implemented in the project degraded lands in the watersheds of Mid-Himalayan region.

8.7.5 Market Potential of Forestry Interventions for Climate Change Mitigation

Role of forest plantations has been increasingly recognized as most cost effective option for climate change mitigation through carbon captured in biomass and soils. Carbon offset opportunities include reforestation, afforestation, farm forestry and improved soil management practices. Fulfilling their emission-limitation commitments under the Kyoto Protocol of UNFCCC, industrialized countries can claim credit for carbon captured in developing countries by executing Afforestation and Reforestation (AR) projects under Clean Development Mechanism (CDM) projects. Further, Government of India in its Nationally Determined Contributions (NDC) to UNFCCC also committed to create an additional carbon sink of 2.5 to 3 billion tonnes of CO₂ equivalent through additional forest and tree cover by 2030.

Among the various carbon standards, the CDM was the only one to see a decline in volume in recent years. The CDM was initially created as a compliance standard under the Kyoto Protocol, but the program faces an uncertain future that will be decided by upcoming negotiations of the Paris Agreement. Many CDM project developers have turned to the voluntary markets to try and find buyers (Forest Trends, 2019).

Among the leading voluntary carbon markets, Verra develops and manages standards that help the private sector, countries, and civil society achieve ambitious sustainable development and climate action goals. One of Verra's standard programs, the Verified Carbon Standard (VCS) program allows certified projects to turn their greenhouse gas (GHG) emission reductions and removals into tradable carbon credits. Since its launch in 2006, the VCS Program has grown into the world's largest voluntary GHG program. Outside of the Kyoto, LULUCF credits have been traded in voluntary market and voluntary carbon standard (VCS) is by far the largest standard in voluntary market.

Presently, The World Bank is among the few buyers of CDM forestry credits. With expiry of Kyoto Protocol and its replacement by new market mechanism under Paris Climate Agreement there is still large uncertainty about the forest carbon market. CDM is likely to be replaced under new Mechanism called Sustainable Development Mechanism with new set of rules and regulations.

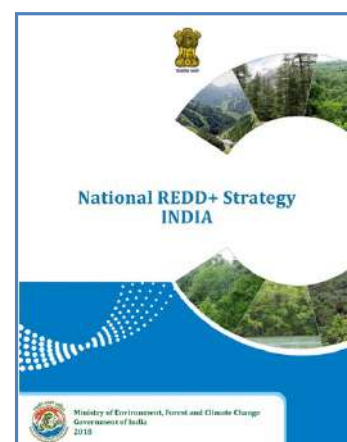
Box 8.1: Case Studies of Himachal Pradesh CDM – A/R Projects

Himachal Pradesh as a good example of CDM Afforestation Reforestation project registered with *UNFCCC* as 'Himachal Pradesh Reforestation Project – Improving Livelihoods and Watersheds'. The project implemented in Himachal Pradesh, India. The Mid-Himalayan Watershed Development Project (MHWDP) was implemented in the Siwalik Hills between 600 - 1800 m amsl, and covers 11 watershed divisions in 10 districts. The project is spread over an area of 2,22,951 ha and covers the catchments of major rivers - Ravi, Beas and Sutlej of Northern India. The project has been developed through a series of consultations with MHWDP and its stakeholder constituents namely, Forest Department, Government of Himachal Pradesh, local Gram Panchayats (GPs) and the World Bank. The project seeks to implement A/R CDM activities on 4,003.07 ha of degraded lands in the watersheds of Mid-Himalayan region. The four guiding principles of the project were: (i) adoption of native and locally preferred tree species for reforestation, (ii) involvement of the local GPs and small and marginal farmers in reforestation activities that will strengthen the ongoing watershed interventions, (iii) facilitation of technical, financial and capacity development support from MHWDP to reforestation activities, and iv) distribution of carbon revenue to the village community (GP and farmers).

Many of the project activities such as protection and management would involve participation of local Panchayats and their delegated Committees. The A/R CDM project is developed under the umbrella of the World Bank funded MHWDP Project and it expected to sequester 828,016 t CO₂-eq of t CERs over the first crediting period of 20-years. The Estimated emission reductions are 41400 metric tonnes of CO₂ equivalent per annum. The estimated CO₂ mitigation from the project is expected to be 10.34 tonnes of CO₂ per ha per annum.

8.7.6 REDD+ Potential for Enhancement of Forest Carbon Stocks

Reducing Emission from Deforestation and Forest Degradation in developing countries (REDD) along with conservation, sustainable management of forests and enhancement of forest carbon stocks is collectively referred to as REDD+. UNFCCC agreements on REDD+ 'Encourages developing country Parties to contribute to mitigation actions in the forest sector by undertaking the activities, i.e., (i) Reducing emissions from deforestation; (ii) Reducing emissions from forest degradation; (iii) Conservation of forest carbon stocks; (iv) Sustainable management of forest; and (v) Enhancement of Forest Carbon Stock. REDD+ is now widely recognized as financial incentive to the communities for their contribution in reducing greenhouse gas emissions from forests by encouraging aforesaid activities.



(i) Scope of REDD+ under forestry Interventions: There is ample scope and opportunities for integrating REDD+ initiative with the community managed forest and Joint Forest Management (JFM). Promoting and integrating REDD+ actions in JFM activities to increase sequestration of carbon stock will meet both national objectives of Climate Change mitigation and international obligations as a responsive member of international community.

(ii) India's National REDD+ Strategy: India's National REDD+ Strategy builds upon existing national programmes, which have been updated in line with India's National Action Plan on Climate Change, Green India Mission and India's Nationally Determined Contribution (NDC) to UNFCCC. India's National REDD+ Strategy has been aligned with the precepts of the National Forest Policy (NFP). The overarching objective of National REDD+ Strategy is to facilitate implementation of REDD+ programme in the country in conformity with relevant decisions of UNFCCC (MoEF&CC, 2018b).

Enhancement of Forest Carbon Stocks: Among the various REDD+ Activities, Enhancement of Forest Carbon Stocks is one of the REDD+ described in the National REDD+ Strategy. This approach could involve restoring carbon stocks in degraded forests, or creating forests in non-forest areas and approaches may include afforestation, reforestation, restoration i.e., through natural regeneration, assisted natural regeneration or planting, rehabilitation or forest landscape restoration. Thus, in the Indian context, enhancement of carbon stocks could be defined as 'conversion of non-forest or degraded forests to forests through afforestation, reforestation, restoration forestry and forest management practices, leading to enhancement of carbon stocks'. Large potential for implementing these activities exists in India. Agroforestry and farm forestry also have a potential to be included under this category of REDD+ activities. National Agroforestry Policy 2014 creates an enabling environment for this action.

New Initiatives like Forestry Intervention in Ganga River under Namami Gange and Forestry Interventions for Other Major River Catchments will contribute towards for Enhancement of Forest Carbon Stocks. This holistic approach of appropriate forestry interventions by way of protection, habitat management, afforestation, catchment treatment-soil and moisture conservation work, ecological restoration of vital riparian forest buffer, bio-remediation, improved livelihood of forest dependent communities and forest dwellers, and alternate income generation activities through regulated tourism and awareness for major river catchments has the potential to be developed as REDD+ Projects in these river basins. The National REDD+ Strategy recognises that the enhancement of forest carbon stocks attained through these actions shall also be considered for REDD+ actions.

8.8 Projected Reduction of CO₂ by Forestry Interventions in the Beas Riverscape, Himachal Pradesh and Punjab:

Restoration efforts of the Beas River Himachal Pradesh and Punjab through forestry Interventions will attempt to plant trees on 18599.5 ha in three landscapes viz., Natural, Agriculture and Urban in Beas Riverscape. The expected CO₂ mitigation benefits from the

proposed forestry interventions have been estimated following the IPCC (2003) Good Practice Guidance by using following formula:

$$C = [V \times D \times BEF] \times (1+R) \times CF$$

Where:

C=Carbon Stock in Biomass (tonnes C).

V=Stand volume ($\text{m}^3 \text{ ha}^{-1}$).

D= Basic wood density in tonnes d.m m^{-3} (Kaul *et al.*, 2009).

BEF= Biomass Expansion Factor (Default) (Kaul *et al.*, 2009).

R=Root Shoot Ratio (Default) (Kaul *et al.*, 2009).

CF=Carbon Fraction (Default value of 0.47 has been considered (IPCC 2006).

Carbon in the biomass has been converted into CO_2eq by multiplying with 44/12

The estimated Carbon Dioxide capture by the plantations raised through forestry interventions in the Beas Riverscape are presented in Table 8.6 and 8.7 after 10 and 20 years respectively. Assuming a modest productivity of plantations at $5 \text{ m}^3/\text{ha}/\text{year}$, the CO_2 captured by the plantations raised under the project will be capable of capturing 9.92 metric tonnes of $\text{CO}_2\text{eq}/\text{ha}/\text{year}$ which will be equal to 159219.67 tonnes of CO_2/year for the entire project area. The expected CO_2 reduction for 20 years period will be 3.18 million tonnes of CO_2eq . Thus forestry intervention for enhancing tree cover in the Beas Riverscape will also serve a major mode of CO_2 mitigation and will continue to make positive contribution towards climate change mitigation at local and regional scales. The estimate has been based on the assumption that the plantation shall be maintained for a minimum of 20 years with usual harvesting at scheduled intervals.

The proposed plantation raised under the forestry interventions will also contribute in capturing significant amount of CO_2 i.e., the GHG mainly responsible for global warming and will this contribute towards climate change mitigation among other co-benefits of the proposed plantations. The DPR intends to develop plantations for the purpose of seeking carbon credits under available market or non-market mechanisms. The agency executing the interventions shall explore the possibility of registering these plantations for the purpose of carbon credits under existing market/ non-market mechanisms under UNFCCC or any other robust carbon standard such as Verified Carbon Standards (VCS). This will help in facilitating determining the additionally of the project. One tons of Carbon Dioxide equivalent will generate one Carbon Credit. Thus the proposed forestry interventions in Beas Riverscape have a potential to generate 3.18 million tonnes of carbon credits as well over a span of 20 years.

Table 8. 6- Estimated Carbon Dioxide Capture by the Plantations Raised under Forestry Interventions in Beas Riverscape, Himachal Pradesh and Punjab (10 Years)

* Values taken from Kaul *et al.* (2009); **A conservative productivity rate of 5m³/ha/year has been considered assuming that the plantations will be maintained for at least 20 years

S.N .	Rive r basi n	State and Landscape NL= Natural Landscape, AL= Agriculture landscape	Propos ed area under Plantat ions (ha.)	Mean Wood density (Mg/cu. m)*	Estimate d Biomass assuming producti vity of 5 m ³ /ha/yr	BEF*	Ratio of below ground biomass to above ground biomass*	Estimated CO ₂ Reduction (metric tonnes CO ₂ Eq/ha/yr)	Estimate d CO ₂ Reductio n (metric tonnes CO ₂ Eq/ year)	Estimate d CO ₂ Reductio n (metric tonnes CO ₂ Eq/ year) in years	Estimated CO ₂ Reduction (metric tonnes CO ₂ Eq/ year) in 10 years**
1	Himachal Pradesh	Natural Landscape	7296	0.47	2.35	1.52	0.28	7.879356	57487.78	1149755. 6	919804.5
		Agriculture landscape	1671	0.47	2.35	1.52	0.28	7.879356	13166.4	263328	210662.4
2	Punjab	Natural Landscape	1020	0.7	3.5	1.57	0.27	12.02654	12267.07	245341.4	196273.1
		Agriculture landscape	3030	0.7	3.5	1.57	0.27	12.02654	36440.42	728808.4	583046.7
Total			13017					39.811792 (Mean)	119361.7	2387233	1909786.7

with usual harvesting/rotation schedule, *** Biomass Expansion Factor

Table 8. 7- Estimated Carbon Dioxide Capture by the Plantations Raised under Forestry Interventions in Beas Riverscape, Himachal Pradesh and Punjab (20 Years)

Sr. No.	Landscape	Proposed Area Under Plantations (ha.)	Mean Wood Density (mg/cu.m)*	Estimated Biomass Assuming Productivity of 5 m ³ /ha/year**	Bef**	Ratio of Below Ground to Above Ground Biomass*	Estimated Co ₂ Reduction (metric tonnes Co ₂ eq/ha/ year)	Estimated Co ₂ Reduction (metric tonnes Co ₂ eq/ year)
	1	2	3	4	5	6	7	8
Himachal Pradesh	Natural	7296	0.47	2.35	1.52	0.28	7.85	57273.6
	Agriculture	1671	0.47	2.35	1.52	0.28	7.85	13117.35
	Natural Regeneration	6310	0.47	2.35	1.52	0.28	7.85	49533.50
	Urban	138.5	0.47	2.35	1.52	0.28	7.85	1087.22
	Total	15415.5					7.85 (Mean)	121011.67

Sr. No.	Landscap e	Proposed Area Under Plantations (ha.)	Mean Wood Density (mg/cu.m)*	Estimated Biomass Assuming Productivity of 5 m ³ /ha/year**	Bef** *	Ratio of Below Ground to Above Ground Biomass*	Estimated Co ₂ Reduct ion (metric tonnes Co ₂ eq/ha/year)	Estimated Co ₂ Reducti on (metric tonnes Co ₂ eq/year)
Punjab	Natural	1065	0.7	3.5	1.57	0.27	12	12780
	Agricultu re	1845	0.7	3.5	1.57	0.27	12	22140
	Urban	274	0.7	3.5	1.57	0.27	12	3288
	Total	3184					12 (Mean)	38208
	Grand Total						19.85	159219.67

* Values taken from Kaul *et al.* (2009); **A conservative productivity rate of 5m³/ha/year has been considered assuming that the plantations will be maintained for at least 20 years with usual harvesting/rotation schedule, *** Biomass Expansion Factor

8.9 Potential Benefits of Plantation and Soil and Moisture Conservation Measures on Water Quantity and Quality

In Asia the millions of people are dependent on the rivers originating from the Himalayan Region for water resources. But anthropogenic activities and landuse changes are considered main culprits for the continuous degradation of water quality and quantity as well. In addition these rivers also carry the highest sediment loads of all world rivers Furthermore, climate change is also altering hydrology regimes and posing greater threat to this fragile ecosystem. In this scenario, forest catchments can play important role in regulating water flow, influencing the availability of water resources and maintaining the water quality (Bergkamp *et al.*, 2003). Therefore, the association between forests and water is a significant issue that must be given high importance.

The one of most important ecosystem services provided by forest ecosystems i.e. Watershed service is gaining acceptance with increased understanding of bio-physical modeling in the research and policy area. These forested catchments provide ahigh proportion supply of the water for domestic, agricultural, industrial and ecological needs in both upstream and downstream areas. Additionally, it also addresses many environmental problems caused by changes in aspects of the hydrological cycle in terms of water demand and quality. However, forest managers are facing challenges in implementing scientific management of forest catchment areas due to lack of recognition of the multi-sectorial forest benefits including regulation

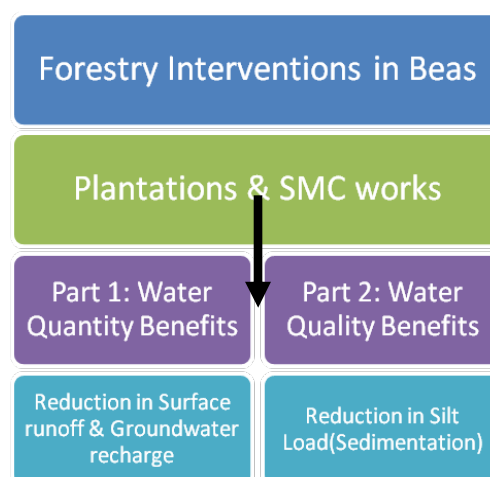


Fig. 8.3 - Benefit Assessment Framework

provision of water resources. It is also important to understand the “Green Water¹” role in the hydrological cycle.

To address this problem, there is vital need for formulating an efficacious plan for restoration and rejuvenation of the forest catchments of major rivers in India. This project is one of the important steps of the Ministry of Environment, Forest & Climate Change(MoEF&CC), Government of India(GoI) towards addressing this issue. The overall benefit assessment framework of the forestry intervention plan proposed in the Beas Catchment area/Riverscape will have 2 components namely; Water Quantity and Water Quality (refer Fig. 8.3).

- The first component will conservatively estimate the green water benefits of the proposed plantation and SMC works in the Beas Sub-basin using SCS Curve Number Method and Groundwater Estimation Committee Methodology, 2015 respectively.
- Second component will quantify the reduction of Silt load (Sedimentation reduction) in the Beas Sub-basin from the forestry interventions.

8.9.1 Component 1: Water Quantity Benefit Assessment

Under component 1, the proposed forestry interventions in Beas Riverscape Area has two major parts namely 1) Plantations & 2) SMC Structures (Table 8.6). The quantitative benefits of the activities are assessed in the following sections:

Table 8. 8- Proposed Forestry Interventions Activities in the Beas Sub basin

State	Riverscape area(ha)	Plantation Area (ha)	Estimated Excavation(Cu.Mt)
Himachal Pradesh	13,70,216	15,415.5	6,29,262.5
Punjab	3,04,085	3,184	2,97,053
Total	16,74,301	18,599.5	9,26,315.5

A: Reduction of Surface Runoff and Recharge from the Plantation Activities

Conceptual Model for Assessment: Water Balance Model The Water balance is based on the law of conservation of mass which states that any change in the water content of a given soil volume during a specified period must equal the difference between the amount of water added to the soil volume and the amount of water withdrawn from it. It helps to quantify the relationships between precipitation, surface and groundwater runoff, evaporation, transpiration, and aquifer drafts, and provides a framework for future planning of sustainable exploitation of the available water resources.

¹Green Water is a Green water is a picturesque name for the water available in the soil for plants and the soil biota i.e., microbes, earthworms, soil insects, etc. to use. It's the water absorbed by roots, used by plants and released to the atmosphere through a process called transpiration.

The water balance of a forest basin can be determined by calculating the input, output, and storage changes of water. The major input of water is from precipitation and major output is runoff. A complete water balance model (Fig. 8.4) may contain four sub-modeling systems describing the hydrologic cycle, namely, an atmospheric water balance sub-system; a surface water balance sub-system; a soil water balance sub-system; and a groundwater balance sub-system (Equation 1).

Depending upon the focus of the analysis, each sub-system can be modeled separately.

The general water balance equation is of the following form:

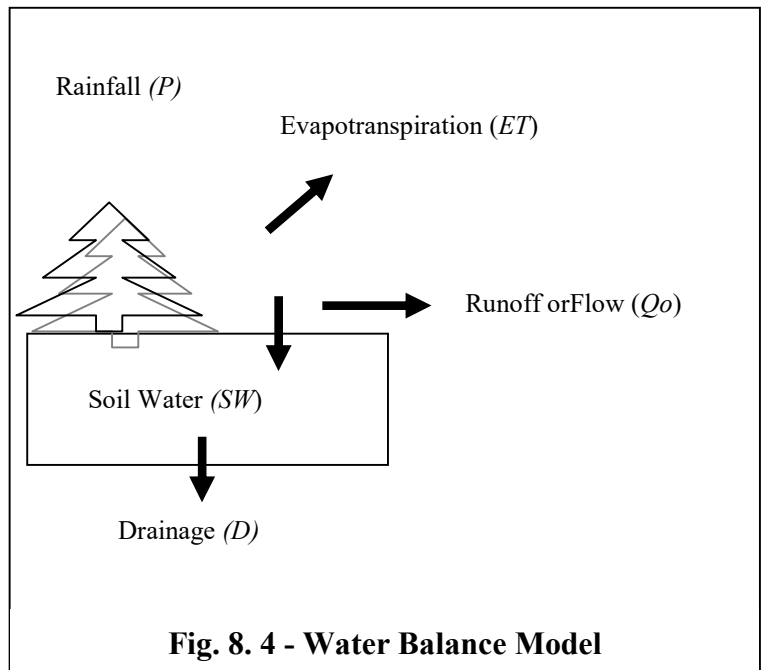
Equation 1

$$G+P = Q_{dsro} + Q_b + ET + \Delta S_g$$

Where, P = Precipitation; G=GlacialInflow; Q_{dsro} = direct surface runoff; Q_b = base flow; E_t = ET = evapotranspiration; ΔS_g = change in groundwater storage(in soil or the bedrock / ground water);

Assumptions:

1. Inflows from Precipitation and Glacial inflows would remain same for both scenarios.
2. Evapo-transpiration (ET) is the sum of evaporation and plant transpiration from the surface to the atmosphere. Evapo-transpiration is an important part of the water cycle. However, for understanding benefits, it is excluded from the calculations showing casing how forestry interventions can reduce surface runoff and improve recharge. In addition, it is also important



note that the ET values in the Forests are much higher than that of other landuse but provides ecological functions such as carbon storage, nutrient cycling, water and air purification, soil protection, microclimatic benefits and maintenance of habitat.

3. From the hydro geological point of view, it is observed that the groundwater occurs in confined (restricted) setting in joints, cracks, fissures, and fractures moving to deeper levels in the weathered zones. As the eastern and south-east part of the basin has already been overexploited in terms of CGWB classification and very low inter aquifers transfers between complex Basaltic Zones and Alluvial Plains, the changes in groundwater storage (S_g) is considered zero for computational purposes.

Equation 2

- Changes in Water Balance = Without Forestry Interventions –With Forestry Interventions
- Changes in surface runoff (Without Forestry Interventions Q_{dsro} - With Forestry Interventions Q_{dsro}) = Changes in base flow (With Forestry Interventions Q_b - Without Forestry Interventions Q_b).

Estimating Changes in Surface runoff (Without Forestry Interventions Q_{dsro} -With Forestry Interventions Q_{dsro})

There are many methods offered for Rainfall Runoff Modeling. Soil Conservation Services and Curve Number (SCS–CN) technique is one of the primogenital and simplest method for Rainfall Runoff Modeling (Kumar *et al.*, 2017). The surface water outflow from the Riverscape Area will be estimated by the Soil Conservation Service Curve Number (SCS-CN) model. The SCS-CN model is based on the single parameter Curve Number (CN) which depends on the land use, land cover, soil type and the antecedent moisture conditions prevailing in the catchment. The direct surface runoff has been estimated using the SCS-CN model given in Equation 3 and 4.

Equation 3

$$Q = \frac{(P - I_a)^2}{(P - I_a + S)} \text{ for } P > I_a ; \text{ and } Q = 0, \text{ for } P \leq I_a$$

Equation 4

$$S = \frac{25400}{CN} - 254$$

Where, P = rainfall; Q = direct surface runoff (mm); S = potential retention (mm); CN = curve number; I_a = initial abstraction;

Step 1: Annual Rainfall (P)

The annual rainfall varies from 1000 - 1700 mm in Himachal Pradesh Region and 800 - 1000 mm in Punjab Region of Beas Sub-basin. In this study we have taken the average rainfall in Beas Sub Region between years 1971-2004.

Step 2: Assessing CN = Curve Number

CN value for soils (Hawkins *et al.*, 2002) having high infiltration rates and for more than 58 mm precipitation conditions, Antecedent Moisture Conditions (AMC-III) are provided below: Considering the high altitude of the basin, AMC III wet conditions are assumed for the calculations. The parameters are given below.

CN Value

Land use	AMC	CN Value
Forest	AMC III	45
Barren/Waste/Agriculture	AMC III	77

Step 3: Calculation of (S) Potential retention (mm)

It is defined as the potential maximum retention after runoff begins. "S" aggregates all variation in the runoff response because of land use, soils, soil moisture, or rainfall pattern, duration, or intensity, plus any other variation into one variable.

Potential Retention

S = potential retention (mm)	With Forestry Interventions	Without Forestry Interventions
$S = \frac{25400}{CN} - 254$	310.4 mm	75.87mm

Step 4 Initial abstractions (I_a)

The initial abstraction consists mainly of interception, infiltration during early parts of the storm, and surface depression storage. The initial abstraction (I_a) is some fraction of the potential maximum retention (S) where in $\lambda = 0.2$ adopted as a standard value for general soils

Initial Abstraction

Landuse	With Forestry Interventions	Without Forestry Interventions
$I_a = \lambda S$	62 mm	15.174 mm

Step 5: Direct Surface Runoff (DSRO)

Direct Surface Runoff is the rain that runs off during the rain event as overland flow or in the vegetation cover above a soil.

Direct Surface Runoff

DSRO	With Forestry Interventions	Without Forestry Interventions
$Q_{dsro} = \frac{(P - I_a)^2}{P - I_a + S}$	842.69	1,059.72

Q = direct surface runoff (mm);

Step 6: Reduction in Surface Runoff and Changes in Base Flow

Base Flow consists of water that infiltrates into the soil and travels laterally down slope through upper soil layers, and groundwater flow that infiltrates and travels through the aquifer. The proposed forestry interventions will reduce surface runoff and increase groundwater recharge, which in turn increase the base flow. The changes in the base flow caused by plantation activity can also be called as “Green Water”.

Changes in Base flow Q_b (Green Water / reduction in runoff)

$$\begin{aligned} &= \text{Area} * (\text{Without Forestry Interventions } Q_{dsro} - \text{With Forestry Interventions } Q_{dsro}) \\ &= 18,599.5 \text{ ha (1,059.72 mm- 842.69 mm)} \end{aligned}$$

B. Groundwater Recharge from Soil and Moisture Conservation (SMC) Measures

Estimating groundwater recharge is important to measure effectiveness for water conservation measures. However, a site specific modeling approaches to forecast groundwater recharge typically requires observed historic data to assist calibration. It is generally not possible to physically observe groundwater recharge activities spreading over large areas. However, the Ground Water Resource Estimation Committee (CGWB GEC-2015) Methodology provides a simple assessment framework for the estimation of ground water recharge due to Soil Moisture Works (SMC). In the present study, this methodology will be employed to project groundwater recharge from the proposed SMC activities.

Assessment Framework

Recharge due to Water Conservation Structures is estimated based on the following formula (GEC 2015).

Equation 5 (cgwb.gov.in):

$$RWCS = GS * RF$$

Where:

- RWCS = Recharge due to Water Conservation Structures
- RF = Recharge Factor;
- GS= Gross Storage= Storage Capacity X No. of Fillings

Step1: Estimating Gross Storage

Storage Capacity: $AWSA * H * \text{Efficiency} * \text{Number of fillings}$

- AWSA = Storage potential created through excavation
- Efficiency of the structures
- Number of Fillings= Number of fillings during the rainfall season
- H= Height

Conservative Assumptions

- SMC Activities proposed in the Riverscape Plan
- Efficiency: = 50% ; Recharge due to Check Dams and *Nallah* Bunds can be taken as 50% of gross storage (assuming annual de-silting maintenance exists) considering leakages & other factors
- Number of fillings assumed to be 8, considering 30- 50 rainy days in the Beas River basin
- $AWSA * \text{Height} = \text{SMC Excavation Quantity and Multiplier factor of 2 applied for calculating the Storage Potential from Area under SMC.}$

Table 8. 9- SMC Activities under Forestry Interventions

State	Area under SMC works ('000 Cubic Meter)	Storage potential created through excavation ('000 Cubic Meter)	Number of Fillings	Efficiency	Gross Storage ('000 Cubic Meter)
Himachal Pradesh	629.26	1,258.52	8	50%	5,034.08
Punjab	297.05	594.10	8	50%	2,376.4
Total					7,410.48

Step 2: Recharge Factor

Expected Groundwater Recharge = Gross storage * Recharge Factor

RF = Recharge Factor as per GEC, 2015 norms

State	Gross Storage ('000 Cubic Meter)	Recharge Factor (%)	Expected Groundwater Recharge ('000 Cubic Meter)
Himachal Pradesh	5,034.08	10%	503.4
Punjab	2,376.4	10%	237.6
Total			741.04

Step 3: Expected Groundwater Recharge

Total Groundwater Recharge = 7,41,048m³

Expected Groundwater recharge from the SMC structures is 0.7 MCM

The Forestry Interventions activities will conserve 41.06 MCM (Million Cubic Meters) water annually.

Table 8. 10- Potential Benefits of Forestry Interventions for Water Quantity in Beas Riverscape, HP and Punjab

Benefits of CAT activities	Component 1: Water Quantity	Plantations	40.36 MCM Water Savings
		SMC works	0.7 MCM Groundwater Recharge
		Total	41.06 MCM

8.9.2 Component 2: Water Quality

Water quality of Beas Sub-Basin is excellent. It deteriorates slightly towards downstream, due to heavy abstraction and discharge of pollutants, but remains very much within permissible limits. Below figure shows schematic representation of some of the main influences on water quality within a river basin (Owens *et al.*, 2004), Water and sediment of the river exhibit seasonal as well as spatial variability, which is contributed by geological, climatologically and anthropogenic factors. However, many a times, it is difficult to assess the contribution from different sources because of different geological terrain and complex variation in weathering, erosion, transport and anthropogenic activities operating in the river catchment. The legacy data of silt rate provides a realistic estimate for the sediment rates from the basin.

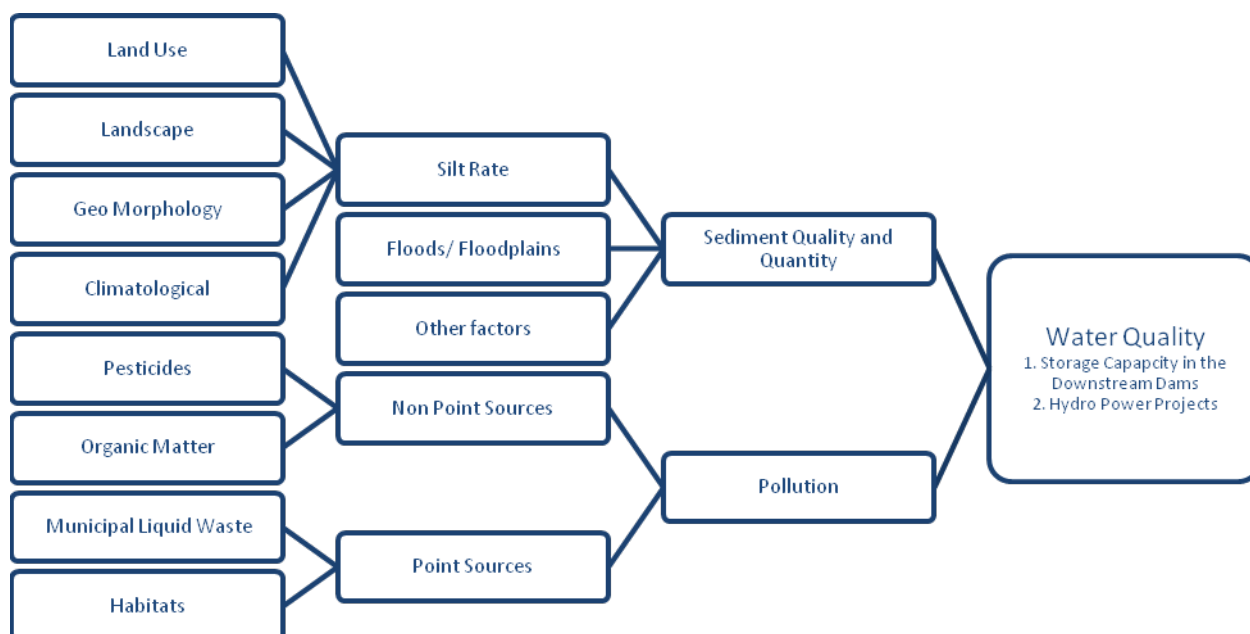


Fig. 8. 5: Main Influences on Water Quality
(Source: Owens *et al.*, 2004)

As per India-WRIS database, there are 9 surface water quality observation stations installed in the Indus River Basin. These stations provide surface water quality in the basin. As per the monitoring results of 2009, the water quality is excellent; however, organic pollution is the predominant reason of pollution in these water resources. Biochemical Oxygen Demand (BOD) and Coliform Bacterial Count are the major indicators of extent of water quality degradation.

Role of Forest Catchments: Forest catchments have often been described as ‘Sponges’ storing rain water and slowly releasing it to maintain groundwater and streams during dry periods (Hamilton and King, 1983). Despite the recognition that trees can improve soil hydraulic conductivity and reduce overland water flow (Sandstorm, 1998), their contribution towards groundwater recharge and improvement of water qualities often understated. In the long term, one of the most important ways in which forest catchments can influence water quality is through their effect on absorbing rainfall variability and seasonal climate variations. It is one of the key factors that influences sediment yield from a given basin. If lands are degraded and soils are unstable, rainstorms can lead to heavy sedimentation from riversheds. Under any given condition, forest catchments have an important impact in reducing sediment yield from watersheds (Conroy *et al.*, 2001).

The Indus river basin is one of the most depleted basins in the world (Sharma *et al.*, 2010). During certain periods of the year, water even does not really reach the sea any more, making it a closed basin (Molle *et al.*, 2010). Rapid population growth, increasing urbanization and industrialization, environmental degradation are the prominent challenges in sustainable water resource management in the said region.

Flooding, erosion and high sedimentation in the region lead to rise of riverbeds between their embankments and also impacting the capacity if reservoirs. The rehabilitation of some forest watersheds can dramatically reduce the rate at which sediments are delivered to a reservoir.

These sediment yields will be calculated by standard extrapolation techniques from previous measurements (Trimble, 1999) (Equation 6).

Equation 6:

Sediment Load = Catchment area * Sediment factor * Trap Efficiency

Step 1: Catchment Area

The Beas River Basin covers an area of 19,002 ha. Out of this, 16,743 ha area is selected for the riverscape management under the proposed project.

Step 2: Sediment Factor

The evaluation of sediment inflow has been always difficult because the sediment content varies considerably for a same river according to the flow and the season. In addition, it also requires complex sediment modeling based on the land use assumptions; besides requires huge time and resources for measurement. Further, the results cannot be very precise and there would be associated uncertainties. However, based on the sedimentation legacy data at the project locations, most reliable sedimentation assessments may be provided. The average siltation rate in Beas Sub-basin is given below.

Average Silt Rate in Beas Sub-basin

State	Major Reservoir	Observed Sediment Rate
Himachal Pradesh	Pong Reservoir	1.943
Punjab		

Source: CWC Compendium on Silting of Reservoirs in India, 2015

Step 3: Trap Efficiency

The rate of sediment production in the catchment area and the actual rate of silting depends on many other factors viz. gradation of silt, maintenance of structures etc. Therefore, we conservatively estimate 90% efficiency of the CAT activities.

Step 4: Estimated Sediment Reduction through Forestry Interventions in Beas Riverscape, Himachal Pradesh & Punjab

Table 8. 11- Sedimentation Estimation

State	Sedimentation factor (000' m ³ /Year)	Trap Efficiency	Total CAT Intervention Area(km ²)	Sedimentation('000 m ³ /Year)
Himachal Pradesh	1.943	0.9	154.15	269.56
Punjab	1.943	0.9	31.84	55.68
Total	1.943	0.9	185.99	325.24

*Assumption: Plantation area has been considered as Intervention Area for the above calculations.

The forestry interventions will reduce 3, 25,240m³ of sedimentation annually.

Monitoring Framework

Component	Parameters	Indicators	Time frame	Rationale
Water Quantity	Water Augmentation through Plantation Activities	Normalized Difference Vegetation Index (NDVI)	Annual	Precise monitoring of improvement in the recharge rates from the forestry interventions is only possible with the availability of historical hydrographs from the Piezometers, recordings from the River Gauging Stations and forestry interventions implemented at the landscape level. Therefore, it is not possible to directly measure these indicators in the present context. However, for all practical purposes, NDVI and NDWI can be used as proxy indicators for monitoring the benefits of the forestry interventions
	Groundwater Recharge from SMC Measures	Normalized Difference Water Index (NDWI)	Pre & Post Monsoon	
Water Quality	Silt Rates	NDVI & NDWI		

Note

- The **Normalized Difference Vegetation Index (NDVI)** quantifies vegetation by measuring the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs).
- The **Normalized Difference Water Index (NDWI)** is known to be strongly related to the plant **water** content. It is therefore a very good proxy for plant **water** stress. The **Normalized Difference Water Index (NDWI)** is a satellite-derived **index** from the Near-Infrared (NIR) and Short Wave Infrared (SWIR) channels.

8.10 Livelihood Generation from NTFP's and Man-days Generated through Forestry Interventions in Beas Riverscape

(i) Potential Benefits from NTFPs (Herbaceous Medicinal Plants)

North-Western Himalaya is having the distinction of being one of the richest repositories of medicinal and aromatic plant resources in the country. Himalayan herbs in fact have received unprecedented attention the world over mainly to their uniqueness and high medicinal value. Medicinal and aromatic plants sector has traditionally occupied an important position in the socio cultural, spiritual and medicinal arena of rural and tribal lives in the region. They have traditional rights to collect medicinal herbs as Minor Forest Produce (MFP) or NTFPs (Non-Timber Forest Products) in designated forestland (Anderson, 1886) and have been an important source of income to the natives (Dobriyal *et al.*, 1997; Tondon, 1997; Badola, 1998, 2002). NTFPs cover all forest products other than major forest products. NTFPs of commercial importance in India may be divided into the following classes; (i) fibers and flosses; (ii) grasses i.e., other than oil-producing grasses, bamboos and canes; (iii) essential oils i.e., including oil-yielding grasses; (iv) oil seeds; (v) tans and dyes; (vi) gums, resins, and

oleo-resins; (vii) drugs, spices, poisons and insecticides; (viii) edible products and (ix) minerals and miscellaneous products (FRIC,1972).

The natural resources in forest provide food, fodder, medicine, clothes, house building materials to human civilization. It is estimated that 275 million poor rural people in India i.e., about 27 % of the total population depend on NTFPs for at least part of their subsistence and cash livelihoods (Malhotra and Bhattacharya, 2010; Bhattacharya and Hayat, 2009). This dependency is particularly intense for half of India's 89 million tribal people, who live in forest fringe areas. According to an estimate the NTFPs sector alone is able to create about 10 million workdays annually in the country (Anonymous, 2011). NTFP contributes to about 20 - 40% of the annual income of forest dwellers who are mostly disadvantageous and landless communities with a dominant population of tribals. It provides critical subsistence during lean seasons, particularly for primitive tribal groups such as hunter gatherers and the landless. Most of the NTFPs are collected and used/sold by women, so it has a strong linkage to women's financial empowerment in the forest-fringe areas (Anonymous, 2011). In view of their ever increasing demand there is urgent need to grow and propagate the species in ex-situ and in-situ conditions. It will help not only in fulfilling the demands but will eventually conserve the resource from bio-diversity point of view.

The estimated values of medicinal plants, average value per hectare from various was calculated following previous works (Singh, *et al.*, 2013; Meena and Shukla, 2003; NMPB, 2004; Samant *et al.*, 2008). The different proposed plantation models in present DPR envisages planting of native species of trees, shrubs, grasses and NTFP's for rejuvenating river and its tributaries. If sustainable harvest practices and beating up of medicinal plants in the intervention areas are followed, two more harvesting i.e. on 7th year and 10th year can be obtained. In temperate to alpine zones, the average values per hectare were assumed after taking survival rate as 60%. The harvesting of plants is taken as 50% after rotation period of 3.5 years. In 7th year of harvesting schedule, 50% of the remaining part of 3.5 year and in 10th year of harvesting schedule, 40% of the remaining part of 7th year is considered. In tropical and sub-tropical areas, the crop harvesting has to be done after rotation period of 1.5 year. The estimated income from growing, selling and extracting NTFP's from medicinal herbs in Beas Riverscape through forestry interventions is presented in **Table 8.11**.

Table 8. 11- Estimated Income Generated through NTFP's in Himachal Pradesh

State	Model Name	Model No.	No. of Herbacious medicinal plant	Area in Hac	Rate Per Hactre	Estimated income after 3.5 years in Lakhs	Estimated income after 7 years in Lakhs	Estimated income after 10 years in Lakhs	Grand Total of Income in Lakhs
Himachal Pradesh	Sub-Alpine Enrichment	BS/HP/N L/02	800	60	3200	1.92	0.96	0.77	3.65
	Temperate Mixed	BS/HP/N L/03	1600	62	6400	3.97	1.98	1.59	7.54

	Forest								
	Temperate Mixed Forest	BS/HP/NL/04	1600	600	6400	38.40	19.20	15.36	72.96
Total				722		44.29	22.14	17.72	84.15

(ii) Man-days Generation: Forestry intervention activities in Beas Riverscape will create employment opportunity for local population. A total of **18214063** man-days will be generated during 10 years of the project period. Of which, 16491090 man-days will be generated during first five years i.e., establishment phase (Phase -I) and 1182213 man-days will be generated during maintenance phase i.e., Phase-II. Year Wise details of man-days to be generated are presented in **Table 8.12**.

The summary of the accrued potential benefits from forestry interventions in Beas Riverscape is presented in **Table 8.13**.

Table 8. 12 Total Working Man-days to be generated during Phase-I and Phase-II in Beas Riverscape

States	Activity	Year											Total	Cost
		Phase I					Total	Phase II					(Rs. in Lakh)	(Rs. in Lakh)
		I	II	III	IV	V	Phase I	VI	VII	VIII	IX	X	Phase II	Phase I+II
Himachal Pradesh	Natural Landscape	243058	1093215	1515565	1299812	821207	4972857	532370	309460	117145	21336	0	980311	5953168
	Fire Protection	1130720	1030460	336020	197570	150710	2845480	60260	0	0	0	0	60260	2905740
	Agriculture Landscape	37584	58992	79920	59406	40614	276516	20514	0	0	0	0	20514	297030
	Urban Landscape	167796	199080	110942	64744	28858	571420	4920	0	0	0	0	4920	576340
	Soil Moisture Conservation	1372660	1252470	1179661	692188	476188	4973167	0	0	0	0	0	0	4973167
	Other Intervention	76480	105040	78080	52080	36720	348400	10800	0	0	0	0	10800	359200
Punjab	Natural Landscape	18925	55404	164826	223210	175191	637556	67291	17498	2530	0	0	87319	724875
	Agriculture Landscape	112300	155670	180210	146530	89880	684590	37800	0	0	0	0	37800	722390
	Urban Landscape	70772	98603	63361	33901	16811	283448	3889	0	0	0	0	3889	287337
	Soil Moisture Conservation	304758	346278	339954	193148	147378	1331516	0	0	0	0	0	0	1331516
	Other Intervention	21970	25040	17120	10470	7100	81700	1600	0	0	0	0	1600	83300
Total		3557023	4420252	4065659	2973059	1990657	17006650	739444	326958	119675	21336	0	1207413	18214063

Table 8. 13- Accrued Potential Benefits from Proposed Forestry Interventions

Sr. No.	Potential Benefits	Quantity
A.	Biomass, Carbon Stock, CO₂ reduction and Carbon Credit	
1	(i) Biomass production in 14981 ha area of five landscapes of Himachal Pradesh after 20 years (t/ha/year)	2.35
	(ii) Biomass production in 9468 ha area of three landscapes of Punjab after 20 years (t/ha/year)	3.5
2	Total biomass production from after 20 years (tonnes)	1218676.0
3	Contribution to Carbon Stock from 24449 ha areas of five landscapes of Himachal Pradesh and three landscapes of Punjab after 20 years (in metric tonnes)	1129427.31
4	Estimated CO ₂ reduction from forestry interventions after 20 years (in metric tonnes of CO ₂ eq/ha/year)	8.64
5	Estimated CO ₂ reduction from forestry interventions from 24449 ha in five landscapes of Himachal and three landscapes of Punjab after 20 years (metric tonnes CO ₂ eq/ year)	207061.69
6	Expected CO ₂ reduction after 20 years period (million tonnes of CO ₂ eq.)	4.14
7	Potential to generate carbon credit from plantation of 24449 ha in five landscapes of Himachal and three landscapes of Punjab over a span of 20 years	4.14
B.	Water Quality and Quantity	
9	Water Quantity: Conservation of water through forestry interventions (Million Cubic Meter/Year)	41.06
10	Water Quality: Estimated sediment reduction through forestry interventions ('000 m ³ /Year)	325.24
C.	NTFP's (Herbaceous Medicinal Plants)	
11	The estimated benefit from NTFP's i.e., herbaceous medicinal plants from 722 ha area of natural landscape in Beas Riverscape after ten years (Rs in Lakhs)	84.15
D.	Man-Days to be Generated	
12	Generation of employment from plantation activities and other conservation interventions (Total man-days in Phase I and Phase II)	18214063

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Annexure 1: Logical Framework Analysis – The Beas Riverscape Management

Project Strategy	Objectively Verifiable Indicators				
Project Objectives and Outcomes	Project Output	Target	Indicator	Source of Verification	Risks and Assumptions
Project Goal - 1	Riverscape Management: Aiming holistic riverine landscape (riverscape) approach for sustainable management of Beas River, its banks, or its riparian areas, within its fluvial system.				
Outcome 1: Creation of an enabling environment for climate resilient, sustainable terrestrial, aquatic (river and wetlands), and floodplain ecosystem management.	Project Objective 1: To promote an enabling environment for sustainable land and river ecosystem-based management approaches focusing on reduced soil erosion, enhanced forest/vegetation cover in the buffer zone, enhanced connectivity and e-flow, and ecological rejuvenation of river Beas and its tributaries.				
	Output 1.1 Enhanced levels and enabling environment created for: (a) multi-sector convergence, alliances, and integration; (b) favourable national and state level policies (forests, agriculture, animal husbandry, watershed management, river management, tribal welfare, infrastructure development, and tourism) those reflect principles of climate resilience, sustainable land and ecosystem management, and mainstreaming biodiversity concerns in production sectors.	The target is to create an enabling environment wherein multiple agencies/sectors working for various production sectors converge and adopt climate resilient and sustainable approaches of land and ecosystem management by mainstreaming biodiversity concerns. Various concerned sectors also work together so as to address gaps and inadequacies in realizing global and national policy objectives relevant to environment, biodiversity, water resources, climate change, and sustainable development.	Integration and convergence of line agencies and various production sectors initiated and notable progress made. Communities mobilized and their active engagement ensured. Biodiversity concerns mainstreamed in production sectors. Gaps and inadequacies in various policies reviewed and actions initiated to address them.	Periodic reports, proceedings of consultative process (workshops, meetings, seminars, etc). Mid-term and final independent evaluations.	Lack of enthusiasm on the part of stakeholders, inadequate sectoral integration, and lack of community participation in the implementation of existing and proposed policies and laws relating to conservation might hinder the promotion of local decision making and also their active engagement in the conservation agenda. Participation of communities particularly marginalized groups is weak due to a fear that their access to natural resources is going to be curtailed or restricted in ways that reduce the income they can derive. Conflict between conservation and local community needs might create difficulty in achievement of intended outcomes. Sectoral departments/agencies are reluctant, not open to integrate/cooperate for

Project Strategy	Objectively Verifiable Indicators				
Project Objectives and Outcomes	Project Output	Target	Indicator	Source of Verification	Risks and Assumptions
					climate resilient and sustainable land and ecosystem management approaches. Project benefits are not captured by intended beneficiaries due to lack of adequate measures, transparency, and appropriate compensation measures. Inadequate and inaccurate flow of information may result in misconceptions about the project and hence lead to opposition/non-participation by some agencies and CSOs. Sectors/agencies primarily responsible for reduced e-flows are rigid, and continue with conventional approaches resulting into fragmentation of rivers, reduced e-flows, and decline in water quality.
	Output 1.2 Capacity of government officials and civil society organizations is developed in promoting community driven, climate resilient, sustainable land and ecosystem	Capacity of agencies, government officials and CSOs for sustainable land and ecosystem management, ecological rejuvenation and ecological integrity of river ecosystem is built.	Training need assessment carried out. Appropriate training learning material developed. Planned awareness and specialized training programmes on priority themes for various target	Periodic reports, appraisal of training schedules, learning material and feedback obtained from trainee participants. Mid-term and final independent	The concept and need of sustainable land and ecosystem management, and climate and its likely impact are not well appreciated by CBOs/different sectors and agencies. The implementing agencies are new to the subject and expected outputs

Project Strategy	Objectively Verifiable Indicators				
Project Objectives and Outcomes	Project Output	Target	Indicator	Source of Verification	Risks and Assumptions
	approaches, and holistic approach to management of river ecosystem.		groups successfully organized. Number of government staff and CSO representatives trained in climate resilient ecosystem management approaches.	evaluations.	and outcomes and also widespread with limited financial management and technical capacity. Lack of interest and support for conservation might result in limited use of training facilities and opportunities. There are flaws in training need assessment and designing appropriate training programmes. Thus, trainings are not appealing and having desired impact.
Project Goal-2	Aviral Dhara, Nirmal Dhara, Ecological Rejuvenation and Biodiversity Conservation: Aim to address the drivers and stressors of river ecosystem and promote sustainable use by balancing ecological needs with livelihood needs.				
Outcome 2: Inter-agency and civil society driven, climate resilient approaches for appropriate forestry and other interventions demonstrated in adequate extents of natural, agriculture, and urban landscapes of the riverscape.	Project Objective 2: To carry out appropriate forestry interventions to restore river connectivity, enhance e-flow, improve water quality, and conserve the terrestrial and aquatic biota within the Beas riverscape.				
	Output 2.1 Plans to reduce/check erosion in the mountainous region and floodplains of Beas and its tributaries by appropriate soil and moisture conservation works and development of optimal strategy for riverbed mining. Sites of landslides are	Various soil and moisture conservation strategies and works in target area of 926315.5 m ³ proposed to be implemented.	Reduced erosion in the hilly tract, reduced and stabilized landslides, decreased bank erosion, and reduced sedimentation rate. Enhanced moisture regime and flow in streams and rivers.	Appraisal of reports on soil and moisture conservation works undertaken, site visits and field observations and assessments, monitoring reports on sedimentation.	Occurrence of natural calamities (e.g. cloudburst, flood, drought, earthquake, landslides, etc). Increase in biotic pressure and enhanced developmental activities (hydropower and road networks) in upstream area without adequate catchment area treatment.

Project Strategy	Objectively Verifiable Indicators				
Project Objectives and Outcomes	Project Output	Target	Indicator	Source of Verification	Risks and Assumptions
	adequately treated and stabilized				
	Output 2.2 Plans for restored and sustainably managed forest lands, agriculture lands in targeted villages and forestry interventions in urban environment for improved forest/vegetation cover achieved. Enhanced assisted natural regeneration through improved protection and other measures.	Forestry interventions by way of various plantations under different treatment models to be undertaken. Plantations in 14671 ha natural landscapes, 3516 ha in agriculture landscapes, and 412.5 ha in urban landscapes are established and maintained.	Reduced biotic pressure on forests and improved regeneration. Improved forest cover in forest lands and TOFs in two States. Reduction in fuelwood extraction pressure on surrounding forests. Increase in average fodder yields, livestock grazing pressure reduced. Perennial vegetation cover increased on degraded lands. Private/community lands mobilized for reviving forest cover, enhancement of ecosystem health and services. Rejuvenation and renovation of existing community-based watershed structures.	Field level assessments and verification. Periodic reports on plantation works carried out. Biennial assessment on forest cover by FSI for two States.	Non-availability of suitable nursery techniques, planting material, inadequacies in plantation works i.e. preparation of plantation site, excavation of pits, poor quality of planting material, inadequate protection and constraints of watering, damage by livestock/wildlife, etc. Non-availability of lands (natural/agriculture/urban) for plantations and non-committal and inadequate support of local communities/farmers/urban agencies. Occurrence of natural calamities (e.g. cloudburst, flood, drought, etc.).
	Output 2.3 Plans for improved protected area management by implementing appropriate protection	Strategies for improved PA management implemented, weed control works undertaken, research on priority themes	Improved protected area management and enhanced management effectiveness. Increased diversity and abundance of	Appraisal of periodic reports and reports of mid-term and terminal evaluation. Report on	Increased biotic pressure and adverse impact of developmental projects. Increased human-wildlife conflict and non-compatible land use in surrounding

Project Strategy	Objectively Verifiable Indicators				
Project Objectives and Outcomes	Project Output	Target	Indicator	Source of Verification	Risks and Assumptions
	strategies, habitat management (e.g. weed control and water management), research and monitoring inputs, and enhanced capacity.	planned and undertaken. Periodic ecological and socio-economic monitoring carried out. Training of frontline/PA staff and other stakeholders planned and implemented.	species. Enhanced conservation values (e.g. catchment value, carbon sequestration, environmental amelioration, etc). Reduced human-wildlife conflict.	Management Effectiveness Evaluation (MEE) for respective PAs. Reports on ecological and socio-economic monitoring.	lands. Inadequate support of local communities and their engagement. Occurrence of natural calamities (e.g. cloudburst, flood, drought, earthquake, landslides, etc).
	Output 2.4 Plans for improved management of prominent wetlands in the riverscape by protection, restoration, zoning, habitat management, and wise use of wetland resources.	Improved wetland management and sustainable use of wetland resources implemented.	Improved and effective management of wetlands accomplished. Wetland habitats restored, effective zone planning accomplished and sustainable wise use of wetland resources promoted.	Periodic reports, appraisal of conservation/ management plans. Site visits and field level assessments. Questionnaire survey and stakeholder consultations.	Enhanced biotic pressure, waste disposal, and more effluents, unsustainable harvests, natural calamity (flood and heavy siltation). Inadequate support of local communities.
	Output 2.5 Plans for improved riverfronts and development of eco-parks.	Riverfronts and eco-parks to be developed.	Improved riverfronts, effective eco-parks, reduced erosion.	Site visits and observations, periodic reports.	Non-compatible land use in surrounds of riverfronts/river, enhanced biotic pressure on eco-parks, damage of riverfronts by excessive floods and mass congregation.
	Output 2.6 Plans for development of forest and river-based ecotourism.	Forest and river/ water resource-based ecotourism.	Healthy forests and rivers/ water resources are maintained. Reduced biotic pressure, ecologically sustainable, and socio-economically viable tourism developed.	Appraisal of periodic reports and ecotourism plans. Site visits and field assessments. Feedback from tourists.	Natural resources are depleted and degraded. Uncontrolled and unregulated mass congregation and adverse impacts.

Project Strategy	Objectively Verifiable Indicators				
Project Objectives and Outcomes	Project Output	Target	Indicator	Source of Verification	Risks and Assumptions
Project Goal -3	Improved Ecosystem Services and Sustainable Livelihoods: This goal aims to specifically seek enhanced ecosystem services and sustainable livelihoods.				
Outcome 3: Enhanced ecosystem services from natural (forest, river, and wetland ecosystems), agroecosystem and urban landscapes	Project Objective 3: To promote improved ecosystem services and support sustainable livelihood opportunities for local communities, particularly forest dwellers and fishermen.				
Outcome 4: Sustainable livelihoods, particularly of forest dwellers and fishermen	Output 3.1 Plans for reduced traditional forest dependence, developed alternate income generation activities, improved livelihoods, and facilitate establishment of viable Small and Micro-Enterprises (SMEs).	Reduced traditional forest dependence and alternate income generation options developed. Improved livelihoods and well-established small and micro-enterprises.	Sustainable livelihoods by way of improved/enhanced natural resources, effective social institutions, better physical assets, enhanced incomes, improved and skilled human resource, reduced vulnerability, well established SMEs. Change in proportion of project participants who are living above the poverty line. Increase in earnings of families from involvement in sustainable management of degraded forest lands. Number of women participants in SMEs increased. Curtailment of distressed migrations. Number of SMEs operationalized.	Household surveys, periodic reports, field level assessments, evidences on reduced conflicts, etc.	Enhanced and frequent natural calamities, external market forces and impact of globalization, neglect and over exploitation of natural resources by local communities.
	Output 3.2 Plans for enhanced levels of protection,	Conservation and sustainable harvests practices implemented	Diversity, abundance, and productivity of medicinal and aromatic plants in	Appraisal of periodic reports, site visits, and field level	Inadequate marketing strategies and mechanisms. Fluctuating market

Project Strategy	Objectively Verifiable Indicators				
Project Objectives and Outcomes	Project Output	Target	Indicator	Source of Verification	Risks and Assumptions
	conservation, and sustainable harvests of medicinal and aromatic plants and development of herbal gardens.	for in situ and ex situ conservation of medicinal and aromatic plants.	wild are enhanced. Herbal gardens developed.	assessments.	demands, supply, and market rates.
Project Goal 4	Effective Implementation, Knowledge Management, and Innovative Approaches: This goal aims to ensure effective implementation of the project, knowledge management, development of innovative approaches (nursery techniques, afforestation, bio-filters and bioremediation), and adopt modern technology.				
Outcome 5 Capacities for adaptive management, learning, and replication of project lessons are developed.	Project Objective 4: To adopt, integrate and implement innovative approaches and modern technology for rejuvenation of Ganga and its tributaries, knowledge management, enhanced capacity, and monitoring and evaluation.				
	Output 4.1 Plans developed for integrated, science based, and community-based monitoring and assessment of impacts, as well as periodic evaluation of the project.	Improved research and monitoring capacity targeted. Adaptive management approach being implemented.	Improved research infrastructure, well designed monitoring system, enhanced scientific capacity, and effective documentation and dissemination of research and monitoring findings. Local level monitoring mechanisms setup. Learnings on best practices and models disseminated within and outside project villages.	Project/research and monitoring reports. Peer reviewed publications, databases, improved natural resource management.	Inadequate support for research and monitoring, lack of incentives, inordinate delays in research permissions, isolationist approach of research and monitoring, inadequate management oriented research.
	Output 4.2 Plans for documentation of lessons learned and preparation of information dissemination products for wider audiences and	Innovative approaches for adaptive management of natural resources, particularly river ecosystem targeted. Successful implementation of community	Successful and effective NRM and river management. Documentation of successful approaches in project design, development, and implementation. Case study on best practices	Reports and periodic evaluation. Case studies and lessons learned, publications, and other documents.	Ineffective research and monitoring and adaptive management approaches. Lack of support for scaling up of riverscape conservation approaches. State level

Project Strategy	Objectively Verifiable Indicators				
Project Objectives and Outcomes	Project Output	Target	Indicator	Source of Verification	Risks and Assumptions
	applicability.	driven management of natural resources and river ecosystems implemented.	developed.		implementing agencies and partner organizations lack capacity to coordinate and monitor project effectively and ensure timely fund flows to landscape/plantation/treatment sites.

Annexure 2:

Set - I

PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR REJUVENATION OF INDUS RIVER BASIN THROUGH FORESTRY INTERVENTIONS

PROFORMA OF DATA COLLECTION FOR PROPOSED SITE HIMALAYAN FOREST RESEARCH INSTITUTE, SHIMLA, HIMACHAL PRADESH

(INDIAN COUNCIL OF FORESTRY RESEARCH & EDUCATION, DEHRADUN-248006)

A. FORESTRY INTERVENTIONS	NATURAL LANDSCAPE
B. MODEL NO.	<i>BS/HP/NL/08-Sub-TROPICAL DRY DECIDUOUS FOREST</i>

C. TREATMENT SITE (DETAILS)		
1.	NAME OF SITE	CPS Jhikli Kothi Smloti Beat
2.	AREA (IN HECTARE)	5
D. GEOGRAPHICAL DETAILS		
1.	Name of River	Satluj Chenab Ravi Beas Jhelum
2.	State	Himachal Pradesh ☐ Punjab ☐ Jammu & Kashmir ☐
3.	District	Kangra
4.	Forest Circle	Dharamshala
5.	Forest Division	Dharamshala
6.	Forest Range	Mallan
7.	Forest Block	Samloti
8.	Forest Beat	Samloti
9.	Development Block Name	Nagrota Bhagwan
10.	Tehsil	Nagrota Bhagwan
11.	Panchayat	Palah Chaku

E. BASELINE DATA		
1.	Current Status of Flora and Fauna	Chil,Khair others B/Leaves Samber, Kakked, Wildboar etc.
2.	Current land use	Grazing
3.	Legal Status of land	Forest land
4.	Geology and Soil type	Sandy Loam Mixed with Gravel
5.	Slope	Modreate to Steep
6.	Aspect	Northen to Western

7.	Average Annual Rainfall (in mm)	2500 m			
8.	Special features of the site e.g. fire prone / landslides / mining areas / avalanche etc.	Fire Prone /Landslides			
9.	Distance from Road (Approximate)	0.00			
10.	Distance from Main River with Name of the river (Approximate)	1.50			
11.	Distance from Main Tributary with name of tributary (Approximate)	0.00`			
12.	Suggestive species for plantation	Khair, Jamun, Kachnar, Ambla, Virjur			
13.	Pit Size	45x45x45 cms			
14.	Details of Fencing works, if required before plantation	Single stand-2100 Rmt			
15.	Details of Soil Moisture and Conservation works, if required before plantation	Check Dam			
16.	Planting Cost including nursery cost (Approximate)	300000.00			
17.	Maintenance Cost of plantation with years (Approximate)	100000.00			
18.	Remarks, if any				
19.	GPS coordinates of the site at all the corners (As per the shape of site, minimum 4 points are required)	1. N : 32.02.56 E: 76.20.52 Ele (m) : 452 m	2. N : E: Ele (m) :	3. N : E: Ele (m) :	4. N : E: Ele (m) :
		5. N : E: Ele (m) :	6. N : E: Ele (m) :	7. N : E: Ele (m) :	8. N : E: Ele (m) :
F. ROUGH SKETCH OF TREATMENT SITE / MAP (AS AN ATTACHMENT)					
G. CURRENT PHOTOGRAPH (AS AN ATTACHMENT)					
Name and Designation		Contact Number		Signature of Forest Officer / Official	

**PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR REJUVENATION OF INDUS
RIVER BASIN
THROUGH FORESTRY INTERVENTIONS
PROFORMA OF DATA COLLECTION FOR PROPOSED
SITE HIMALAYAN FOREST RESEARCH INSTITUTE, SHIMLA,
HIMACHAL PRADESH
(INDIAN COUNCIL OF FORESTRY RESEARCH & EDUCATION, DEHRADUN-248006)**

A. FORESTRY INTERVENTIONS	AGRICULTURE LANDSCAPE
B. MODEL NO.	<i>To be proposed</i> BS/HP/AL/02 BLOCK PLANTATION

C. TREATMENT SITE (DETAILS)		
1.	NAME OF SITE	Dharamshala 1
2.	AREA (IN HECTARE)	2
D. GEOGRAPHICAL DETAILS		
1.	Name of River	Satluj ☐ Chenab ☐ ☐ ☐ ☐ Ravi ☐ ☐ ☐ ☐ ☐ ☐ Beas ☐ Jhelum ☐
2.	State	Himachal Pradesh ☐ Punjab ☐ Jammu & Kashmir ☐
3.	District	Kangra
4.	Forest Circle	Dharamshala
5.	Forest Division	Dharamshala
6.	Forest Range	Dharamshala
7.	Forest Block	Dharamshala
8.	Forest Beat	Dharamshala
9.	Development Block Name	Dharamshala
10.	Tehsil	Dharamshala
11.	Panchayat	Dharamshala
E. BASELINE DATA		
1.	Current Status of Flora and Fauna	
2.	Current land use	
3.	Legal Status of land	
4.	Geology and Soil type	
5.	Slope	

6.	Aspect				
7.	Average Annual Rainfall (in mm)				
8.	Special features of the site				
9.	Distance from Road (Approximate)				
10.	Distance from Main River with Name of the river (Approximate)				
11.	Distance from Main Tributary with name of tributary (Approximate)				
12.	Suggestive species for plantation				
13.	Pit Size				
14.	Details of Fencing works, if required before plantation				
15.	Planting Cost including nursery cost (Approximate)				
16.	Maintenance Cost of plantation with years (Approximate)				
17.	Remarks, if any				
18.	GPS coordinates of the site at all the corners (As per the shape of site, minimum 4 points are required)	1. N : 31.2159 E: 76.3237 Ele (m) : 1293	2. N: E: Ele (m) :	3. N : E: Ele (m) :	4. N : E: Ele (m) :
		5. N : E: Ele (m) :	6. N : E: Ele (m) :	7. N : E: Ele (m) :	8. N : E: Ele (m) :
F. ROUGH SKETCH OF TREATMENT SITE / MAP (AS AN ATTACHMENT)					
G. CURRENT PHOTOGRAPH (AS AN ATTACHMENT)					
Name and Designation		Contact Number		Signature of Forest Officer / Official	

**PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR REJUVENATION OF
INDUS RIVER BASIN THROUGH FORESTRY INTERVENTIONS**

**PROFORMA OF DATA COLLECTION FOR PROPOSED SITE HIMALAYAN
FOREST RESEARCH INSTITUTE, SHIMLA, HIMACHAL PRADESH**

(INDIAN COUNCIL OF FORESTRY RESEARCH & EDUCATION, DEHRADUN-248006)

A. FORESTRY INTERVENTIONS	URBAN LANDSCAPE
	☐ a. Bioremediation & Bio-filtration ☐ b. River Front Development & Ecotourism ☐ c. Eco Park Development ☐ d. Institutional / Industrial Plantation ☐ e. Any Other (Please Specify.....)

B. SITE DETAILS		
1.	NAME OF SITE	Dharamshala 1
2.	AREA (IN HECTARE)	1
C. GEOGRAPHICAL DETAILS		
1.	Name of River	Satluj ☐ Chenab ☐ Ravi ☐ Beas ☐ Jhelum ☐
2.	State	Himachal Pradesh ☐ Punjab ☐ Jammu & Kashmir ☐
3.	District	Kangra
4.	Forest Circle	Dharamshala
5.	Forest Division	Dharamshala
6.	Forest Range	-
7.	Forest Block	Mallan
8.	Forest Beat	Massal
9.	Development Block Name	Nagrota Bhagwan
10.	Tehsil	Nagrota Bhagwan
11.	Name of Sub Urban Area /Town	Massal
12.	Municipal Corporation /Committee/ Notified Area Committee (NAC)	Nagrota Bagwan

D. BASELINE DATA					
1.	Current land use	Grazzing Land			
2.	Land Use Status five years ago	Grazzing Land			
3.	Legal Status of land	D.C. Land			
4.	Soil Type	Sandy Loam			
5.	Average Annual Rainfall (in mm)	2647			
6.	Special features of the site	-			
7.	Distance from Road (Approximate)	0.5			
8.	Distance from Main River with Name of the river (Approximate)	3			
9.	Distance from Main Tributary with name of tributary (Approximate)	-			
10.	Suggestive species for plantation	Ornamental Plants			
11.	Pit Size	45x45x45			
12.	Details of Fencing works, if required	210 Rmtx 4 Stand			
13.	Planting Cost including Nursery Cost (Approximate)	36000.00			
14.	Maintenance Cost of plantation with years (Approximate)	141000.00			
15.	Remarks, if any	-			
16.	GPS coordinates of the site at all the corners (As per the shape of site, minimum 4 points are required)	1. N : 32.0949 E: 76.3885 Ele (m) : 1816	2. N : 32.0945 E: 76.3864 Ele (m) :	3. N : 32.0940 E: 76.4147 Ele (m) :	4. N : 32.0943 E: 76.3875 Ele (m) :
		5. N : E: Ele (m) :	6. N : E: Ele (m) :	7. N : E: Ele (m) :	8. N : E: Ele (m) :
F. ROUGH SKETCH OF TREATMENT SITE (AS AN ATTACHMENT)					

G. CURRENT PHOTOGRAPH (GEOREFENCED FROM ONE CORNER AS PER POINT No. 16. (AS AN ATTACHMENT)				
G. SITE SPECIFIC ACTIVITIES				
S. NO.	YEAR	NAME OF ACTIVITIES	UNIT (AREA/ NO.)	FINANCIAL OUTLAY (IN RS.)
1	2021			
2	2022			
		GRAND TOTAL		
Name and Designation		Contact Number	Signature of Forest Officer / Official	

**PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR REJUVENATION OF
INDUS RIVER BASIN THROUGH FORESTRY INTERVENTIONS
PROFORMA OF DATA COLLECTION FOR PROPOSED
SITE HIMALAYAN FOREST RESEARCH INSTITUTE, SHIMLA,
HIMACHAL PRADESH
(INDIAN COUNCIL OF FORESTRY RESEARCH & EDUCATION, DEHRADUN-248006)**

A. OTHER INTERVENTIONS	☐ a. Wetland Management (Natural and Artificial) ☐ b. Wildlife Management ☐ c. Riparian Wildlife Management ☐ d. Soil and Water Conservation ☐ e. Moraine Management ☐ f. Others (Specify please).....

B. SITE DETAILS		
1.	NAME OF SITE	GHNP 1
2.	AREA (IN HECTARE)	50
C. GEOGRAPHICAL DETAILS		
1.	Name of River	Satluj ☐ Chenab ☐ Ravi ☐ Beas ☐ Jhelum ☐
2.	State	Himachal Pradesh ☐ Punjab ☐ Jammu & Kashmir ☐
3.	District	Kullu
4.	Forest Circle	GHNP Shamshi
5.	Forest Division	GHNP Shamshi
6.	Forest Range	Wild Life Range
7.	Forest Block	
8.	Forest Beat	
9.	Development Block Name	
10.	Tehsil	
11.	Panchayat	
D. BASELINE DATA		
1.	Current land use	National Park
2.	Land Use Status five year ago	National Park
3.	Legal Status of land	National Park
4.	Soil Type	Loamy
5.	Average Annual Rainfall (in mm)	1300 mm

6.	Special features of the site	-			
7.	Distance from Road (Approximate)	0.50			
8.	Distance from Main River with Name of the river (Approximate)	1.00 (Beas)			
9.	Distance from Main Tributary with name of tributary (Approximate)	0.00			
10.	Remarks, if any				
11.	GPS coordinates of the site at all the corners (As per the shape of site, minimum 3 points are required)	1. N : E: Ele (m) :	2. N : E: Ele (m) :	3. N : E: Ele (m) :	4. N : 32.0943 E: 76.3875 Ele (m) :
		5. N : E: Ele (m) :	6. N : E: Ele (m) :	7. N : E: Ele (m) :	8. N : E: Ele (m) :
F. ROUGH SKETCH OF TREATMENT SITE (AS AN ATTACHMENT)					
G. CURRENT PHOTOGRAPH (GEOREFRENCED FROM ONE CORNER AS PER POINT No. 11. (AS AN ATTACHMENT)					
H. SITE SPECIFIC ACTIVITIES					
S. NO.	YEAR	NAME OF ACTIVITIES	UNIT (AREA/ NO.)	FINANCIAL OUTLAY (IN RS.)	
	2021	Silt detention dam type activity	10	200000	
	2022	Silt detention dam type activity	10	200000	
		GRAND TOTAL			
Name and Designation		Contact Number		Signature of Forest Officer / Official	

**PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR REJUVENATION OF INDUS
RIVER BASIN THROUGH FORESTRY INTERVENTIONS
PROFORMA OF DATA COLLECTION FOR PROPOSED
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A. OTHER ACTIVITIES				
NAME OF ACTIVITY	☐ Civil society involvement (like Nehru Yuva Kendra, Eco clubs, Street play, community meeting, advertisement and publication etc.	☐ Baseline data w.r.t. water discharge and sediment load (SOP) data collection; on field research etc .	☐ Capacity building	☐ Participatory monitoring

B. SITE DETAILS			
1.	NAME OF STATE	Himachal Pradesh	
2.	NAME OF SITE	P39 K Ranital C-4 C	
4.	FOREST DIVISION	Dharamshala	
C. ACTIVITIES			
1.	YEAR	NAME OF ACTIVITY	FINANCIAL OUTLAY
2.	2020- 2021	Fire Suits for Field Staff to fight fire Efficiently and contribute in Rejuvenation of River basin by maintaining Flora and Fauna=15 nos.	500000/-
3.			
4.			
TOTAL			
Name and Designation		Contact Number	Signature of Forest Officer / Official

Annexure 3: Different Plant Species Suitable for Different Plantation Models of Three Landscapes of Beas Riverscape in Himachal Pradesh and Punjab

Sr. No.	Botanical Name	Common Name	Family	Habit	Uses
1.	<i>Abies pindrow</i> (Royle ex D. Don) Royle	Silver Fir	Pinaceae	Tree	Potent antioxidant and the wood is used for house interior, furniture and fuel.
2.	<i>Abies spectabilis</i> (D. Don) Mirb.	Himalayan Fir	Pinaceae	Tree	Leaves are used as astringent and used as expectorant and tonic.
3.	<i>Acacia catechu</i> (L.f.) Willd.	Khair	Leguminosaceae	Tree	Extract is used in preserving fishing nets, used for dyeing cotton and silk. Medicinal preparation combats skin disorders.
4.	<i>Acacia nilotica</i> (L.) Delile	Babul	Mimosaceae	Tree	The plant has anti-microbial, anti-plasmodia and antioxidant activity.
5.	<i>Acer cappadocicum</i> Gled.	Maple	Sapindaceae	Tree	The wood is used for construction, ploughs, bedsteads, and poles to carry loads.
6.	<i>Acer acuminatum</i> Wall. ex D. Don	Tapering Leaf Maple	Sapindaceae	Tree	Leaves are used as tea substitute and the leaves are packed around apples to preserve them.
7.	<i>Acer caesium</i> Wall. ex Brandis	Bluish Grey Maple	Sapindaceae	Tree	The juice of the bark is used externally to treat muscular swellings, boils and pimples.
8.	<i>Acer pictum</i> Thunb.	Yellow-paint Maple	Sapindaceae	Tree	Ornamental plant and the wood is used for ploughs, bedsteads, and poles to carry loads.
9.	<i>Acer oblongum</i> Wall. ex DC	Himalayan Maple	Sapindaceae		Used for agricultural implements and minor construction etc.
10.	<i>Aconitum heterophyllum</i> Wall. ex Royle	Atish/Patish	Ranunculaceae	Herb	Migraines, headaches, vomiting, piles, burning sensation, etc.
11.	<i>Aconitum violaceum</i> Jacquem. ex Stapf	Dudhia-Bis, MithaTelia	Ranunculaceae	Herb	The plant is used in traditional Tibetan medicine.
12.	<i>Haldina cordifolia</i> (Roxb.) Ridsdale	Haldu	Rubiaceae	Tree	Used in Ayurvedic medicine preparation treats skin diseases, wounds, vomiting and intestinal worms.
13.	<i>Aegle marmelos</i> (L.) Corrêa	Bael	Rutaceae	Tree	Fruit pulp is used to prepare delicacies like murabba, puddings and juice. Bael fruits are used in the treatment of chronic diarrhea, dysentery and

Sr. No.	Botanical Name	Common Name	Family	Habit	Uses
					peptic ulcers.
14.	<i>Aesculus indica</i> (Wall. ex Cambess.) Hook.	Khanor, Bankhor	Sapindaceae	Tree	It is used in traditional Indian medicine for the treatment of some skin diseases and rheumatism.
15.	<i>Agropyron longiaristatum</i> (Boiss.) Boiss.	Wheat grass	Poaceae	Grass	Couch grass has been used as a diuretic in cases of bladder catarrh and bladder/kidney stones.
16.	<i>Agrostis gigantea</i> Roth	Bent grass	Poaceae	Grass	Fodder and soil conservation.
17.	<i>Agrostis palustris</i> Huds.	Creeping Bent grass	Poaceae		Fodder and soil conservation.
18.	<i>Agrostis pilosula</i> Trin.	Bent grass	Poaceae	Grass	Fodder and soil conservation.
19.	<i>Ailanthus excelsa</i> Roxb.	Indian Tree of Heaven, Mahanimb	Simaroubaceae		Aromatic leaves have medicinal properties and bark is a febrifuge and can be used as a treatment against asthma, bronchitis and dysentery.
20.	<i>Ainsliaea aptera</i> DC.	Tito Butee	Asteraceae	Herb	Roots are dried and crushed in a pestle mortar in a small quantity of water, 2-3 g of paste are then taken orally 3-4 times with lukewarm water to relieve stomachache, constipation and acute fever.
21.	<i>Ajuga integrifolia</i> Buch.-Ham.	Neelkanthi	Lamiaceae	Herb	The juice of the root is used in the treatment of diarrhea and dysentery.
22.	<i>Albizia julibrissin</i> Durazz.	Persian acacia, Silk tree	Leguminosaceae	Tree	Fodder
23.	<i>Albizia chinensis</i> (Osbeck) Merr.	Chinese Albizia, Kala Siris	Leguminosaceae	Tree	Used for ornamental purpose and is helpful for slope stabilization and soil improvement. Its wood is used to make light furniture and boat building.
24.	<i>Albizia lebbek</i> (L.) Benth.	Siris	Leguminosaceae	Tree	Used as an astringent, treats eye diseases, lung problems and also used as tonic.
25.	<i>Allium humile</i> Kunth	Wild Onion	Amaryllidaceae	Herb	Wild onion has economic value. Used for spices.
26.	<i>Alstonia scholaris</i> (L.) R. Br.	Devil tree, Saptaparni	Apocynaceae	Tree	Its milky juice is used to treat ulcers and its bark is used in ayurvedic medicines. The leaves and latex are applied externally to treat tumors.

Sr. No.	Botanical Name	Common Name	Family	Habit	Uses
27.	<i>Anemone tetrasepala</i> Royle	Four petal Anemone	Ranunculaceae	Herb	Used to treat traumatic injury, rheumatic arthralgia and ascariasis.
28.	<i>Angelica glauca</i> Edgew.	Chora	Apiaceae	Herb	Used in the treatment of various skin diseases, bites of poisonous animals, fever, rhinitis, gastric and psychiatric disorders. Used as a spice.
29.	<i>Apluda mutica</i> L.	Mauritian Grass, Tachula	Poaceae	Grass	Poultice of the plant is used to cure sores of cattle.
30.	<i>Araucaria araucana</i> (Molina) K. Koch	Christmas tree	Araucariaceae	Tree	Ornamental
31.	<i>Arnebia benthamii</i> (Wall. ex G. Don) I.M. Johnst.	Mahaarang ee, Ratanjot, Ultebhootk eshi	Boraginaceae	Herb	Used in preparation of sherbet (syrup) and jam useful in various diseases of tongue, throat, fever and cardiac disorders. Also used in skin diseases and hair tonic.
32.	<i>Artemisia</i> spp.	Artemisia	Asteraceae	Herb	Medicinal herb (Anti Malaria)
33.	<i>Arundinella nepalensis</i> Trin.	River grass	Poaceae	Grass	The canes are used for thatching and fencing.
34.	<i>Avena fatua</i> L.	Wild Oats	Poaceae	Grass	Straw has wide range of use; fibre, mulch, paper-making & thatching.
35.	<i>Azadirachta indica</i> A. Juss.	Neem	Meliaceae	Tree	Neem leaf is used for leprosy, eye disorders, bleeding nose, skin ulcers and intestinal worms.
36.	<i>Bambusa bambos</i> (L.) Voss	Indian Thorny Bamboo, Baans	Poaceae	Tree	Leaves are antispasmodic and relieve menstrual pain. Also used as fodder, pulp is used for paper making and the seeds are edible.
37.	<i>Bauhinia variegata</i> L.	Kachnar	Leguminosae	Tree	The leaves and flowers are edible and eaten as vegetables.
38.	<i>Berberis aristata</i> DC.	Indian Barberry, Chitra	Berberidaceae	Shrub	Used as tonic and used in treatment of diarrhea, jaundice, skin diseases and urinary disorders.
39.	<i>Berberis lycium</i> Royle	Indian Barberry, Darhaldi	Berberidaceae	Shrub	The roots are carminative, febrifuge and ophthalmic. Leaves are used in treatment of jaundice.

Sr. No.	Botanical Name	Common Name	Family	Habit	Uses
40.	<i>Bergenia ciliata</i> (Haw.) Sternb.	Hairy bergenia, Pather-chut	Saxifragaceae	Herb	The root juice is used to treat coughs and colds, haemorrhoids, asthma and urinary problems.
41.	<i>Bergenia stracheyi</i> (Hook.f. & Thomson) Engl.	Pashanbhe da	Saxifragaceae	Herb	The root is used as a tonic in the treatment of fevers, diarrhea and pulmonary affections.
42.	<i>Betula alnoides</i> Buch.-Ham. ex D. Don	Bhojpatra	Betulaceae	Tree	Inner bark is edible and is used for making cakes and bread.
43.	<i>Betula utilis</i> D. Don	Bhojpatra	Betulaceae	Tree	Treatment of various ailments and diseases such as skin disinfectant.
44.	<i>Boerhavia diffusa</i> L.	Punarnava	Nyctaginaceae	Grass	Popular in Ayurveda, this herb is known for its anti-inflammatory and analgesic properties.
45.	<i>Bombax ceiba</i> L.	Silk Cotton Tree, Shalmali	Bombacaceae	Tree	The plant possesses astringent properties, cooling, stimulant and aphrodisiac.
46.	<i>Bougainvillea</i> spp.	Bougainvillea	Nyctaginaceae	Shrub	Landscaping
47.	<i>Capparis decidua</i> (Forssk.) Edgew.	Bare Caper, Kair	Capparidaceae	Shrub	The plant is traditionally used to cure toothache, arthritis, asthma, cough and malaria.
48.	<i>Carpinus viminea</i> Wall. ex Lindl.	Himalayan Hornbeam	Betulaceae	Tree	Root powder is taken in porridge or in tea. It has hepato protective properties.
49.	<i>Cedrus deodara</i> (Roxb. ex D. Don) G. Don	Devdar	Pinaceae	Tree	Timber tree
50.	<i>Celtis australis</i> L.	Khirak	Urticaceae	Tree	The decoction can also be used to astringe the mucous membranes in the treatment of diarrhea, dysentery and peptic ulcers. It is good fodder tree.
51.	<i>Chrysopogon fulvus</i> (Spreng.) Chiov.	Dholu, Gorla	Poaceae	Grass	Used for erosion control, lawns, forage and medicines.
52.	<i>Cinnamomum tamala</i> (Buch.-Ham.) T. Nees & Eberm.	Indian Bay Leaf, Tejpatta	Lauraceae	Tree	Treats diabetes, cough, and arthritis and is also used as a spice or flavoring agent.
53.	<i>Cornus capitata</i> Wall.	Evergreen Dogwood	Cornaceae	Tree	It is edible but sometimes bitter.

Sr. No.	Botanical Name	Common Name	Family	Habit	Uses
54.	<i>Cornus macrophylla</i> Wall.	Large Leaf Dogwood	Cornaceae	Tree	Anodyne and astringent but mainly used for ornamental purpose.
55.	<i>Cornus oblonga</i> Wall.	Oblong-Petal Dogwood	Cornaceae	Shrub	Used principally to reduce heavy menstrual bleeding and unusually active secretions.
56.	<i>Corylus jacquemontii</i> Decne.	Bhotiya badam	Betulaceae	Tree	The nuts of all hazels are edible.
57.	<i>Cotoneaster bacillaris</i> Wall. ex Lindl.	Dhalkephol	Rosaceae	Shrub	Garden shrubs, grown for their attractive habit and decorative fruit.
58.	<i>Cupressus torulosa</i> D. Don	Himalayan cypress	Cupressaceae	Tree	Traditionally used in cold and cough. Ornamental.
59.	<i>Cymbopogon distans</i> (Nees ex Steud.) W. Watson	Malabar Grass, Lemongrass	Poaceae	Grass	Used as a medical herb and in perfumes.
60.	<i>Cymbopogon martini</i> (Roxb.) W. Watson	Gandhabel	Poaceae	Grass	Used as traditional medicine, its oil are used to treat rheumatism, hair loss, arthritis, lumbago and spasms. The essential oil is a strong fungicide.
61.	<i>Dactylorhiza hatagirea</i> (D. Don) Soó	Salem Panja,	Orchidaceae	Herb	It is used as a nerve tonic and aphrodisiac.
62.	<i>Dalbergia sissoo</i> DC.	Indian rosewood, Shisham	Leguminosae	Tree	Used as firewood, timber, tool handles. It is used as windbreak and for erosion control.
63.	<i>Danthonia</i> spp.	Wallaby grass	Poaceae	Grass	It is used as ornamental grass.
64.	<i>Daphne oleoides</i> Schreb.	Kashmir Daphne	Thymelaeaceae	Shrub	An infusion of the bark and leaves are used in the treatment of cutaneous affections.
65.	<i>Daphne papyracea</i> Wall. ex G. Don	Indian Paper Plant	Thymelaeaceae	Shrub	Main source of raw material for the production of lokta paper, a hand-made paper from Nepal.
66.	<i>Debregeasia saeneb</i> (Forssk.) Hepper & J.R.I. Wood		Urticaceae	Shrub	Fiber is obtained from bark and wood is used for fuel.
67.	<i>Delphinium denudatum</i> Wall. ex Hook.f. &	Nirbishi	Ranunculaceae	Herb	Useful in ailments such as aconite poisoning, brain diseases, fungal infection,

Sr. No.	Botanical Name	Common Name	Family	Habit	Uses
	Thomson				piles and toothache as analgesic and astringent.
68.	<i>Dendrocalamus hamiltonii</i> Nees & Arn. ex Munro	Tama Bamboo	Poaceae	Grass	Culms are used for temporary constructions like houses and bridges.
69.	<i>Dendrocalamus strictus</i> (Roxb.) Nees	Calcutta Bamboo, Hard bamboo, solid bamboo, stone bamboo, Bans	Poaceae	Grass	Used as raw material in paper mills and used for light construction, furniture, mats and sticks.
70.	<i>Desmodium elegans</i> DC.	Elegant Desmodium, Chamlai	Leguminosae	Shrub	Roots are carminative, diuretic and used as tonic.
71.	<i>Desmodium gangeticum</i> (L.) DC.	Sal Leaved Desmodium, Dhruva.	Leguminosae	Shrub	Antioxidant and protects body from diseases and boosts immunity.
72.	<i>Deutzia corymbosa</i> R.Br. ex G. Don	Clustered Coelogyne	Hydrangeaceae	Shrub	The plant is known to clear heat and toxins, activate blood circulation, promote diuresis and relieve stranguria.
73.	<i>Deutzia staminea</i> R.Br. ex Wall.	Clustered Coelogyne	Hydrangeaceae	Shrub	The plant is known to clear heat and toxins and activate blood circulation.
74.	<i>Diospyros montana</i> Roxb.	Bombay ebony, Bistendu	Ebenaceae	Tree	The fruits are applied externally to boils and spider stings.
75.	<i>Drepanostachyum falcatum</i> (Nees) Keng f.	Nigalo Bans	Poaceae	Grass	Small timber.
76.	<i>Eulalia aurea</i> (Bory) Kunth	Hardy pampas grass	Poaceae	Grass	Aggressive grass that has been sold in nurseries for use as an ornamental grass in gardens, and for stabilizing soil to prevent erosion.
77.	<i>Eucalyptus</i> spp.	Safeda	Myrtaceae		Essential oil is obtained from the leaves.
78.	<i>Euonymus tingens</i> Wall.	Dadul, Dharua	Celastraceae	Shrub	Wood is traditionally used for the making of spindles for spinning wool. Ornamental.
79.	<i>Ferula jaeschkeana</i> Vatke	Wild Asafoetida, Hing	Apiaceae	Herb	Treats hysteria, bronchitis, whooping cough and asthma.
80.	<i>Festuca rubra</i> L.	Red Fescue	Poaceae		Ornamental
81.	<i>Ficus</i>	Banyan	Moraceae	Tree	Useful in diseases of head

Sr. No.	Botanical Name	Common Name	Family	Habit	Uses
	<i>benghalensis</i> L.	Tree, Barh			and blood, leprosy and nose bleeding.
82.	<i>Ficus carica</i> L.	Common Fig, Anjeer	Moraceae	Tree	Used to treat gastrointestinal tract and urinary tract infection.
83.	<i>Ficus palmata</i> Forssk.	Punjab Fig, Anjiri	Moraceae	Tree	Fruit is demulcent, emollient and laxative.
84.	<i>Ficus racemosa</i> L.	Cluster fig, Goolar	Moraceae	Tree	Treats liver disorders, hemorrhoids and urinary diseases.
85.	<i>Ficus rumphii</i> Blume	Golden Rumph's Fig, Pilkhan	Moraceae	Tree	Juice from the plant kills worms and has anti cancer properties.
86.	<i>Ficus</i> spp.	Anjeer	Moraceae	Tree	Used to cure diabetes, liver disorders, diarrhea, inflammatory conditions, hemorrhoids, respiratory, and urinary diseases. Fruits are edible.
87.	<i>Geranium nepalense</i> Sweet	Nepal Geranium, Bhanda	Geraniaceae	Herb	Astringent and treats renal diseases.
88.	<i>Geranium wallichianum</i> D. Don ex Sweet	Raaklaamool	Geraniaceae	Herb	Garden worthy plant.
89.	<i>Ginkgo biloba</i> L.	BalKumari	Ginkgoaceae	Tree	Used to treat altitude sickness (prevention), cerebral vascular insufficiency, cognitive disorders and dementia.
90.	<i>Grewia optiva</i> J.R. Drumm. ex Burret	Bihul	Malvaceae	Tree	Important agro-forestry tree species and provides fodder, fiber and fuel.
91.	<i>Hedychium spicatum</i> Sm.	Spiked Ginger Lily, Sandharlika	Zingiberaceae	Herb	It is aromatic, antiseptic, expectorant and anti inflammatory.
92.	<i>Heracleum candicans</i> Wall. ex DC.	Chhataya, Aswal	Apiaceae	Herb	Spices, flavoring, aphrodisiac, tonic, colic, digestive, antipyretic, diaphoretic, itching, skin disorders, etc.
93.	<i>Heteropogon contortus</i> (L.) P. Beauv. ex Roem. & Schult.	Bunched Spear Grass	Poaceae	Grass	Planted for erosion control and revegetation of degraded habitats.
94.	<i>Hibiscus</i> spp.	Bladder Ketmia	Malvaceae	Shrub	Treat heart and nerve diseases, and as a diuretic to

Sr. No.	Botanical Name	Common Name	Family	Habit	Uses
					increase urine production.
95.	<i>Hydrangea</i> spp.	Wild Hydrangea	Hydrangeaceae	Shrub	Ornamental uses.
96.	<i>Hyoscyamus niger</i> L.	Khurasani Ajwain	Solanaceae	Herb	Henbane is used in Homeopathic medicine.
97.	<i>Hypericum oblongifolium</i> Choisy	Hypericum	Hypericaceae	Shrub	Used as a treatment for numerous ailments, including hepatitis, gastric ulcers and bee stings.
98.	<i>Hypericum perforatum</i> L.	Perforate St Johns Wort, Choli Phulya	Hypericaceae	Shrub	Used to treat anxiety, mild to moderate depression and sleep related disorders.
99.	<i>Indigofera heterantha</i> Brandis	Himalayan Indigo	Leguminosae	Shrub	The branches are used in basket making and in making twig bridges.
100.	<i>Juglans regia</i> L.	Walnut	Juglandaceae	Tree	The leaves are used to treat skin ailments and purify the blood. Kernel edible.
101.	<i>Jurinea macrocephala</i> DC.	Dhup	Asteraceae	Herb	The bruised root is applied as a poultice to eruptions.
102.	<i>Justicia adhatoda</i> L.	Malabar Nut, Arus	Acanthaceae	Shrub	Treats asthma, cough and breathing troubles.
103.	<i>Lonicera quinquelocularis</i> Hard.	Long-Flower Honeysuckle	Caprifoliaceae	Shrub	Used as a low hedging plant, and for topiary.
104.	<i>Lyonia ovalifolia</i> (Wall.) Drude	Angeri	Ericaceae	Tree	The young leaves and buds are toxic, but they are used externally as an infusion to treat skin diseases and external parasites.
105.	<i>Maesa indica</i> (Roxb.) A. DC.	Karmighna	Primulaceae	Shrub	Fruits and bark are used in poisoning fish.
106.	<i>Magnolia grandiflora</i> L.	Him champa, Bull Bay	Magnoliaceae	Tree	It is a commonly grown ornamental shrub.
107.	<i>Magnolia liliiflora</i> Desr.	Lily Magnolia, Star magnolia	Magnoliaceae	Shrub	It is a commonly grown ornamental shrub.
108.	<i>Mallotus philippensis</i> (Lam.) Müll. Arg.	Kaamala Tree, Kamala	Euphorbiaceae	Tree	Used to treat tape worm infestations and is applied externally for parasitic skin diseases.
109.	<i>Malus baccata</i> (L.) Borkh.	Wild apple	Rosaceae	Tree	Wild edible fruits.
110.	<i>Malus</i> spp.	Seb	Rosaceae	Tree	Fruits

Sr. No.	Botanical Name	Common Name	Family	Habit	Uses
111.	<i>Morus alba</i> L.	Shahtoot	Moraceae	Tree	Used in traditional Chinese medicine to treat asthma, bronchitis, edema, and diabetes. Fodder and silkworm production.
112.	<i>Murraya koenigii</i> (L.) Spreng.	Curry Leaf, Kari patta	Rutaceae	Shrub	Used as stimulant and for management of diabetes. Also used to flavor curries.
113.	<i>Murraya paniculata</i> (L.) Jack	Orange Jasmine, Kamini	Rutaceae	Shrub	Used to treat cough, hysteria and rheumatism.
114.	<i>Myrica esculenta</i> Buch.-Ham. ex D. Don	Box Myrtle, Kaphal	Myricaceae	Tree	Treats cough, asthma, inflammation and anemia.
115.	<i>Nardostachys jatamansi</i> (D. Don) DC.	Jatamansi	Valerianaceae	Herb	Roots and rhizomes treat hysteria, epilepsy and mental weakness.
116.	<i>Neolitsea pallens</i> (D. Don) Momiy. & H. Hara	Chirchira	Lauraceae	Tree	The bark and leaves are used for treatment of fractures. The powdered leaf is used for dusting the cut surface of coconut inflorescences in the process of toddy tapping.
117.	<i>Nerium oleander</i> L.	Kaner	Apocynaceae	Shrub	It is bitter, acrid, anthelmintic, adaptogenic, analgesic, and aphrodisiac anticancer and anti-inflammatory.
118.	<i>Nyctanthes arbor-tristis</i> L.	Parijat, Shefali	Oleaceae	Shrub	Used in various ailments like fever, enlargement of the spleen, malaria, blood dysentery, cough and gastritis.
119.	<i>Oroxylum indicum</i> (L.) Kurz	Broken Bones Tree, Bhut-vriksha	Bignoniaceae	Tree	Often grown as ornamental tree and is known to treat fever, cough and diarrhea.
120.	<i>Parrotiopsis jacquemontiana</i> (Decne.) Rehder	Parrotia, killer	Hamamelidaceae	Shrub	Used for skin infections and in wound healing.
121.	<i>Machilus duthiei</i> King	Duthie's Bay Tree	Lauraceae	Tree	Essential oil is extracted from the plant and is used against inflammation and asthma.
122.	<i>Phleum pratense</i> L.	Alpine Cat Tail	Poaceae	Grass	Used in small amounts as part of a new hay fever vaccine.
123.	<i>Phlomis bracteosa</i> (Royle ex Benth.)	Purple Jerusalem Sage	Lamiaceae	Herb	Analgesic and antidiarrheal properties.

Sr. No.	Botanical Name	Common Name	Family	Habit	Uses
	Kamelin & Makhm.				
124.	<i>Phoenix</i> spp.	Parusakah	Arecaceae	Tree	Date Palm is used in treatment of bladder stones, piles, fevers, dysentery, rectal prolepses, cough, urinary tract infections, etc.
125.	<i>Phytolacca acinosa</i> Roxb.	Himalayan Pokeberry	Phytolaccaceae	Herb	The root is antiasthmatic, antibacterial, antidote, antifungal, antitussive, diuretic, expectorant, laxative and vermifuge.
126.	<i>Picea smithiana</i> (Wall.) Boiss.	Himalayan Spruce, Rai	Pinaceae	Tree	Wood used in construction, crates and household purposes.
127.	<i>Picrorhiza kurroa</i> Royle ex Benth.	Kutki, Karwi	Scrophulariaceae	Herb	Used to treat disorders of the liver and upper respiratory tract, chronic diarrhea, and scorpion sting.
128.	<i>Pinus roxburghii</i> Sarg.	Chir pine	Pinaceae	Tree	Timber, resin and oleoresin.
129.	<i>Pinus wallichiana</i> A.B. Jacks.	Himalayan Blue Pine, Kail	Pinaceae	Tree	Used in construction, crates, household purposes.
130.	<i>Pistacia chinensis</i> subsp. <i>integerrima</i> (J. L. Stewart ex Brandis) Rech. f.	Kakkar, kakra-singi	Anacardiaceae	Tree	Used as timber, dye and fodder. Leaf galls are used in traditional herbalism.
131.	<i>Pittosporum eriocarpum</i> Royle	Doon cheesewood	Pittosporaceae	Tree	Used in treatment of narcotic, expectorant and bronchitis.
132.	<i>Platanus orientalis</i> L.	Oriental plane	Platanaceae	Tree	The fresh leaves are bruised and applied to the eyes in the treatment of ophthalmic. Ornamental.
133.	<i>Poa pratensis</i> L.	Smooth Brome	Poaceae	Grass	Used in lawns and gardens. Fodder.
134.	<i>Podophyllum hexandrum</i> Royle	Ban Kakri, Himalayan May Apple	Berberidaceae	Herb	Used to provide symptomatic relief in some of the allergic and inflammatory conditions.
135.	<i>Polygonatum cirrhifolium</i> (Wall.) Royle	Coiling Leaf Polygonatum, Mahmeda	Asparagaceae	Herb	Used in the treatment of loss of vigor, pain in the kidneys and hips, swelling and fullness in the abdominal region.
136.	<i>Polygonatum verticillatum</i> (L.) All.	Whorled Solomon's Seal, Meda, Salam-	Asparagaceae	Herb	Extensively used to cure various health troubles as cardio-tonic, antiperiodic, demulcent, diuretic, energizer, aphrodisiac,

Sr. No.	Botanical Name	Common Name	Family	Habit	Uses
		misri			sedative, hypoglycemic, antitumor, pain reliever, general tonic, nervine tonic, etc.
137.	<i>Pongamia pinnata</i> (L.) Pierre	Pongam Tree, Karanj	Leguminosae	Tree	Used as crude drug for tumors, piles, skin diseases and ulcers.
138.	<i>Populus alba</i> L.	Silver Poplar	Salicaceae	Tree	It is used internally in the treatment of rheumatism, arthritis, gout, lower back pains. Timber tree.
139.	<i>Populus ciliata</i> Wall. ex Royle	Himalayan Poplar, Ban Peepal	Salicaceae	Tree	Timber
140.	<i>Populus deltoides</i> Marshall	Necklace Poplar	Salicaceae	Tree	The bark is anodyne, anti-inflammatory and febrifuge. Timber tree.
141.	<i>Prinsepia utilis</i> Royle	Bhekhal	Rosaceae	Shrub	As a treatment for rheumatism and muscular pain caused by hard work. Edible oil from kernels.
142.	<i>Prunus cerasoides</i> Buch.-Ham. ex D. Don	Padmakashtha	Rosaceae	Tree	Used to treat vomiting, nausea and gastritis.
143.	<i>Prunus cornuta</i> (Wall. ex Royle) Steud.	Himalayan bird cherry	Rosaceae	Tree	Edible fruits.
144.	<i>Pterocarpus marsupium</i> Roxb.	Indian Kino Tree, Vijayasara	Leguminosae	Tree	Bark is used for bleeding gums and toothaches.
145.	<i>Punica granatum</i> L.	Darru	Punicaceae	Tree	Used for making <i>anardana</i> which is used as souring agent in various preparations? It has anti bacterial and anti-tumor properties.
146.	<i>Pyrus pashia</i> Buch.-Ham. ex D. Don	Wild pear, Kainth	Rosaceae	Tree	It is used in gastrointestinal disorders, fever and headache, sweating of body. Edible fruits.
147.	<i>Quercus floribunda</i> Lindl. ex A. Camus	Mohru Oak, Moru	Fagaceae	Tree	Used as fuelwood, charcoal, timber and fodder.
148.	<i>Quercus glauca</i> Thunb.	Glaucous Oak, Banni	Fagaceae	Tree	Fuelwood, charcoal, timber and construction of agricultural implements.
149.	<i>Quercus oblongata</i> D. Don	Ban Oak	Fagaceae	Tree	Bark is used to make tea which is effective against diarrhea, fever and cold.
150.	<i>Quercus</i>	Kharshu	Fagaceae	Tree	Any galls produced on the

Sr. No.	Botanical Name	Common Name	Family	Habit	Uses
	<i>semecarpifolia</i> Sm.				tree are strongly astringent. The juice of the bark is applied externally to treat muscular pain.
151.	<i>Rheum australe</i> D. Don	Himalayan Rhubarb	Polygonaceae	Herb	The root is antiseptic, antispasmodic, antitumor, astringent, demulcent, diuretic, laxative, purgative, stomachic and tonic.
152.	<i>Rheum moorcroftianum</i> Royle	Chukri	Polygonaceae	Herb	It is commonly used for the management of renal function disorders, cancer and improves the memory in senile patients.
153.	<i>Ricinus communis</i> L.	Castor bean, Arandi	Euphorbiaceae	Shrub	Castor oil is extracted from it and it has antimicrobial property.
154.	<i>Rosa moschata</i> Herrm.	Ban Gulab	Rosaceae	Shrub	Used for the treatment of abdominal spasm and diarrhea.
155.	<i>Rubus biflorus</i> Buch.-Ham. ex Sm.	Raspberry	Rosaceae	Shrub	Fruit edible.
156.	<i>Rubus ellipticus</i> Sm.	Himalayan raspberry	Rosaceae	Shrub	Fruit is edible and renal tonic is prepared from the plant.
157.	<i>Rubus macilentus</i> Jacquem. ex Cambess.		Rosaceae	Shrub	Fruit edible.
158.	<i>Rubus niveus</i> Thunb.	Mysore Raspberry, Kala hinsalu	Rosaceae	Shrub	Edible fruit.
159.	<i>Saccharum bengalense</i> Retz.	Munj Sweetcane, Sarkanda	Poaceae	Grass	Planted for soil conservation.
160.	<i>Saccharum spontaneum</i> L.	Kans grass, Kaans	Poaceae	Grass	Roots are astringent, diuretic, tonic and aphrodisiac.
161.	<i>Salix alba</i> L.	White Willow	Salicaceae	Tree	Bark is used for pain, including headache, muscle pain, menstrual cramps. Timber and cricket bats.
162.	<i>Salix babylonica</i> L.	Weeping Willow	Salicaceae	Tree	The leaves and bark are antirheumatic, astringent and tonic. Ornamental.
163.	<i>Salix daphnoides</i> Vill.	Violet Willow	Salicaceae	Tree	Ornamental purpose and also used as food.
164.	<i>Sapindus mukorossi</i> Gaertn.	Chinese Soapberry, Ritha	Sapindaceae	Tree	Seeds are used to remove tan and freckles from the face.
165.	<i>Actinoscirpus</i>	Kaseru,	Cyperaceae	Herb	Bio-remediation

Sr. No.	Botanical Name	Common Name	Family	Habit	Uses
	<i>grossus</i> (L.f.) Goetgh. & D.A.Simpso.	Club-rush			
166.	<i>Selinum wallichianum</i> (DC.) Raizada & H.O. Saxena.	Leaf Milk Parsley	Apiaceae	Herb	Used to treat rheumatism and kidney disease.
167.	<i>Sesbania sesban</i> (L.) Merr.	Common sesban, Jayanti	Leguminosae	Tree	Used as forage and green manure.
168.	<i>Setaria glauca</i> (L.) P.Beauv.	Bandra, Bankauni	Poaceae	Grass	It is regarded as a fairly good green fodder for cattle. The grains of the wild as well as cultivated types are used as food.
169.	<i>Setaria viridis</i> (L.) P. Beauv.	Foxtail grass	Poaceae	Grass	It is regarded as a fairly good green fodder for cattle.
170.	<i>Shorea robusta</i> Gaertn.	Sal	Dipterocarpaceae	Tree	Astringent and burned as incense in Hindu ceremonies.
171.	<i>Spiraea canescens</i> D. Don	Jhar Mairala	Rosaceae	Shrub	The leaves and flowering stems are alterative, anti-inflammatory, antiseptic, aromatic, astringent, diaphoretic, diuretic, stomachic and tonic.
172.	<i>Stipa roylei</i> (Nees) Duthie	--	Poaceae	Grass	The bulb is antiasthmatic, antirheumatic, febrifuge, galactagogue, haemostatic and ophthalmic and oxytocic.
173.	<i>Syringa emodi</i> Wall. ex Royle	Himalayan Lilac	Oleaceae	Shrub	Used as folk medicine
174.	<i>Taxus wallichiana</i> Zucc.	Thuno, Rakhal	Taxaceae	Tree	Anti-cancerous, cold, cough, fever and pain. Ornamental.
175.	<i>Tecomella undulata</i> (Sm.) Seem.	Honey Tree, Roheda	Bignoniaceae	Tree	Bark is used as remedy for syphilis.
176.	<i>Tectona grandis</i> L. f.	Teak, Sagun	Lamiaceae	Tree	Useful agroforestry tree species. Wood is useful in treatment of piles.
177.	<i>Tephrosia purpurea</i> (L.) Pers.	Sarapunkha	Leguminosae	Shrub	Plant is antihelminthic, alexiteric, restorative and antipyretic.
178.	<i>Terminalia arjuna</i> (Roxb. ex DC.) Wight & Arn.	Arjun Tree	Combretaceae	Tree	Used to treat asthma, scorpion stings and poisoning.
179.	<i>Terminalia bellirica</i> (Gaertn.) Roxb.	Bedda nut tree, Bahera	Combretaceae	Tree	Protects liver and treats respiratory tract infections.

Sr. No.	Botanical Name	Common Name	Family	Habit	Uses
180.	<i>Terminalia chebula</i> Retz.	Chebulic Myrobalan, Harad	Combretaceae	Tree	Used to lower down high cholesterol level and digestive disorders.
181.	<i>Thamnocalamus spathiflorus</i> (Trin.) Munro	Hill Bamboo	Poaceae	Shrub	Basket making.
182.	<i>Thysanolaena maxima</i> (Roxb.) Kuntze	Bamboo Grass	Poaceae	Grass	The leaves provide green forage for livestock, the roots promote soil conservation.
183.	<i>Toona ciliata</i> M. Roem.	Toon	Meliaceae	Tree	Bark is used for tanning leather. It is used as astringent and also used as tonic.
184.	<i>Trifolium pratense</i> L.	Tripatra	Leguminosae	Grass	Fodder
185.	<i>Trillium govanianum</i> Wall. ex D. Don	Himalayan Trillium, Nagchhatri	Melanthiaceae	Herb	Roots are used to stop postpartum bleeding.
186.	<i>Ulmus wallichiana</i> Planch.	Himalayan Elm	Ulmaceae	Tree	Fodder, Medicinal, Fuel and Timber.
187.	<i>Ulmus villosa</i> Brandis ex Gamble	Cherry Bark Elm	Ulmaceae	Tree	Fodder and Fuel.
188.	<i>Valeriana jatamansi</i> Jones	Mushq Bala, Jatamansi	Valerianaceae	Herb	It is used as a remedy for hysteria, hypochondriasis, nervous unrest and emotional stress.
189.	<i>Chrysopogon zizanioides</i> (L.) Roberty	Khas-khas	Poaceae	Grass	Used as coolant and aids in digestion. Considered as high class perfume.
190.	<i>Viburnum cotinifolium</i> D. Don	Smoke tree, Leaved Bhatnoi	Adoxaceae	Shrub	Fodder plant.
191.	<i>Viburnum grandiflorum</i> Wall. ex DC.	Grand Viburnum	Adoxaceae	Shrub	Leaves are purgative and diuretic and bark is used to treat malaria.
192.	<i>Viburnum mullaha</i> Buch.-Ham. ex D. Don	Starry Viburnum	Adoxaceae	Shrub	Treats menstrual pain and morning sickness.
193.	<i>Viburnum nervosum</i> D. Don	Molo	Adoxaceae	Shrub	Used in traditional medicine as a blood purifier
194.	<i>Viola biflora</i> L.	Yellow Wood Violet, Banaksha	Violaceae	Herb	The flowers are antispasmodic, diaphoretic, emollient and pectoral.
195.	<i>Viola pilosa</i> Blume	Banaksha	Violaceae	Herb	Antipyretic, diuretic and febrifuge in action. It treats

Sr. No.	Botanical Name	Common Name	Family	Habit	Uses
					various respiratory diseases.
196.	<i>Woodfordia fruticosa</i> (L.) Kurz	Red Bell Bush, Dhawai	Lythraceae	Shrub	Flower is applied externally to relieve burning sensation and it is a powerful astringent.
197.	<i>Zanthoxylum armatum</i> DC.	Tejphal, Tirmir	Rutaceae	Shrub	Used in many chronic problems such as rheumatism and skin diseases; chilblains, cramp in the leg, varicose veins and varicose ulcers. Also used as spice.
198.	<i>Ziziphus nummularia</i> (Burm.f.) Wight & Arn.	Jhar Beri,	Rhamnaceae	Shrub	Analgesic, anti inflammatory and antihelminthic.
199.	<i>Ziziphus jujuba</i> Mill.	Ber	Rhamnaceae	Shrub	Fruit is edible and is used to improve muscular strength and weight. It reduces constipation.

Annexure 4: Suitability of Species for Different Plantation Models of Three Landscapes of Beas Riverscape, Himachal Pradesh

Sr. No.	Botanical Name	Plantation Models																			
		Natural Landscape													Agricultural Landscape		Urban Landscape				
		BS/ HP/ NL/ 01	BS/ HP/ NL/ 02	BS/ HP/ NL/ 03	BS/ HP/ NL/ 04	BS/ HP/ NL/ 05	BS/ HP/ NL/ 06	BS/ HP/ NL/ 07	BS/ HP/ NL/ 08	BS/ HP/ NL/ 09	BS/ HP/ NL/ 10	BS/ HP/ NL/ 11	BS/ HP/ NL/ 12	BS/ HP/ NL/ 13	BS/ HP/ AL/ 01	BS/H P/AL /02	BS/H P/ UL/0 1	BS/H P/ UL/0 2	BS/ HP/ UL/ 03	BS/H P/ UL/0 4	BS/ HP/ UL/ 04
1.	<i>Acacia catechu</i>								✓	✓	✓										
2.	<i>Acer caesium</i>		✓		✓																
3.	<i>Acer pictum</i>		✓		✓																
4.	<i>Acer oblongum</i>																				
5.	<i>Aconitum heterophyllum</i>	✓	✓	✓	✓																
6.	<i>Adina cordifolia</i>								✓	✓	✓										
7.	<i>Aegle marmelos</i>								✓	✓	✓										
8.	<i>Aesculus indica</i>				✓																
9.	<i>Agropyron longearistatum</i>					✓	✓	✓													
10.	<i>Agrostis gigantea</i>	✓					✓	✓	✓												
11.	<i>Agrostis palustris</i>																				
12.	<i>Agrostis pilosula</i>																				
13.	<i>Ailanthus excelsa</i>																				
14.	<i>Albizia chinensis</i>								✓	✓	✓							✓	✓	✓	
15.	<i>Albizia procera</i>																	✓	✓	✓	
16.	<i>Albizia lebbeck</i>							✓	✓	✓	✓										
17.	<i>Allium humile</i>	✓	✓																		
18.	<i>Alstonia scholaris</i>									✓											

19.	<i>Angelica glauca</i>	✓	✓	✓	✓						✓	✓									
20.	<i>Apluda mutica</i>										✓	✓									
21.	<i>Araucaria araucana</i>																				
22.	<i>Arnebia benthamii</i>	✓	✓																		
23.	<i>Artemisia</i> spp.																				
24.	<i>Arundinella nepalensis</i>					✓					✓	✓									
25.	<i>Avena fatua</i>					✓					✓	✓									
26.	<i>Azadirachta indica</i>								✓												
27.	<i>Bambusa bambos</i>								✓		✓	✓									
28.	<i>Bauhinia variegata</i>						✓	✓	✓		✓	✓									
29.	<i>Berberis aristata</i>						✓									✓					
30.	<i>Berberis lycium</i>						✓	✓	✓												
31.	<i>Bergenia ciliata</i>			✓	✓																
32.	<i>Butea monosperma</i>																	✓		✓	
33.	<i>Bergenia stracheyi</i>		✓	✓																	
34.	<i>Betula alnoides</i>				✓																
35.	<i>Betula utilis</i>		✓																		
36.	<i>Boerhavia diffusa</i>								✓		✓	✓									
37.	<i>Bombax ceiba</i>																				
38.	<i>Bougainvillea</i> spp.																	✓		✓	
39.	<i>Cedrus deodara</i>			✓	✓																
40.	<i>Celtis australis</i>								✓		✓	✓									
41.	<i>Chrysopogon fulvus</i>						✓	✓	✓		✓	✓									
42.	<i>Cinnamomum tamala</i>						✓	✓	✓												

43.	<i>Cornus capitata</i>				✓															
44.	<i>Cornus macrophylla</i>																			
45.	<i>Cornus oblonga</i>			✓																
46.	<i>Corylus jacquemontii</i>		✓																	
47.	<i>Callistemon citrinus</i>																✓			
48.	<i>Cotoneaster bacillaris</i>			✓	✓															
49.	<i>Cupressus torulosa</i>			✓																
50.	<i>Cymbopogon distans</i>					✓		✓												
51.	<i>Cymbopogon martini</i>								✓											
52.	<i>Dactylorhiza hatagirea</i>	✓	✓																	
53.	<i>Dalbergia sissoo</i>								✓	✓	✓						✓	✓	✓	
54.	<i>Danthonia cuminsii</i>	✓				✓														
55.	<i>Daphne oleoides</i>																			
56.	<i>Daphne papyracea</i>			✓	✓															
57.	<i>Debregeasia hypoleuca</i>			✓	✓			✓	✓											
58.	<i>Dendrocalamus hamiltonii</i>						✓		✓	✓										
59.	<i>Dendrocalamus strictus</i>						✓		✓	✓	✓									
60.	<i>Desmodium elegans</i>			✓			✓													

61.	<i>Desmodium gangeticum</i>								✓												
62.	<i>Deutzia corymbosa</i>				✓																
63.	<i>Deutzia staminea</i>				✓																
64.	<i>Diospyros montana</i>						✓		✓	✓	✓										
65.	<i>Diospyros lotus</i>														✓	✓					
66.	<i>Diospyros edulis</i>														✓	✓					
67.	<i>Diospyros kaki</i>														✓	✓					
68.	<i>Drapanostachyum falcatum</i>					✓															
69.	<i>Eulalia aurea</i>					✓	✓	✓													
70.	<i>Eucalyptus</i> spp.																				
71.	<i>Embelia ribes</i>															✓					
72.	<i>Ficus bengalensis</i>						✓		✓												
73.	<i>Ficus carica</i>																				
74.	<i>Ficus palmata</i>																				
75.	<i>Ficus racemosa</i>						✓	✓	✓												
76.	<i>Ficus rumphii</i>						✓	✓	✓												
77.	<i>Geranium wallichianum</i>	✓	✓	✓	✓																
78.	<i>Grevillea robusta</i>																✓	✓	✓		
79.	<i>Ginkgo biloba</i>																				
80.	<i>Grewia optiva</i>						✓	✓	✓	✓	✓										
81.	<i>Heracleum candicans</i>	✓	✓	✓	✓																
82.	<i>Heteropogon contortus</i>						✓		✓	✓	✓										
83.	<i>Heteropogon</i> spp.							✓													
84.	<i>Hypericum</i>			✓	✓																

	<i>oblongifolium</i>																			
85.	<i>Indigofera heterantha</i>			✓																
86.	<i>Jacaranda mimosifolia</i>																✓	✓	✓	
87.	<i>Justicia adathoda</i>						✓	✓	✓											
88.	<i>Lemna minor</i>															✓				
89.	<i>Kigelia pinnata</i>																✓	✓		
90.	<i>Lyonia ovalifolia</i>						✓	✓												
91.	<i>Maesa indica</i>						✓	✓	✓											
92.	<i>Magnolia grandiflora</i>																			
93.	<i>Mallotus phillippensis</i>						✓		✓	✓	✓									
94.	<i>Morus alba</i>																			
95.	<i>Murraya koenigii</i>						✓	✓	✓											
96.	<i>Murraya paniculatus</i>						✓	✓	✓											
97.	<i>Myrica esculenta</i>								✓						✓	✓				
98.	<i>Melia composita</i>																	✓		
99.	<i>Nymphaea spp.</i>															✓				
100.	<i>Nerium oleander</i>																✓		✓	
101.	<i>Neolamarckia cadamba</i>																	✓		
102.	<i>Nyctanthes arbor-tristis</i>						✓	✓	✓								✓		✓	
103.	<i>Oroxylum indicum</i>								✓											
104.	<i>Machilus duthiei</i>																			

105.	<i>Phleum pratense</i>						✓	✓		✓	✓									
106.	<i>Phytolacca acinosa</i>		✓	✓																
107.	<i>Picea smithiana</i>		✓	✓	✓															
108.	<i>Picrorhiza kurroa</i>		✓	✓																
109.	<i>Pinus roxburghii</i>						✓													
110.	<i>Pinus wallichiana</i>		✓	✓	✓															
111.	<i>Platanus orientalis</i>																			
112.	<i>Poa pratensis</i>	✓				✓	✓	✓	✓											
113.	<i>Podophyllum hexandrum</i>	✓		✓	✓															
114.	<i>Polygonatum cirrhifolium</i>				✓															
115.	<i>Polygonatum verticillatum</i>	✓	✓	✓	✓															
116.	<i>Polyalthia longifolia</i>																✓	✓		
117.	<i>Pongamia pinnata</i>																	✓		
118.	<i>Prinsepia utilis</i>			✓	✓															
119.	<i>Prunus cerasoides</i>				✓															
120.	<i>Prunus armeniaca</i>													✓	✓					
121.	<i>Prunus mira</i>													✓	✓					
122.	<i>Prunus cerasifera</i>													✓	✓					
123.	<i>Prunus domestica</i>													✓	✓					
124.	<i>Prunus persica</i>													✓	✓					
125.	<i>Prunus cornuta</i>		✓		✓															
126.	<i>Punica granatum</i>							✓												
127.	<i>Pyrus pashia</i>								✓		✓									
128.	<i>Quercus floribunda</i>				✓															
129.	<i>Quercus glauca</i>				✓				✓											

130.	<i>Quercus oblongata</i>				✓		✓	✓			✓									
131.	<i>Quercus semecarpifolia</i>		✓		✓															
132.	<i>Rheum australe</i>	✓																		
133.	<i>Rheum moorcroftianum</i>	✓																		
134.	<i>Ricinus communis</i>						✓	✓	✓											
135.	<i>Rosa moschata</i>			✓					✓										✓	
136.	<i>Rubus biflorus</i>				✓															
137.	<i>Rubus ellipticus</i>				✓															
138.	<i>Rubus niveus</i>				✓															
139.	<i>Saccharum spontaneum</i>					✓														
140.	<i>Salix alba</i>																✓	✓	✓	
141.	<i>Saraca asoca</i>																✓	✓	✓	
142.	<i>Salix babylonica</i>																			
143.	<i>Salix daphnoides</i>																			
144.	<i>Santalum album</i>														✓					
145.	<i>Sapindus mukorossi</i>								✓	✓	✓				✓					
146.	<i>Selinum wallichianum</i>	✓	✓																	
147.	<i>Setaria glauca</i>					✓														
148.	<i>Setaria viridis</i>																			
149.	<i>Spiraea spp.</i>																✓		✓	
150.	<i>Shorea robusta</i>								✓											
151.	<i>Spirodela</i>															✓				

	<i>polyrhiza</i>																			
152.	<i>Stipa roylei</i>	✓																		
153.	<i>Syringa emodi</i>			✓																
154.	<i>Syzygium cumini</i>																✓	✓		
155.	<i>Taxus wallichiana</i>			✓	✓															
156.	<i>Tecoma stans</i>															✓				
157.	<i>Tectona grandis</i>																			
158.	<i>Tephrosia purpurea</i>						✓	✓	✓											
159.	<i>Terminalia arjuna</i>								✓	✓	✓					✓	✓			
160.	<i>Terminalia bellirica</i>								✓	✓	✓					✓	✓			
161.	<i>Terminalia chebula</i>								✓	✓	✓									
162.	<i>Thysanolaena maxima</i>						✓	✓	✓	✓	✓									
163.	<i>Thuja spp.</i>																	✓	✓	
164.	<i>Toona ciliata</i>							✓			✓									
165.	<i>Trifolium pratense</i>	✓				✓														
166.	<i>Trillium govanianum</i>			✓																
167.	<i>Ulmus wallichiana</i>				✓															
168.	<i>Ulmus villosa</i>																			
169.	<i>Valeriana jatamansi</i>			✓	✓															
170.	<i>Viburnum cotinifolium</i>			✓																
171.	<i>Viburnum</i>			✓	✓															

	<i>grandiflorum</i>																				
172.	<i>Viburnum mullaha</i>				✓																
173.	<i>Woodfordia fruticosa</i>						✓	✓	✓												
174.	<i>Zanthoxylum armatum</i>				✓			✓	✓						✓						
175.	<i>Ziziphus nummularia</i>						✓	✓	✓												
176.	<i>Ziziphus jujuba</i>						✓	✓	✓												

Annexure 5: Suitability of Species for Different Plantation Models of Three Landscapes of Beas Riverscape in Punjab

Sr. No.	Botanical Name	Plantation Models											Agricultural Landscape		Urban Landscape			
		Natural Landscape																
		BS/PB/ NL/01	BS/PB/ NL/02										BS/PB/ AL/01	BS/PB/ AL/02	BS/PB // UL/01	BS/P B/UL /02	BS/P B/UL /03	BS/P B/UL /04
1.	Acacia catechu	✓																
2.	Acacia nilotica	✓	✓															
3.	Adhatoda vasica													✓				
4.	Aegle marmelos	✓											✓	✓				
5.	Ailanthus excelsa	✓	✓															
6.	Albizia chinensis		✓														✓	✓
7.	Albizia lebbek		✓										✓					
8.	Albizia procera		✓												✓		✓	✓
9.	Araucaria araucana																✓	✓
10.	Asparagus racemosus													✓				
11.	Azadirachta indica	✓	✓										✓					
12.	Bambusa bambos													✓				
13.	Bombax ceiba	✓																
14.	Bougainvillea															✓		✓

Sr. No.	Botanical Name	Plantation Models											Agricultural Landscape		Urban Landscape			
		Natural Landscape																
		BS/PB/ NL/01	BS/PB/ NL/02									BS/PB/ AL/01	BS/PB/ AL/02	BS/PB // UL/01	BS/P B/UL /02	BS/P B/UL /03	BS/P B/UL /04	
	spp.																	
15.	<i>Butea monosperma</i>		✓											✓			✓	
16.	<i>Cinnamomum verum</i>												✓					
17.	<i>Callistemon viminalis</i>														✓	✓	✓	
18.	<i>Capparis decidua</i>	✓																
19.	<i>Cassia fistula</i>	✓																
20.	<i>Cinnamomum tamala</i>												✓					
21.	<i>Cordia myxa</i>	✓																
22.	<i>Cryptomeria japonica</i>															✓	✓	
23.	<i>Dendrocalamus hamiltonii</i>												✓					
24.	<i>Dalbergia sissoo</i>	✓	✓												✓	✓	✓	
25.	<i>Dendrocalamus strictus</i>												✓					
26.	<i>Eichhornia</i>													✓				

Sr. No.	Botanical Name	Plantation Models													Agricultural Landscape		Urban Landscape			
		Natural Landscape																		
		BS/PB/ NL/01	BS/PB/ NL/02										BS/PB/ AL/01	BS/PB/ AL/02	BS/PB // UL/01	BS/P B/UL /02	BS/P B/UL /03	BS/P B/UL /04		
	<i>crassipes</i>																			
27.	<i>Embelia ribes</i>													✓						
28.	<i>Eucalyptus</i> spp.															✓		✓		
29.	<i>Gmelina arborea</i>												✓	✓						
30.	<i>Grevillea robusta</i>		✓													✓	✓	✓		
31.	<i>Grewia elastica</i>	✓																		
32.	<i>Gymnema sylvestre</i>													✓						
33.	<i>Holarrhena antidysenterica</i>												✓	✓						
34.	<i>Jacaranda mimosifolia</i>		✓													✓	✓	✓		
35.	<i>Kigelia pinnata</i>															✓	✓	✓		
36.	<i>Melia composita</i>	✓	✓										✓	✓			✓			
37.	<i>Melia azedarach</i>		✓																	
38.	<i>Morus alba</i>	✓																		
39.	<i>Mucuna pruriens</i>													✓						
40.	<i>Neolamarckia cadamba</i>		✓														✓			

Sr. No.	Botanical Name	Plantation Models													Agricultural Landscape		Urban Landscape			
		Natural Landscape																		
		BS/PB/ NL/01	BS/PB/ NL/02										BS/PB/ AL/01	BS/PB/ AL/02	BS/PB // UL/01	BS/P B/UL /02	BS/P B/UL /03	BS/P B/UL /04		
41.	Nerium oleander															✓		✓		
42.	Nyctanthes arbor-tristis															✓		✓		
43.	Phyllanthus emblica											✓	✓							
44.	Polyalthia longifolia															✓	✓	✓		
45.	Pongamia pinnata	✓															✓			
46.	Populus deltoides											✓	✓							
47.	Prosopis cineraria	✓																		
48.	Pterocarpus marsupium	✓																		
49.	Rosa spp.															✓		✓		
50.	Salix alba		✓														✓	✓		
51.	Santalum album											✓	✓							
52.	Sapindus mukorossi												✓							
53.	Saraca asoca															✓	✓	✓		

Sr. No.	Botanical Name	Plantation Models													Agricultural Landscape		Urban Landscape			
		Natural Landscape																		
		BS/PB/ NL/01	BS/PB/ NL/02									BS/PB/ AL/01	BS/PB/ AL/02	BS/PB // UL/01	BS/P B/UL /02	BS/P B/UL /03	BS/P B/UL /04			
54.	<i>Actinoscirpus grossus</i>													✓						
55.	<i>Sesbania sesban</i>	✓																		
56.	<i>Spiraea</i> spp.														✓		✓			
57.	<i>Spirodela polyrhiza</i>													✓ _s						
58.	<i>Syzygium cumini</i>											✓	✓			✓				
59.	<i>Terminalia bellirica</i>		✓									✓	✓							
60.	<i>Terminalia chebula</i>		✓										✓							
61.	<i>Tamarindus indica</i>											✓	✓							
62.	<i>Tecoma stans</i>													✓						
63.	<i>Tecomella undulata</i>	✓																		
64.	<i>Tectona grandis</i>	✓																		
65.	<i>Terminalia arjuna</i>	✓										✓	✓							
66.	<i>Thuja orientalis</i>															✓	✓			

Sr. No.	Botanical Name	Plantation Models															
		Natural Landscape										Agricultural Landscape		Urban Landscape			
		BS/PB/ NL/01	BS/PB/ NL/02									BS/PB/ AL/01	BS/PB/ AL/02	BS/PB // UL/01	BS/P B/UL /02	BS/P B/UL /03	BS/P B/UL /04
67.	<i>Tinospora cordifolia</i>												✓				
68.	<i>Toona ciliata</i>	✓	✓														

Annexure 6: Consent letter on availability of land for various forestry intervention in state of Punjab

To

Government of Punjab
Department of Forest & Wildlife Preservation
O/o Principal Chief Conservator of Forests (HoFF),
Forest Complex, Sector 66, SAS Nagar (Mohali)

Director General,
Indian Council of Forestry Research & Education,
P.O. New Forest,
Dehradun.

No.
Dated:

Subject: Feedback and comments on availability of land for forestry interventions proposed in the DPR for Rejuvenation of Rivers.

Reference: Your letter No. 41-58/2019/ADG (M&E) /ICFRE/DPR/ VOL.III/ 113 dated 12/10/2020 and NAEB letter No.12-4/2017 B-III (NAEB) dated 17/09/2020

With reference to above mentioned letters concerning the availability of land to carry out the prescribed forestry interventions, it is intimated that the required information has been provided by the respective divisions of the Punjab Forest Department with regard to the locations along the river scapes of Beas, Ravi and Satluj and its tributaries. The proposed forestry interventions have been deliberated in the stake holders meeting.

In view of above, it is intimated that the sufficient land is available to take up the forestry interventions along the river scapes of Beas, Ravi and Satluj in respective forest divisions of Punjab State.

Principal Chief Conservator of Forest (HoFF)
Punjab, SAS Nagar, Mohali.

No. SP2/1730-31

Dated - 27/10/2020

Copy is forwarded to the following for information and necessary action.

1. Assistant Commissioner (Forest), Ministry of Environment Forest & Climate Change (NAEB), New Delhi.
2. Director, HFRI, Shimla, Himachal Pradesh.

Principal Chief Conservator of Forest (HoFF)
Punjab, SAS Nagar, Mohali.

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Annexure 7: Consent letter on availability of land for various forestry intervention in state of Himachal Pradesh



No. Ft.15-642/2019(D)DPR/IRB
Himachal Pradesh Forest Department

To

The Director,
Himalayan Forestry Research Institute,
Conifer Campus, Panthaghati, Shimla-1710013.

Dated Shimla-1, the - 3 NOV 2020

Subject

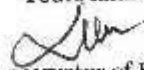
Request to provide information on availability of land for forestry interventions and certificate of verification of plantation and cost.

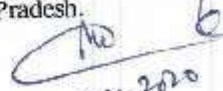
Sir,

Kindly refer to your office letter No.4 (Vistar-28) Hf.v.a.s./2020/1288 dated 25.09.2020 on the subject cited above.

2. In this regard it is certified that land is available in the concerned Forest Divisions for proposed forestry interventions as mentioned in the Draft Detailed Project Reports (DPRs) for rejuvenation of five major rivers i.e. Beas, Chenab, Jhelum, Ravi & Satluj prepared/finalized by the Himalayan Forest Research Institute, Shimla in consultation with the field officers of this department as per geo coordinates given in the DPRs.

Yours faithfully,


Chief Conservator of Forests (Fin.)
Himachal Pradesh.


3.11.2020