ANNUAL REPORT 2022-23

G.B. Pant National Institute of Himalayan Environment (NIHE)
(An Autonomous Institute of Ministry of Environment, Forest & Climate Change)

Kosi-Katarmal, Almora 263643, Uttarakhand, India
Website: www.gbpihed.gov.in

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Member Secretary

Director
NIHE, Kosi-Katarmal, Almora

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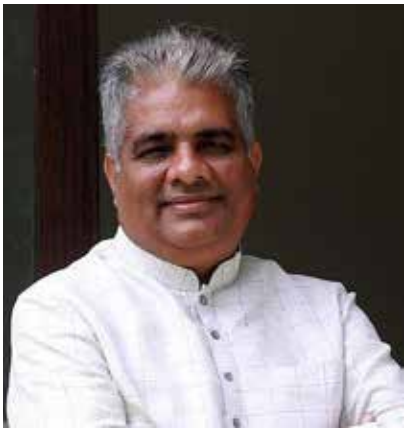
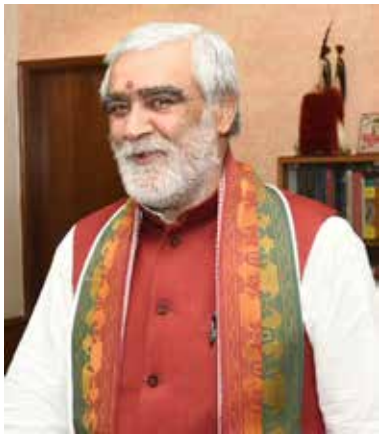


Sh. Bhupender Yadav
Hon'ble Union Minister
Ministry of Environment, Forest & Climate Change
Government of India



Sh. Ashwini Kumar Choubey
Hon'ble Union Minister of State
Ministry of Environment, Forest & Climate Change
Government of India

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FOREWORD

GB Pant National Institute of Himalayan Environment (NIHE) has been a distinguished name in research and developmental work pertaining to the Indian Himalayan Region (IHR). The Institute is accomplished with a wide range of in-depth research activities in the IHR in close coordination with its national and international partners. The priority R&D issues of the IHR which are being addressed can be placed in four core areas i.e., Land and Water Resource Management (LWRM), Socio-Economic Development (SED), Biodiversity Conservation and Management (BCM) and Environmental Assessment & Climate Change (EA&CC). The Thematic Centres based on the four core areas, and six Regional Centres of NIHE have established their visibility and relevant presence across the IHR through their innovative and intensive R&D endeavours. During the Year 2022-23, the Institute has comprehensively reoriented its approaches to extend its research activities to find solutions to burgeoning problems of the mountainous region and to further strengthen the policy, science and people interface. The initiatives are structured for enabling the outcomes to strike a balance between the conservation of natural resources and developmental aspirations of the people. The development of 13 district-level Environmental Management Plans for Uttarakhand prepared as per the Hon'ble NGT guidelines and submitted to the State Pollution Control Board, Uttarakhand, can be considered as one of the major policy-level contributions of the Institute. Moreover, the Institute has completed three regional level landscape development programs (KSLCDI, KLDI and Hi-LIFE) in collaboration and support from International Centre for Integrated Mountain Development (ICIMOD) involving four neighbouring countries, Nepal, China, Bhutan and Mynmar. It is expected that the project outcomes of these regional collaborations will not only help in shaping the developmental trajectories and socio-economic development of the IHR but also strengthen the regional cooperation for addressing the issues of transboundary conservation and management. Presently, the Institute is working on contemporary issues in the IHR to address the challenges of water security, climate change, biodiversity conservation, and limited livelihood opportunities. To address these challenges, the Institute through its multi-disciplinary thematic groups targeted various aspects simultaneously. Some noteworthy initiatives during the reporting time include rejuvenation of natural springs using the spring sanctuary concept, development of a mobile application "Jaldhara" for in-site data acquisition, a long-term database for aerosol climatology, radiative forcing, temperature rise and major ambient air pollutants like PM10, PM2.5, SO_2, NO_2, BC, etc., a database for extreme weather events of Beas valley, Himachal Pradesh, promotion of rural technologies for improving the livelihoods, conservation of threatened and endemic species, establishment of plant genetic resource centre, the discovery of new species of Balsamina (Impatiens rajibgogoii) from Sikkim, development of custom-made Hydroponic system and its replication in different commercial establishments of Leh town, regular training and capacity-building programs for a diverse group of stakeholders across all Regional Centres and HQs etc.

Climate change has severely affected the planet Earth and people in developing countries are more vulnerable to it due to various factors. Climate change is irreversible hence along with mitigation strategies the institute is exploring its dimension to gain benefits so as to secure the livelihood of the society as well as best coping mechanisms. In this endeavour NIHE has initiated work towards developing a climate smart village framework by mapping, risk resilience and challenges in sustainable modernization of villages and landscapes in the IHR. Faculty and researchers of the Institute are now passionate and committed to develop innovative research projects for investigating some unexplored dimensions of the Himalayan region to bring out conducive solutions for sustaining ecosystems, socio-economic development of the region and publish quality research outcomes. During this reporting year, more than 100 research papers have been published in reputed national/international journals and 58 articles as books chapters/ conference proceedings. Additionally, 22 authored books/edited books/bulletins/monographs have also been published. Faculties and researchers of the Institute have been actively engaged in organizing more than 65 events for awareness generation, capacity building and knowledge exchange/ dissemination during the year. To strengthen the R&D activities the institute has signed MoU with 04 primier organizations of our country. In this year the institute has brought more than 20 research projects on contemporary themes to achieve its mandate.

I record my gratitude and thanks for the support and guidance that the Institute receives from the Hon'ble President, Hon'ble Vice-President and all members of the Society and respected Chairperson and all members of the Governing Body and Scientific Advisory Committee of the Institute. I extend my heartfelt thanks to all the scientists, staff and research scholars/students of NIHE for their support and cooperation in making all efforts for the achievements. With the support and guidance of all our apex bodies (i.e., the Society, the Governing Body and the Scieintific Advisory Committee) and the commitments of the young and motivated group of researchers, faculties & staff, we are confident to taking the Institute further in our R&D activities and achieving our goals of global excellence.

Prof. (Dr.) Sunil Nautiyal
Director

MAJOR ACHIEVEMENTS (2022-23)

- A greywater treatment system is installed in the NIHE Kosi campus; it is based on fixed bed experiments and is functional at both lab and pilot levels. The carbon with the highest performance is demonstrated as an exceptional breakthrough and enhances regeneration capacities, even at minimal bed heights. This experiment is expected to be beneficial at the commercial level while applying the greywater treatment process.

- A total of 6124 springs have been inventoried and geo-tagged on the HIMAL portal covering 111 blocks in 25 districts of 12 States/UTs of IHR through different spring rejuvenation projects. A mobile app – 'Jaldhara' has also been developed under the Jal Abhayaranya project to have wider applications for in-situ data acquisition of springs and other water sources.

- Hydrometeorology studies in Pine-Oak dominated systems indicate that the NEE of the Oak ecosystem is moisture-driven as compared to the Pine ecosystem, which is heat-dominated. This signifies that the Oak ecosystem strategically provides effective soil and water conservation services.

- Towards popularizing rural technologies for improving the livelihood across the IHR, various training programmes on protected cultivation, integrated fish farming, medicinal and aromatic plants cultivation, beekeeping, hydrponics, mushroom cultivation, etc., have been organized through HQs Kosi-Katarmal, NERC Itanagar, HPRC Kullu, SRC Pangthan and LRC Leh.

- Capacity building of the Gram Pradhan, CBOs, and other line agencies was carried out for the baseline data collection to assess the resources and mapping at the household level of 25 villages of 5 districts in the Kumaon sector and across Regional centres. Interventions made in Jeoli village cluster improved farmers' income by around (68%), which is a step forward in doubling the farmer's income.

- Database for Extreme Weather Events (Cloudburst, Flash Flood) in the Beas basin from 1994 to 2022 has been prepared, indicating a drastic 409% increase in the frequency of extreme weather events.

- Long-term database generated on aerosols climatology, radiative forcing, temperature rise, and on major ambient air pollutants like PM10, PM2.5, SO_2, NO_2, BC, etc., in the Kullu, Himachal Pradesh and Kosi-Katarmal, Almora (Uttarakhand)

- For the first time, a new species of Balsaminaceae (*Impatiens rajibgogoii*) from Sikkim was discovered, and 2 new records of orchids, each from Sikkim and West Bengal, India, were recorded. The first report of *Dothiostroma pini* stain DPE01 causing leaf spots on *Ageratina adenophora* in India is reported.

- Efforts were made to conserve the threatened and endemic species of the Himalayan region. In this context, a sanctuary of 5 species of Berberis and Mahonia (*B. asiatica, B. lycium, B. jaunsarensis, B. aristatand* and *Mahonia jaunsarensis*) has been developed in Surykunj, Almora.

- A Genetic Resource Centre is established in Kullu and Narayan Ashram, Pithoragarh, for the conservation and multiplication of quality planting material for threatened and high-value medicinal plants like *Picrorhiza kurroa, Rubia cordifolia, Swertia chirayita, Nardostachys jatamansi, Hedychium spicatum, Valeriana jatamansi, Angelica glauca* and *Allium stracheyi*.

- A custom-made Hydroponics system with a polycarbonated greenhouse at the Rural Technology Centre (RTC) of LRC is developed and successfully installed at different hotels in Leh. Similarly, NERC hydroponic was established using bamboo and PVC pipes to cultivate and promote economic and medicinal plant species of the north-eastern region of India.

- The Institute is providing technical support to the Biodiversity Boards of Arunachal Pradesh, Himachal Pradesh, Sikkim, Uttarakhand, and Leh to prepare the People Biodiversity Register. During this year, the Institute facilitated 75 PBRs with Arunachal Pradesh, Himachal Pradesh, and Sikkim Biodiversity Boards.

- As per the honerable NGT guidelines, Environment management plans of 13 districts of Uttarakhand have been prepared and submitted to the State Pollution Control Board, Uttarakhand.

- The Institute developed Eco-restoration plans for the Gangotri-Govind and Darma Byans landscapes, (its campuses like Surya Kunj in Katarmal, Mohal Khad and Dohranalain Kullu Valley, Banswara in Kedarnath valley, etc).

Publications:

1. Peer Reviewed National & International Journals	104
2. Chapters in Books / Proceedings	58
3. Authored/ Edited / Books / Booklets / Bulletins / Monographs	22
4. Popular Articles	21
5. Policy Papers	03

EXECUTIVE SUMMARY

The G.B. Pant National Institute of Himalayan Environment (NIHE), mandated for environmental conservation and sustainable development of the Indian Himalayan Region (IHR), addresses front-running environmental issues of physical, biological and socio-economic nature in an integrated manner to cater to the needs of a range of stakeholders including academia, policymakers and planners, Govt. line agencies engaged in field implementation, NGOs and CBOs etc. The R&D mandate of the Institute is broad and covers all the facets of the mountain environment and development. Towards achieving this goal, in-depth knowledge generation through multidisciplinary R&D projects and integration of multiple subjects is the guiding principle. Further, emphasis is given to the interlinking of natural and social sciences in all the R&D projects. In this endeavour, special attention is placed on the intricate balance between the fragility of mountains, indigenous knowledge and sustainable use of natural resources. Stakeholders' viewpoint and feedback is invited and considered in designing and implementing R&D activities. Adequate efforts are devoted to addressing priority environmental problems and developing and demonstrating best practices, technology packages and delivery systems for improved livelihood and socio-economic development of the people. Also, conscious efforts are made to mobilize various stakeholders (students, researchers, academicians, farmers, citizens, NGOs, policymakers, National and International funding agencies and others) to participate in Institute programmes through different initiatives and mechanisms. Training, education and awareness of various stakeholders are the essential components of all the R&D programmes. The R&D activities of the Institute are conceptualized, governed and executed through four thematic Centres and five regional Centres. Thematic Centres include (i) Centre for Land and Water Resource Management (CLWRM); (ii) Centre for Socio-Economic Development (CSED); (iii) Centre for Biodiversity Conservation and Management (CBCM); and (iv) Centre for Environmental Assessment and Climate Change (CEA&CC). The regional Centres of the Institute are (i) Himachal Regional Centre; (ii) Garhwal Regional Centre; (iii) Sikkim Regional Centre; (iv) North-East Regional Centre; (v) Ladakh Regional Centre; (vi) The 6th Centre Mountain Division Regional Centre housed in MoEF&CC, New Delhi to look into policies issues across IHR. These regional centres cater to the specific R&D needs of the respective States/ regions. During the reporting period, 41 R&D projects (ongoing) were implemented across the IHR and completed 16 projects. A summary of R&D activities and achievements of different Centres of the Institute during the reporting year 2022-23 is as follows:

1. Thematic Centres

(i) Centre for Land & Water Resource Management (CLWRM)

In line with the Center's overarching goal to offer R&D based sustainable solutions to freshwater-related problems in the Indian Himalayan Region, the Center's research and development initiatives in 2022-23 were focused on scientific understanding of water-related problems and formulating holistic replicable strategies for conservation and management of water to promote the integrated development in IHR. The Center's R & D activities in 2022-23 cover all 11 states and 1 UT of IHR to address the key challenges of land and water resources ranging from spring ecosystem assessment and management, spring rejuvenation for water security, assessment of hydrometeorology and ecosystem services of Pine-Oak systems, Pine needle-based wastewater treatment etc. The major in-house project aims to the scientific understanding of spring-ecosystems functioning and conservation and management through the Jal Abhayaranya concept across of four IHR states four regional centers of the Institute. Along with the inventory of 6124 springs in 111 blocks in 25 districts of twelve States/UTs of IHR, the monitoring of spring quality and quantity, delineating spring recharge potential zones, continues across the project sites. Moreover, ground-based engineering interventions have also started for rejuvenating of spring sources to provide possible water security at the village level. The impact of the same will be monitored in the coming years. Further, the awareness and training programmes were also organized to sensitize the populous on springshed management, including creating a cadre of para-hydrogeologists. Other 5 externally funded R&D projects were also implemented during 2022-23 to support the centre's R & D mandates. The first phase of the mobile app – 'Jaldhara' developed under this project, has a wider application for in-situ data acquisition of springs and other water sources. One of the first attempts to address the drying of springs and its revival using hydro-geological action research in the cold desert region is also started in Lahaul and Spiti region, Himachal Pradesh, by the center. A thorough assessment of the Pine-Oak-dominated ecosystem is also carried out to address the multiple research and policy issues of the hydrometeorology and ecosystem services of Pine-Oak systems of the IHR. A study of permafrost mapping and its characterization in the

Western Himalayan Region is also being conducted in the center. Subsequently, water, permafrost leachates and soil samples were collected at different locations in Leh, Ladakh for analysis. Further, the possibility of pine needles as a source for designing grey water treatment material is being explored in one of the projects at the lab and pilot scale. This experiment is expected to be beneficial for commercial application in greywater treatment processes and alternative usage of pine needles, which is considered one of the major reasons for forest fires

(ii) Centre for Biodiversity Conservation & Management (CBCM)

The Center for Biodiversity Conservation and Management (CBCM) has made substantial contributions and is actively involved in research and development activities in the Indian Himalayan Region. The center has made notable efforts to tackle significant regional biodiversity issues through its ongoing projects. During 2022-23, CBCM established (i) the first GLORIA site in the Spiti Valley of Himachal Pradesh Pradesh, North-Western Himalayan region; (ii) two long-term ecological monitoring (LTEM) sites in *Pinus wallichaina* and *Abies pindrow* forest types of Himachal Pradesh; (iii) carbon stock analysis of the LTEM plots in the western Himalaya; (iv) Photosynthetic gas exchange behaviour studies of the dominant and co-dominant species at different LTEM sites; (v) Species distribution modeling of *Pinus roxburghii* in Pithoragarh district, (vi) Estimation of Economic Losses in real Term Per Hectare Basis in Uttarakhand and Madhya Pradesh; (vii) documentation of endemic species funded by MoEFCC, (viii) promoting the cultivation of medicinal plants at farmers field; and (ix) generating awareness on the various issues of biodiversity. The centres have organized various workshops and awareness programmes to address biodiversity issues in the Indian Himalayan region. For instance, workshops focusing on forest-based resources and livelihood options helped to identify viable opportunities for sustainable management of forest resources and strategies for livelihood development; two awareness programs in Bamnigard and Jyoli village cluster of Almora district as a part of the "International Year of Millets 2023" focused on generating awareness about our traditional crops; celebration of different national and International days and training and capacity-building programmes for school children and teachers, University students and researchers, farmers and local people helped to connect people towards the biodiversity. The centre's R&D efforts covered a wide span of activities: strengthening the database through incentivization and prioritization of biodiversity (flora and fauna), assessment of floristic diversity among diverse ecological conditions such as cold deserts, wetlands and aquatic systems, arboreal habitats, etc., population status of RET category of species, threat assessment (due to biotic interference, invasion of weeds, etc.), use pattern of bio-resources (NTFPs) based on pilot studies, digital database development, documentation of case studies

and indigenous knowledge on conservation and sustainable management of biodiversity and suggest methods for reducing pressure on biodiversity and promoting sustainable use.

(iii) Centre for Socio-economic Development (CSED)

The overarching vision of the Centre for Socio-Economic Development is promoting ecological, economic and sustainable development across the Indian Himalayan region. The centre has always been part of the core programme of the organization and was called Sustainable Development of Rural Ecosystems when it was established in 1988-89. The Centre focuses on integrated watershed management, rehabilitation of degraded land and addresses the socio-economic issues that impede the sustainable development of society and conservation of biodiversity. The centre's activities revolve around the core competence that includes location-specific eco-development, rehabilitation of degraded land through multi-purpose tree species, sustainable use of natural resources, socio-economic development that includes value chain development, product development, ecotourism promotion, protected cultivation, and MAPs. The centre is also responsible for documentation of indigenous knowledge and natural resources management planning. Social outreach is provided through the Rural Technology Centre to central, state governments and line agencies through capacity building and technological backstopping. Quality planting material is also raised through appropriate nursery techniques. The group works towards a circular economy that begins and ends in nature through low cost livelihood enhancing technologies. The centre works in synchrony with the SDG 2030 goals and Sansad Adarsh Gram Yojna and aptly works towards the Prime Minister's clarion call towards Van Dhan, Jan Dhan and Govardhan, a major economic component of our country.

(iv) Centre for Environmental Assessment & Climate Change (CEA&CC)

In the year 2022-23, the Centre for Environmental Assessment and Climate Change (CEA&CC) implemented multiple projects, including an in-house project and eight externally funded projects, and completed one project. The In-house project on 'Fostering Climate Smart Communities in the Indian Himalayan Region' aims to assess the vulnerability of Himalayan communities, develop a decision support system, and foster climate-smart communities and climate change leaders in the IHR. The second and third projects mainly pertain to aerosols and gaseous pollutants and their impacts on radiative forcing and temperature rise. Aerosols including black carbon and gaseous pollutants, that have been driving climate change from local to regional levels have been monitered under the "Aerosols Radiative Forcing over India (ARFI)" and "Atmospheric Chemistry, Transport, and Modelling" programs of ISRO-GBP since 2007. The fourth project focuses on District/State environmental management plans in view of important environmental issues raised by the Hon'ble National Green Tribunal (NGT), studying gaps and suggesting action plans as policy guidelines. The fifth and sixth

externally funded projects from DBT are mainly concerned with using important medicinal plants. One project studies nano-pesticide biosynthesis and its impact assessment on secondary metabolism (*Picrorhiza kurroa*), and the other aims at bio-prospecting of medicinal plants of Sikkim Himalaya against Breast Cancer Angiogenesis. The seventh project funded by DST aims at assessing the "Geospatial variability of soil microbial indices of climate-sensitive alpine treeline ecotone of Indian Western Himalaya and its linkages to soil organic carbon fractions. The eighth DST-funded project pertains to one of the eight National missions titled, "Forest Resources and Plant Biodiversity, TF-3 Phase II (NMSHE; DST, 2021-2026)". Similarly, the ninth NMHS-funded project titled, "Himalaya Calling: Bridging Science Policy & Practice Fosters Sustainable Development in the Indian Himalayan Region under NMHS funded Project" aims to promote sustainable development in the Indian Himalayan Region. Lastly, the tenth MoEFCC cum UNDP funded project on the ecorestoration of degraded land has been finalized by suggesting a strategy to plant in alpine and subalpine grassland ecosystems as a complement to the commencement of the United Nations Decade on Ecosystem Restoration (2021-2030).

2. Regional Centres

(i) Himachal Pradesh Regional Centre (HPRC)

During the reporting period of 2022-23, spring inventory for a total of 50 from the Mandi district of Himachal Pradesh has been prepared, and their Water Quality Index was also calculated under the Water Security in Himalaya through Spring-Ecosystem Assessment and Management. Under the project Community driven eco-smart model village development to improve livelihoods and fostering ecological security in the Himalayas, Unnat Bharat Abhiyan (UBA) questionnaire survey for 1221 households in the identified villages of different districts of Himachal Pradesh has been completed, and baseline information on socio economic indices were collected through secondary data from various departments of the state. Different parameters for landslide inventory and fire data, such as LULC, fire event data, road, settlement, soil texture, landslide inventory, precipitation data, population density, etc., were collected to calculate the Environmental Vulnerability Index (EVI) of Himachal Pradesh. Under the project, Mainstreaming Himalayan Biodiversity for Sustainable Development, high value medicinal plant cultivation is being promoted in the farmers field by providing quality plant and seed material to cultivators/farmers. Established 2 herbal gardens by planting *Taxus contorta, Swertia chirayita, Withania sominfera, Gingko Biloba, Bergenia ciliata*, as part of ex-situ conservation of threatened medicinal plant species. Under the project, Conservation and Management of traditional beekeeping (*Apis cerana*) practices through the development of a honeybee based sustainable livelihood chain in the Kullu Valley, Himachal Pradesh, 150 beekeepers trained as master beekeepers in the Tung Panchayat and incentivised with one active beehive of indigenous bee species *Apis cerana* along with major & minor beekeeping tools. Physical and Chemical Analysis of Honey has been done as per the FSSAI norms. Under the project, Gaseous air pollution in the background sites of sprawling urban environment in Himachal Pradesh, Sulphur Dioxide showed the highest average concentration of 2.12±0.03ppb in October 2022. It showed the lowest average concentration of 0.57±0.02 ppb in June 2022. AOD values at shorter wavelengths are higher, indicating increased anthropogenic activities. The mean AOD500nm at Mohal (1154 m AMSL) in 2022 stood to be 0.34±0.0. Under the project Modelling and Forecasting of High Impact Weather Events in the Beas Basin and Designing a Proto-type Advance Warning System for mitigating their Adverse impacts, a flood Hazard Susceptibility Map was prepared using AHP Modelling Approaches. As per the perception study, only 11% and 17% of the respondents in the Parvati and Beas basins were aware of the disaster management authority in their district and no Mock- drills have been conducted by any authority in the vulnerable regions of the district. Under the project, Implementation of Environment Monitoring Programme and Impact Evaluation of Sainj Hydroelectric Project during the Operation phase, soil samples were collected around the 10 km radius of the hydroelectric project and their soil moisture, pH and EC were tested in the laboratory.

(ii) Garhwal Regional Centre (GRC)

During the current year (2022-23), the key areas of focus were spring-ecosystem assessment and management, developing community driven eco-smart modal villages to foster climate smart communities, developing biodiversity database networks and propagation protocols for MAPs through the implementation of 4 In-house and 6 externally funded projects. Under the In-house projects, baseline inventory on springs (location, discharge and physical parameters) in Khirsu and Jakholi blocks, demographic and household surveys (socio-economic profiles, forest resources, livestock and land use) in Joshimath block have been done. A technical

manual for artificially recharging springs has been submitted to Rudraprayag district's DFO, and a combined initiative for constructing pits and trenches is being planned. A bio-brequett unit has also been established at Pangroli village to strengthen participatory learning of the local community regarding the model. Genetic diversity of various populations of high-value medicinal plants (such as *Rheum australe*, etc.) has been done in order to suggest in situ and ex situ conservation measures and maintain wide genetic pools. Apart from this, under NMHS, a database on 152 accessions of Rajmas from Uttarakhand has been prepared in the Centre following the standard pattern of NBPGR. The breeders could utilize genetic resources developed through this study for large-scale screening of useful traits in common bean accessions and other Fabaceae members for conservation and production improvement. A demonstration of different accessions has also been prepared for RTC Triyuginarayan. Geo-coordinated datasets have been generated for the alpine biodiversity of Pithoragarh, west Himalaya. Under NMSHE, a database on lichen diversity and threatened plant diversity in the Indian Himalayan Region has been completed. The centre has done a total of 8 outreach events in the form of workshops, trainings, demonstrations, etc., to sensitise local populations towards rural technologies to generate income through market linkages. Moving away from subsistence-based agriculture on marginal lands in high-value farm and non-farm products with comparative advantage in hill areas is considered a central element of the strategy for sustainable development. Due to the constraints imposed by inaccessibility to markets and services and environmental sensitivity to some of the useable resources, the choices of activities, technology and scale need to be carefully applied to ensure sustained income generation and environmental conservation.

(iii) Sikkim Regional Centre (SRC)

The R&D activities during 2022-23, were focused on spring rejuvenation and sustainability, improving livelihood and ecological security, fostering climate smart communities, biodiversity conservation, tree ring growth dynamics, strengthening regional cooperation for trans-boundary landscape management, knowledge networking, and establishment of Nature Learning Centre through the implementation of 4 In-house and 5 externally funded projects, 1 Trans-boundary landscape programme and 1 fellowship programme. Under the In-house projects, activities of mapping of springs, village resource-use maps, framework for district and block level vulnerability assessment, validation of PBR, thematic distribution maps of RET, medicinally and economic plants were carried out. Three rain gauges and soil moisture sensors were established in the South Sikkim district. The cultivars of large cardamom (Dzongu Golsey, Sawney, Seremna, Ramsey, and Varlangey) were prioritized in their suitable elevation range for Sikkim State. Also, a network of Siri cattle farmers and Yak herders was strengthened, and an integrated organic farming model was replicated in Kalimpong. An Orchid trail and Orchidarium (with 120 species) and a rhododendron trail (with 12 species) were strengthened. A long-term study plot was also established inside the arboretum for ecological, biodiversity and climate change monitoring, and a network of students and teachers of eco-clubs was created to raise awareness towards environmental conservation. Under the Himalayan Knowledge Network (HKN), two thematic documents on the Conservation and management of High-Altitude Wetlands and Natural Hazards were drafted for Sikkim. Further, LoA was signed with Tripura University for the implementation of HKN in Tripura. Further, thematic priorities for Assam and Meghalaya were identified through state-level consultations. Field validation of

indigenous soil and water conservation practices adopted by communities was carried out. Under NMSHE Task Force-3 (Phase-II), dendro-chronological potential tree species and growth response of selected tree species to climatic parameters for North East Himalaya were assessed based on an extensive review of the literature. Further, 210 tree cores of *Tsuga dumosa, Cryptomeria japonica, Pinus roxburghii* were collected from Sikkim to study the growth response of these tree species to climate change. The centre also organized various workshops, awareness, training and capacity building programme (e.g. workshop on Himalaya Calls for Action: Scoping regional cooperation and knowledge networking, State level workshop on High Altitude Wetlands of Sikkim, Natural Hazards, and trainings on different subjects, such as statistical methods in environmental studies, organic farming, vegetation sampling, hospitality and housekeeping services, etc., and exposure events) for dissemination of the knowledge and extension of activities. This year, the Sikkim Regional Centre published 37 publications, including 24 research papers, 01 policy brief, 07 book chapters, 01 edited book, 02 authored booklets and 02 popular articles.

(iv) North-East Regional Centre (NERC)

The NERC's main R&D functions are (i) conservation of biological diversity (ii) sustainable socio-economic development and livelihood security, (iii) adaptation/ mitigation of climate change impacts, (iv) ecotourism (v) low-cost rural technologies and (vi) networking and collaborations with other Institutes/ organizations. Currently, the NERC is running 4 in-house and 2 externally funded projects. During the reporting year (2022-23), nearly 35 nos. of trainings, awareness and capacity building programmes, webinars, field demonstrations, etc. have been conducted for diverse stakeholders, including line departments, CBOs, Gram Panchayat leaders, local NGOs, women farmers, students and teachers from different parts of Arunachal Pradesh and others north-eastern states. The subjects covered include biodiversity conservation and assessment, climate change impact, disaster management, low-cost rural technologies, alternative livelihood options, value-addition and marketing of agri-horticultural produce, ecotourism, etc. Under alternative livelihood options, hands-on training has been conducted in vermi-composting, homestay, mushroom cultivation, and pickle making. Skill-based trainings on Para-hydrology, PRA tools and Village Resource mapping have also been conducted during the year for local youths and students to build their green skills. To fulfill common R&D goals as well as to organize different activities/events, the NERC also collaborate with other State Government Departments and academic and research institutions, including Rajiv Gandhi University (RGU), Arunachal Pradesh, Mizoram University, Nagaland University, Manipur University, Arunachal Pradesh State Council for Science & Technology, Department of Environment, Forest, and Climate Change, Govt. of Arunachal Pradesh; Botanical Survey of India-APRC, Zoological Survey of India-APRC, Arunachal State Science Centre, etc. NERC initiated the establishment of the Nature Learning Centre at Itanagar in collaboration with the Department of Environment, Forest, and Climate Change, Govt. of Arunachal Pradesh. During the year, about 35 events have been organized. The major events include (i) Brainstorming cum State-Level Consultation Workshop on Sustainable Himalayan Ecosystems; (ii) Annual Day and 9th Popular Lecture; (iii) Showcasing of R&D Activities in G20 delegates meet at Itanagar, and (iv) Training of Trainer (ToT) programme on Conservation Education etc.

(v) Ladakh Regional Centre (LRC)

The Ladakh Regional Centre of the Institute has a mandate for in-depth research on environmental issues and targeted intervention for livelihood development of the Trans-Himalayan region. Subsequently, the in-house activities of Ladakh Regional Centre during 2022-2023 were primarily focused on the assessment of water scarcity scenarios, livelihood improvement of Trans-Himalayan residents through innovating and implementing low-cost technologies using greenhouse development for winter agriculture, and developing the capacity of the local villagers for nature-based product commercialization and hands-on training for value addition techniques. As a result, long-term changes in the glacier mass balance within the Ladakh region were estimated, along with identifying the distribution of short- and medium-term drought-prone areas. To address the water scarcity issues, efforts were also made to construct ice-reservoirs in the Ursi village using peoples' participatory approach, wherein 19 households with a total population of 130 persons benefitted. The low-cost earthen brick-based polycarbonate greenhouse, established in collaboration with LAHDC-Leh was a new technology tested at the RTC-Leh for agriculture activities in the peak winter months of November to March. We could note that the system performed well in winter as air temperature within the system did not fall below -6.0^{o}C when ambient temperature remained -15 to -18^{o}C. The capacity building and training programmes were carried out in 7 villages surrounding Leh wherein 121 villagers participated in creating eco-friendly products from locally available plant materials. Although the Trans-Himalayan region of Ladakh is categorized as a Cold Desert, the flora and fauna of the region are unique. Recognizing the importance of faunal diversity within the region, a book on the 'Mammals of Ladakh' was published in collaboration with the Wildlife Conservation and Birds Club of Ladakh and the Department of Wildlife Protection, Ladakh UT. The book reports the first photographic evidence of a Golden Jackal in Drass at an elevation of 3300 masl. During the reporting period, the Centre executed three externally funded projects, and an externally funded project was completed. Under the project for preparing the Peoples' Biodiversity Register for Leh town, supported by Urban Local Bodies and Municipal Committee Leh, a total of 06 shrubs, 30 herbs, 09 grasses, 01 climbers, 11 medicinal plants and 4 timber plants, along with 87 birds, 10 mammals, 45 insects, 3 fishes, and 01 reptiles were identified. Documented under the project for estimating tourism carrying capacity for the Leh town, supported by the Mountain division, efforts were made to quantify long term changes in the tourist in-flow and tourism infrastructure over Leh town. The centre also organized 16 workshops, awareness, and training programmes for knowledge dissemination and outreach activities.

(vi) Mountain Division Regional Centre (MDRC)

The MoEF&CC has established a dedicated unit as the 'Mountain Division' within the MoEF&CC at New Delhi as one of the Centres of NIHE to address specific issues of the mountain ecosystem in an integrated manner through its Institutions across the relevant key Ministries, and with NGOs and academia to ensure the conservation of mountain ecosystems and sustainable development of the mountain regions. The envisaged broad objectives of the Mountain Division are: (i) To contribute to sustainable development of mountain ecosystems in integrated manner within divisions of the MoEF&CC and across the key ministries; (ii) To sharpen focus on mountain issues by bringing in "Mountain Perspective" across policies, programmes, missions and schemes; (iii) To foster linkages between upstream and downstream regions by influencing policy & planning based on

mutual dependence; and (iv) Develop a suitable framework of incentives for providers of ecosystem services. During the reporting period, the following six project based studies were carried out through Himalayan Research Fellows and Associates that address various important research and policy issues across the IHR: (i) GIS based land use modeling for studying the future projection and dynamic impact on IHR; (ii) GIS based land use modeling for deriving the trends of urban sprawl in the cities of IHR; (iii) Understanding the process of change in Far-Eastern Indian landscape linking with conservation and management; (iv) Mapping and promoting conservation of medicinal plants of Sikkim Himalaya; (v) Water quality assessment of existing water sources in the lower Parbati Basin; and (vi) Assessment and valuation of alpine and sub-alpine ecosystems of Himachal Pradesh in relation to climate change.

1. INTRODUCTION

During the year 2022-23 various R&D activities focusing on environmental conservation and sustainable development were executed by the Institute at different locations of the IHR through its HQs at Kosi-Katarmal (Almora) and regional Centres, viz., Himachal Regional Center (Kullu), Garhwal Regional Center (Srinagar-Garhwal), Sikkim Regional Center (Pangthang), NE Regional Center (Itanagar), Ladakh Regional Centre (Leh) and Mountain Division Regional Center (MoEF&CC, New Delhi). In all the R&D activities, a major thrust has been to deal with issues of environmental conservation and sustainable development in the IHR, develop region-specific approaches, demonstrate their efficacy in the field, and disseminate information to various stakeholders. The diverse problems thus addressed through carrying out in-depth research on bio-physical and socio-economic aspects of the mountain environment, devising R&D based strategies for natural resource conservation and management, documenting traditional practices of NRM, promoting livelihood opportunities, developing approaches for biodiversity conservation, devising mitigation measures to the impact of climate change, biotechnological applications for conservation of important plant taxa, etc. The Institute implements its activities through core funds provided by the MoEF&CC, Govt. of India, and the projects financed by external funding agencies (National and International). The Institute also funds the R&D activities of partner Institutions in different Himalayan states through the Integrated Eco-development Research Programme (IERP) and National Mission on Himalayan Studies (NMHS). The Scientific Advisory Committee (SAC) of the Institute reviews the progress of existing projects annually and guides the development of new R&D programmes. All these R&D projects are implemented through the four themetic centres of eminence: (i) Center of Land and Water Resource Management (CLWRM), (ii) Center for Socio-Economic Development (CSED), (iii) Center for Biodiversity Conservation and Management (CBCM), and (iv) Center for Environmental Assessment and Climate Change (CEA&CC), and the region specific issues of the IHR are addressed by regional Centres such as (i) Himachal Regional Centre (HRC), (ii) Garhwal Regional Centre (GRC), (iii) Sikkim Regional Centre (SRC), (iv) North-East Regional Centre (NERC), and (v) Ladakh Regional Centre (LRC) (vi) The Mountain Division Regional Centre (MDRC) housed at MoEF&CC, New Delhi is focus on the policy related matter of the institute. During the reporting period, R&D work was pursued on various projects across the IHR. The summary of these projects' major outputs/outcomes is given in this report, along with the summary of completed projects. Relevant detailed documents will be published and made available for the various stakeholders. Particular thrust will be placed to bring out policy imperatives to handle front-running environmental issues of the region. This report presents a brief account of academic and other activities, along with the statement of accounts for 2022-23 carried out under various in-house and externally funded projects. The Institute would be most grateful to receive critical comments and suggestions for improving the quality of outputs of various R&D activities.

2. MAJOR EVENTS

Workshop on Assessment of glacier-climate functional relationships across the IHR

A hybrid mode workshop was organized at NIHE, Almora, on 19th April 2022 to interact and develop a multi-institutional project on assessing glacier-climate functional relationships of the Indian Himalayan region (IHR). This workshop brought together the researchers and planners of Himalaya for a critical assessment of project methodologies and identification of suitable project partners. The meeting was chaired by Prof. Anil. Kulkarni, IISc, Bengaluru, and participants from SAC, ISRO Ahmedabad, IIT Roorkee, ICIMOD Nepal, IIT Bombay, IISCER, Pune, IIT Indore, MoEF&CC, NIH Roorkee, WIHG Dehradun and scientists from NIHE actively participated in the event.

International Day for Biological Diversity

The day was celebrated in HQs Kosi-Katarmal, Almora and all the regional centre of the Institute. In the HQs, the day was celebrated at Kaneli-Bisra village in Jyoli village cluster, Hawalbagh block, where a cleanliness campaign was conducted, and a large plantation of Banj Oak (*Quercus leucotrichophora*) and Tej Patta (*Cinnamomum tamala*) was organized with the villagers. Around 40 participants from Kaneli and Jyoli villages participated. An awareness event for the students of Government Senior Secondary School, Bojhoghari, with this year's theme "Building a shared future for all life", was organized as a part of Him-Nature Learning Centre project supported by the Ministry of Environment, Forest & Climate Change, and Government of India under National Mission on Himalayan Studies. The sole aim of organizing the event was to observe the day, simultaneously sensitize young minds, and cultivate a sense of affinity towards nature and its conservation. The event was attended by 20 students from Government Senior Secondary School, Bojhoghari, eco-teacher, scientists and researchers from the institute. A painting competition was organized at Donyi Polo Vidya Bhawan (Preparatory School), at NERC Itanagar to celebrate the day. The event's main aim was to spread mass awareness on the Conservation of Biodiversity in Arunachal Pradesh. A total 22 students (10 male and 12 female) participated in the painting competition. A plantation drive at the Rural Technology Centre of NERC followed by the main event was organised. All the research scholars, scientists and staff of NERC planted various medicinal plants on the college campus. At LRC Leh, the day was celebrated by organizing a Quiz Competition on "Ladakh Biodiversity" among the urban Schools, where 21 students from 7 Schools participated. In the HRC Kullu a Webinar on the IDB-2022 theme "Building a Shared Future for All Life" was organized. Dr. Pankaj Sharma delivered a guest lecture on "Biodiversity: Issues and concerns in Himachal Pradesh", and about 35 participants attended the webinar.

Workshop on "Strengthening Yak Network in Khangchendzonga Landscape (KL), India"

To establish a strong yak network in the entire KL and outside and formation of yak herder's association at local level, a two days "Consultation –cum-Workshop on Strengthening Yak Network in Khangchendzonga Landscape –India" was organized in Lachung, North Sikkim from 31 May to 01 June 2022, in collaboration with Animal Husbandry & Veterinary Services (AH&VS) Department and Government of Sikkim. The workshop was attended by 23 stakeholder representatives, including yak herders of Lachung, Lachung, Dzumsha representatives, officials of the AH&VS Department and Govt. of Sikkim.

World Environment Day

World Environment Day (5 June 2022) was celebrated at NIHE HQs and across all the regional centers. In HQs, the day was celebrated in collaboration with Uttarakhand Centre for climate change, SSJ University, Almora. A total of 35 participants from SSJ University, NIHE including DFO Almora attended the event with a thematic lecture on *ONLY ONE EARTH* for living sustainability in harmony with nature, lifestyle for environment protection, and forest fires. The SRC, Sikkim organised "A one-day hands-on training programme on Water quality tests", which was attended by 47 eco- club students and 6 teachers of both the schools and researchers from the SRC. Apart from this an online brainstorming workshop themed "Natural Hazards and Climate: Living Sustainably in Harmony with Nature" was organized jointly with the Department of Science and Technology (DST), Government of Sikkim. The event was aimed to (i) take stock of the available knowledge base, issues, gaps, and priorities vis-a-vis climate change in Sikkim, (ii) mitigation measures and risk reduction approaches - challenges and options for coping with natural hazards, (iii) enhancing resilience, reducing the impacts and managing natural hazards with sustainable approaches, (iv) develop an institutional knowledge network and policy framework (document) for holistic assessment of natural hazards. The NERC Itanagar organized an awareness programme among school students and local people towards protecting our ecosystem and environment for future generations with 21 participants. The programme was celebrated with school children on 5th June 2022 and 6th June 2022, at LRC, Leh. The event encompasses a total of five competitions, which include (i) Poem, (ii) Speech for Jr. and Sr. classes, (iii) Drawing for Jr. and Sr. classes, (iv) Extempore speech, (v) Quiz on Glaciers. A total of 54 Leh and 61 students of Zanskar participated in the event. At HRC, the day was celebrated by organizing a National conference on "Living sustainably in harmony with nature". The conference was conducted in hybrid mode, with 29 participants attending in person and 112 participants attending online. The conference had 2 technical sessions and included 3 keynote speakers, 20 researchers from different universities/institutes presenting their work both virtually and physically. The conference focused on environmental sustainability, declining biodiversity, changing climate in the Himalayan ecosystem, and youths' role as sustainability stakeholders. A total of 141 participants from different research institutions, universities, and colleges from all over the country participated in the conference.

Institute Society Meeting

The twenty-third meeting of the G.B. Pant Society of Himalayan Environment (NIHE) was held under the Chairmanship of Shri Ashwini Kumar Choubey, Hon'ble Minister of State (MoS) for Environment, Forest & Climate Change, and the Vice-President of GBPSHED on 2nd August 2022 at MoEF&CC, New Delhi. The annual report of institute was adopted by the socity during the meeting.A book on biodiversity conservation in Western Himalayan States/UT of Himanchal Pardesh, Jammu & Kashmir and Uttarakhand release by the society.

Scientific Advisory Committee Meeting

The 29th Meeting of the Scientific Advisory Committee (SAC) was held on 11-12 August 2022 through Hybrid mode to discuss the progress of the R&D work of the institute. The following SAC members attended the Meeting. The SAC meeting was chaired by Dr. Eklabya Sharma, Vice Chancellor, TERI University. Among the SAC members, Prof. Arun Kumar Saraf, Prof. R. M. Pant, Prof. Sandeep Tambe, Dr. Kalachand Sain, Dr Dhriti Banerjee, Prof. Sunil Nautiyal, Director, GBPNIHE and Institute members Dr. Rajesh Joshi, and Dr. Arun Jugran participated the SAC meeting.

Training and Capacity Building on Village Development Action Plan

A Training and capacity-building program on the Village Development Action Plan for the project team of NERC and Village Representatives of Sopo and Poma Gram Panchayats under Papumpare district was undertaken at NIHE, NERC, from 23-24 August, 2022. The resource persons from the State Institute of Rural Development & Panchayati Raj (SIRD&PR) and Arunachal State Rural Livelihood Mission (ArSRLM) were involved in training of the 44 participants of the programme. Field demonstration activity was conducted at Sopo Village, Doimukh, Papum Pare. The participants were also trained in baseline data collection using village and household questionnaires following the Unnat Bharat Abhiyan format and resource mapping by PRA tools.

Beginner's Certificate Course on "Remote Sensing and GIS for Biologist"

A two-day Beginner's Certificate Course on "Remote Sensing and GIS for Biologists" was organized on 25-26 August, 2022 at NERC, Itanagar. In this program, 22 students of biology background from different universities/ institutions of Arunachal Pradesh have participated to use the Remote Sensing and GIS techniques for mapping of the natural resources and forest conservation and management.

Annual Day Celebration

The annual day of the Insitute was celebrated on September 10, 2022 at its HQs Kosi-Katarmal and all the regional centres of the Institute. In addition, 28th annual lecture program was organized at G.B. Pant National Institute of Himalayan Environment, Kosi-Katarmal, to commemorate Govind Ballabh Pant Jayanti. Pandit Govind Ballabh Pant Memorial Lecture was delivered by distinguished scientist Dr. Navin Juyal. During the program, the institute's director, Prof. Sunil Nautiyal, welcomed the guests and presented progress of the institute. He highlighted the institute's efforts in environmental conservation, social and economic development, climate change studies, and the management of water and land resources. He emphasized the need for community participation in the success of any project. Addressing the gathering, Chief guest Hon'ble Minister Shri. Subodh Uniyal discussed the importance of environmental protection and development. He stressed that any work related to environmental conservation and development is not possible people's social participation. He mentioned the need for public involvement in controlling forest fires and emphasized efforts to control them. He also discussed the issue of glacial sedimentation and the need addressing it. Dr. Navin Juyal, delivered the 28th Pant Memorial Lecture on the topic of inevitable atmospheric temperature rise in the Himalayan region. He elaborated on the impacts of climate change, such as recent floods in Pakistan and natural disasters in Uttarakhand. He discussed various aspects, including the Himalayan cryosphere, glacier retreat, flash floods, recurring seismicity, rainfall, snow-based water sources, and hydropower projects. Member of Parliament Shri Ajay Tamta appreciated the institute's efforts and emphasized the need to internalize the contributions made by Pt. Govind Ballabh Pant for the country, society, and human welfare. The event witnessed the presence of several dignitaries and attendees, including Cabinet Minister Subodh Uniyal, Prof. A.N. Purohit, Vice-Chancellor of SSJU, Prof. N.S. Bhandari, Padma Shri Prof. Shekhar Pathak, former Secretary of the MoEF&CC Shri Hem Pandey, former secretory, Govt. of India, Dr. R.B.S. Rawat, Shri Ajay Tamta, Mp Almora and Pithoragarh. The Annual Day function of the Institute was celebrated across the regional centers and HQs of the Institute. At SRC celebrated the Annual Day function of the Institute at its campus at Pangthang, Sikkim on 10th September 2022 which was presided over by Shri Karma Lodey Bhutia, Honb'le Minister of Forest & Environment, Government of Sikkim, and 9th Himalayan Popular Lecture was delivered on "Impacts of Enthno-Microbiology of the Himalayan Ethnic Fermented Foods on Agro-environment and Food Security". Besides the event, publications of the Sikkim regional center, a newsletter on Himalayan Ecology entitled "Timberline Dynamics in Himalayan Region" were released.The NERC organised 9th a Himalayan Popular Lecture on "Shifting Cultivation: Transformational

approaches to sustainable development in North-East India" Dr. M.Q. Khan, Principal Dera Nantung Govt. College, Itanagar, Arunachal Pradesh, was invited as the Chief Guest and Er. Bamang Apo, Joint Director, AP State Council of Science & Technology, Itanagar, Arunachal Pradesh, graced the event as Special Guest with a total of 22 participants.

National Workshop cum Brainstorming on "Plant Functional Trait-based Evaluation of Ecosystem Functioning and Services of Himalayan Forests"

NIHE organized a National Workshop cum Brainstorming on "Plant Functional Trait-based Evaluation of Ecosystem Functioning and Services of Himalayan Forests" during 10-11 September 2022 at the institute headquarter. The workshop aimed to develop a model reflecting the relationship between services and plant functional traits (PFTs) and species diversity, which is currently lacking in temperate forests. Prof. Sunil Nautiyal, Director of NIHE, welcomed guests, panelists, faculty members, and participants to the workshop organized under NMSHE and NMHS-funded projects. Dr. I.D. Bhatt, Center Head CBCM, NIHE, provided an overview of the proposed consultation and the expected outcome of the meeting. Dr. Rajiv Pandey, Scientist E, ICFRE presented on "Ecosystem Functioning and Services of Himalayan temperate forests", discussing different forest types and trait-based evaluation sampling methodologies.

Dr. J.C. Kuniyal, Scientist G, center head CCEA presented on "Forest Resources and Biodiversity", explaining the objectives of the project and establishing LTEM and GLORIA sites. Shri. Hem Pandey, Former Secretary, Govt. of India emphasized the importance of proper methodology for evaluating plant functional traits and linking ecosystem services to those traits. He also highlighted that forest resources of the Himalayan region provide around 350 crore revenue. Prof. Zafar Reshi, University of Kashmir suggested the study of plant functional diversity and its relationship to carbon storage, as well as the importance of ecological aspects in the project's future study. He also discussed niche complementarity and drivers of carbon storage in ecosystems. Dr. RBS Rawat, Former HoFF, Govt. of Uttarakhand, discussed the policy perspectives of Himalayan forests. He emphasized the need for a synthesized data framework for the study of plant functional traits in different forest types of the Himalayan region. At Session I Dr. Rajiv Pandey discussed the methodology of plant functional trait-based evaluation of ecosystem functioning and services of Himalayan forests. Dr. G. S. Rawat, Former Director WII suggested overlaying the map of selected sites and studying the dynamics of associated species along with functional traits. Dr. S.S. Samant, Former Director HFRI suggested to include different gradients in the study and focusing on the replacement of dominant tree species. Prof. Sunil Nautiyal suggested focusing on abiotic and anthropogenic dynamics of functional traits and long-term monitoring of forest ecosystems. In Session-II on Forest resources and plant biodiversity, experts provided suggestions for the progress of Phase II of the NMSHE-TF project. The experts emphasized the need for uniform criteria for selecting Long-Term Ecological Monitoring sites across the Indian Himalayan Region (IHR) and defining resources for evaluating plant traits such as wild edibles and medicinal plants. The experts recommended exploring the patterns of community management of forest resources, including the diversity and distribution of invasive species, and studying the economic value of plant species, as well as good practices from mountain communities. In the concluding session, Shri. Hem Pandey emphasized the need to elaborate on climate change vulnerability studies with examples. He recommended identifying and replicating best community practices in different places and reforming the capacity-building initiative. He further suggested that the area of Jammu & Kashmir should also be included in the study area due to its rich biodiversity. Dr. A.N. Purohit, Former Director of NIHE and former VC of HNB Garhwal University concluded the session by suggesting that subject/domain experts should be identified for specific tasks and that integration of collected data is essential for conserving and sustaining the environment for society.

Institute Governing Body Meeting

The 44th meeting of Governing Body of G.B. Pant National Institute of Himalayan Environment (NIHE) was held on December 1, 2022 under the Chairmanship of Ms. Leena Nandan, Chairperson, Governing Body GBPNIHE, and Secretary, MoEF&CC. Following were present and attended the meeting. Shri C.P. Goyal, Director General of Forest (DGF), Shri. Pravir Pandey, Additional Secretary and Financial Advisor, MoEF&CC, Smt. Nameeta Prasad, Joint Secretary, MoEF&CC, Dr. V.P. Dimri, Former Director & CSIR Distinguished Scientist, Hyderabad, Shri Hem Pande, Shri B.M.S. Rathore, Bhopal, M.P., Shri. Raghu Kumar Kodali, Scientist-F/Director, MoEF&CC, Prof. Sunil Nautiyal, Director, NIHE.

International Mountain Day

International Mountain Day (IMD) was celebrated with the villagers of Manadunga, Lohaghat specifically with women, on 11th December 2022. A 'seminar cum Field Demonstration Programme' was organized to highlight the important contribution of women as a manager of different Himalayan resources followed by the demonstration of hydro-meteorological, water quality testing, and geological mapping instrumentation to 120 participants including the villagers, students and teachers.In the HRC, under the theme "Women Move Mountains". Ms. Oshin Sharma, Assistant Commissioner cum Block development Officer, Naggar, Kullu, was the Chief Guest, and Ms. Aanchal Thakur, International Alpine Skier, was the Special Guest. In the SRC, a training-cum-workshop on "Hospitality and Housekeeping Services in the Homestays: Empowering Rural Women" was organized during 11-12 December 2022 concentrating on the theme of International Mountain Day 2022 at Jaubari village, Mamlay watershed, Namchi, aimed to: i) promote homestay steering in rural and cultural tourism, ii) build skill and capacity of rural women on hospitality and housekeeping management, and iii) promote gender equality and empower rural women.

Brainstorming cum State-Level Consultation Workshop on "Sustainable Himalayan Ecosystems"

A "Brainstorming cum State Level Consultation Workshop" on Sustainable Himalayan Ecosystems was organized at the D.K. Convention Hall Itanagar on 16th December 2022. The workshop was organized to identify challenges and issues for empowering the local communities of Arunachal Pradesh and identify research gaps in different major thematic areas, viz., biodiversity, water resource management, and socio-economic issues in connection with climate change. Total 75 stakeholders, including scientists, faculties, research scholars, and representatives from different state research and administrative departments, were present in the workshop.

Stakeholder consultation for Forest Resources and Biodiversity conservation in Himalaya

Two stakeholder's consultation meetings on Himalayan biodiversity conservation and forest resource management was organized by Centre for Biodiversity Conservation and Management of NIHE, Kosi-Katarmal, Almora at Digtoli and Rawalgaon villages of District Pithoragarh. Prof. Sunil Nautiyal, Director NIHE was the chief guest of the event.During the event he interacted with villagers and various issues related to Biodiversity Conservation, Land restoration, Outmigration, Human Wildlife Conflict, Degrading Traditional Knowledge were discussed. Afterwards a visit of restoration model site was conducted by the director, scientists and stakeholders at Digtoli and Rawal gaon villages. This site was established as India's first pilot tested site using Restoration Opportunities Assessment Methodology (ROAM) in collaboration with IUCN as a follow up of Bonn Challenge in 2018 under Kailash Sacred Landscape Conservation and Development Initiative program of the Institute. A total of 150 participants/stakeholders participated including Gram Pradhan and Sarpanch and nearby villages & scientists and researchers of NIHE.

Training-cum-Workshop on "Statistical Methods in Environmental Studies (SMES) using R"

A three-day training-cum-workshop on "Statistical Methods in Environmental Studies (SMES) using R" was organized at Pangthang, Sikkim during 27 February - 1 March 2023 under the NMSHE Task Force-3 (Phase-II) project. During the workshop, the use of appropriate statistical techniques (such as probabilistic and stochastic models, data collection, data analysis, inferential statistics, linear and generalized linear models, univariate/ multivariate methods, time series analysis etc.) applicable to a wide range of environmental issues (including pollution, water quality, vegetation studies, forestry, climate, soil quality, etc.) across all fields of interest and concern were explained to over 40 young researchers from different universities and institutions.

World Water Day

The center celebrated World Water Day - 2023 with the villagers of Bisra village on 22nd March 2023 under the in-house project "Water Security in Himalaya through Spring-Ecosystem Assessment and Management". The programme was focused to make the villagers aware of the water crisis, water conservation and particularly with the activities under springshed management. Demonstration of handheld water quality testing instruments, GPS, etc. was also given to the villagers followed by a cleanliness drive in the vicinity of the Spring source. The programme was part of a larger celebration of LiFE, G20 and Azadi ka Amrit Mahotsav themes where 30 villagers participated.

Regional Workshop on "Himalaya Calls for Action: Scoping regional cooperation and knowledge networking"

A three-day regional workshop on "Himalaya Calls for Action: Scoping Regional Cooperation and Knowledge Networking" was organized by SRC at Pangthang, Gangtok from 16 -18 March 2023. Hon'ble Governor of Sikkim Shri. Laxman Prasad Acharya inaugurated the event as chief guest. Prof. Eklabya Sharma, Former DDG, ICIMOD and Chairman, Scientific Advisory Committee of NIHE delivered a keynote lecture on "Indian Himalayan Region Comprehensive Assessment" and "IHR Call for Action" followed by a panel discussion. During the event, Youth Forum activity on "mentoring young researchers on contemporary research" was also organized. The event was attended by more than 100 participants including scientists, professors and researchers from Sikkim, Mizoram, Meghalaya, Assam, Arunachal Pradesh and Tripura.

Regional Awareness Programme-cum-Workshop on Biodiversity Conservation and Climate Change

Three regional awareness programmes-cum-workshop on 'Biodiversity Conservation and Climate Change' on 19th, 22nd and 25th March 2023 was organized at M'Pen village (Changlang district), Basar (Leparada district), and Itanagar (Papumpare district) of Arunachal Pradesh respectively. These events aimed to generate awareness and sensitize the local stakeholders, including village leaders, youths, and community-based organizations, on the importance of biodiversity conservation for combating climate change. National Bank for Agriculture and Rural Development (NABARD), Itanagar, sponsored the programme. Altogether ~170 participants comprising local stakeholders, including Gaon Burahs, members of local CBOs and SHGs, and representative officers from NABARD attended the programmes.

Showcasing of R&D Activities in G20 delegates meets at Itanagar (25th March, 2023)

North-East Regional Centre of the Institute showcased regional centre research activities in G-20 delegates meeting (Research Innovation Initiative Gathering Exhibition) at Itanagar, Arunachal Pradesh on dated 25th March, 2023. The Hon'ble Chief Minister of Arunachal Pradesh, Shri Pema Khandu ji visited institute stall and appreciated the R&D work carried by the NERC. During that the Hon'ble Chief Minister released the Institute Publication.

Workshop on Climate Change Adaptations and Smart Agriculture Practices in Sikkim Himalaya

A two days workshop was organized by SRC in collaboration with Central Agricultural University, Ranipool, Sikkim during 29-30 March 2023 at Bhanjang&Jaubari, Namchi district with an aim to (i) aware community on climate change adaptations and enhance agricultural productivity for improved livelihood, and (ii) enhance resilience and foster climate smart community. During the workshop, exposure and awareness on climate change, impacts, and need for adaptations, effective land based practices for soil & water management, carbon farming and agriculture waste management, and smart agriculture practices for climate change adaptations were explained to the farming community. More than 35 farmers from Maniram-Phalidara GPU of Namchi district participated in the event.

Scientific Advisory Committee Meeting (SAC)

The 30th Meeting of the Scientific Advisory Committee (SAC) was held on 31 March 2023 through online mode to discuss and recommend a revised Annual Performance Appraisal Report (APAR) format for the scientific staff of the Institute. The SAC meeting was chaired by Dr. Eklabya Sharma, Vice Chancellor, TERI University. Among the SAC members, Prof. Arun Kumar Saraf, Prof. R. M. Pant, Prof. Sandeep Tambe, Dr. Kalachand Sain, Dr Dhriti Banerjee, Prof. Sunil Nautiyal, Director, NIHE and Institute members Dr. Rajesh Joshi, and Dr. Arun Jugran participated. Additionally, two invited faculty members of the Institute Dr. I. D. Bhatt and Er. M.S. Lodhi also attended the meeting. During the meeting APAR formatwas presented and the SAC members suggested useful comments / inputs on the presentations for better R&D outputs of the Institute.

Summary of major events organised by NIHE (2022-2023)

S.N.	Date (s)	Title of the Event	Venue	Total Participants
1	21 April 2022	Webinar on Protected areas of Uttarakhand	HQs Almora	104
2	22 April 2022	One-day Workshop on Air pollution monitoring, dendrochronology and their application in climate change studies	HQs Almora	45
3	22 April 2022	One day program on beat Plastic: Meet Sustainability	HQs, Almora	15
4	21-22 April 2022	Training cum Demonstration on Integrated Organic Farming and Climate Change Adaptation	NERC, Itanagar	35
5	19 May 2022	Workshop on Spring Rejuvenation for Water Security in Himalaya	NERC, Itanagar	-
6	23 May 2022	Entrepreneurship Development Program (EDP)	Sri Narayan Ashram, Pithoragarh	35
7	25 May 2022	Awareness programme on drinking water and its impact on health conditions in tribal inhabitants of Kumaun	Munsiyari	98
8	27 May 2022	Awareness programme on drinking water and its impact on health conditions in tribal inhabitants of Kumaun	Sama, Bageshwar	61
9	30 May 2022	Webinar on Significance, threats, and conservation of biodiversity	HQs, Almora	75
10	2 June 2022	Workshop on the identification of rural technologies for livelihoods	HQs, Almora	-
11	5 June 2022	Celebration of World Environment Day & Organization of Entrepreneur Development Programme at Manan	Bamanigad, Almora	36
12	6-7 June 2022	Climate Change Awareness Programme for Himalayan Rang Community of Darma Valley, Pithoragarh	Darma valley, Pithoragarh	33
13	11 July 2022	Webinar on Biodiversity and its conservation measures	HQs, Almora	128

14	12-13 July 2022	Available forest resources and its sustainable utilization: challenges and opportunities in Sacred Aadi-Kailash and Om Parvat region	Gunji, Pithoragarh	35
15	14 July 2022	Honeybee rearing and Chicken husbandry	Pangroli, Rudraprayag	35
16	14 July 2022	National Hindi workshop on rural livelihoods in Himalayan regions	Kullu,Himachal Pardesh	45
17	16 July 2022	Uttarakhand Harela Festival	Katarmal, Almora; Digtoli & Baram, Pithoragarh	87
18	22 July 2022	Biodiversity Conservation Education	Kullu, Himachal Pardesh	82
19	4 August 2022	Workshop on High Altitude Wetlands of Sikkim: Status, Issues & Policy	SRC, Sikkim	-
20	23-24 August 2022	Biodiversity Conservation and Management with School Students & Teachers	GIC, Triyuginarayan, Rudraprayag	130
21	25 August 2022	Organic farming and bio-fertilizers preparation	RTC, Triyuginarayan	25
22	23-24 August 2022	Training and Capacity Building program on Village Development Action Plan	NERC, Itanagar	44
23	25-26 August 2022	Beginner's Certificate Course on Remote Sensing and GIS for Biologist	NERC, Itanagar	22
24	19 September 2022	Promoting conservation education: Diversity of medicinal plants in Uttarakhand and livelihood options	HQs, Almora	41
25	22-23 September 2022	Consultative meeting on climate change impact and adaptation strategies	NIHE, GRC	58
26	23-24 September 2022	Livelihood generation through Beekeeping and poultry farming	Saari-Karokhi, Rudraprayag	61
27	6 October 2022	Celebration of Wildlife Week 2022	Jyoli, Almora	70
28	7 October 2022	Celebration of Wildlife Week 2022	Almora	61
29	10 October 2022	Celebration of Wildlife Week 2022	Dharchula, Pithoragarh	68

30	3 November 2022	Brainstorming on Forest Based Resources and Livelihood Options	HQs, Almora	70
31	4 November 2022	Climate change enhanced hazards in the Himalayas: Impacts experienced and Risk management	HQs, Almora	45
32	7 November 2022	Sensitization of school students for promoting Conservation Education	Champawat	120
33	10 November 2022	Honeybee rearing and Hen farming	Bajeera-Kapadiya, Jakholi, Rudraprayag	26
34	14 November 2022	Stakeholders perception on changing climate and bio-briquetting preparation from pine needle at village Pangroli, Jakholi	Pangroli, Jakholi, Rudraprayag	32
35	16-17 November 2022	Organic farming and bio-fertilizers preparation	Ringi, Joshimath	41
36	13 December 2022	Empowering Mountain Women for Climate Change Adaptation and Resilience Building	Kathpuriya, Almora	65
37	13 December 2022	Consultation workshop for Establishment of Netaji Subhash Chandra Bose, University of Excellence, Government of Sikkim	Chakung, Soreng (West Sikkim)	20
38	19-20 December 2022	Biodiversity Conservation and Management with School Students & Teachers	GIC, Rampur, Rudraprayag	120
39	20 December 2022	Biodiversity Conservation and Management with school student & Teachers	GIC, Triyuginarayan, Rudraprayag	120
40	22 December 2022	Capacity building on Heritage tourism	Block office Dharchula, Pithoragarh	44
41	23 December 2022	Awareness programme on drinking water and its impact on health conditions in tribal inhabitants of Kumaun	Jyoli, Almora	65
42	1 January 2023	Stakeholder consultation for Forest Resources and Biodiversity conservation in the Himalayas	Rawalgaon, Gangolihat	47

43	13 February 2023	Science: Challenges and Opportunities	Devbhumi Public School, Nakot, Srinagar Garhwal	93
44	13 February 2023	One day programme with school students on Science: Challenges and Opportunities	Srinagar, Uttarakhand	93
45	27-28 February 2023	Training of Trainer (ToT) programme on Conservation Education	NERC, Itanagar	18
46	28 February 2023	Sustainable Lifestyle for Combating the Changing Climate	HQs, Almora	18
47	14-15 March 2023	Organic farming and bio-fertilizers preparation	Kothiyara, Jakholi	68
48	19-25 March 2023	Regional Awareness Programme-cum-Workshop on Biodiversity Conservation and Climate Change	NERC, Itanagar	170

CENTRE FOR LAND AND WATER RESOURCE MANAGEMENT (CLWRM)

The Institute has been involved in research and development of land and water resource management since its inception. Over the years, various programs in fields of mountain hydrology, water resource augmentation, glacier dynamics and hydrometeorology, geo-tectonics and landslide restoration, catchment area treatment, soil and water conservation technologies have been implemented to address pertinent issues of land and water resources in the Indian Himalayas, resulting in the establishment of a dedicated Centre for Land and Water Management (CLWRM) in 2017, with the responsibility of more focused research and development activities across IHR. With the challenges posed by globalization and climate change, melting glaciers, increasing incidents of drought, water scarcity, waterborne disasters, outmigration of Himalayan people, and a better understanding of the Himalayas' existence value as a water tower or third pole, climate regulator, and ecosystem service provider to the entire North Indian plains, the need for more focused research and development for conservation and management of land and water resources of the Himalayas has become apparent. The Centre's activities cover various themes of interest, such as spring ecosystem, water security, glacier dynamics, interaction of water-climate-biodiversity, rainfall-induced disasters, livelihood, wastewater, and water pollution, with the objectives of (i) conducting studies on land and water and related eco-sociological processes at the watershed to regional level including upstream-downstream linkages; (ii) developing tools and techniques for sustainable land management considering various developmental interventions; and (iii) providing inputs to government and policy makers to bring in a mountain perspective in land and water resource management policies.

Water Security in Himalaya through Spring-Ecosystem Assessment and Management Funding Agency (In-house, 2020-2025)

Springs are ecosystems where groundwater is ex¬posed, and typically flows from the Earth's surface. Springs vary greatly in flow, water chemistry, geomorphology, ecology, socio-cultural and economic importance. However, problem of drying of springs is being increasingly felt resulting into substantial alteration of springs ecosystem structure and functions. It has been observed that the interaction of dependent ecosystem services of springs is hardly documented or being studied over Himalaya, and no standardized spring-ecosystem management practice is available. This has set the stage for development of protocols to enhance systematic inventory and spring ecosystem research components. The objectives of the present study are two-fold; first to provide a better understanding of functioning of the spring-ecosystems and secondly to enhance water security through revival of spring through Jal Abhayaranya concept. This project being a transformative in nature in IHR, will be carried out in 4 IHR states through 4 regional centers of the Institute.

Objectives:

- Development of 'Spring-Ecosystem' inventory protocol and compilation of the baseline data/ information of mountain springs
- Selection and quantification of ecosystem health indicators, and designing of spring-ecosystem assessment protocol as a performance evaluation tool
- Implementation of 'Jal Abhayaranya' concept based on the scientific approaches integrating hydro-geology, spring-ecosystem environment, socio-economy and climate aspects.

- Development and dissemination of interdisciplinary approaches for spring-ecosystem restoration and management in collaboration with different stakeholders.

Achievements:

HQs (Kosi-Katarmal)

1. Overall, under the spring-ecosystem inventory protocol and data generation, total 25 districts covering 111 blocks of twelve states/UTs of IHR have been covered for inventorization and geo-tagging of springs; wherein, 6124 springs have been inventoried. A mobile app – 'Jaldhara' has been developed under Jal Abhayaranya project for *in-situ* data acquisition of spring and other water sources. Various thematic maps have been generated towards delineating the spring ecosystem boundary and potential recharge zones for Manadunga and Jyoli village cluster, Lower Subansiri, Kullu and Rudraprayag sites. To strengthen the identification of potential recharge zone the isotopic sampling (29 rain and spring water samples) has been done at two project sites, Kullu, Himachal Pradesh and Manadunga, Uttarakhand; and sent to WIHG for further analysis.
2. Based on potential recharge zone mapping, ground-based engineering interventions has been started for spring rejuvenation at Manadunga, Uttarakhand and South Sikkim, Sikkim sites. In total, 360 engineering interventions (includes, contour trenches, recharge pits, toe tranches in agriculture land etc.) have been carried out in respective springshed area to harvest the rainfall for spring rejuvenation (Fig. 1). Further, to quantify spring ecosystem health indicators, Water Quality Index (WQI) has been derived for Uttarakhand, Himachal Pradesh, Sikkim and Arunachal Pradesh sites which with few exception falls under good to excellent water category (Table 1).
3. Total 13 dissemination and outreach programmes were organized across four states that include capacity building cum training programs, awareness program, workshop, field demonstration (Fig. 1); wherein 657 stakeholders were participated. Among them, 181 participants were trained as 'Para-hydrogeologists' through lectures and field demonstration.

Fig. 1: Different activities across project sites: (a) training programme at GRC site, (b) engineering intervention at South Sikkim site, (c) awareness prgramme cum field demonstration at Manadunga, Uttarakhand, and (d) engineering intervention at Manadunga, Uttarakhand

Table 1: Range of Physico-chemical parameters in Post Monsoon months (October-February) for springs in Jyoli village cluster

S. No	Parameters	B.I.S (Standard)	Jyoli	Bisra	Kharkuna	Kujyadi	Dilkot
1	pH	6.5-8.5	6.65-7.44	6.54-7.63	6.6-7.7	6.57-7.43	6.52-7.45
2	EC		112.6-146.8	72.3-115.7	176.3-515	77.2-138.8	70.7-102.3
3	TDS	500-2000 mg/L	79.8-103.6	51.2-84.6	124-368.9	58.3-95	52.1-72.6
4	Turbidity	1.0-5.0 NTU	0	0	0	0	0
5	TH	200-600 mg/L	32-92	26-88	58-132	29.4-74	26-86
6	CaH		25.2-46.2	14.7-35.7	52.5-100.8	18.9-54.6	16.8-63
7	Ca	75-200 mg/L	10.09-18.5	5.88-14.29	21.02-40.37	7.56-21.86	6.712-25.23
8	Mg	30-100 mg/L	1.14-11.25	0.19-8.4	2.3-16.35	1.16-9.93	0.12-9.01
9	Cl	250-1000 mg/L	4.26-12.78	2.84- 14.2	7.1-22.72	4.26-19.88	5.68-12.78
10	Nitrate	45 mg/L- no relaxation	0.187-0.53	0.028-0.31	0.462-1.21	0.07-0.41	0.05-0.214
11	Sulphate	200-400 mg/L	0.034-0.215	0.014-0.7	0.13-0.67	0.023-0.142	0.017-0.103
12	Alkalinity	200-600 mg/L	125-275	100-225	175-425	100-225	100-200
13	Sodium		7.23-8.52	6.32-8.56	7.68-12.56	5.79-7.54	5.46-7.59
14	Potassium		5.68-8.4	4.37-7.52	6.78-12.56	4.12-7.23	3.98-7.65
15	TSS	10-30 mg/L	0.024-0.196	0.0024-0.32	0.0076-0.6196	0.0072-0.384	0.008-0.416

Garhwal Regional Centre

1. A total of 63 springs were inventoized in Khirsu block (Fig. 2), covering 49 villages and measured their physical parameters (pH, temperature, conductivity) and discharge. The springs discharge varied from 0.5 to 60 LPM. Out of 63 springs, 13 are non-perennial and other remains active springs throughout the year. Morphometric, land use/land cover and soil texture characteristics were analyzed for the three watersheds of the block.
2. Daily discharge monitoring of the Kothiyara springs was started in August 2022 and baseline information on spring flow and rainfall pattern was generated for the micro watershed. A technical manual for artificially recharge the springs in Kothiyara village has been submitted to Rudraprayag district's DFO, and a combined initiative for constructing pits and trenches with the district's forest authority is currently in the planning stages.

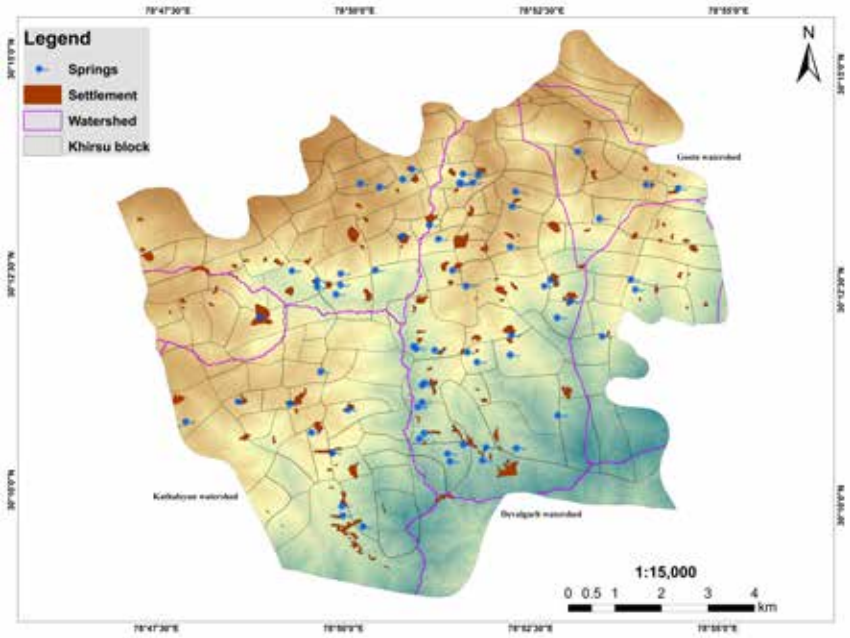


Fig. 2: Spring inventory map of the study area, Khirsu block, highlighting the surveyed villages and springs

North East Regional Center

1. During the reporting period, a total of 53 new springs (Fig. 3 (b)) were inventoried and a geospatial database was developed on the GIS platform. The total spring inventoried till now is shown in Fig. 3 (a).

2. Spring discharge measurements and water quality assessment were carried out for newly inventorized springs. Further, RS-GIS based thematic maps of land use/land cover, settlements, DEM, geology, drainage network and others were prepared for the study area.

3. A total of 178 individuals were educated on the topic of Spring-Ecosystem Assessment and Management through four (4) distinct awareness or training programmes.

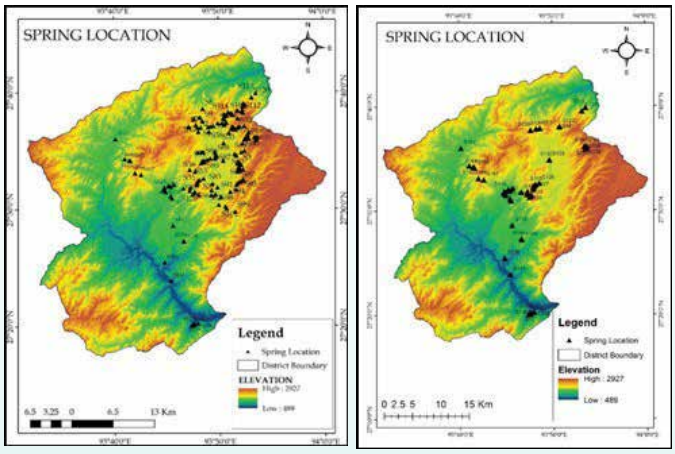


Fig. 3: Geo-tagged spring map of the Lower Subansiri, Arunachal Pradesh. a)April 2021 to March 2023 b) April 2022 to March 2023.

Himachal Regional Center

1. Regular monitoring of physico-chemical parameters for 75 springs showed the ranges well within the permissible limits of BIS 2012 and WHO 2011 drinking water standards. A new spring inventory of 50 springs (23 springs from Barot Valley and 27 springs from Seraj Valley) of the Mandi district of Himachal Pradesh has been prepared. A total of nine water samples (surface water, groundwater (springs) and rainwater) from three sites were sent to WIHG, Dehradun for the isotope analysis.

2. Landuse/land cover change detection from the year 2005 to 2020 showed 7.7% increase in Forest cover, 2.09% increase in built-up areas, 0.05% increase in barren areas, and 1.24% decrease in cropland, 3.67% decrease in shrubland, 5.2% decrease in glaciated areas, and, while water bodies showed negligible amount of change (Fig. 4).

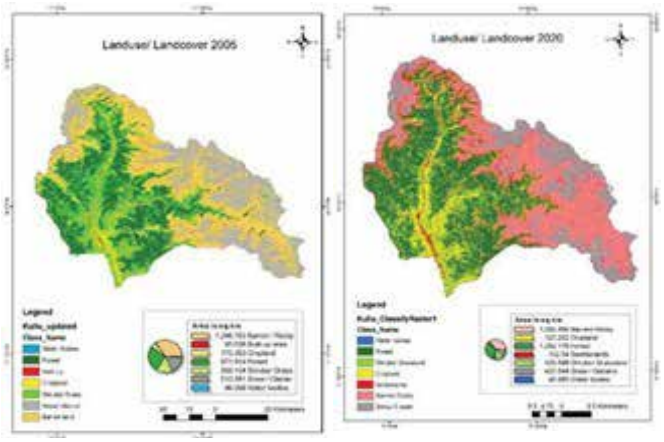


Fig. 4: LULC change detection (2005-2020

3. A capacity building cum training programme for Para-hydrologists was conducted at the Shirhar Panchayat of Kullu district, where in a total of 60 participants and were apprised of basic knowledge about groundwater conservation and spring recharge intervention techniques.

Sikkim Regional Center

1. Two springs, namely Hattiy Gaire and Dharey Kharka were selected for the spring rejuvenation activities. The springs of South Sikkim dried up or showed a decline in discharge from December to June. The daily monitoring of the HattiyGairy source shows a similar trend of sudden reduction in discharge from December to June (Fig. 5).

2. The Spring Sanctuary model was initiated to rejuvenate selected springs by making 100 recharge structures with a cumulative capacity of 125,000 liters in the Tandong forest area in the Namchi district. The preliminary results showed that these trenches increased water discharge in the Hattiy Gaire source.

3. Under the various training programme; 20 villagers panchayat members were trained as Parhydrologists, whereas 133 school students were trained in water conservation practices. Further, a rock museum was also established at Sikkim Regional Centre, where a few samples of 351 million years old rocks are kept in the museum for training and research purposes.

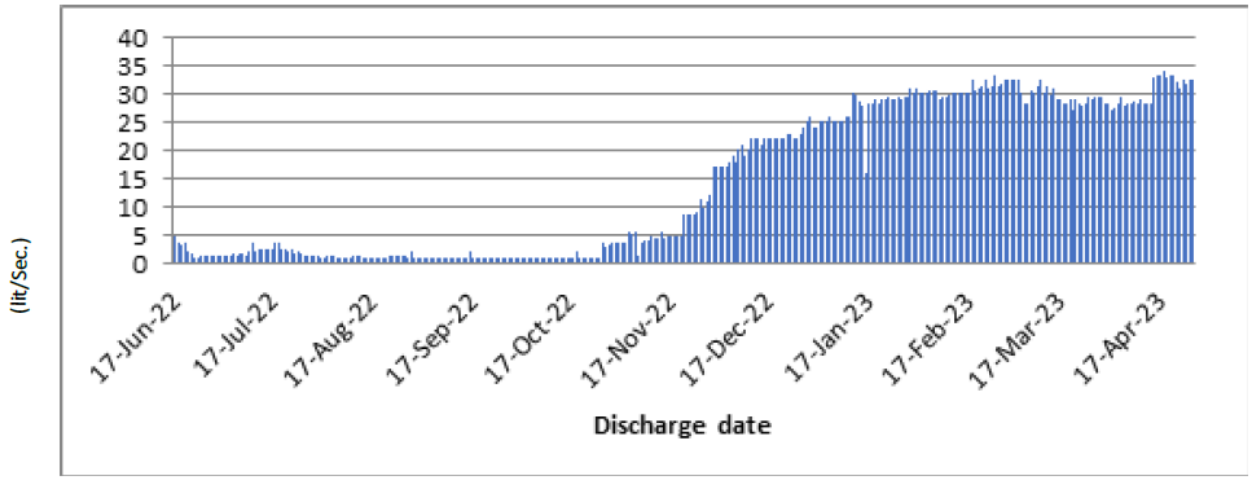


Fig. 5: Discharge rate (lit/Sec.) of HattiyGaire Spring in Upper Jawabari, South Sikkim

Spring Rejuvenation for Water Security in Himalaya (NMHS, GoI, 2020-2023)

Mountain natural springs are one of the principle fresh water sources for millions of people across the Himalayas for satisfying their daily water needs. Over the years, these precious resources are increasingly drying up, or becoming seasonal, inducing untold misery to inhabitants of the Indian Himalayan Region (IHR).Subsequently, many programs were undertaken by different agencies to revive these drying springs using various concept but resulted in limited success. Learning from the successful and failure studies, a concept of Jal Abhayaranya is proposed, wherein science based practices/ model for spring rejuvenation will implemented to ensure water security at village level. This concept is amalgamation of bio-engineering methods with social engineering movement to create awareness, sense of responsibility among the stakeholders to protect and manage the water resources at village level. The project is under implementation in 11 states (Uttarakhand, Himachal Pradesh, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, West Bengal) and 1 UT (Jammu & Kashmir) of Himalayan region.

Objectives:

- To develop at least one Jal Abhyaranya demonstration model in each Aspirational District of all 12 Himalayan States.
- To promote replication of field model for rejuvenation of drying springs in the Himalayan States through Technology and Community based approaches for providing water security to local communities in collaboration with state agencies.

Achievements:

1. Bio-engineering interventions under Jal Abhayaranya concept has been started at all 12 sites (i.e. 11 states and 1 UT of IHR) which cover total 32 springs. Till date, 800 engineering structures (includes, trenches, percolation pit/ ponds, toe trenches, check dam, small water storage/conveyance structures etc.), 5 rooftop rainwater harvesting system/model and near-about 4000 plantations was done across the sites (Fig. 6 for representation). A mobile app named 'Jaldhara' has been developed under the project for in-situ data acquisition of springs/ water sources and tested at 12 project sites for its functionality.
2. A total of 07 'Village Water Security Committees' has been formed till date at Mandunga, Lohaghat, Uttarakhand; Lonthonger, Khiphire, Nagaland; Kihar, Chamba, Himachal Pradesh; Kandy, Kupwara, Jammu and Kashmir; Ailawng,

Mamit, Mizoram; RongliRongliot, Darjeeling, West Bengal and Umsning, RiBhoi, Meghalaya to facilitate spring rejuvenation work and other activities of the project at respective sites as a part of citizen science approach or community participation.

3. As a part of the social engineering concept under Jal Abhayaranya to create awareness among the populous about water conservation and management and to train the local villagers and relevant stakeholders, a total 22 programmes were organized across 12 sites wherein 850 stakeholders participated and got exposure to project activities. Through training and field demonstration total of 190 participants were trained as "Para-hydrogeologists" towards creating a cadre of skilled human resources for the spring rejuvenation mission.

Fig. 6: Bio-engineering intervention/activities across the study sites – (a & d) RongliRongliot, Darjeeling; (b) Manimohan-Rowaja para, Dhalai, Tripura; (c) Chandel, Manipur; (e) SKUAST, J & K; (f) Manadunga, Uttarakhand

Water Security through Inventory and Revival of Springs using Hydro-geological Action Research in Cold Desert Region of Himachal Pradesh (DST-SEED, GoI, 2022-2025)

The springs are vital to the lives of the Himalayan communities and a primary source of high-quality fresh drinking water, especially in the rural parts of the Himalayas. In Lahaul and Spiti district, also known as the cold desert area, springs are the principal water resource for human settlements, agriculture, livestock and other dependent ecosystems. In recent decades, the decline in the discharge of springs and drying of springs has been observed due to manifold reasons, ranging from spatiotemporal change in precipitation, change in snow or glacier melt, change or disturbance in land use/land cover in spring recharge area, unplanned developmental activities etc. and have repercussion on human settlements, agricultural production and livestock populations which makes spring water a crucial development issue and a policy challenge. Therefore, the proposed project focuses on understanding the hydro-geology of the spring sources and envisages ground-based bio-engineering interventions in the springshed area for spring rejuvenation to save the springs in the long run.

Objectives:

- To review the springs' related planning and management practices for identifying policy paralysis
- To carry out inventory and systematic mapping of

springs to develop Spring Geo-database/Registry
- To develop Action Research based Spring Revival Model (AR-SRM) using hydro-geological science and participatory approach
- To develop Springshed Health Card (SHC) for long term monitoring and management of the springs
- To carry out capacity building activities for stakeholders to sensitize them on the conservation of springs

Achievements:

1. Total of 190 spring sources have been identified from primary and secondary sources, and same has been geo-tagged in GIS format for Lahaul and Spiti regions (Fig. 7). GIS based slope, drainage, and geology map has been prepared for Lahaul region which will help in future springshed conservation and management work. Out of 190 springs, 12 springs were selected for monitoring purposes. Seasonal water quality monitoring (10 physio-chemical parameters) of 12 springs has been started, and the water quality index (WQI) was calculated for initial post-monsoon sampling, which indicates that all of the 12 springs fall under good water quality when compared with BIS specification for drinking water,

2. The recent water related policies and programmes were specifically studied to identify their coherence in context with the springs conservation and management aspects. Further, traditional practices in pretext with Himachal Pradesh for water and spring conservation have been studied. Various unique and diverse structures and/or practices have been documented that showed the geographical diversity in using and conserving the water sources.

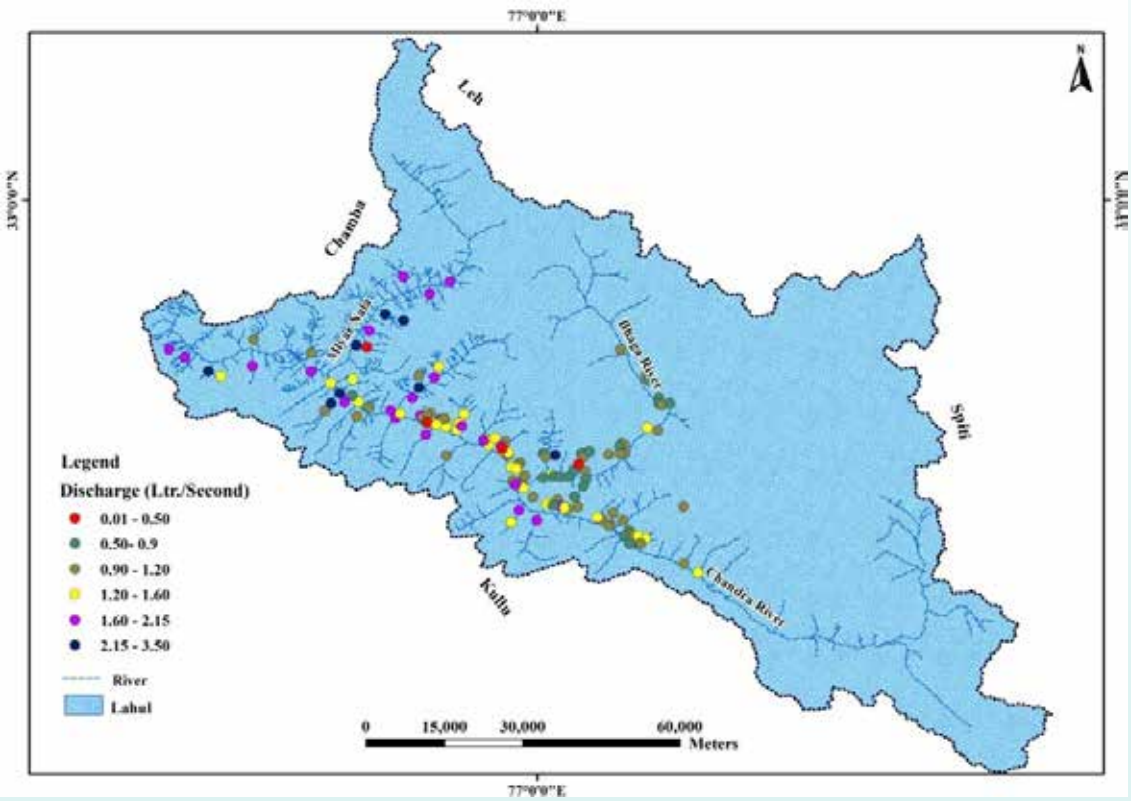


Fig. 7: Geo-tagged springs of Lahaul region, Himachal Pradesh

Pine and Oak System: Interactions of water, climate and plant biodiversity (NMHS, GoI, 2019-2022)

There is an increasingly common perception that Himalayan Pine (Pinusroxburghii) stands may systematically be replaced with Oak (Quercusleucotrichophora) forests, and subsequently, the paradigm of water, climate and biodiversity is expected to change significantly from its current state. However, a thorough assessment of differences in hydro-meteorological properties, hydrological budgets and ecosystem exchanges of carbon and water over these forests, including their anticipated changes in a warmer climate, are seldom carried out. Moreover, a recent study based on long-

term direct measurement of net ecosystem exchange (NEE) from Pine and Oak dominated forest patches indicates that Pine dominated forest ecosystem may have a higher carbon sequestration rate than an Oak dominated forest ecosystem, indicating potential for a detailed study. Therefore, this proposal was framed to address multiple research and policy issues pertaining to the hydrometeorology and ecosystem services of Pine-Oak systems of the IHR.

Objectives:

- Assessment of Pine and Oak Forest distribution under a warmer climate over two watersheds of Central Himalaya
- Assessment of hydrological budget of Pine-Oak dominated watersheds of Central Himalaya
- Assessment of microclimate variability of Pine-Oak dominated forests and future changes under a warmer climate
- Assessment of eco-hydro-climatological processes with information theory-based process network and understanding resilience under shock

Achievements:

1. It was noted that both Chir-Pine and Banj-Oak dominated ecosystems are the annual sink of carbon, and Chir-Pine dominated ecosystem sequesters around 1.8 times higher carbon than the Banj-Oak. A systematic enhancement in the carbon assimilation of the Chir-Pine dominated ecosystem is noted with increasing rainfall spells following a statistically significant power-law relationship (Fig. 8).

2. Rainfall amount thresholds were also identified for Chir-Pine, and Banj-Oak dominated ecosystems (10±0.7 and 17±1.2 mm, respectively) that resulted in the highest ecosystem carbon assimilation in monsoon. In general, Banj-Oak dominated ecosystem was found to be more sensitive to maximum rain with in a spell, whereas the Chir-Pine dominated ecosystem is more responsive to increasing rainfall spell duration.

3. At a sub-daily scale, the transfer entropy links amongst microclimate drivers and NEE indicate that the Pine ecosystem is more sensitive to air temperature and uptakes more carbon than the Oak ecosystem. The transfer entropy causal links show that the NEE of the Oak ecosystem is moisture-driven in contrast to the Pine ecosystem, which is heat-dominated.

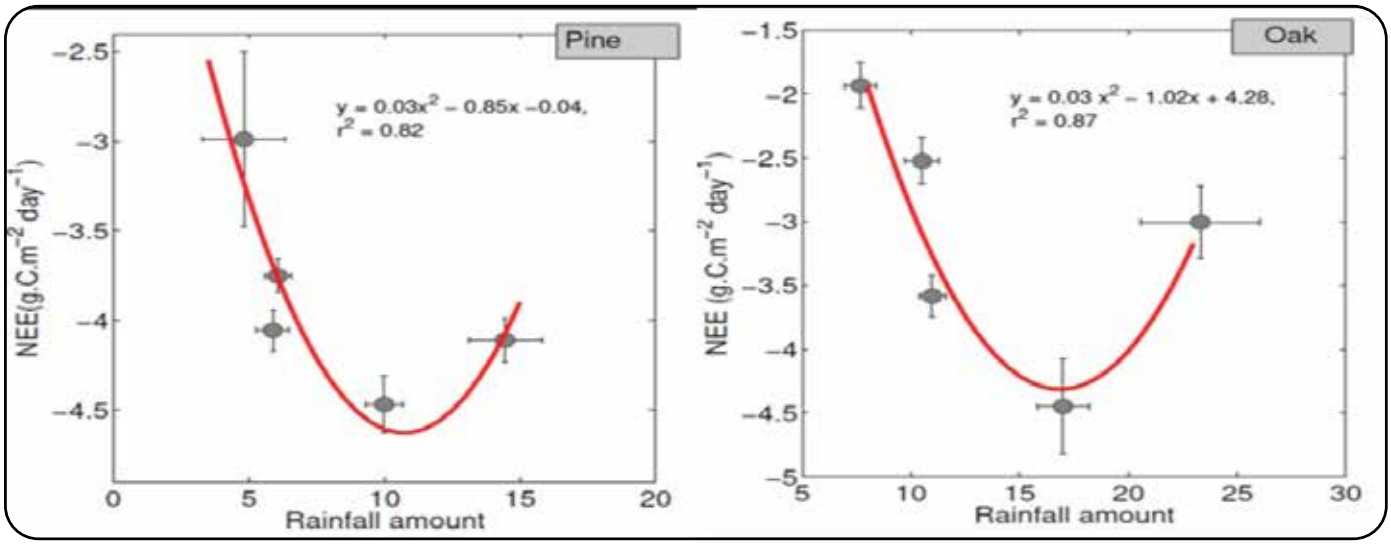


Fig. 8: Subplots represent the variation of net ecosystem exchange (NEE) with rainfall amount. The vertical and horizontal lines represent standard errors. The red lines indicate fitted quadratic equation where 'y' is NEE and 'x' is rainfall amount

Permafrost Mapping and Characterization of Western Himalayan Region (NMHS, GoI, 2019-2022)

Permafrost is unconsolidated sediment or bedrock frozen for at least two consecutive years. Permafrost studies are sparse in the Hindu Kush Himalayan (HKH) region, particularly IHR. Preliminary studies in the Ladakh region indicate that the ground ice melt could be significant for the streams of this region. Permafrost (perennially frozen) soils store vast amounts of organic carbon (C) and nitrogen (N) that are vulnerable to mobilization as dissolved organic carbon (DOC) and dissolved organic and inorganic nitrogen (DON, DIN) upon thawing. Such releases will affect the biogeochemistry of permafrost regions. The DOC, DON, DIN and total dissolved nitrogen (TDN) broadly influence terrestrial and aquatic ecosystem functions and greenhouse gas emissions. Hence, it is critical to quantify sources that become newly available as permafrost thaws. Subsequently, water, permafrost leachates and soil samples were collected at different locations of Leh, Ladakh, within the altitudinal range of 3405-5437 m. The major areas covered during sampling were Upshi, Tso kar/ Tso morari, Upshi, Warila, Tanglangla, Zingrel, North Pullu, South Polo, Changla, and Ganglass.

Objectives:

- Modelling of permafrost extent in Leh district of Ladakh region
- Modelling active layer thickness of Permafrost in selected study areas
- Assessment of regional climate and fluxes over permafrost regions
- Assessment of water quality and biogeochemistry of permafrost horizon with special emphasis to DOC, DOM, DON and DIN in active layer
- Assessment of ground-ice-melt contribution to regional water resources and estimate the sources of local, and transported moisture using isotope technique

Achievements:

1. The water quality investigation of the water samples collected from Tso kar to Tso moriri and Puga hot water source areas in July-Sept 2021 reveals a higher amount of dissolved Organic and inorganic carbon (DOC, DIC). The Tsokar to Tso moriri area indicated the highest Total Nitrogen % (TN) (Fig. 9, 10).

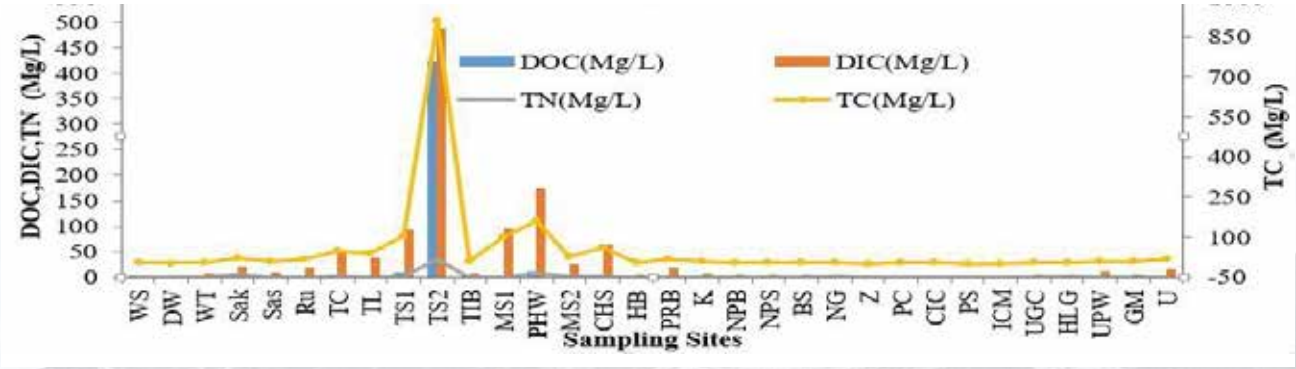


Fig. 9: DOC, DIC, TN and TC concentration in water samples collected from permafrost areas

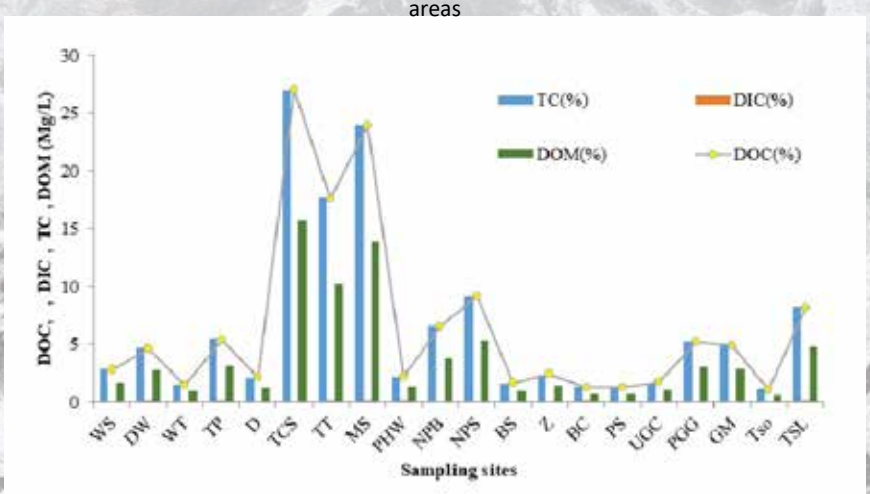


Fig. 10: DOC, DIC, TC and DOM in the soil samples collected from permafrost area

2. The soil sample analysis from the same area showed the highest DOC in the Tsokar camp site area, followed by Mahe near the Samdho river area, and the Total carbon % was highest in Tsokar camp site area (Fig. 10).

Pine needle-based wastewater treatment method for recycling of domestic waste effluents (NMHS, GoI, 2019- 2022)

Grey water is wastewater without any input from toilets, which means it consists of wastewater produced in bathrooms (e.g. bathtubs, showers, hand basins), washing areas (e.g. laundry machines), kitchen (e.g. kitchen sinks) in households, office buildings, schools etc. Various technologies are available for treating grey water, such as physico-chemical, wetland, and advanced treatment. Pine needles litter are believed to be a problem due to the enhancer of forest fire. The fire enhancing property is due to its unique composition of lignocellulosic and volatile matter. The possibility of pine needle for using as a source for designing greywater treatment material are being explored in this project both at the lab and at the pilot scale. Along with adsorptive treatment of grey water, phytoremediation mode is also being tested using fast growing plants.

Objective:

- To synthesize the activated and bacterial activated carbon in bulk and their characterization
- To standardize combined water purification system having phytoremediation, bioremediation and fixed-bed activated carbon-based process
- To demonstrate the standardized purification system with model contaminants mixture and actual contaminated water

Achievements:

1. Tests were carried out on the pilot greywater treatment system installed on the NIHE campus (Fig. 11), using activated and bacterial carbon. Additionally, experiments involving phytoremediation setup with plants were conducted for greywater treatment.

2. During fixed bed experiments at both lab and pilot levels, the carbon with the highest performance demonstrated exceptional breakthrough and regeneration capacities, even at very small bed heights. Some good performing carbon samples are prepared in lot, which are being continuously characterized on a lot basis.

3. In phytoremediation experiments, the targeted contaminants were not found concentrating in the edible parts of *Brassica juncea* (L.) Czern (lai) and *Mentha spicata* L. (pudina) i.e. leaves (Fig. 12). Both plants have shown good performance even with real grey water in terms of selected wastewater quality parameters.

Fig. 11: Greywater treatment pilot setup in the NIHE-Almora campus in the backyard of hostel mess

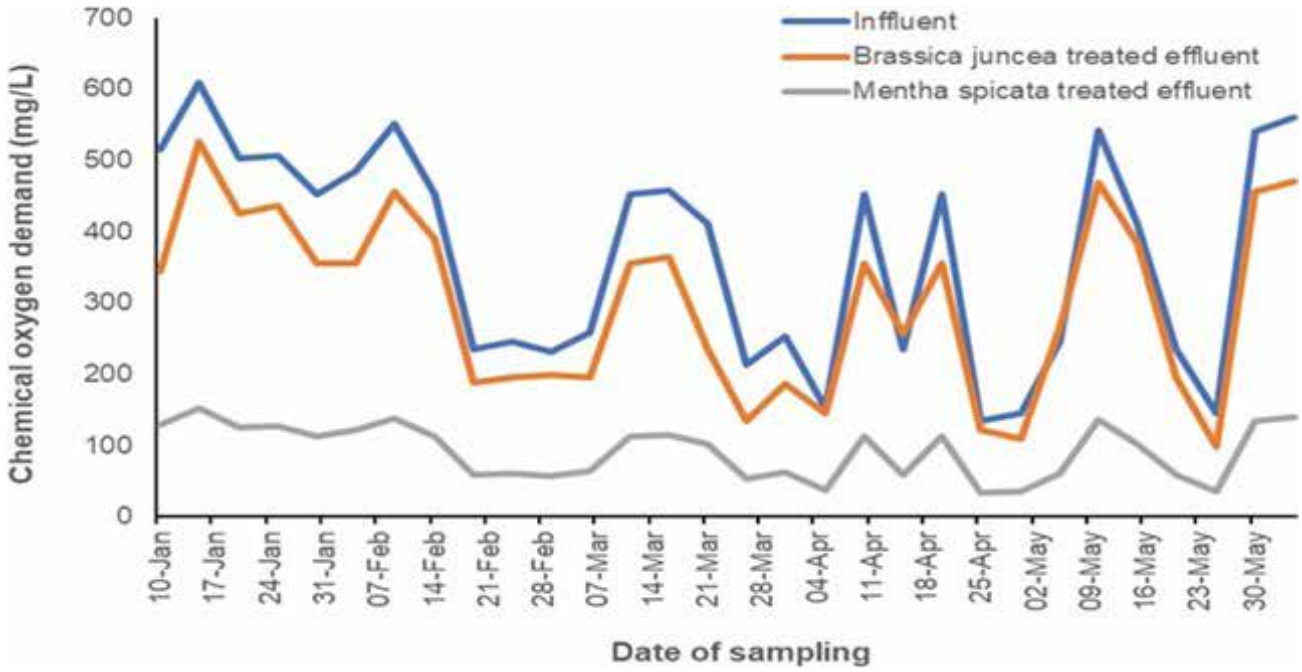


Fig.12: Reduction in Chemical Oxygen demand (COD) in grey water after treatment using plants

CENTRE FOR BIODIVERSITY CONSERVATION AND MANAGEMENT (CBCM)

The Institute, since its inception, has identified Himalayan Biodiversity Conservation as a major thematic thrust. The R&D contributions made over the years by the Institute faculty and researchers have been recognized from local to global level, and as per the SCOPUS database, the Institute ranks number one in the world w.r.t. the number of scientific publications on Himalayan biodiversity and conservation. With this strong base, the Institute has established Centre for Biodiversity Conservation and Management (CBCM) to play a more proactive role in the Himalayan biodiversity sector. The aim of the centre is to strengthen science based understanding on Himalayan biodiversity further to promote its conservation and to ensure a sustained flow of its services for human well-being under a global change scenario. Over the years, the CBCM has expanded its scope of R&D activities by devising both *in-situ* and *ex-situ* packages of practices on biodiversity conservation approaches and scaling up these approaches among a wide range of stakeholders spanning from rural landscapes, to school children and research community, forest department and policy makers and practitioners. The participatory models of biodiversity conservation and management are being promoted particularly among the rural communities by taking up pilots on medicinal and aromatic plant cultivation and wasteland restoration on community lands. In this process, the capacity and skills of stakeholders are built, and opportunities for replication of such models are ensured to achieve the mandate of CBCM. Thus CBCM has set in the following objectives for executing its R&D activities: (i) mainstreaming of Himalaya biodiversity knowledge in conservation decision-making at the local/state/national level, (ii) establishing representative long-term ecological monitoring sites/plots so that LTEM data become part of a regional synthesis and long-term predictions, (iii) promoting partnership and collaboration for knowledge networking and capacity improvement to address issues of biodiversity conservation at local to the sub-national level, and (iv) standardizing protocols/approaches for sustainable utilization of bioresources (i.e., harvesting, nutritional and therapeutic potential assessment, propagation and cultivation packages, etc.)

Mainstreaming Himalayan Biodiversity for Sustainable Development (In-House, 2020-2025)

The Himalayan region is one of the 36 global biodiversity hotspots. It supports peoples' livelihoods directly and indirectly through a range of ecosystem goods and services, including the most desired carbon sink. With a broad goal of ensuring sustainable use of Himalayan biodiversity for human well-being and improved ecosystem health, the project intends to facilitate the formation of BMCs and PBRs to strengthen the Access and Benefits Sharing (ABS) mechanism in IHR. Also, the project targets *ex-situ* and *in-situ* conservation of selected endemic and threatened plants. Further, establishing market value chains for selected high value medicinal/wild edible plants, as envisaged, will help the stakeholders to optimise the benefits. The project finally attempts to create a cadre of green skilled, nature-oriented, and conservation-awakened youth and women for sustainable use and long-term maintenance of Himalayan biodiversity.

Objectives:

- To facilitate BMCs & PBR formation for implementing the Biodiversity Act (2002) in selected villages of IHR
- To develop and demonstrate the applicability of *ex-situ* conservation of selected endemic and threatened plants in the IHR
- To identify and map selected biodiversity-rich areas for the promotion of *in-situ* conservation in the IHR
- To establish marketing value chains of selected high-value medicinal plants and wild edibles in the IHR
- To engage and inspire diverse stakeholders towards biodiversity conservation through conservation education and green skill-building programme

Achievements:

HQs (Kosi-Katarmal)

1. A total of 1211 endemic vascular plants were documented from IHR based on the review of literature and herbarium records and developed a grid-based distribution map for further identification and strengthening of endemic-rich

areas (Fig. 13).

2. A total of seven medicinal plant species, namely *Aconitum heterophyllum, Cinnamomum tamala, Hedychium spicatum, Nardostachysjatamansi, Picrorhiza kurrooa, Swertia chirata, Tinospora cordifolia* were identified and prioritized for value chain development.

3. *Ex-situ* conservation is promoted through developing large production of threatened medicinal plants (i.e., *Allium stracheyi; Paeonia emodi; Paris polyphylla; Polygonatum verticillatum; Saussurea costus; Cinnamomum tamala; Hedycium spicatum*) through different methods (i.e., seed germination, vegetative propagation, in-vitro techniques), and transferred in *ex-situ* conservation sites at Surya-Kunj.

4. A total of 12 conservation education programmes were organized in Almora, Champawat and Nainital districts of Uttarakhand for sensitization of students towards biodiversity conservation, and benefited 1560 students (700 male, 860 female).

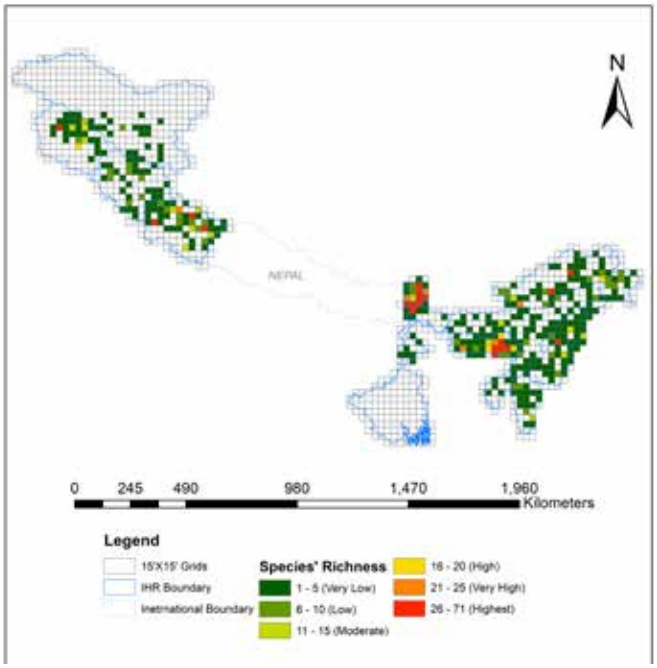


Fig. 13: Endemic species distribution map of Indian Himalayan Region (IHR)

Himachal Pradesh Regional Centre

1. Technical support was provided to Regional-Cum-Facilitation Centre (RCFC), National Medicinal Plants Board (NMPB), Joginder nagar, Himachal Pradesh, for the preparation of 05 People Biodiversity Registers (PBRs) of Chamba, Mehla, Bhattiyat, Tissa and Salooni blocks of Chamba district, Himachal Pradesh.

2. *Ex situ* conservation was promoted through the production of planting material of high value threatened medicinal plants (i.e., *Taxus baccata, Swertia chirata, Trillium govanianum, Angelica glauca, Valeriania jatamansi)* through seed germination and vegetative propagation. A detailed Package of Practices (PoPs) of selected 17 medicinal plant species were prepared.

3. High-value medicinal plant cultivation is promoted in the 2 acre farmer's field Kutla village of Parvati valley by providing quality plant and seed material of *Sassurea costus, Picrorhiza kurrooa, Swertia chirata, Trillium govarinaum, Podophyllum hexandrum, Aconitum heterophyllum.* Plantlets of species like *P.kurrooa, S. chirata,* seed material for *S. costus, A. heterophyllum, Angelica glauca* and *Inula racemosa* have been provided to the selected farmers to prepare the nursery in the part of their fields.

4. Established two herbal gardens at Govt. Sr. Sec. School Kharahal (Kinja), and Kendriya Vidyalaya, Sainj, Kullu. The home herbal garden concept was initiated in different villages of Kullu districts, and different medicinal plants like *S. chirata, A. heterphyllum, I. racemosa, S. costus* were distributed.

Garhwal Regional Centre

1. Phytosociological study of *Rheum austral* across the Uttarakhand Himalaya showed the maximum density (1.2 ind/m^2) in Kafni site followed by Ghamsali bugyal (0.9 ind/m^2), minimum in Tungnath (0.5 ind/m^2). Maximum abundance at Kafni site was observed (2.13 ind/m^2), followed by Latakhark (1.96 ind/m^2). Thirty-three associate species were recorded from the study site with a dominant species of *Danthonia* followed by *Potentilla atrosanguinea* G.Lodd. ex D.Don.

2. Morphological responses from 13 selected geographical locations and habitat types of *R. australe* revealed significant variation (CV%) in 8 (15.90%) of the 12 studied quantitative traits.

3. Phytochemical assessment of *Malaxis acuminata* w.r.t. total phenolics, flavonoids and antioxidant activities showed variation in different populations and the highest phenolics (2.04± 0.0032 mg GAE/g) were found in the Sandev population. In contrast, flavonoids were highest (2.09±0.0012 mgQEq/g) in Jakholi population. DPPH antioxidant activity was highest (1.33±0.73mgAAE/g) in the Gangolihat population and FRAP activity was reported highest (6.51±0.19mgAAE/g) in the Jakholi population.

4. Three training programmes were organized in which 343 participants (55.68% female and 44.31% male) from three schools attended the programme. The training was given in different aspects, i.e., Biodiversity conservation and management, Bioinoculants for treatment of traditional crops to enhance production, *In-situ* & *ex-situ* conservation of biodiversity, Plant Herbarium Techniques, etc.

Sikkim Regional Centre

1. Propagation protocols of endemic plants of Himalaya, viz. *Berginia cilliata, Swertia chirata*, and *Tetra diumfraxinifolium* were refined for large-scale propogation. Plants of *Rhododendron cilliatum, R. maddenii, Swertia chirata* were produced (>1000 nos.) using existing propagation protocol and distributed to different stakeholders (e.g., Botanical Survey of India Gangtok, Forest Department, Sonam Gyatso Mountaineering Institute, and different School around Gangtok). Over 3000 plants of Nettle fibre were also produced in nursery at Dzongu for nettle fibre production.

2. Point distribution records of threatened and endemic plant species *Rhododendron* of Sikkim Himalaya were collected for grid-based mapping from field surveys in Barsey *Rdododendron* sanctuary, Rey-Rumtek area, and Tandong Forest. A total of 125 distribution records of RET and endemic plant species were recorded. Additionally, a total of 445 distribution records of 5 threatened, endemic, medicinal and economic plant species (*Aconitum hetrrophyllum, Dendrobium nobile, Myrica esculenta, Hedychium spicatum, Roscoea procera* and *Roscoea alpina*) collected

3. A new species of Balsaminaceae from Sikkim, India, *Impatiens rajibgogoii* was discovered. Also, two new records of orchids for Sikkim (*Thrixs permumformosanum* and *Taenio phyllumglandulosum*), 2 new records of orchids for West Bengal, 2 new reports of Orchids for India were reported with the presence of only a few individuals in their populations in Sikkim Himalaya (Fig 14).

5. A total of 122 species of orchids were conserved in the Orchidarium of the SRC, which represented 18% of the orchid diversity of the Sikkim State. These species include, 17 threatened species (11 endangered, 4 new to Sikkim, 1 new to West Bengal, 1 new to India).

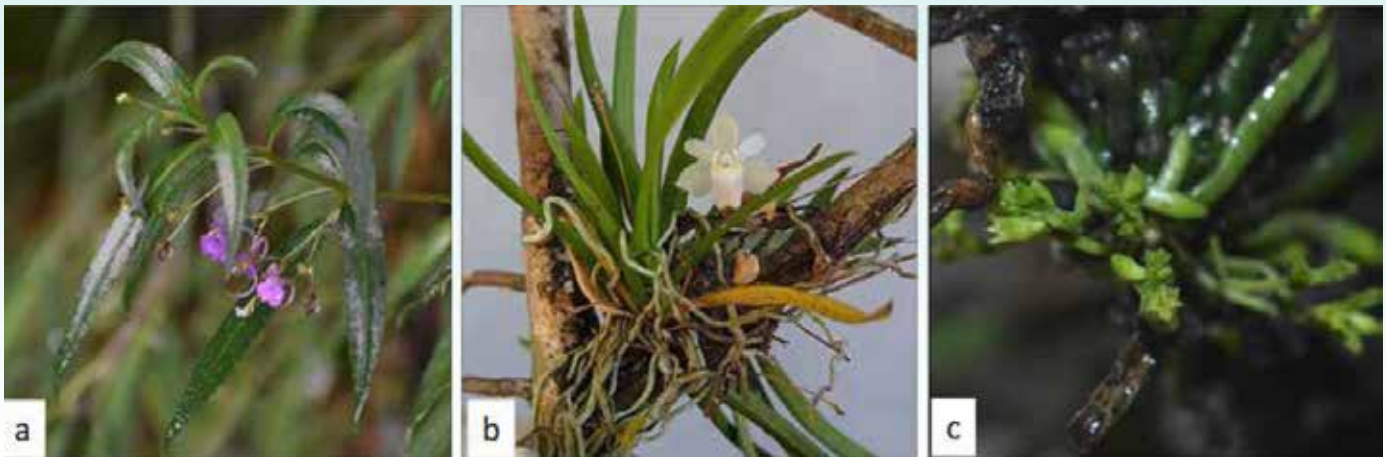


Fig. 14 : New species discovered from Sikkim as (a) *Impatiens rajibgogoii*, and new reports of the species (b &c) in Sikkim as *Thrix spermumformosanum* and *Taenio phyllumglandulosum*

North-East Regional Centre

1. NERC revised and submitted 70 PBRs to the Arunachal Pradesh Biodiversity Board.

2. For cultivating and promoting locally available medicinal plants, NERC has developed a custom-made Hydroponics system with locally available products like bamboo and PVC pipes at its RTC.

3. To identify the biodiversity-rich areas in IHR, 2093 different locations of 1179 different species of plants from Arunachal Pradesh, Mizoram and Nagaland were recorded. A total of 2238 range maps of the vertebrate fauna and 3167840 occurrence data of Birds have been compiled for the IHR region. Raster datasets of 48 different environmental variables have been generated for IHR, and a richness map of mammals in Northeast India has been prepared (Fig. 15).

4. Awareness programme on different aspects of Biodiversity and its conservation through 5 different events were organized in which 121 students participated.

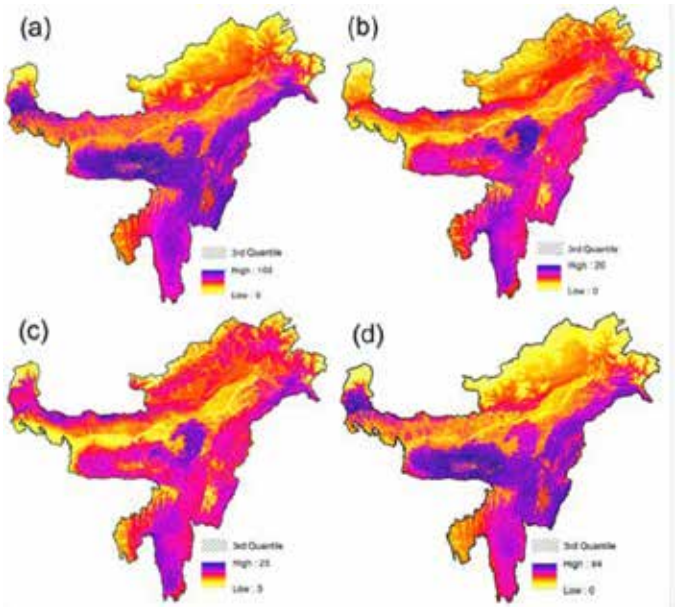


Fig. 15: Map representing mammalian richness in Northeast India with highlighted highly rich areas (a) All Mammals (b) Threatened Mammals (c) Large Bodied Mammals (d) Small Bodied Mammals.

Ecosystem functioning and services of Himalayan temperate forest under Anthropogenic Change: A Plant functional trait-based evaluation (NMHS, GoI, 2019-2023)

Forest ecosystems deliver numerous services to mankind for their survival and are at the center stage of climate change dynamics as they act both as a source (degrading or deforested) and sink (under afforestation and reforestation) of carbon dioxide. The effective management of forests can be achieved by analysing the linkages between the delivery of services and the characteristics of the forests and the environment. Two dissimilar but related frameworks can investigate it: a) the community species composition approach and b) the functional diversity and composition approach. The relationship can be established based on functional attributes characterizing the tree community with the services delivered by the tree communities. These functional attributes are plant functional traits (PFT), which respond to environmental change, affect ecosystem processes and functioning, and determine ecosystem service delivery. Significant gaps exist in the scientific understanding of the ecosystem services delivery mechanisms due to a lack of studies. An understanding of the functioning of the ecosystem can be achieved by developing a model reflecting the relationship between the services with PFTs and the diversity of species. The model development for the measures of ecosystem functioning requires primary data on various ancillary and covariate functional traits, which are lacking in temperate forests. Therefore, it is imperative to generate a database on functional traits for modelling the ecosystem functions to understand the production mechanism of the various ecosystem services (carbon storage, soil functioning, nutrient dynamics, and litter decomposition) by these forests. The PFT-based approach for evaluating the association between forest ecosystem functions and its plant communities to understand the ecological change is more parsimonious due to quick response in PFT against the disturbances than the traditional modelling approach which based on the relationship between diameter and height with biomass.

Objectives:

- To characterize the ecosystem based on plant function traits
- To characterize the interrelationship between different functional traits with major ecosystem services in the Indian Himalayan Region
- To understand the biomass accumulation in the temperate forest ecosystem of the Indian Himalayan Region
- To predict and develop a model for assessment of the delivery of ecosystem services based on functional traits in the Indian Himalayan Region
- Total economic value for the forest types for control and other sites
- Valuation of intangible ecosystem services for carbon capturing and climatic functions

Achievements:

1. A total five sites selected in different location of Kumaun Himalaya region viz, Moru Oak forest (Kilbury, Nainital), Banj Oak Forest (Pangot, Nainital), Kharsu Oak forest (Kunja khadak, Nainital), Moist temperate deciduous forest (Dunagiri, Almora) and Moist Deodar Forest (Jageshwar, Almora) (Table 2). In these selected sites vegetation assessment through Quadrate method conducted during the reporting period (Fig. 18). Afterwards, dominant and co dominant tree species were selected for further assessment of seasonal responses of Plant functional traits (27 traits).

2. In selected sites soil nutrients were found maximum in rainy season as compared to the summer and winter, whereas, only nitrogen content was recorded highest in Kharsu oak forest in winter season.

3. Specific leaf area (SLA 56.25 cm^2 g^{-1}), Chlorophyll content (32.63mg/L), Leaf nutrients (Carbon (22.22%), phosphorus (1.64%), Leaf photosynthetic rate and stomatal conductance (0.098mol H_2O m-2 s^{-1}) reported maximum for *Quercus semecarpifolia* in Kharsu oak forest, Nainital.

4. Water use efficiency was recorded maximum for *Lyonia ovalifolia* (101.8 µmol^{-1}) followed by *Rhododendron arboreum* (89.98 µmol^{-1}). A strong positive relationship between plant functional traits and ecosystem processes, such as carbon and nutrient cycling, water use, and biomass production was observed in the study area.

Table 2: Details of sites selected for study

Forest type	Site	Latitude (N)	Longitude (E)	Elevation (m)
Banj Oak Forest	Pangot (Nainital)	29˚24.575’ 29˚25.502’	79˚25.378’ 79˚24.575’	2015-2033
Moru Oak Forest	Kilbury (Nainital)	29˚24.905’ 29˚25.320’	79˚26.248’ 79˚26.181’	2125-2290
Kharsu Oak Forest	Kunjakhadak (Nainital)	29˚30.293’ 29˚30.194’	79˚19.064’ 79˚19.232’	2480-2547
Moist Deodar Forest	Jageshwar (Almora)	29˚62.675’ 29˚62.661’	79˚83.839’ 79˚84.166’	1897-1941
Moist Temperate Deciduous Forest	Dunagiri (Almora)	29˚84.067’ 29˚83.896’	79˚44.530’ 79˚44.5294’	1905-2167

Fig. 18: Different field activities in selected study sites for collection Plant functional trait responses A) CBH measurement, B and C) Marking of trees D) Leaf sample collection E) Soil sample collection F) Physiological measurement using Li Cor 6800 Portable Photosynthesis system

Promoting Restoration Programmes on Degraded Lands through Medicinally Important Species - A Participatory Approach (NMBP, 2022-2023)

Forests, the sentinels of mountain biodiversity, face several threats in the form of over-exploitation, unmanaged utilization, illegal trade, increased demand for fuel, fodder, timber, fiber, wild edibles, MAPs, land use changes, forest fire, climate change, etc. The factors mentioned above have resulted in the degradation, adaptation, and depletion of forests and biodiversity resources. Restoration is likely to reverse the loss of biodiversity, improve ecosystem resilience, enhance ecosystem services, and mitigate the effects of climate change. Therefore, it would be pertinent to undertake land restoration, which will help to reduce pressure on natural resources, play an important role in biodiversity conservation, uplift people's economic conditions and provide ecosystem goods and services for the well-being of people.

Objectives:

- To establish convergence with community institutions for restoration through livelihood promotion and biodiversity conservation
- To promote restoration through the plantation of medicinally important species
- To enhance the capacity of the diverse groups of stakeholders on the restoration of degraded land
- To develop the value chain of the medicinally important produce and value addition
- To make a cost-benefit analysis of each prototype developed

Achievements:

- A totsl of 14.0 hectares of degraded land planted by 16,900 medicinal tree species,with survival rate of 68%.

- Across three pilot sites under, a total of 6 awareness, plantation and training programmes were organized on restoration interventions (medicinal plant plantation in which 400 villagers (male 210; female 190) from 9 villages participated.

Summary of the Completed Projects/Activities

Science Awareness Activities/Exposure Visits/ Hands on Training (UCOST, 2022-2023)

Science awareness activities/exposure visits are important to sensitize different stakeholders towards understanding the science-based approaches for conserving and utilising natural resources. The Institute organized several awareness programmes like scientific paper writing, biodiversity conservation, and academic exposure to sensitize stakeholders towards science. These workshops included visits to RSC Dehradun and Surya-Kunj NIHE Almora, and 1386 stakeholders, 813 male and 573 female, participated. Besides, 16 workshops and awareness campaigns were organized to promote science awareness in the Kumaun region, benefiting 1192 stakeholders, of which 663 were male and 529 female. These initiatives aim to promote sustainable development in the Kumaun region and encourage participation from various stakeholders.

Major Outcomes:

- Entrepreneurship Development Programme was organized in Sri Narayan Ashram Pithoragarh and Bamnigad Almora, and benefited 101 farmers (male 65; female 36) (Fig. 19).
- Awareness programmes on drinking water and its impact on health condition in Tribal inhabitance of Kumaun were organized at Munsyari, Sama, Champawat and Almora and benefited 252 stakeholders (male 147, female 105) (Fig. 20).
- Various science popularization workshops on scientific paper writing, awareness and sensitization campaign w.r.t. biodiversity conservation and academic exposure visit RSC Dehradun & *ex-situ* conservation site Surya-Kunj NIHE Almora, and a total of 1386 stakeholders (male 813; female 573) actively participated.

Fig. 19: Entrepreneur Development Programme at Sri Narayan Ashram, Pithoragarh

Fig. 20: Awareness programme on drinking water and its impact on health condition in tribal inhabitants of Kumaun at Sama, Bageshwar

Centre of excellence on forest-based livelihood in Uttarakhand – A pilot study (UCOST, 2022-2023)

The Ministry of Environment, Forest and Climate Change (MoEF&CC) has created a Centre of Excellence (CoE) on Forest-based Livelihood in Uttarakhand with Uttarakhand State Council for Science & Technology (UCOST). A first of its kind in the state, the CoE researches forest-based products and the dependence of forest fringe dwellers on forest resources. The uniqueness of the mountain specificities of Uttarakhand forests and grasslands and their contributions to livelihoods was collected, accounted, and collated, and an analytical approach based on secondary data sources was devised to establish a link between the ecological and economic concerns of the region. In addition, the generated data on various aspects of forest resources in the region is hosted in a web server to make it accessible to the wider masses. The CoE is a nodal hub in providing the updated dataset and information related to forest-based livelihood. Uttarakhand forests have been an essential part of the state development, and nearly 80% of people are directly or indirectly dependent on forests for their sustenance or subsistence. Forests create a microclimate for the cultivation of several hill

crops and provide various forest-based products like fodder, fuel wood fruits, etc. CoE thrives on generating datasets on forest-based livelihood and income-generating opportunities.

Major outcomes:

- A total of 1672 households comprising 92 villages were surveyed in different altitudinal ranges of 6 districts of Kumaon region, Uttarakhand state. Primary data was collected on forest-based NTFP, agriculture and livestock during the questionnaire survey. Focused Group Discussion (FGD) and interviews were also conducted to estimate community dependency on forests, agriculture and livestock for their livelihood in the study area.

- Forest dependency in the villages is mainly subsistence-oriented for meeting basic household requirements. Forests primarily fulfil the basic household requirements for timber, fuelwood, fodder, natural fertilizers (leaf litter), timber, medicine, fruits, and other food-related products. The harvesting and collecting of forest resources i.e., wild edibles and medicinal plants, employ a larger group of people in these villages.

- Fuelwood remains the only source for cooking and heating purposes for most village households.

P. roxburghii, Pinus wallichiana and Quercus spp., are the dominant species used for fuelwood in most of the villages. The fuelwood consumption varies from place to place and the average per capita consumption of fuel wood varies from season to season. However, with the availability of alternative energy options i.e., LPG gas has minimised the dependence on fuelwood in a few villages.

- A one day Workshop-cum-brainstorming on "Forest-based resources and livelihood options" organized on November 3, 2022 at G.B. Pant National Institute of Himalayan Environment (NIHE), Kosi-Katarmal, Almora, Uttarakhand (Fig. 21).

Fig. 21: Workshop on forest based resources and livelihood options at NIHE Almora

Estimation of Economic Loss in real Term Per Hectare Basis Due to Forest Fire in Uttarakhand and Madhya Pradesh (CAMPA, MoEF&CC, 2019-2023)

Forest fire has been an integral part of the ecosystem since the origin of forests. It is among the major factors responsible for environmental transformation in various natural ecosystems. Every year, forest fires are affecting millions of hectares of forest throughout the globe and changing biodiversity patterns, landscape stability and ecosystem function. It is also responsible for potential loss or damage to the ecosystem's goods and services. In the 2016 summer, Uttarakhand witnessed a major forest fire (2069 forest fire incidences affecting 4423 ha of forests), and the loss was estimated to be Rs. 46.2 lakhs by the Uttarakhand Forest Department following the traditional method of damage and loss assessment methodology. As this was a major disaster which not only caused huge damage and loss to natural vegetation but also resulted in the death of 6 persons and 7 animals and injury to 23 people, the Government of India decided to send the Parliamentary Standing Committee (PSC) on Science & Technology, Environment and Forests, Govt. of India to visit Uttarakhand and H.P. In June 2016, the committee visited both the states and held consultation meetings with a wide range of stakeholders to discuss the causes of forest fire and its control measures and assess the monetary loss due to this menace. The PSC realized that the monetary loss values estimated by the Forest Department were too low. Without proper methodology and baseline data, assessing the actual monetary loss and compensation due to forest fires was difficult. In this context, the PSC recommended assessing the damage and loss due to forest fires in a more comprehensive manner, incorporating all essential elements related to forest fire impacts viz., socio-economic and environmental impacts, direct and indirect. Following the recommendations of PSC the present pilot project was developed after intensive rounds of discussion among the partner organization. The project was undertaken with the major mandate of "Estimation of economic losses in real terms per hectare basis due to forest fire in Uttarakhand and Madhya Pradesh", involving leading organizations of the region viz., Indian Council of Forestry and Research (ICFRE), Dehradun; Forest Survey of India (FSI), Forest Research Institute (FRI), Dehradun; Tropical Forest Research Institute, Jabalpur; Govind Ballabh Pant 'National Institute of Himalayan Environment (NIHE), Almora; Wildlife Institute of India (WII), Dehradun, and National Institute of Hydrology (NIH), Roorkee for two years. NIHE estimated the losses in provisioning and cultural services on an economic per hectare basis due to forest fires in Uttarakhand and Madhya Pradesh, India. The study was undertaken for three years from January 2020 to assess the loss of ecosystem services such as timber, fuelwood, fodder, wild edibles, non-timber forest products (NTFPs), medicinal and aromatic plants (MAPs), forest regeneration (seedlings and saplings), and forest floor litter due to forest fires.

Major Outcomes:

- 42 forest fire (FF) polygons were selected out of 289 polygons in Uttarakhand and 49 FF polygons were selected out of 228 FF-affected polygons in Madhya Pradesh (Fig. 22 and 23).
- The study organized 35 meetings in Uttarakhand and 31 meetings in Madhya Pradesh among nearby villages to estimate the monetary loss due to the forest fires.
- In Uttarakhand, the estimated price of timber loss ranged from Rs. 142994/ha with a mean of 5.86 m^3/ha.
- In Madhya Pradesh, the estimated market price of timber loss ranged from Rs. 96560/ha with a mean of 6.51 m^3/ha.

Fig. 22: Demonstration of field techniques and survey methods for monetary loss evaluation in the field

Fig. 23: Phyto-sociological studies to estimate forest wealth

Kailash Sacred Landscape Conservation and Development Initiative (ICIMOD, Nepal, 2020-21)

The project 'Kailash Sacred Landscape Conservation Initiative: Developing a Transboundary Framework for Conservation and Sustainable Development in the Greater Mt. Kailash Region of China, India, and Nepal' attempts to initiate and promote transboundary biodiversity and cultural conservation, ecosystem management, sustainable development, and climate change adaptation within the Kailash Sacred Landscape (KSL). This landscape covers remote southwestern portion of Tibet in China, and contiguous areas of northwestern Nepal, and India. The identified landscape represents a wide range of bio-physical; socio-cultural and environmental conditions, and is considered amongst most revered sacred landscapes of the world. The spiritual and sacred values of this landscape attract tens of thousands of pilgrims every year. Unfortunately, the landscape is equally known for its extreme vulnerability to changing faces of development and global climate. As a result, the rich and unique biological diversity, the ecosystem goods and services, and the value based cultural heritage of this landscape are severely threatened. All these attributes and many more, qualify it for urgently taken-up as transboundary landscape so as to promote transboundary biodiversity and cultural conservation, ecosystem management, sustainable development, and climate change adaptations. With this realization, ICIMOD in collaboration with UNEP and in consultation of three countries (i.e., China, India and Nepal), formulated the above project to address (i) Enhance cooperation among the regional member countries through establishment of a Regional Cooperation Framework (RCF), development of a strategy for conservation ofKailash Sacred Landscape (KSL), and developing a transboundary regional knowledge base; (ii) Increase collection of climate change data in the KSL and facilitate coordination among the various actors and stakeholders within the KSL landscape through enhancing transboundary collaboration in ecological and climate change monitoring and information exchange networks; and (iii) Recognize, and strengthen local capacity efforts for community-based participation inconservation and sustainable development, and enhance cultural-socio-ecological resilience.

Achievements

1. In the second phase KSLCDI carry forwarded many activities of KSLCDI phase-I, while doing necessary amendments and reorientation for deeper strengthening of transboundary dialogues and agreements. The Transboundary Forum (TB) forum established for addressing the issues of illegal wildlife trade in phase-I was upgraded further to be more inclusive and formed as 'TB forum on Biodiversity Management'. During the year 2020-21, attempts were made to revitalize the forum by holding an interactive dialogue aimed for prioritizing the issues of biodiversity management at Munsiyari with diverse stakeholders groups. The outcomes of deliberation were subsequently shared at a transboundary level deliberation for critical expert inputs from within and across the borders especially with the ANCA and ICIMOD.

2. Similarly for conserving critical species and ecosystem, the often overlook dimension of Ecosystem Services (ES) was targeted for the first time by conducting participatory assessments of Cultural Ecosystem Services (CES) for impact of climate chnage in the two identified priority sites of Mesarkund in Munsiyari and Thal Kedar in Pithoragarh.

3. The project also attempted conservation of critical species and ecosystem by documenting orchid diversity of Gori valley. A document on orchid diversity of Gori valley was prepared to give impetus to conservation and commercial possibilities.

CENTRE FOR SOCIO-ECONOMIC DEVELOPMENT (CSED)

The villages of IHR are endowed with natural resources that need to be used sustainably, keeping in view the carrying capacity concept and creating ecologically smart villages with a circular economy that begins and ends in nature. In addition, rural Himalayas should have the following facilities: good education, health care centres, better communication & infrastructure, proper sanitation, waste management, renewable energy, clean drinking water, environment protection and resource use efficiency, particularly natural resources. Many Central and State Government schemes are working towards social and economic upliftment of villages, but very few programmes are working to secure the ecology and conserve biodiversity of Himalayan villages. The CSED Centre with following objectives aim to (i) strengthen environmental management and sustainable development through resource planning and management and livelihood up-gradation, (ii) build stakeholder's capacity and skills for socio-economic development and natural resource management, and adopt technologies created elsewhere into forms that will be readily acceptable by society.

Community Driven Eco-Smart Model Village Development to Improve Livelihoods and Foster Ecological Security in the Himalaya (NIHE In-House, 2020- 2025)

Different approaches to village development have been envisaged as "SmartVillage" with a vision to transform villages as examples of sustainable development based on environmentally responsible individual and collective action for reducing human ecological foot-print and through judicious use of natural resources. This project aims at developing 'Eco-smart Model Villages' across four representative localities in the IHR through an innovative community-driven process by promoting participatory planning and development strategies through a combination of natural resource management activities, services, policies, and stakeholders (including Govt. line Deptt.) engagement to improve livelihood, income and employment generation health, energy, sanitation, water, and environmental status in rural areas of the IHR, while safeguarding the ecological balance of targeted villages /village cluster employing carrying capacity concept and consequently lead to the creation of an Eco- smart model village.

Objectives:

- Identification of representative villages/village cluster for community-led planning process for preparation of eco-smart model village plans across the IHR
- Preparation of baseline datasets and resource-use maps of the target villages through stakeholder's participation
- Capacity building of rural communities to implement "Eco-smart model village" plans for integrated natural resource management for livelihood improvement
- Demonstrate and develop 'Eco-smart model villages' for enhancing livelihood, and upscaling by Govt. Line Depts. to foster ecological security in the region

HQs (Kosi-Katarmal):

1. Backyard poultry farming and green-skill development activities were taken up during the reporting period. Under these activities, 85 HH have earned a total Rs.470008 through the sale of poultry products, and 19 households have earned a total Rs. 21900 through selling Rakhi and aipan prepared through pine needles and pine paper.

2. At Jyoli village cluster, three activities of protected cultivation of horticultural crops (Fig. 24), promotion of organic farming through vermi-composting and bee keeping were also taken up. Under these activities, 66 HH have earned approximately Rs. 400444 through the sale of horticulture crop products, 7 households have earned approximately Rs. 52600 through selling vermi-compost and 19 HH have earned around Rs. 136500 through selling organic honey.

3. Capacity building of village representatives (Gram Pradhans, SHGs etc.) of five villages with the highest number of BPL families in five districts

of the Kumaon region of Uttarakhand, namely Almora, Bageshwar, Champawat, Pithoragarh and Nainital was done on baseline data generation of households and village level resources.

Fig. 24: Rakhi making and strawberry production under protected cultivation at Eco-smart model village, Jyoli

Himachal Regional Centre

1. Questionnaire survey has been completed for 1221 households in the identified villages of Kullu (232), Mandi (317), Lahual (111), Kinnaur (140), Chamba (218) and Kangra (203) districts for the baseline dataset collection and the preparation of resource use maps.
2. A quantitative assessment of forest biomass for firewood availability was carried out through the quadrate method for the forests of Saraach, Pachahli, Buragran, Muthal, and Kareri villages.
3. Resource availability has been calculated for all the 232 households of 6 Cluster villages of Khadihar (Pahnallah, Pachahli, Buragran, Kareri and Muthal) and Balh II (Saraach) panchayats of Kullu District.
4. The water and fuel wood availability in the village of Pahnallah has been determined through the data gathered in 2022 during the field survey on the flow of natural and quadrate sampling and biomass estimation.

Garhwal Regional Centre

1. The household survey was conducted at four villages of Rung community at Joshimath block, namely, Lata, Bhalgaon, Sukhi and Raini to collect baseline data on the socioeconomic status of the people. Survey of a total 104 households was completed for assessment of household income, livelihood options, livestock, milk production land holdings and agriculture production.

2. The population of Lata, Bhalgaon, Sukhi and Raini villages is 169, 142, 114 and 138 respectively. The total income of Lata village from agricultural produce is Rs 27758.33 per year, and from jobs and other income sources is Rs 108008.33 per year. Bhalgaon village's total income from Agriculture production is Rs 2783.33 per year, and from other income sources is Rs 48441.66 per year. Total livestock of Lata village is 165, 44 Cows, 48 bulls, 33calves, 12 sheep, 19 goats, 9 horses. Bhalgaon village has total livestock of 243, 44 cows, 37 bulls, 29 calves, 11 sheep, 81 goats, 41 hens, Sukhi village having livestock of 107, 29 cows, 15 bulls, 24 calves, 14 sheep, 7 goats, 18 hens, Raini village having total livestock of 55, 21 cows, 3 bulls, 22 calves, 9 goats in it. The total milk production of Lata village is 37.5 Liters/day ,Bhalgaon village total milk production is 45.5 Liters/day, Sukhi village's total milk production is 27 Liters/day, and Raini village total milk production is 20 Liters/day, Total land holdings of Lata village1054.5 Nali, Bhalgaon village 343 Nali, Sukhi village 949 Nali, Raini village 290 Nali. Total Agricultural production of Lata village is 8679 kg, Bhalgaon village's total agriculture production is 3674 kg, Sukhi village is 4602 kg, and Raini village's total agriculture production is 9884 kg (Fig. 25).

3. Two capacity-building training programs were organized through which 55 participants were trained (50 women and 5 men) from different villages of district Rudraprayag and self-help groups, NGOs, Govt. Line departments, local people and farmers were trained in beekeeping, poultry farming and preparing juices, jams, jelly, and pickle from natural resources available in the region.

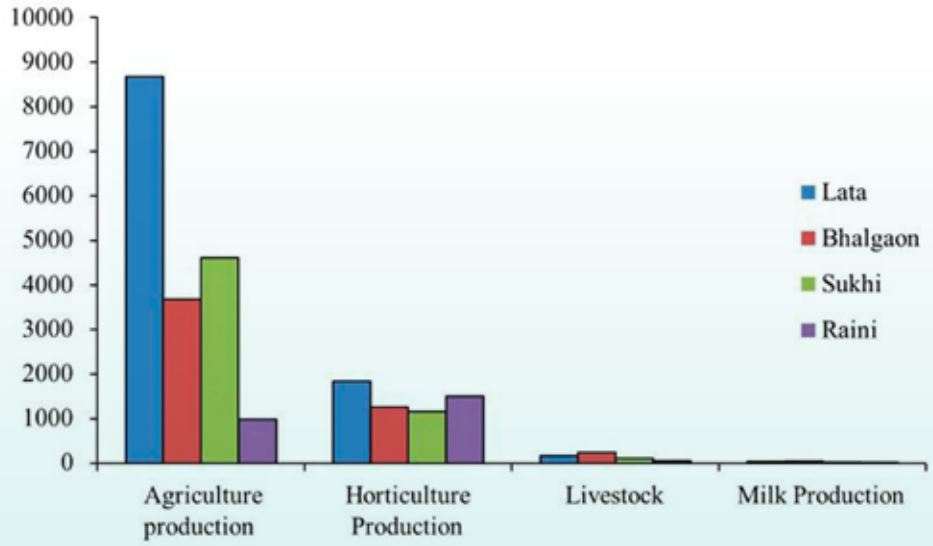


Fig. 25. Baseline household survey data from four different villages of Rung Community, Joshimath Uttarakhand

Sikkim Regional Centre

1. Conducted baseline household survey of 10 villages (4 villages of South Sikkim District e.g., Upper Mamlay, Lower Mamlay, Upper Kamrang, Lower Kamrang and 06 villages of East Sikkim District e.g., Upper Rakdong, Lower Rakdong, Upper Samdong, Lower Samdong, Upper Tintek, Lower Tintek) in current progress year (total surveyed village 20) using Unnat Abhiyan Bharat Questionnaire. Kharif and Rabi Crop's productivity revealed that ginger production was high in all villages during the Kharif season, while potato production was high in the Rabi season.

2. Among the interventions for livelihood upliftment in project sites, vermi-composting was targeted. Organized awareness and capacity building on 'Vermi-Compost Process and Application for improved organic farming Practices Fostering Ecological Security' in Upper Jaubary village on 31 January 2023, where one vermi-compost (Pit method) model was developed in participatory approach.

3. A village resource map was prepared for 6 villages (e.g., Punzitar, Chemchey, Lower Jaubari, Upper Jaubari, Upper Mamlay, Upper Rakdong) in the current reporting year using a capacity building training programme.

4. Two Training Programs were organized on Village baseline data collection and resource map preparation at Upper Mamlay and Rakdong, and in the training programmes a total of 35 participants were present.

5. A phytosociological study was done in the nearby forest of Damthang village, where Oak species and other dominant species including *Schima wallichii*, *Madhuca longifolia, Albizia lebbeck,*

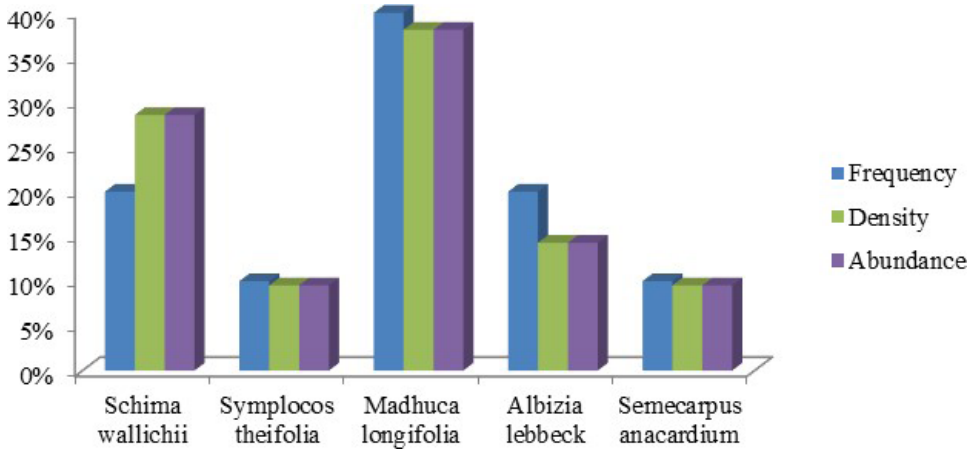


Fig. 26: Phytosociological parameters of few dominant tree species

Quercus lamellosa were present in Sub-tropical mixed broad leaves forest. Whereas the Sub-tropical mixed broad-leaved forests near the Pakchay village were represented by *Schima wallichii, Symplocos theifolia, Madhuca longifolia, Albizia lebbeck, Semearpus anacardium species. Madhuca longifolia* represented higher density, frequency and abundance values in this forest. (Fig. 26).

North-East Regional Centre

1. A Village Resource Mapping Program using GPS was organized from 15th March, 2023 to 19th March 2023 at the cluster of 5 villages with an objective to the digitized resource maps of Dikopita (Fig. 27), Byapin, Manipoliang, Miring and Siichusi village using GPS, to develop skilled manpower who can be employed in similar works for village development planning, natural resource management and other relevant fields. Gram Panchayat Chairpersons and GP members of the 5 villages, along with community members, supported the programme in identification of the village boundaries, land uses and resources for mapping. A total of 15 participants attended in the programme.
2. A training and capacity building programme on the Village Development Action Plan for the project team of NERC and village representatives of Sopo and Poma Gram Panchayats of Papumpare district was undertaken at NIHE, NERC on 22nd - to 24th August 2022. External resource persons from the State Institute of Rural Development & Panchayati Raj (SIRD&PR) and Arunachal State Rural Livelihood Mission (ArSRLM) were involved in training of 44 participants who attended the programme. Field demonstration activity was conducted at Sopo Village, Doimukh and Papum Pare. The participants were also trained in baseline data collection using PRA techniques and questionnaires for villages and households.
3. A stakeholder training & capacity building program on village development plan & baseline data collection was organized at M'PEN II village of Miao, Changlang district, on January 18th, 2023 to build the capacity of various stakeholders to develop a village plan for the respective villages and stimulate thinking and creativity for engaging community members in preparing a village action plan to cope with any difficult situation where a total of 20 participants attended the programme.

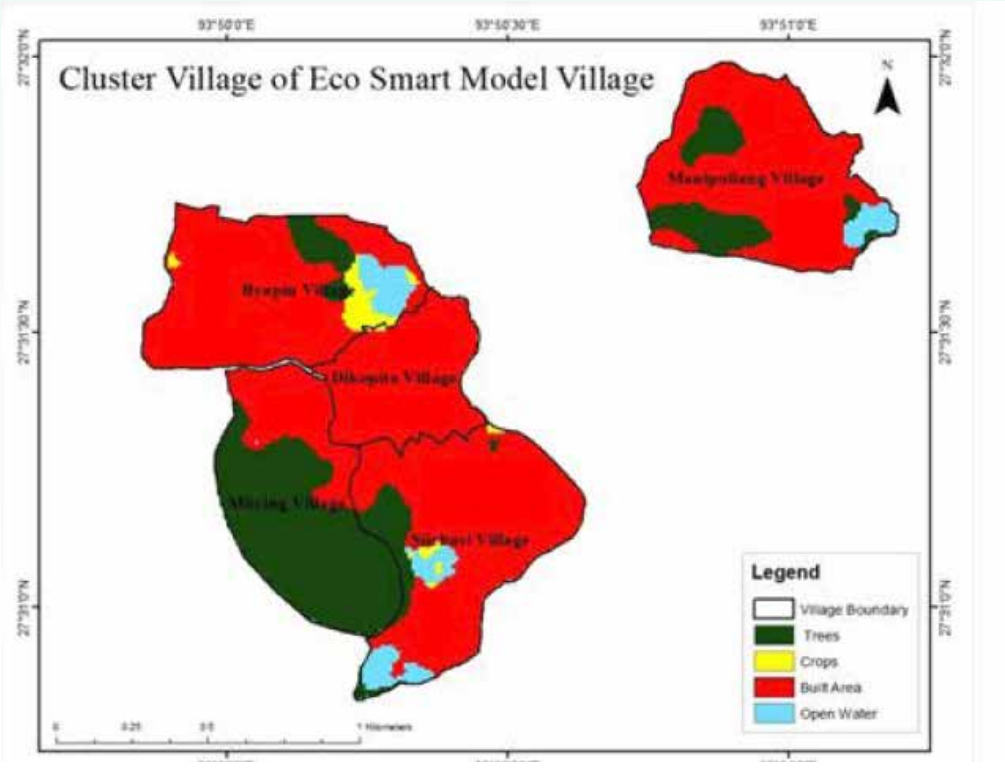


Fig. 27: Digitized Village Resource Maps of Dikopita, Miiring, Byapin, Manipoliang and Siichusi villages

Garhwal Regiona Centre

Biochemical and molecular characterization of selected legume crops for identification of suitable germplasm to bridge the nutritional and yield gaps in Uttarakhand (UCB, 2022-2025)

Uttarakhand is a rich Agri-biodiversity state. A rich diversity of legumes grown in as monoculture and mixed cropping systems. All of them have certain nutritional as well as therapeutic values. Despite the importance of these legumes, little research has been devoted to their improvement and understanding of the genetic diversity and nutraceutical values of these landraces. The present study is therefore focused on evaluating the genetic diversity and nutritional quality of these legumes and their yield potential to popularize them in Uttarakhand for large-scale cultivation and potential to get GI tag.

Objectives:

- To evaluate morphological traits of the germplasm of target species viz., soybean (*Glycine max*) and horse gram (*Macrotyloma uniflorum*), french bean (*Phaseolus vulgaris*) from a range of localities across Uttarakhand encompassing various agro-climatic conditions
- To measure the nutritional and nutraceutical properties of the target species
- To evaluate the molecular diversity among the genotypes of target species collected from various locations
- To build the capacity of rural people to promote and adopt superior varieties for large-scale cultivation

Achievements:

1. The germplasm (seed) of total 80 landraces of *Phaseolus vulgaris*, 25 landraces of *Macrotyloma uniflorum* and 30 landraces of *Glycine max* have been collected from different locations of Uttarakhand i.e., Dharchula, Munsiyari, Chakrata, Harsil, Mukteshwar, Uttarkashi, Chamoli and Almora (Fig. 28).

2. A good diversity has been observed among landraces of target species based on plant morphology (flower colour, pod length, pod width, number of seeds per pod and seed colour, etc.) and phyto-chemical traits cultivated under similar environmental conditions.

Fig. 28: Some landraces of *Glycine max* and *Phaseolus vulgaris*

CENTRE FOR ENVIRONMENTAL ASSESSMENT & CLIMATE CHANGE (CEA&CC)

Environmental factors, including climate change, influence an ecosystem, further exacerbated by human-induced perturbations. Changes in climate regimes over the last few decades have already started affecting natural resources worldwide, including mountain regions. Subsequently, the natural resources of the Himalayas have become vulnerable. Now, it is known that climate change (CC) is a major global environmental challenge that will affect ecosystems in various ways and will pose a threat to social and economic development in the IHR, where societies' dependence on natural resources is very high. The Centre for Environmental Assessment & Climate Change (CEA&CC) caters to the Himalayan needs on these issues in tune with MoEF& CC and SDGs (Goal no. 13), which requires urgent action to combat CC and its impacts. The broad approach for achieving these goals includes (i) identification and prioritization of climate-sensitive sectors in the Himalaya for research and resource generation, (ii) development of indicators of CC in the Himalaya in identified sectors, (iii) inclusion of a Citizen Science approach in research, and adaptation and mitigation strategies, (iv) practice Science-Policy-People connect through the integration of community-level experiences (acclimatization/ adaptation /coping mechanism) in policy framework, and (v) collaboration with other organizations / Universities on CC projects. The objective of the CEA&CC is to assess and monitor physical, biological and socio-economic environmental parameters for the development in the IHR, and design measures for CC mitigation and adaptation by communities and developing ecosystem resilience to cope with CC risks. Thus, our vision is that in due course of time, the Centre will become reasonably self-sustaining and play a leading role in Environmental Assessment and Climate Change research and advisory in the IHR. Our mission is to bridge between research and practice on the impacts of CC in identified key sectors in the Himalaya.

Fostering Climate Smart Communities in the Indian Himalayan Region (NIHE In-House Project-3, 2020-2025)

Climate change is realized as the greatest global challenge; however, its impacts are more prominent in the Himalayan region, providing valuable ecosystem goods and services. During recent decades, the Indian Himalayan region has experienced higher warming rates and high variability in precipitation patterns, leading to a higher frequency of extreme events. Climate change is affecting the flow in the mountain streams, agriculture, socio-economic systems, and livelihood of native communities. Due to limited livelihood options and social infrastructure, the mountain communities depend on natural resources for their subsistence. Under such circumstances, these communities will likely be more vulnerable to climate change. Therefore, assessment of the vulnerability of the communities is imperative, which can help in identifing its drivers and may assist in adaptation interventions in the IHR. The present study deals with identifying the vulnerable communities in the IHR for developing resilience and adaptive capacity to climate change.

Objectives:

- Development of climate vulnerability framework for identification of the vulnerable communities in IHR and their mapping
- Designing adaptation and resilience-building mechanism in response to climate change for fostering climate smart communities
- Nurturing Climate Awakened Society in the Himalaya (CASH), and formulating policy guidelines for the vulnerable communities

Achievements:

1. The environmental vulnerability map of Uttarakhand has been developed based on confirmed principal components and using the integrated evaluation index. The area under environmental varies within vulnerability class-High (14.71%) to Severe (3.25%) (17.96%). The highest contributing factor to the environmental vulnerability was forest Cover (57.50 %), followed by Landslide susceptible layer (56.80%), Forest fire risk zonation (21.78 %), LULC (10.63%) and population density (3.16 %).

2. A total of 22 training and awareness programs

were organized, covering 909 beneficiaries from the IHR during 2022-2023 (Fig. 28).

HQs (Kosi-Katarmal)

1. A forest fire risk zonation map has been developed for Uttarakhand. The results show that out of 2487 fire incidents, 772 occurred in high and very high-risk zones, with most fires in areas covered with moderately dense forest. A landslide susceptibility (LS) map was also developed for Uttarakhand, where the highest number of landslides occurred in the very high (44.75%) and least (6.79%) susceptible classes.
2. A household survey using a semi-structured questionnaire was conducted to explore surrounding resources and to promote appropriate technology at the community level. A total of 48 plant species belonging to 43 genera and 40 families with 8 different use patterns such as medicinal (25 species), wild edibles (11 species), fuel wood (6 species), timber/ construction (4 species), handicraft (3 species), religious (3 species), dye/fiber (2 species) and fodder (2) were found to be used as NTFPs by the local communities of Darma valley, Pithoragarh district, Uttarakhand.

Himachal Regional Centre

1. A questionnaire survey was conducted in the villages of three Himachal Pradesh districts of Kullu, Mandi and Lahual & Spiti districts. The vulnerability analysis revealed that the Koksar village in Lahual & Spiti district shows high vulnerability to climate change with vulnerability Indices (VI)=1 due to a higher degree of changes in climatic conditions, which affects the livelihood options (agriculture and tourism) as well as natural resources. Nau Panchayat in Mandi district showed moderate vulnerability with Vulnerability Indices (VI)= 0.97 due to water stress and pest diseases, whereas Kharihar Panchayat in Kullu district showed less vulnerability with Vulnerability Indices (VI)= 0.94 due to less adaptive capacity.

Garhwal Regional Centre

1. A detail household survey on the socio-economic profile, forest resources, livestock and land use system of village clusters located at high (1800-2700 masl), middle (800-1800) and low (500-800 masl) altitudes was carried out to document the perceived climate change events in the region. Based on the people's responses at different altitudes, about 94% of respondents indicated that decreasing crop yield at high and middle altitudes, followed by a rise in temperature and rainfall fluctuation, are the major events. The perceived climate change events have severely affected middle altitude, followed by high and low altitudes.
2. Organized three climate change awareness and consultative workshops at different altitudes to cover a wider range of stakeholders. A total of 235 (94 Male and 141 Female) participants belonging to different sections of the society, i.e. students, local people, teachers, NGOs, MMDs, SHGs and Govt. line departments attended thw workshops.

Sikkim Regional Centre

1. The forest fire data of Sikkim (2017-2022) showed that 85.45% of fires occurred during the pre-monsoon season and 14.5% in winter, which resembles the region's dry season. Among the districts of Sikkim, the South district accounted for the highest number of forest fires, followed by the West district.
2. A household (HH) level survey in South Sikkim revealed that only 70% of HH use bio-fertilizers and pesticides, and 56.6% of the HH have adapted to change in agricultural practices vis-a-vis climate change. The polyhouse based farming practice is found to be the most common adaption practice by the rural community, helping them cope with adverse climate impacts and increase land-based productivity, largely supported by the Government.

North-East Regional Centre

1. The Topographic Wetness Index (TWI) was developed and analyzed for Arunachal Pradesh, Himachal Pradesh, and Sikkim. In Arunachal Pradesh, TWI ranges from 0.7 to 21.9, 0.04 to 20.7 in Himachal Pradesh, and -0.74 to 20.8 in Sikkim. Higher TWI values indicate areas more susceptible to flooding, erosion, and landslides, thereby increasing climate vulnerability. Conversely, areas with lower TWI values are more vulnerable to climate change impacts such as droughts, wildfires, and soil erosion.

2. In the last decade, there has been a noticeable reduction in vegetation in the Ziro Valley, which the construction of a highway has exacerbated. Most respondents identified forest degradation as the area's primary driver of climate change, followed by land use change.

Fig. 29: Various activities conducted under the project (a,b,c,d) in Uttarakhand, (e) Himachal, (f) Sikkim, and (g) Arunachal Pradesh

Aerosol Climatology over the North-western Indian Himalayan Region: Himachal Pradesh & Uttarakhand (ISRO-SPL, 2005-06 &Onwards)

One of the world's most difficult problems is the changing climate by pollution, declining air quality, and rising GHG levels. Aerosols in the atmosphere also have a significant impact on it. Anthropogenic aerosols have become more prevalent due to fast industrialization and urbanization in the Indian Himalayas. It has a negative impact on the glaciers, climate, ecosystem, and people's health. The distribution of aerosols in the atmosphere causes a great deal of variation in their production. It was also impacted by a rise in native people and tourist influx. Aerosol characteristics vary both spatially and temporally,ofa shorter atmospheric lifetime. Additionally, if it is deposited on snow and ice, black carbon aerosol darkens the surface, diminishes albedo, and accelerates snowmelt. It further causes glaciers to retreat, reduces snowpack, and causes a decrease in precipitation and an increase in temperature. In the sensitive and vulnerable Himalayan topographical region, the current study intends to reveal aerosol (AOD) status.

Objectives:

- To obtain variations in aerosol optical depths (AODs) at UV, visible and NIR spectrums (380-1025 nm) using Multi-wavelength Radiometer (MWR) and Microtops-II Sunphotometer
- To obtain black carbon (BC) aerosol concentrations on land and glaciers using Aethalometer
- To relate AODs with the meteorological parameters with the help of Automatic Weather Stations (AWSs) installed at Mohal (Himachal Pradesh) and Katarmal (Uttarakhand)

- To estimate radiative forcing using different models

Achievements:

HQs (Kosi-Katarmal, Almora)

- Annual Average AOD 500 nm was observed in the range of 0.31 - 0.43 from 2019 to 2022 (Fig. 30 a-c). BC concentration was 2942±160 ng m-3 in 2022 (Fig. 30 d) due to biomass burning as a main contributor (Fig. 31). Average values PM2.5: 49.3±9.8 µg m–3, PM10: 84.9 ±7.6 µg m–3, TSPM: 155.2 ± 6.8 µg m–3.

- **Average ARF on TOA, SFC, and ATM, from 2019-22 (Fig. 30 e):** Mohal: – 21. 7 Wm–2, – 48.3 Wm–2 and + 26.6 Wm–2 and Kosi (2019-22): – 21.3 Wm–2, – 44.3 Wm–2, and + 23.0 Wm–2, respectively

- **Heating rate: Mean ARFATM (Fig. 30 f):** Mohal: +26.6 Wm–2 equivalent heating rate = 0.75 K day-1 and seasonally, maximum in post-monsoon with 1.13 K day-1. Kosi: +23.0 Wm–2 equivalent heating rate = 0.65 K day-1 and seasonally, maximum in pre-monsoon with 0.65K day-1.

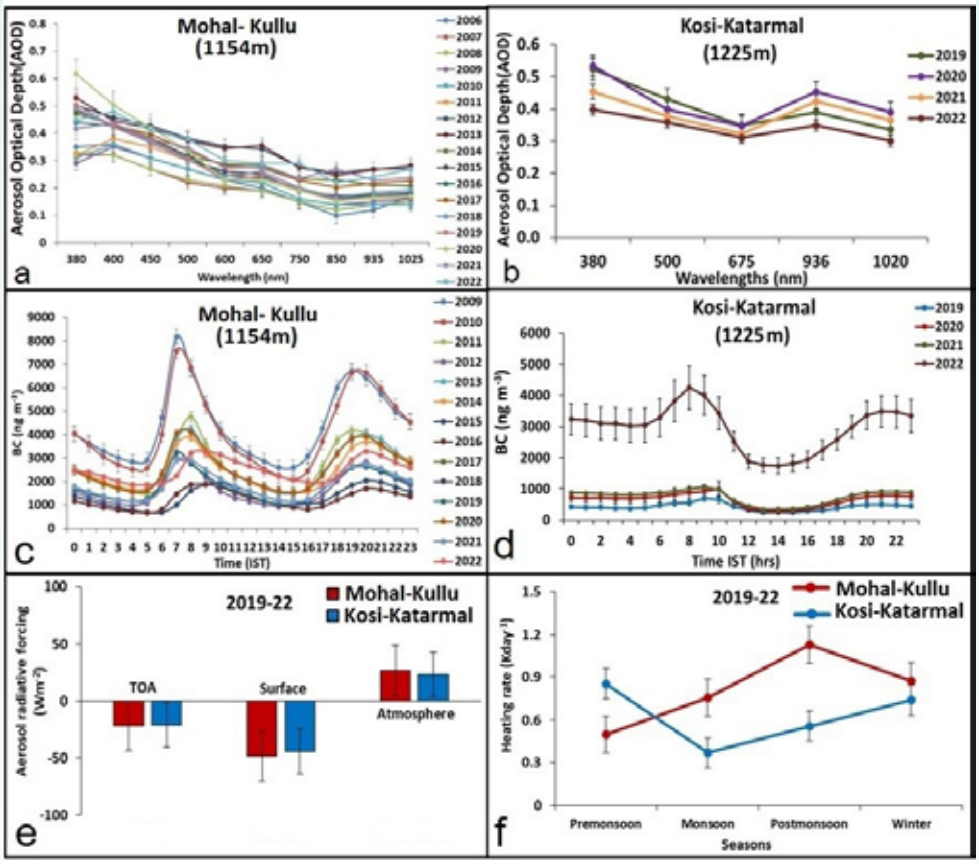


Fig. 30: (a&b) AOD, (c&d) Concentration of Black carbon (BC), (e &f) comparative ARF and the heating rate at Mohal- Kullu and Kosi- Katarmal respectively

Fig. 31: (a) Multi-wavelength radiometer (MWR) set up for aerosol measurements at Mohal (b) Air quality monitoring station at Kosi-Katarmal, Almora

Mohal-Kullu, Himachal Pradesh (1154 m amsl)

- AOD values at shorter wavelengths are higher indicating an increase in the anthropogenic actives. Fig. 31 a & b shows a Multi-wavelength radiometer (MWR) set up for aerosol measurements at Mohal. The mean AOD 500nm at Mohal in 2022 stood to be 0.34±0.0, while the same was observed maximum 0.44 in 2020, and minimum 0.22 in 2007.

- Black carbon shows a bimodal peak, the average concentration peaked at 2478.5±99.80 ngm-^{3} in 2022.

- PM10 showed an average concentration of 54.74 µgm-3 while PM2.5 showed 33.3µg m-^{3}.

Gaseous Air Pollution in the Background Sites of Sprawling Urban Environment in Himachal Pradesh and Uttarakhand (ISRO, EO AT-CTM,PRL, 2008-09 & Onward)

A secondary pollutant is ozone (O_3) at the ground or at the surface. Anthropogenic and natural sources release primary pollutants, including nitrogen oxides (NO+NO_2). A pollutant called NO, which has a short lifespan, turns into NO_2 when it combines with air oxygen. These photochemical processes further facilitate the formation of surface ozone and other dangerous pollutants. One of the biggest scientific issues with gaseous pollutants is the relationship between O_3 and its primary components. The absolute and relative concentrations of ozone's precursors and the strength of solar radiation determine the ozone concentration. In the atmosphere, secondary pollutants like PM10 and PM2.5, which are harmful to the environment, are produced when other trace gases, including SO_2, react. NAAQS for particulate matter and trace gases has been established by the Environment Protection Agency (EPA). It is crucial to regularly assess the air quality to understand baseline values and make improvements.

Objectives:

- To measure the concentration of gaseous pollutants such as Ozone (O_3), Nitrogen Dioxide (NO_2), Carbon Monoxide (CO), Sulfur Dioxide (SO_2) and Carbon Dioxide (CO_2) due to anthropogenic sources such as vehicular emission and biomass burning as well as natural sources (dust, storm) to establish background values in the Himalayan region
- To observe local meteorological parameters, relate to these with gaseous pollutants, and analyze in the background of long-range sources
- To suggest some feasible mitigating measures for implementation at the policy level

Achievements:

HQs (Kosi-Katarmal)

- From 2019-2022, the AQI found light air pollution (LAP) on non-fire days while severe air pollution (SAP) on fire days (Fig.32 c).

- The rate of change for NO_2, and SO_2 in forest fire to non-forest fire days was found to be -6%, -32%, while in pre-lockdown to lockdown periods, were -50%, -37%, respectively.

Mohal-Kullu, Himachal Pradesh

- Sulfur dioxide shows a maximum concentration of 2.12±0.03 ppb and a minimum of 0.57±0.02 ppb in 2022. Seasonally, the maximum was observed in winter and the lowest in monsoon and summer (Fig. 32 a).

- Nitrogen dioxide showed a maximum of 6.86±0.54 ppb and a minimum of 2.20±0.25 ppb in 2022. Seasonally, maximum concentration was observed in summer and minimum in winter and monsoon (Fig. 32 b). A similar seasonal trend was observed using SENTINEL-5P data through Google Earth Engine.

- Source apportionment using positive matrix factorization (PMF) revealed the major factor contribution (Fig. 32 d). SO_2: dust transport 65%, biomass burning 33% for Mohal, dust transport 0.9%, and biomass burning 99% at Kosi- Katarmal. NO2: vehicles are the major contributors of NO_2 86% and NOx 82% at Mohal, while vehicles at 91.8% and transported dust at 7% Kosi- Katarmal.

- The fixed box model revealed the measured value of the pollutants with an absolute error varying from 0.27 to 0.28 at Mohal and 0.05 to 0.23 at Kosi, respectively (Table 3). HYSPLIT model gives backward trajectories, which showed that during monsoon season, the direction of an air parcel is from the marine area, which is clear, while the air parcel movement from land, especially from the northwestern region, is polluted.

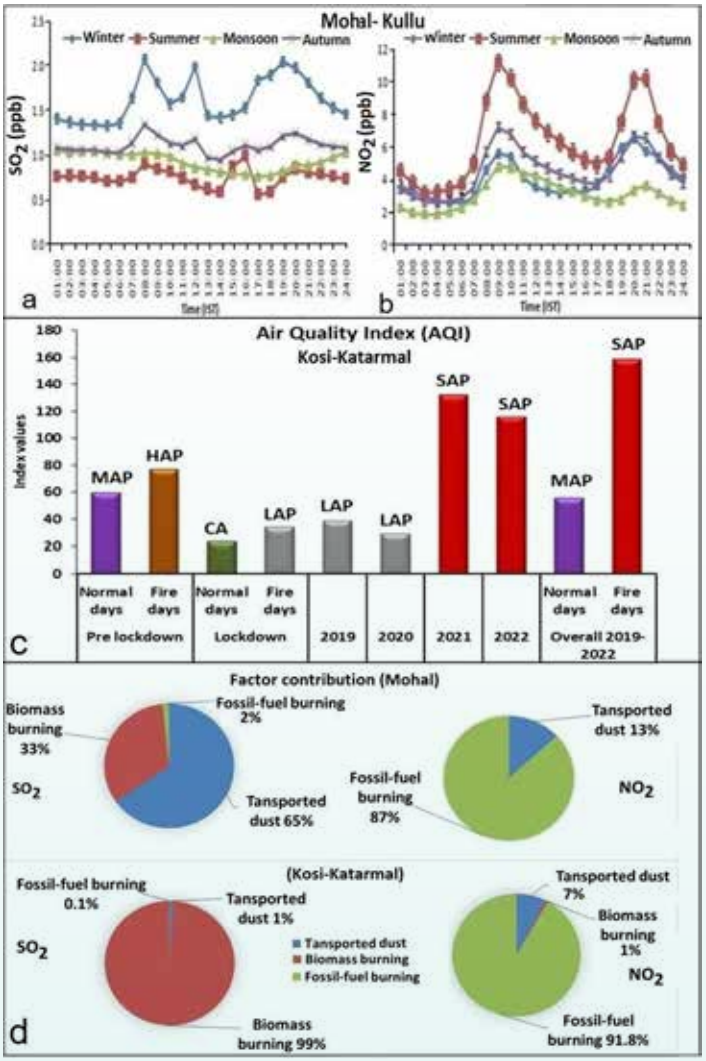


Fig. 32 (a&b) Seasonal Variability of SO_2 and NO_2 at Mohal-Kullu (c) Air Quality Index from 2019-2022 Kosi-Katarmal Almora (d) Source apportionment using PMF for SO_2 and NO_2 at Mohal Kullu and Kosi-Katarmal.

Table 3. Measured and predective value of the pollutants with an absolute error in HP & UK

Site	Pollutants	Measured Value	Predicted Value	Absolute error
Mohal-Kullu	SO_2 (ppb)	1.36	1.64	0.28
	NO_2 (ppb)	4.19	4.47	0.28
	NO (ppb)	1.39	1.67	0.28
	NOx (ppb)	5.42	5.69	0.27
Kosi-Katarmal, Almora	Total Columnar ozone (DU)	86.26	86.22	0.05
	SO_2 (ppb)	4.43	4.44	0.23
	NO_2 (ppb)	5.17	5.18	0.19

Preparation of District/State Environment Plan for Uttarakhand (UKPCB, 2020-2023)

The Central Pollution Control Board (CPCB) was directed to assist all District Magistrates (DM) in the preparation of the District Environment Plan by placing a model plan on its website by the Hon'ble National Green Tribunal (NGT) via order dated 26/09/2019 in O.A. No. 360 of 2018 filed by Shree Nath Sharma Vs. Union of India and others. All districts administered by the DMs may implement this model plan following local requirements.

The aforementioned directive further stipulates that the Department of Environment in each State must compile district plans in order to create a State Environment Plan, which the State's respective Chief Secretaries shall oversee. Under the direction of the Chairman, CPCB, and Secretary, MoEFCC, should draw a National Environment Plan based on State Environment Plans.

Objectives:

- To examine the current status of the thematic areas as identified based on the data or information provided by the concerned departments in Urban Local Bodies (ULBs)/districts
- To assign a desirable level of compliance, identify gaps and proposals to fill up the gaps as notified within the set of rules from different departments in a district/state
- To prepare the District / State Environmental Plans

Achievements:

1. Consultative workshops in each district of waterland on preparation for the District Environment Plan with District administration organised during the Pre- and Post-draft periods 2020 and 2022 (Fig. 33).

2. Developed the format for data collection for each district in Uttarakhand.

3. Presently, all 13 District's (Almora, Bageshwar, Chamoli, Champawat, Haridwar, Pithoragarh, Rudraprayag, Tehri Garhwal, Uttarkashi, Pauri Garhwal, US Nagar, Dehradun and Nainital), Environmental Management plans are completed and State Environment Plan is under progress.

Fig. 33. Consultative workshops for the preparation of District Environment Plan in September, 2022 with different district Magistrate's and other officers at District Headquarter's.

Nano-Pesticide Biosynthesis and their Impact Assessment on Secondary Metabolism of Endangered Medicinal Plant Picrorhizakurroa (DBT- RA Programme, 2020-2023)

Picrorhiza kurroai is an important endangered medicinal plant, endemic to the alpine Himalayan region of India. The medicinal values of this plant are due to its secondary metabolites (especially monoterpene glycosides). In the sustainability of *P. kurroa*, unscientific excessive harvesting, limited cultivation and attack of pathogens are major problems. The considerable yield loss of *P. kurroa* is observed with the attack of fungal pathogens such as *Alternaria tenuissima* (Alternaria leaf spot disease), etc. In recent years, nanotechnology has exponentially increased to develop nano-pesticides that overcome chemical pesticide problems and sequentially improve crop productivity. In this study, we aim to biosynthesize nano-pesticide against the pathogens of

P. kurroa and also to evaluate the impact of formulated nano-pesticide on secondary metabolites production in Picrorhiza.

Objectives:

- Green synthesis of bioactive nano-pesticides against phytopathogens of *P. kurrooa*
- Evaluation of nano-pesticides induced cytotoxicity and modulations in physio-biochemical behavior of *P. kurrooa* under in-vitro conditions
- Assessment of nano-pesticides impact on secondary metabolites production and expression profiling of their bio-synthesis related functional genes in *P. kurroa*.

Achievements:

- *A. bracteosa* and *P. Eriocarpum* leaves have good potential to synthesize small-sized (~ 21.8 nm and 55.8 nm, respectively) bioactive compounds coated AbAgNPs and PeAgNPs.
- XRD analysis confirms the formation of the face-centered cubic and crystalline structure of both AgNPs.
- *A. bracteosa* synthesized AgNPs showed maximum inhibitory potential against A. tenuissima with 66.9% suppression of mycelium growth (Fig. 34).
- Full-strength solid MS media supplemented with 5.0 mg/L TDZ was found to be the most effective for callus regeneration of *P. kurroa*.

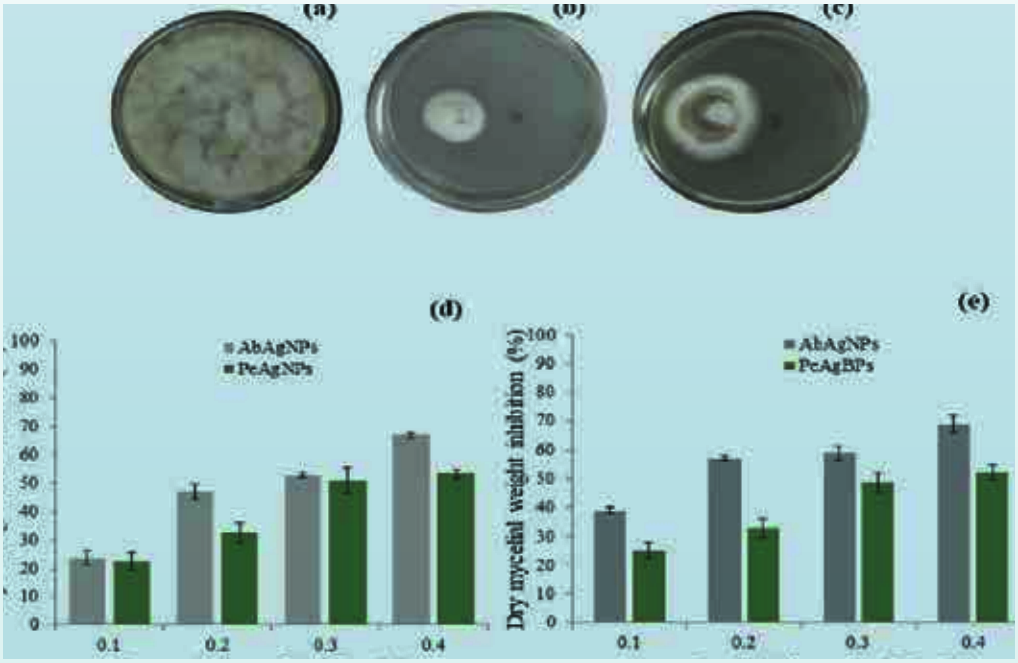


Fig. 34: Bio-control efficiency against Alternaria tenuissima (a) control; (b) AbAgNPs; (c) PeAgNPs; (d) AgNPs impact on mycelia growth; and (e) AgNPs impact on mycelia weight of phytopathogen.

Bio-prospecting of Medicinal Plants of Sikkim Himalaya Against Breast Cancer Angiogenesis (DBT, 2022-2023)

Breast cancer is a major health concern worldwide, and angiogenesis plays a crucial role in its progression. Angiogenesis is the process of new blood vessel formation necessary for the growth and spread of cancer cells. Bio-prospecting of medicinal plants from the Sikkim Himalaya region against breast cancer angiogenesis is a promising area of research. The Sikkim Himalaya region is known for its rich biodiversity and traditional use of medicinal plants for various ailments, including cancer. The bioactive compounds present in these medicinal plants have the potential to inhibit angiogenesis and prevent the growth and spread of breast cancer cells. The present study aimed to investigate potential medicinal plants of Sikkim Himalayan region against breast cancer angiogenesis and subsequent identification and isolation of biologically active molecules and lead structures that can be used to develop effective anti-angiogenic or anti-breast cancer drug leads.

Objectives:

- Survey and collection of potential medicinal plants from high altitude regions as regard to the anti-angiogenic properties in the state of Sikkim
- Screening of selected medicinal plants from the high altitude region of Sikkim Himalaya based on preliminary bioassays and phytochemical analysis
- Identification and quantification of major bioactive compounds in extracts showing good activity using different chromatographic techniques like HPLC

Achievements:

1. Phytochemical compositions and biological activities of two parts viz. leaf and root of *P. sikkimensis* were compared.

2. Qualitative screening of phytocompounds revealed the presence of phenol, flavonoids, tannin, saponin, alkaloids and glycosides in the *P. sikkimensis* extracts. The total phenol, flavonoids and tannin content were significantly higher in the methanolic leaf extract of *P. sikkimensis* than in the other extracts (Table 4).

3. Gas chromatography-mass spectrometry (GC-MS) analysis of the methanolic extracts detected the presence of 28 compounds in the leaf and 31 in the root. Flavone was found to be the most abundant compound.

4. The results of antioxidant assays revealed that methanolic leaf extract has the highest antioxidant activity with the lowest IC50 values i.e., 123.06 ± 5.02 µg ml-1 and 13.61 ± 3.41 µg ml-1 in DPPH and ABTS free radical scavenging assays, respectively.

5. Results showed that among all the tested plant part extracts, the methanol leaf extract of *P. sikkimensis* has has the maximum potential to combat free radical-induced DNA damage (Fig. 35).

Table 4: Total flavonoid, phenol and tannin content in methanol and ethanol solvent extracts of *Primula sikkimensis*

	Methanol		Ethanol	
	P. sikkimensis (leaf)	*P. sikkimensis* (root)	*P. sikkimensis* (leaf)	*P. sikkimensis* (root)
TPC (mg GAE/g extract)	54.81 ± 0.47^{a}	10.77 ± 0.05^{c}	50.08 ± 1.14^{b}	5.30 ± 0.10^{d}
TFC (mg QE/g extract)	19.46 ± 0.07^{b}	1.80 ± 0.07^{c}	17.56 ± 0.77^{a}	1.12 ± 0.05^{c}
TTC (mg TAE/g)	35.24 ± 0.86^{a}	10.5 ± 0.51^{b}	7.41 ± 0.88^{c}	4.00 ± 0.09^{d}

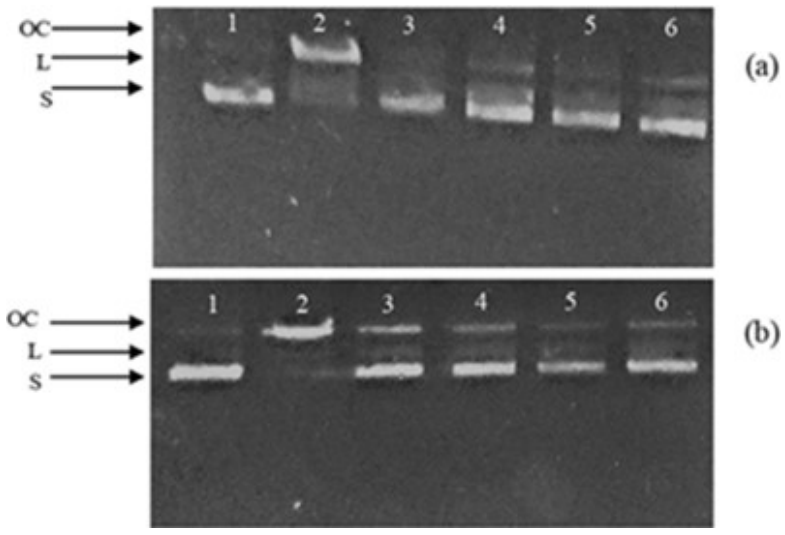


Fig. 35. Gel images depicting DNA damage inhibition potential of *Primula sikkimensis* (a) leaf extracts; (b) root extract Lane 1- only pBR322; Lane 2- pBR322, H2O2 and UV exposure; Lane 3- (4µg/ml methanolic extract), Lane 4- (8µg/ml methanolic extract), Lane5- (4µg/ml ethanolic extract), Lane 6- (8µg/ml ethanolic extract). S- super coiled DNA; L- linear DNA; and OC- open circular DNA.

Forest Resources and Plant Biodiversity, TF-3 Phase II (NMSHE-DST, 2021-2026)

The National Action Plan on Climate Change (NAPCC), among others, recognizes the Himalayan ecosystem as vital for preserving the country's ecological security. Also, it underlines the intense vulnerability of this ecosystem towards both anthropogenic and environmental perturbations. This mission envisages measures for sustaining and safeguarding the glaciers and mountain ecosystems. Among six Task Forces, Task Force 3 'Forest Resources and Plant Biodiversity' was coordinated by G. B. Pant National Institute of Himalayan Environment (NIHE). In this project, we have developed a database of plants in the IHR under different life forms, i.e., tree and shrub species of western Himalaya, invasive species of the Indian Himalayan Region (IHR), threatened plants and wild edibles in the IHR, etc. The database generated under the Task Force will be available for all the stakeholders through published books and papers. The complete database and awareness generation on threatened plants, status of forest resources and economically important species have been prepared. This would help in promoting participatory conservation and sustainable use by the society.

Objectives:

- Strengthen the database on forest resources and plant biodiversity in IHR using field datasets and a geospatial platform
- Establish an effective monitoring system for plant diversity and forest resources in relation to changing climate
- Analyse growth dynamics and carbon exchange potential under climate change scenarios
- Assess the climate change vulnerability of ecologically and economically important plants and forests
- Demonstration, capacity building, and sensitization in forest resources management and plant biodiversity conservation

Achievements:

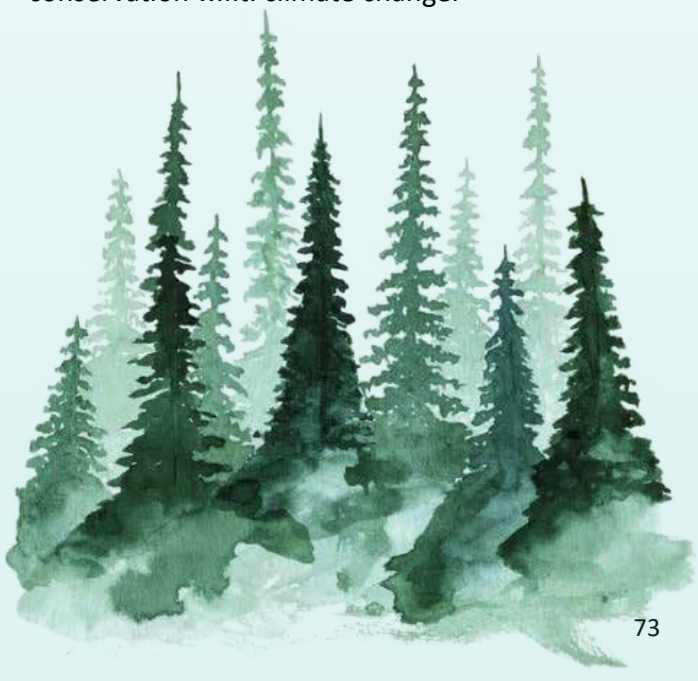
1. The lichen diversity of IHR has been inventoried with 1931 taxa (1888 species, 34 varieties, and 9 subspecies) belonging to 348 genera and 78 families. Of these, Family Parmeliaceae with 321 taxa dominates the IHR followed by Graphidaceae (263) and Physciaceae with only 97 taxa.

2. Initial finding from the newly established GLORIA site in Spiti valley of Himachal Pradesh highlights as: maximum species richness was recorded at Chandertal camps summit (CHT) followed by Losar (LOS), Kunzam pass (KNZ), and Chandertal Wildlife Sanctuary (CWL) with an equal number of species. Maximum species richness was recorded in the North aspect (28), followed by the South aspect (26) and the West aspect (18), and the lowest species richness was recorded in the East aspect (16).

3. Major highlights of campaign mode floristic diversity survey along the altitudinal gradient in Byas valley (Distt. Pithoragarh, Uttarakhand) revelaed a total of 154 plant species distributed in 103 genera, and 48 families along an altitude range from 2800 m to 4600 m in Byans valley (Distt. Pithoragarh) in September 2022.

4. Analysis of tree ring and monthly climate data (temperature and precipitation) of Himalayan cedar (*Cedrus deodara*) using 17 forest sites extending from extreme north-west to the north-east part of Hindu Kush Himalayan (HKH) revealed spring (March-May) and winter (November) season climate limits the growth of deodar trees.

5. Capacity-building training programmes were organized in Uttarakhand, Sikkim, Itanagar and Himachal Pradesh (a total 15) on various issues of forest management and climate adaptation/ mitigation issues. A total of 556 participants (male-312 & Female- 244) were sensitized to various environmental degradation issues and causes. The participants were also made aware of forest resource management and biodiversity conservation w.r.t. climate change.



Geo-spatial variability of Soil Microbial Indices of Climate Sensitive Alpine Treeline Ecotone of Indian Western Himalaya and its linkages to Soil Organic (DST, 2022-2025)

Soil microbial communities are critical in regulating carbon and nutrient cycling in ecosystems. However, the impact of climate change on the abundance and composition of these communities and their effect on ecosystem processes is not well understood. Alpine and sub-alpine ecosystems are particularly sensitive to climate change, and their carbon cycle may influence vegetation patterns. The physiognomic discontinuity between forests and treeless alpine meadows, known as the alpine treeline, is an ecotone of immense bio-geographic importance. Yet, the vast and diverse microbiota found in the alpine environment makes it challenging to understand the responses of microbial communities to climate change. Different high-altitude ecosystems also comprise different microbial communities, further affected by land use, management practices, and biogeographical patterns. This project aims to address these gaps in knowledge by investigating the influence of climate change (using altitude as a proxy indicator of temperature) on the microbial ecology and soil carbon dynamics of major plant communities in the alpine and sub-alpine ecosystems of the Indian Western Himalaya.

Objective:

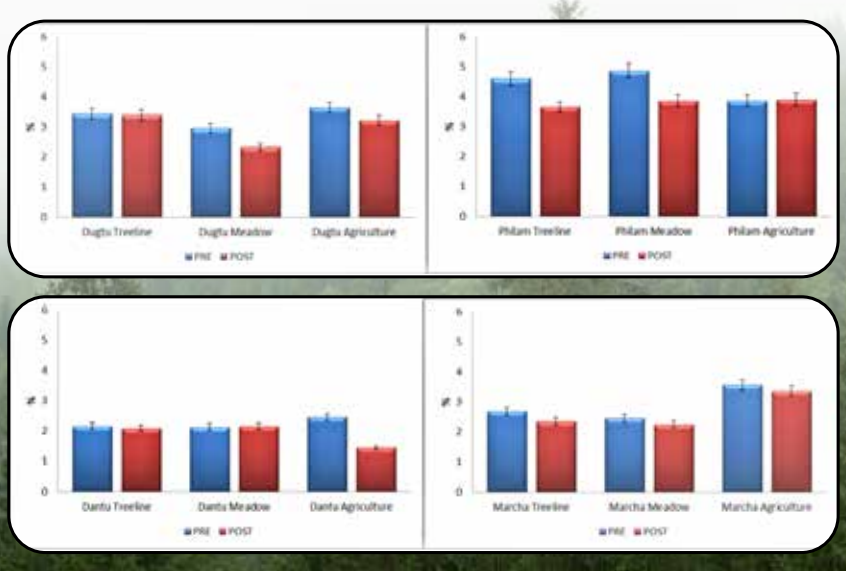
- To study the rhizosphere effect of treeline ecotone of the Indian Western Himalaya on soil enzyme, soil C & N, and other physicochemical properties of soil
- To assess the rhizospheric community composition using high through put sequencing along an altitudinal gradient (a proxy of temperature) of treeline ecotone of the Indian Western Himalaya
- To study the Geospatial variability of the soil microbial indices of Alpine treeline ecotone in the Western Himalayan region using a geostatistical approach

Achievements:

1. Two representative treeline ecotones in Uttarakhand were selected at different elevation ranges. Pre-monsoon sampling and establishment of monitoring sites at representative treeline ecotones and alpine region in Darma Valley Pithoragarh Uttarakhand. Post-monsoon sampling and establishment of monitoring sites at the same site of Pre-mansoon sampling and Pinder-Chail Valley, Chamoli District Uttarakhand, at different elevation ranges.

2. The organic carbon content of Pre and Post monsoon soil samples of alpine treeline, alpine meadow, and agricultural soil samples of various villages (Tidang, Baling, Bonn Glacier, Zero point Panchachuli, Dugtu, Dantu, Philam, Marcha, Gabbe Meadow) of Darma valley Pithoragarh showed that organic Carbon content found highest in Baling Treeline (4.113%) and Philam meadow (4.865% and 3.859%) and Lowest in Zero Point Panchachuli (1.278%) (Fig.36).

3. Soil enzyme activity of soil samples showed that Dehydrogenase activity of Zero Point meadow 0.0652 and 0.06987 (TPF µg/g dry soil/h) was found highest and lowest dehydrogenase activity in Dantu tree line 0.01135 (TPF µg/g dry soil/h). Urease activity was highest in Dugtu agricultural soil 0.0724 and 0.07202 (N µg/g dry soil/h) and lowest in Baling meadow 0.012114 (N µg/g dry soil/h) whereas the highest Phosphatse activity was in Tidang soil sample 0.07374 (phenol µg/g dry soil/h) and lowest activity was found in Dantu meadow 0.0125 (phenol µg/g dry soil/h) (Fig. 37).



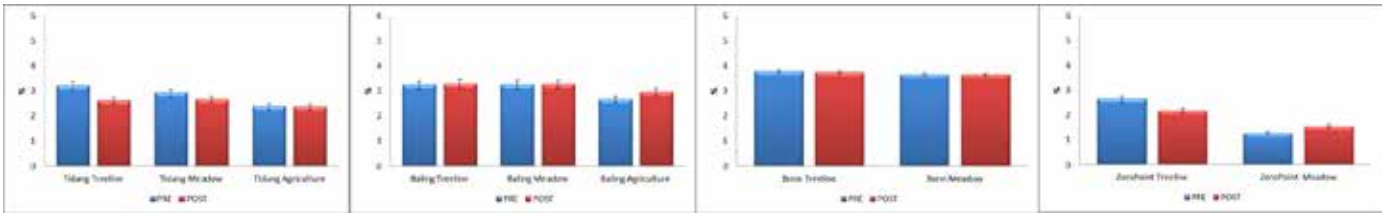


Fig. 36 : Pre and Post Monsoon Organic carbon content (%) in soil sample of Darma Valley Pithoragarh Uttarakhand

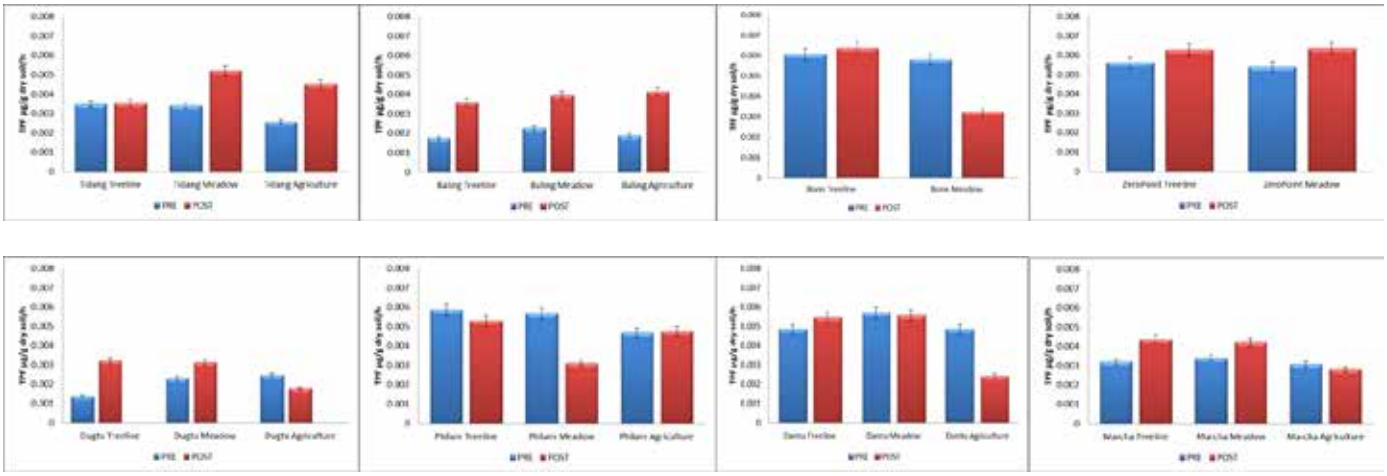


Fig. 37: Pre and Post Monsoon Dehydrogenase activity (TPF µg/g dry soil/h) in soil sample of Darma valley of Pithoragarh Uttarakhand

Himalaya calling: Bridging science policy & Practice to foster sustainable development in the Indian Himalayan Region (IHR) (NMHS, GoI, 2019-2023)

The Indian Himalayan region extending to 12 states (10 fully and 2 partially) comprises 4% of India's population (in upstream) and a floating population of 90 million people annually (tourists). It represents Global Bio-hotspots (44% Country's biodiversity), the whole alpine and glacial system of India (63% of the water budget), and the origin of the main rivers of India (Ganges, Indus, Brahmaputra) is the basis for food and water security of millions in downstream. It is also known as Asia's Water Tower and also known as the "Third Pole". The region is generally data-deficient (e.g. long-term climate changes), and knowledge and learning to customize policy and practices to IHR-specific situations are limited. Apart from a lack of synergy and convergence across disciplines, sectors, and actors working on the issues of the IHR, stand-alone good practices do not get out and upscaled. In view of addressing these critical issues, there is a need to foster collaboration and networking among scientists, policymakers and practitioners, leading to improved convergence and synergistic actions in a holistic and integrated manner. The present project, therefore, addresses that gap.

Objectives:

- To foster an effective and collaborative network of different constituencies, academic institutions & universities working within and outside of the Indian Himalayan region for sustainable mountain development
- To cater the need for quality knowledge, capacity and capabilities of research and educational institutes by bringing together academicians, researchers, and leaders through HKN forum
- To transfer evidence-based knowledge and expertise in key sectors into policies and practices in the IHR region

Achievements:

HQs (Kosi-Katarmal)

1. Established 12 HKN State Chapters (Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya, Jammu & Kashmir, Ladakh, and Assam)

2. State-level workshops for network development (9 nos.) were conducted, and State-specific thematic reports (12 nos.) were developed.

3. Established 08 Youth Forum (571 students registered)

4. HKN Website (https://hkn.org.in/) and Subject Expert Database of Universities, R&D and NGOs prepared

Sikkim Regional Center

1. Based on the deliberations of the regional workshop on "Natural Hazards and Climate: Living Sustainably in Harmony with Nature" organized on 5th June 2022, key issues, gaps, and priorities vis-a-vis climate change and natural hazards in Sikkim, mitigation measures and risk reduction approaches, enhancing resilience, reducing the impacts and managing natural hazards with sustainable approaches were identified to develop an institutional knowledge network and policy framework (document) for holistic assessment of natural hazards in Sikkim. Further, LoA was signed with Tripura University to implement Himalayan Knowledge Network (HKN) and establish its state chapter in Tripura.

2. Two thematic documents on Conservation & Management of High Altitude Wetlands and Natural Hazards were drafted for Sikkim. Based on a systematic review of the literature on historical floods, a flood susceptibility map for Sikkim using 09 influential factors-elevation (i.e. slope, precipitation, distance from the river, drainage density, topographical wetness Index, Land cover, soil, and normalised difference vegetation index, was prepared (Fig. 38). The study identified lower elevation zones of Sikkim, particularly, Chungthang, Mangan, Jorethang, Rangpo and Melli as the high susceptible areas for flood.

3. A study has been carried out to prepare a landslide hazard map for Sikkim using secondary data sources. A total of 18 incidents have been recorded, along with other related information. Further, an assessment of past earthquake events that occurred during 2001-2021 in Sikkim, with their magnitude over different scales, has been made to demarcate the areas prone to frequent earthquakes.

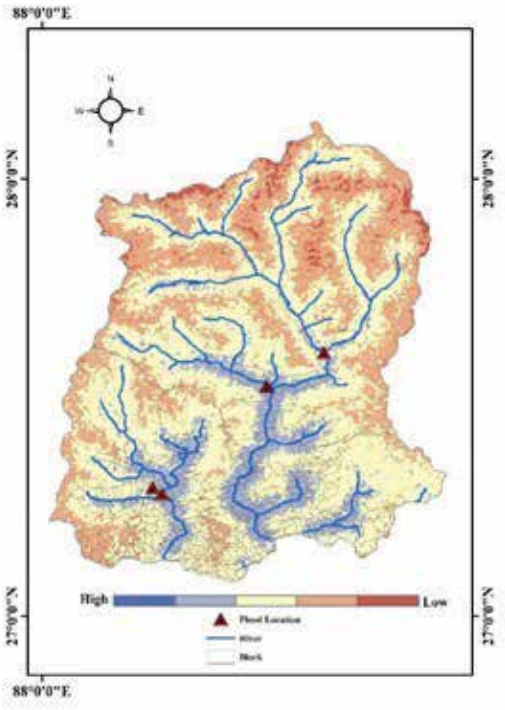


Fig. 38: Flash flood susceptibility map of Sikkim

North East Regional Center

1. Thematic reports have been developed on two State-specific priority thematic areas identified through State-level consultation programmes at Manipur, Nagaland and Mizoram State Chapters. The two priority thematic areas identified for Nagaland State were (i) Biodiversity conservation and (ii) Water Security. Similarly, the identified thematic areas for Mizoram were (i) Deforestation, biodiversity loss and land degradation and (ii) Water scarcity for consumptive and non-consumptive use and for Manipur, thematic groups where youth forums have been constituted in all three states: Manipur, Mizoram and Nagaland.

2. Each State Chapter organized two events under Mission LiFE covering different LiFE themes such as Single-Use Plastics Reduced, E-Waste Reduced, and Healthy Lifestyle (Fig. 39).

Fig. 39: Awareness programme on biodiversity conservation

Summary of the Completed Projects/Activities

Undertaking a Study to Define the Extent and Intensity of Habitat Degradation, to Identify the Drivers of Degradation and Prepare a Study Proposal for Developing Model Mitigation Plan in Alpine and Sub-Alpine Areas in SECURE Himalaya Project Landscapes of Uttarakhand (UNDP & GEF, 2018 - 2021)

With the commencement of the United Nations Decade on Ecosystem Restoration during 2021-2030, the fast depletion of natural resources in sub-alpine and alpine ecosystems has become a global concern. The present report is focused on the development of landscape-level degradation assessment followed by effective model for eco-restoration/ mitigation for the SECURE Himalaya landscapes of Uttarakhand, (Gangotri-Govind landscape and Darma-Byans) under the project entitled, "Undertaking a study to define the extent and intensity of habitat degradation, to identify the drivers of degradation and prepare a study proposal for developing model mitigation plan in alpine and sub-alpine areas in SECURE Himalaya project landscapes of Uttarakhand". The project started in December 2018 under SECURE Himalaya of the United Nations Development Programme (UNDP).

Objectives:

- To develop an understanding of the issues related to pastureland, specifically in the context of degradation
- To identify the areas of intensive degradation which have the potential of impacting the habitat characteristics of the landscapes
- To prescribe interventions for eco-restoration/ mitigation

Alpine degradation threats included over-grazing, uncontrolled tourism, illicit natural resource utilization, environmental vulnerability and poor socio-economic conditions. Under the first objective, the degradation of vulnerability assessment framework was designed for indexing the degradation status of different alpine and sub-alpine pastures (bugyals) from the landscapes. Fourteen alpine pastures from the Gangotri–Govind landscape were identified and mapped for their degradation status. 8 representative pastures were analyzed individually to know their present degradation status. The pastures, namely, Nelang (3819m), Kairakoti (3511 m), Gomukh (4069 m) and Sattal from the Gangotri landscape and Harkidun (3849 m), Ruinsara (3500m), Pustar (3860) and Kedarkantha (3448 m) from the Govind landscape were studied in view of 3 different criteria, viz., anthropogenic and ecological for direct measurement and socioeconomic status for indirect analysis of degradation in alpine and sub-alpine areas of the landscape. To achieve the first objective, 12 individual sub-criteria, including 7 qualitative and 4 quantitative parameters, were taken into account. Major factors of habitat degradation in the areas were overgrazing, uncontrolled tourism, irrational resource utilization patterns, colonization of weeds, etc. Under the second objective, different measurement indices were considered to carry out multi-criteria decision analysis, e.g., grazing capacity, tourists' carrying capacity, solid waste generation, resource utilization index, Shannon–Weiner index, environmental vulnerability index, socioeconomic index, and finally, degradation vulnerability index. In the Darma-Byans landscape, assessment of degradation status was initially done by mapping the entire landscape for the identification of alpine pastures of the area. After that, vegetation analysis was done in 8 representative pastures, viz., Tidang (3503 m), Sipu (3771 m), Sangosthi (3749 m) and Gabbye (3999 m) from the Darma landscape and Jeolinkong (4502 m), Kuti (4010 m), Nabi (3876 m) and Garbeyang (3495 m) from the Byans landscape for understanding the vegetation profile of the landscape followed by normalized difference vegetation index trend and environmental vulnerability analysis. Finally, secondary data related to village-level human and livestock populations, resource utilization patterns and tourism status were analyzed. Conclusively, the areas namely, Nelang (3819m m), and Kedarkantha (3448 m) from the Gangotri-Govind landscape, and Sangosthi (3749 m) and Jolingkong (4502 m) from the Darma–Byans landscape have been mainly proposed for the Eco-restoration interventions (Fig. 40). Several other alpine and sub-alpine areas under diverse degradation threats from the landscapes have also been identified and précised for eco-restoration interventions. Under the third and final objective, pasture-based eco-restoration strategies for controlling grazing within its capacity (~8166 CU/ year for Nelang and 2194 CU/year for Kedarkantha) (Fig. 41), sustainable tourism within its carrying capacity (120 tourist per day in Kedarkantha) and eco-tourism practice, soil erosion control by check dams and geo-coir matting followed by plantation, sustainable resource utilization management practices, etc. have been

prescribed for the identified degraded alpine and sub-alpine areas of both the landscapes. New practices like the establishment and monitoring of shepherd's night staying sites near alpine areas, pine needle-made bio-briquette centres, and integrated nature-based adaptive agricultural systems in the selected villages are given for reducing the pasture dependency of the villagers and also promoting livelihood options in the current Covid-19 situation.

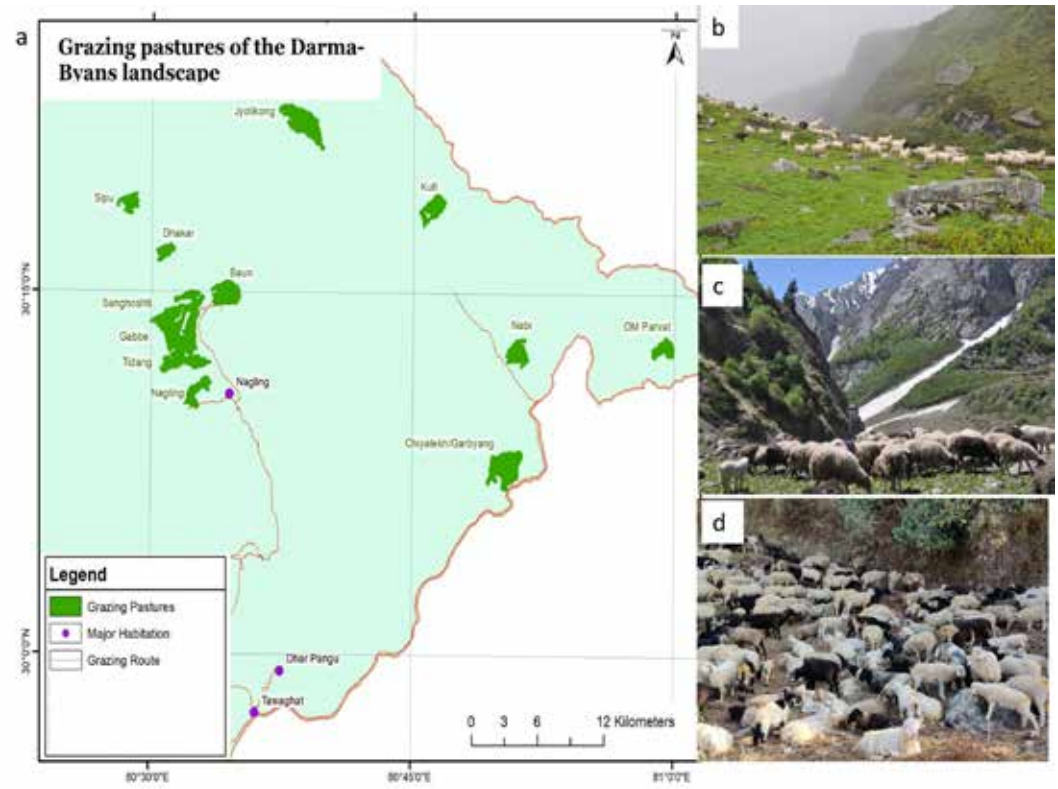


Fig 40: (a) Alpine pastures and grazing routes in the Darma-Byans landscape. (b) Grazing in the Gabbe alpine pasture (3999 m) in the Darma landscape. (c) Grazing route near Gungi and Kuti village. (d) Animals coming back from the Darma-Byans landscape during November in Dharchulla

a

Dominant palatable species	Density (ind./m²)	AGB (gm/m²)
Nelang		
Poa alpina	0.4	6
Taraxacum officinale	0.2	5.4
Festuca valesiaca	0.2	6.3
Oryzopsis lateralis	0.1	5.8
Danthonia cachemyriana	1.93	405
Trachydium roylei	0.4	158
Poa annua	0.2	6
Trigonella pubescens	0.1	8.3
Gangotri		
Trachydium roylei	3.4	160
Danthonia cachemyriana	1.7	398
Trifolium repens	0.8	24.2
Carex nubigena D. Don	0.6	1.2
Taraxacum officinale	1.2	5.4
Ranunculus hirtellus Royle	1.8	6.1
Primula denticula	0.4	2.9
Prunella vulgaris	1.2	1.3
Cyanunthus lobatus	0.8	6.1
Achillea millefolium	0.93	3.1
Govind		
Cicerbita macrorhiza	0.17	5.8
Cyanthus lobatus	0.5	6.1
Danthonia cachemyriana	2.01	410
Nardostachys jatamansi	0.2	8.6
Parnassia nubicola	0.8	2.8
Potentilla atrosanguinea	0.83	7
Taraxacum officinale	0.57	5.4
Trachydium roylei	0.3	164

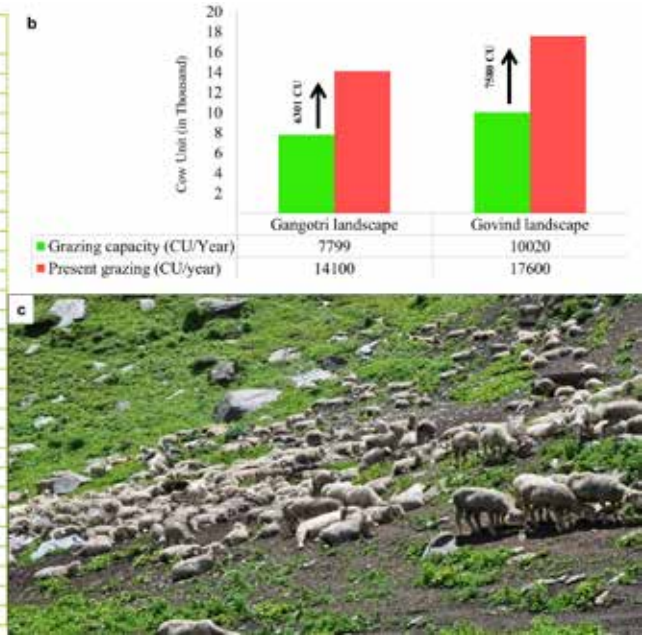


Fig. 41: (a) Grazing status of the Gangotri-Govind landscape. Dominant palatable species and their above-ground biomass (b) Incidence of over-grazing in both landscapes. (c) Livestock grazing in plant residual matter near Harkidun pasture land

HIMACHAL PRADESH REGIONAL CENTRE (HPRC)

To strive for excellence in research, assessing the effectiveness of policies in sustaining and promoting ecosystem services and empowering stakeholders for conservation and management of natural resources in the Indian Himalayan region. Secondly undertake innovative research on environmental problems and related knowledge intervention towards the sustainable development of the North-Western province of IHR, the Himachal Regional Centre (HRC) caters to the needs of the entire Himachal Pradesh state. The region is recognized for its ecological and economic values manifested by ecosystem integrity, adaptability and ecosystem services. Its protective and productive functions for upland and lowland dwellers are well known. Major R&D thrust areas in this region are vulnerability assessment and conservation prioritization of biodiversity from anthropogenic pressure; cultivation of medicinal and aromatic plants; management of solid waste; hydrology and water resources; value addition of locally available bio-resources and market linkages; ambient air quality monitoring; conservation of pollinators; eco-tourism; environmental impact assessment; sustainable rural livelihood and rural development; entrepreneurship development; green skill development and capacity building of indigenous mountain communities. The centre works on the (i) Vulnerability assessment of biodiversity; (ii) Assessment, characterization and valuation of ecosystem services, crops/farming and sustainable management of ecotourism; (iii) Promoting environmentally sustainable income-generating activities for livelihood enhancement and socio-economic development, (iv) Development and strengthening institutional mechanism for information sharing and capacity building, (v) document traditional knowledge through demand driven action research and technological innovations, and (vi) development of strategies for monitoring and management of water resources, ambient air quality under climate change scenario.

Conservation and Management of traditional beekeeping (*Apiscerana*) practices through the development of a honeybee based sustainable livelihood chain in the Kullu Valley, Himachal Pradesh (NABARD, 2021-2023)

Beekeeping with indigenous honeybees (*Apiscerana*) is a century-old practice in most of the Himalayas and is still being practised in the selected rural areas of Himachal Pradesh. The Himalayan Honeybee (*Apiscerana*) is wild, and its colony prefers wild habitats, i.e. tree trunks, rocks, etc. Beekeeping is an agriculture and horticulture-based industry in which honeybees are kept and managed. Based on the natural choice, it is traditionally kept in the wall hives, locally named Madhi or Teere, and log hives, locally called tultha or dhindhor. In the last one or two decades, there has been an apparent decline in the indigenous honey bee population, which is mainly due to the construction of modern houses, habitat degradation, heavy use of Agro-chemicals, pesticides, climatic changes, the introduction of European honeybees in hilly areas and lack of management practices. Kullu valley is well known in India for cultivating> 40 pollination dependent cash crops (fruits, vegetables, nuts, oilseeds, fibre, spices, pulses, medicinal plants, etc.). Therefore, to conserve these species in their natural habitat while educating locals on its management and linking the activity with entrepreneurial activity, this century-old practice can be revived in the region. This will benefit both economic and environmental aspects while conserving the species.

Objectives:

- Conservation of declining populations of the indigenous honeybee (*Apiscerana*)
- Plantation of prioritized highly preferred native honeybee plants
- Promotion of high demand and cost-effective monofloral honey
- Promotion of 100% pure honey production using super chamber beehives in native honeybee keeping
- Value-added enterprise development
- Awareness/Capacity building for the role of native honey bees' pollination aspect

Achievements:

1. Identified and trained 150 beekeepers as master beekeepers in the Tung Panchayat and distributed one active beehive of indigenous bee species *Apiscerana* along with major & minor beekeeping tools (veil, gloves, queen cage, gate, smoker, tool, honey extractor).

2. Physical and chemical analysis of Honey has been

done as per the FSSAI norms, which resulted in Moisture -18.1%; Specific Gravity-1.42%; Acidity-0.11%; Total Ash-0.09%; Sucrose- 2.34%; Total reducing sugar – 74.90%.

3. Harvesting, value addition and marketing of around 100 kg honey and value-added products of beeswax as lip balm has been done. Marketing and display of products during state-level fair organized by NABARD on their 41st foundation day in Shimla.

4. An assessment of preferred bee flora in the region has resulted in 81 plant species high in nectar and pollen. Plantation of bee flora such as salix, soap nut *(Sapindus)* and bottle brush (*Callistemon*) (425) has been done in the panchayat (Fig. 42).

Fig. 42: Master training certificate distribution and distribution of beekeeping equipments (beehive, extractor, minor tools, etc.)

Developing Entrepreneurship and livelihood through value-added products of Seabuckthorn (*Hippophae rhamnoides*) in Lahaul & Spiti, Himachal Pradesh (NABARD, 2022-2024)

In the last decade, there has been attractive economic growth in the country, but poverty remained a major development challenge, particularly in Himalaya, mainly due to several biophysical and socioeconomic reasons. The tribal district of Lahaul & Spiti in Himachal Pradesh is quite different in its geographical characteristics, natural resources, climatic conditions, agriculture practices and inhabitants. The district consists of mainly two valleys: Lahaul Valley and Spiti Valley. Lahaul is greener and moister, while Spiti is barren and cold desert-like. In these mountain regions, the livelihood security of the people greatly depends on the status and condition of natural resources available and their optimized use in a sustainable manner. Seabuckthorn (*Hippophae rhamnoides* L.), belonging to the Elaeagnaceae family, is a deciduous shrub species, usually 2 to 4 meters in height, producing yellow or orange colour berries. It is naturally distributed in the cold desert areas of the Northwestern Himalayan region, ranging between 2500 to 4200 m amsl. Various studies on seabuckthorn (SBT) have shown that a range of bioactive compounds (e.g. flavonoids, carotenoids, lycopene, unsaturated fatty acids, vitamins and various essential amino acids) are found in its leaves, seeds and berries. It is considered one of the most nutritious and vitamin-rich fruits and hence also known as 'Wonder Plant', 'Golden Bush of Himalaya', 'Super Plant' etc. Locally, it is also known by several names, viz. Charma, Nak-tser, Shishu-lulu, sTarbu, etc.

Objectives:

- Formation/involvement of Women/Farmer Self Help Groups for entrepreneurial activity of SBT
- Development/Customization of berries harvesting tool
- Establishment of processing unit in the region
- Product development and testing
- Enterprise and Value chain creation of SBT
- Awareness/Capacity building of stakeholders on various aspects of SBT
- Marketing linkages

Achievements:

1. Field visits, literature review, identification of the Women Self Help Groups has been done in the valley.

2. For up gradation and strengthening of the Technology Centre at Kirting Village equipment's like; Solar Dryer, Electric Weighing Machine and Packet Sealing Machine were purchased.

3. Interactive meetings with the women self help groups has been done for the value chain creation of seabuckthorn and its economical, ecological and medicinal values were discussed

Modelling and Forecasting of High Impact Weather Events in the Beas Basin and Designing a Prototype Advance Warning System for mitigating their Adverse impacts (NMHS, GoI, 2019-2022)

The extensive development in the past few years has changed the world's climate differently. The changes in the intensity and duration of weather and climate extreme events due to climate change can be easily presumed. These extreme events include cloud bursts, flash floods, landslides, mudslides, torrential rain, etc. Such events have led to the loss of biodiversity and human lives and harm to the economy. Extreme weather events are also common in the New Fold Mountains, i.e., the Indian Himalayan Region, due to its susceptibility and fragile nature. The area of District Kullu of Himachal Pradesh chosen for the study has always been a potential hazard zone for such disasters. The excess rainfall of 1994 in the Kullu Valley took the lives of around 20 people in the Fozal village, and the flash flood of 2018 in the river Beas resulted in immense loss to roads and infrastructure in the Beas Basin. It has affected the lives of the inhabitants in numerous ways, such as loss of human and livestock lives, agricultural land loss, tourism, and accessibility to roads. The project intends to develop and integrate the technologies for assessing and forecasting extreme weather events in the IHR region.

Objectives:

- Calibrated forecast configurations with 24-hour lead time over Beas Basin (Himachal Pradesh) with quantitative skill for High Impact Weather Events like cloud bursts, heavy rainfall, flash flood, etc
- Development of an advanced warning system over Himachal Pradesh for mitigating adverse impacts of high weather events
- Integrated Disaster Assessment and Forecast Platform over Beas Basin (Himachal Pradesh) on GIS platform for mitigating adverse impacts

Achievements:

1. A Flood Hazard Susceptibility Map was created using AHP Modelling Approaches. 21 indicators were identified as controlling factors for modeling flood-prone areas. Redundant and unavailable indicators were discarded. The factors were grouped into 4 criteria based on similar properties and consistency defining flood hazard vulnerability: hydrological criterion, morphometric criterion, permeability criterion, and landscape dynamics. The indicators were used to create flood susceptibility maps based on each criterion, and a final flood hazard susceptibility map was created using F-AHP(Fig. 43).

2. A questionnaire survey was carried out in the study area to know the community's awareness and perception of extreme weather events in the past. 89% and 83% of the respondents in the Parvati and the Beas basin, respectively, considered that nature is the cause of these extreme weather events. However, 69% and 88% of the Parvati and the Beas basins respondents believed deforestation was the major cause of such events (Fig. 44).

3. As per the perception study, only 11% and 17% of the respondents in the Parvati and Beas basins were aware of the disaster management authority in their district but Mock- drills have not been conducted by any authority in the vulnerable regions of the district. There was no measure for the early warning in the Parvati basin. However, only one village (Patlikuhal) in the Beas basin had early warning signals in the form of a police siren.

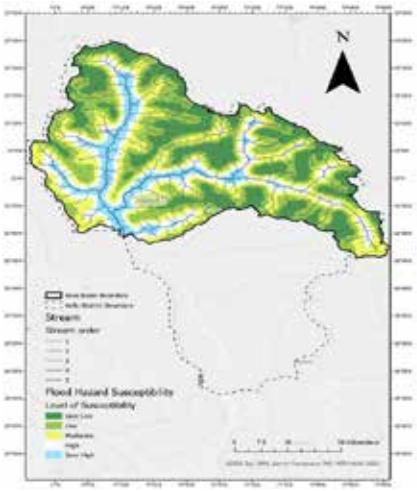


Fig. 43: Flood Hazard Susceptibility Map

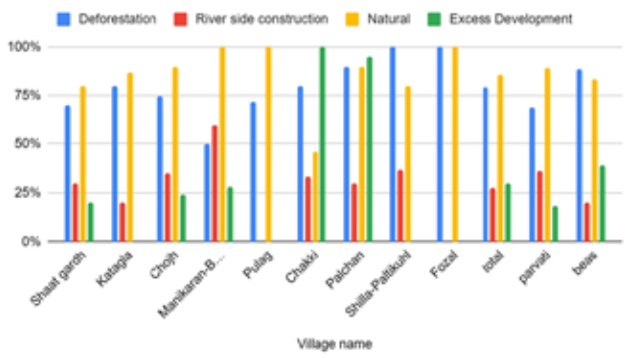


Fig. 44: Perception on cause of Extreme Weather Events

Implementation of Environment Monitoring Programme and Impact Evaluation of Sainj Hydroelectric Project during Operation phase (HPPCL, 2021-2026)

Hydroelectric projects involving the construction of big dams, tunnels and powerhouses are causing several environmental problems. The approach for formulation of an Environmental Management Plan (EMP) is to maximize the positive environmental impacts and minimize the negative ones. The steps suggested include modifications of plans, engineering designs, construction schedules and techniques, and operational and management practices. After selecting suitable environmental mitigation measures, the cost required for implementing various management measures will also be worked out. An Environmental Monitoring Programme for implementation during project construction and operation phases has been estimated to oversee the environmental safeguards, ascertain the agreement between prediction and reality, suggest remedial measures not foreseen during the planning stage but arising during operation, and generate data for further use. The Sainj Hydro-Electric Project (100 MW), a run of the river development on river Sainj, a tributary of river Beas in Kullu district is located at Neuly in Sainj Valley on the periphery of the Great Himalayan National Park. The main purpose of the EMP is to determine the environmental impacts of the project and to give an idea about how to mitigate the adverse impacts, their effects, and their monitoring periodically after the project do operational.

Objectives:

- To assess the Soil quality, Erosion and Siltation around Sainj HEP
- To assess the change in the migration pattern of aquatic and terrestrial fauna
- To check the change in the land pattern of the study area
- To assess the status of aquatic ecology
- To identify the remedial issues and suggest suitable management options for the Sainj HEP

Achievements:

1. To understand the study area, various maps like Rainfall, Soil texture, Land use land cover, Normalized difference vegetation maps were created.
2. Soil samples were collected around the 10 km radius of the hydroelectric project, and their soil moisture, pH and EC were checked in the laboratory. The values of soil moisture percentage ranged between 4.77 - 33.66, whereas in pH and EC, the range are 5.46 - 6.54 and 0.03- 0.74, respectively, and spatial distribution maps for these parameters were created using Arc GIS Environment.
3. The revised Universe soil loss equation model has been created by using the Rainfall- Runoff Erosivity Factor, Soil-Erodibility Factor, Slope Length Factor, Slope Gradient Factor, Cropping Management Factor, and Support Practice Factor. The Resultant map was classified into Six classes (Fig. 45), and the mean soil loss for the entire study area is “11.15 tons/ ha/ yr”. Soil erosion using RUSLE model reveals that the annual predicted soil loss ranges between “0 to 541 tons/ ha/ yr”.
4. To detect the change in the surrounding environment of the Hydroelectric project, 5 Land use Land cover classes (LULC) for the years 2014 and 2022 were identified using Landsat 7 and Landsat 8 images of 30m resolution using support vector machine in Arc GIS Pro environment. Barren Land in the study area shows a greater variation. In 2014, Barren land covered almost 8.3 % of the total area; in 2022, it increased to 15.89%. The feature class Water and Glacier show depletion in the study area, approximately 2% and 4%, respectively.

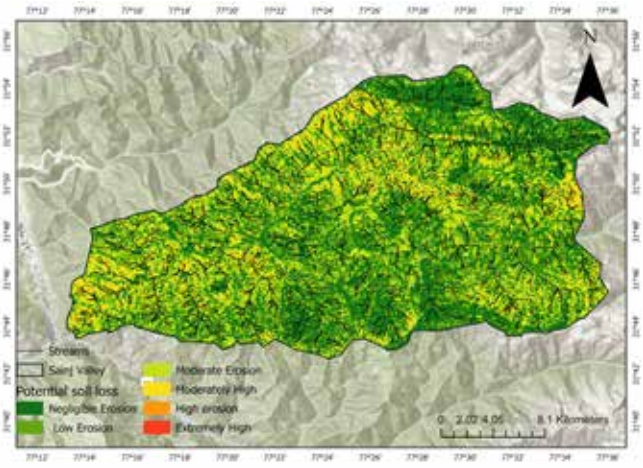


Fig. 45: Potential soil loss (tons/ ha/ yr) in Sainj valley

Summary of the Completed Projects/ Activities

Identification of Elite Planting Material of Selected Temperate Medicinal Plants, Mass Multiplication, Field Demonstration and Post- post-harvest processing (DBT, GoI, 2018- 2022)

Local communities have traditionally been the custodians of natural biological resources and have accessed them freely for their livelihoods. However, legal restrictions on collecting medicinal plants from natural habitats have caused economic constraints for these communities and a shortage of raw materials for the pharmaceutical and herbal drug industries. This shortage has led to illegal procurement, substituting, and adulterating medicinal plant raw materials. To address this problem, a network project was undertaken by three institutes to identify elite planting material of selected temperate medicinal plants, mass multiply them, and optimize post-harvest processing. Approximately 6.5 lakh plants of *Swertia chirayita* and 5.0 lakh plants of *Picrorhiza kurroa* were grown in different locations in Uttarakhand and Himachal Pradesh, and 7,600 plants of *Nardostychus jatamansi* were grown in Himachal Pradesh and Uttarakhand. The project also included training sessions for farmers and the establishment of a Genetic Resource Centre to conserve elite material. The project's outcomes would be highly useful, particularly for the extremely endangered species of *S. chirayita* and *N. jatamansi*.

Returning Taxus to the Forests and the People: a study in Shimla and Kullu Districts of the IHR (NMHS, GoI, 2019-2022)

The Western Himalayan yew (*Taxus contorta* Griff., Thuner, Rakhal) faces a severe population decline of up to 90% in the Indian Himalayan region. This species is one of 14 yew species found in the world, with two natural species (*Taxus wallichiana* and *Taxus contorta*) found in the Indian Himalayas, both of which are categorized as Endangered in the IUCN Red List. Ecological niche modeling was used to identify suitable habitats for *Taxus contorta* in the Western Himalayan region based on 61 occurrence records. The modeling showed that only 4.73% of the area is highly suitable for this species, with an additional 4.57% being moderately suitable, 10.14% low suitable, and 80.57% not suitable. The probability of occurrence in the Kullu district was also assessed using the Maxent model. The sampled population of *Taxus contorta* had a range of 2-9 trees, 3-18 shrubs, and 8-48 herbs. The relative density of *Taxus contorta* ranged from 2.8-78.38%. Technical support was provided to the Himachal Pradesh Forest Department on the mass propagation technique of *Taxus contorta*, and training programs were organized for forest divisions in the Kullu district. Around 100,000 cuttings and 20,000 saplings of *Taxus contorta* were developed in different forest nurseries, and 10 awareness cum training programs were organized for stakeholders in the villages of Kullu district. A Technical Manual and a research paper were also published under the project.

GARHWAL REGIONAL CENTRE (GRC)

The Garhwal Regional Centre (GRC) has been actively working in biotechnology, water resource sustainability, tourism and climate change impacts, and dynamic engagement in training and demonstration through several skill development programs. In essence, it caters to the regional needs of diversification of livelihood options in rural ecosystems by demonstrations of eco-friendly rural technologies, water resources management, sustainable land use and eco-friendly tourism practices in field demonstration sites in different Garhwal Region districts. The R&D activities of the center focus on (i) understanding climate change's impact on the rural landscape and adaptation and livelihood strategies (agriculture, horticulture, pastoralism and traditional livestock husbandry, NTFPs including MAPs), (ii) identifying sustainable tourism (nature/community-based rural tourism, pilgrimage, etc.) and its environmental, economic and socio-cultural impacts, (iii) approaches for water resource assessment, use and management, (iv) appropriate technology interventions for sustainable development of the rural ecosystem, and (v) development of plant propagation packages for conservation, management and large scale cultivation using biotechnological and microbiological tools. The Centre also contributes to the sensitization of local stakeholders towards Swatch Bharat Abhiyan.

Standardization of propagation protocols for mass multiplication, biochemical assessment and elite identification of *Malaxis muscifera and Malaxis acuminata* in Western Himalaya (NMPB, 2019-2023)

The Himalayas have extensive reserves of medicinal and aromatic plants (MAPs), making them one of the most diverse natural habitats of medicinal herbs worldwide. Previous studies report that the Indian Himalayan Region accounts for up to 50% of India's total flora, of which about 30% of species are endemic. The region comprises various natural resources, including medicinal plants (MPs), which play a vital role in the healthcare system and act as a vital source of livelihood, local consumption, and culinary practices for local inhabitants of the region. Certain plant families possess higher numbers of medicinal plant species and have higher proportions of threatened species than others. Orchidaceae is one such family, rich in medicinal and threatened plants. Plant species like *Malaxis muscifera* and *Malaxis acuminata* belong to the family Orchidaceae, which possess high medicinal values and are important ingredients of the Ashtavarga group of medicinal plants. The two plants, i.e., *Malaxis muscifera* and *Malaxis acuminata* have been selected for the present study. In this study,qualitative and quantitative analysis of the two target plants, germplasm characterization through morphological and phytochemical analysis along with germplasm accessioning, standardization of the propagation protocols, mass multiplication, and hardening and domestication practices have been proposed and are being carried out. The study will be beneficial for understanding the target species' actual population status in the wild, filling the gap between supply and demand, ensuring the availability of high-quality raw materials and ongoing supplies of the target species, and ensuring their conservation and ecological sustainability. The research work and its assessment have been completed, and following major points have been raised by the project evaluation committee of the National Medicinal Plant Board (NMPB), New Delhi, based on the project presentation and evaluation of the first- and second-year report. Hence, during the progress year, we have completed the population status assessment for germplasm evaluation and developed the morphological descriptors for both the target species along with ecological and soil analysis to have a detailed knowledge of all the necessary requirements for the target species' cultivation. Along with the above-mentioned work details, tissue culture experiments for multiple shoot bud initiation have been cultured for in vitro plantlet formation of *M. acuminata*.

Objectives:

- Exploration, population status assessment and germplasm collection of *M. muscifera* and *M. acuminata* in Western Himalaya
- Identification of elite germplasm of *M. muscifera* and *M. acuminata* using qualitative and quantitative morphological and phytochemical variations
- Standardization of micro-propagation techniques

for elite germplasm of *M. muscifera* and *M. acuminata*

- Development of domestication protocols for target species

Achievements:

1. Ecological assessment and soil analysis from 35 study sites of *M. acuminata* in Uttarakhand state were completed during the progress year.

2. For phytochemical assessment of *M. acuminata*, total phenolic content, total flavonoid content and antioxidant activities were analysed where the highest phenolic content (2.04± 0.0032mgGAE/g) was found in Sandev population (AG sample) and highest flavonoid content (2.09±0.0012 mgQEq/g) was found in Jakholi population (AG). While DPPH antioxidant activity was found to be highest (1.33±0.73mgAAE/g) in the Gangolihat population (AG), and FRAP activity was reported highest (6.51±0.19mgAAE/g) in the Jakholi population (AG) (Fig. 46 & 47).

3. Experimentations for shoot and callus induction in *M. acuminata* explants have been initiated in MS media with different PGR concentrations. Multiple shoot bud initiation has been observed in tissue-cultured plants.

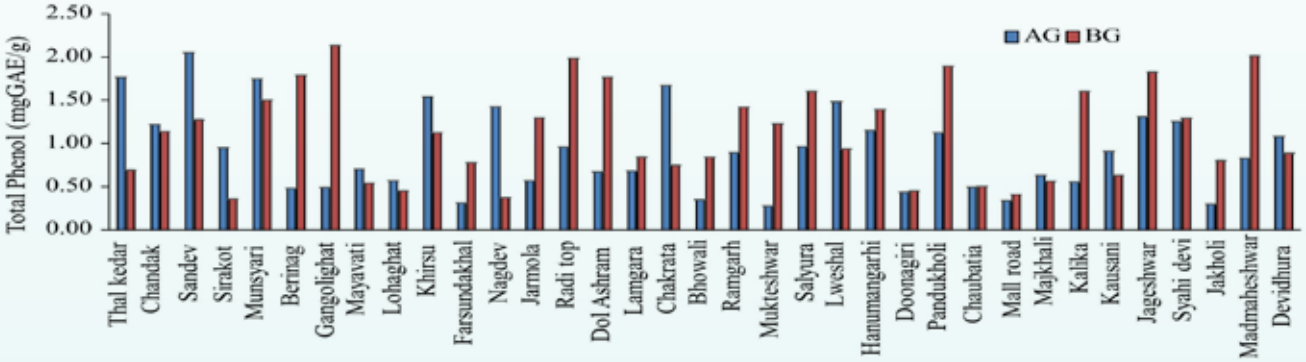


Fig. 46: Total phenolic content in *M. acuminata* populations

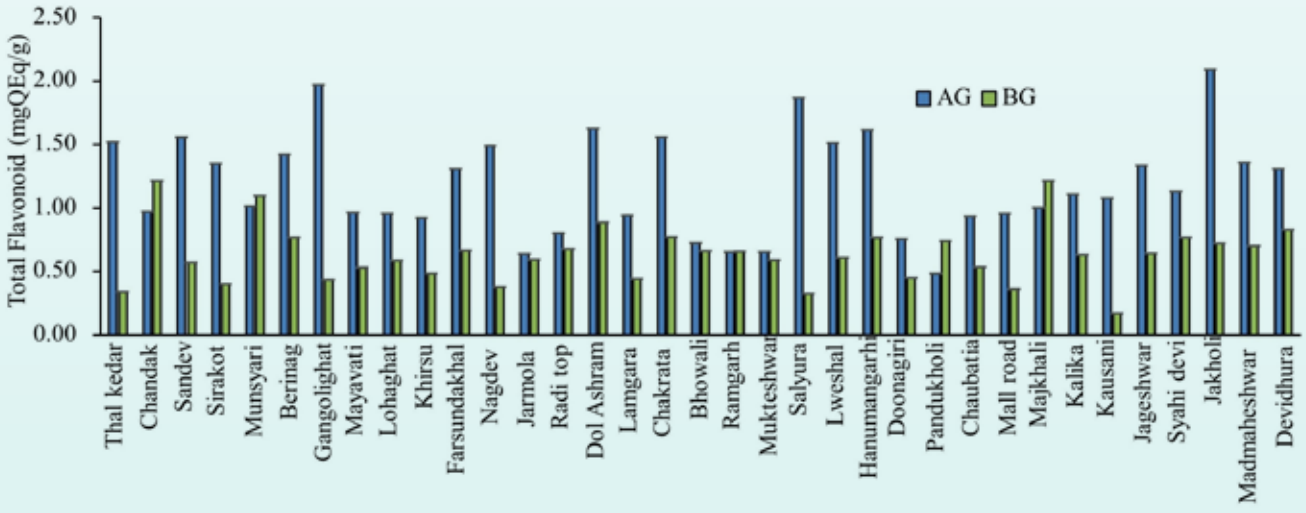


Fig.47: Total Flavonoid content in M. acuminata populations

Himalayan Alpine Biodiversity Characterization and Information System – Network (NMHS-IIRS, 2020-2023)

The Himalayan alpine zone (3000-3500 m elevation), spread over 33% land area of the Indian Himalayan Region (IHR), is remarkably rich in plant diversity. Globally, ecologists and space agencies have stressed the development of a space-based monitoring system for tracking changes in biodiversity and under the Group on Earth Observations – Biodiversity Observation Network. It has been agreed to define Essential Biodiversity Variables (EBVs) that can be routinely monitored from space. The three aspects of biodiversity − composition, structure and function- integrating six EBVs classes: genetic composition, species populations, species traits, community composition, ecosystem structure and ecosystem function. Hence, we need to initiate the development of a satellite-based EO approach and methodologies for tracking some of the above-defined EBVs for the alpine region in the Indian Himalaya, one of the priority ecosystems for plant biodiversity and ecosystem services.

Objectives:

- To characterise the spatial extent and patterns of alpine plant communities in Western Himalaya (erstwhile J&K, H.P. and U.K.) using multi-scale EO data
- To assess alpine vegetation composition and diversity following a unified systematic and multistage sampling protocol
- To determine EO-based environmental proxies of alpine biodiversity and ecosystem dynamics
- To develop predictive models for multi-scale prediction of Indian Himalayan alpine plant diversity patterns linking environmental proxies and habitat variables
- To develop a web-based information system on IBIN supporting species and spatial database, web analytics and data/information dissemination for planning and management

Achievements:

1. A total of 1364 quadrats of (1×1)m^2 were analysed for assessing the alpine plant diversity in Bageshwar (Dangugwar- 64, Sundardunga-200) and Pithoragarh (Chiplakedar-600, Namik-100, Byans- 200, Khaliya-200) districts (Table 5).

2. A total of 73 soil samples from Chiplakedar (39), Namik (7), Byans (21), and Dangugwar (6) from different communities of the alpine region were collected at depths, i.e., 0-10 cm & 10-20 cm at different elevations and further analysed for physico-chemical properties. It was observed that along the elevation, Soil pH value ranges from (3.5-8.2) having a maximum value at 3865m and a minimum value at 3127m. Soil water holding capacity (%) value ranges from (20-97) having maximum and minimum values at 3637m and 3183m, respectively. Nitrogen content (%) values range from (0.1- 0.9), with a maximum value of 3127m and a minimum of 3404m. The Phosphorus (%) values vary between (0.0003492-0.0023135) having maximum and minimum values at 3183 m and 3432 m, respectively. Similarly, the value for Potassium (%) varies between (0.0012452-0.0358603), having maximum and minimum values at 3637m and 3105m, respectively.

Table 5: Densities of species at different locations

Location	Most Dominant taxa (individuals/m^2)	Least Dominant taxa (individuals/m^2)
Dangugwar	*Parnassia wightiana* (2.08), *Oxygraphis polypetala* (1.01)	*Picrorhiza kurroa* (0.01), *Gentiana tubiflora* (0.07)
Sunderdunga	*Trachydium roylei* (1.99), *Geume latum* (1.97)	*Saxifraga brunonis* (0.013), *Erigeron multiradiatus* (0.006)
Chiplakedar	*Viola biflora*(3.09), *Anemone obtusiloba* (2.57)	*Angelica glauca* (0.02), *Impatiens brachycentra*(0.04)
Namik	*Oxygraphis polypetela* (1.84), *Trachydium roylei* (1.79)	*Cremanthodium arnicoides* (0.05), *Allium stracheyi* (0.051)

Byans	*Danthonia cachemyriana* (1.4125), *Viola biflora* (1.425)	*Delphinium vestitum* (0.01), *Anaphalis nubigena* (0.012)
Khaliya	*Bistorta affinis* (1.425), *Anaphalis nubigena* (1. 25)	*Bupleurum rupestre* (0.02), *Corydalis cachemeriana* (0.025)

Cumulative Impact Assessment for Cascading Interventions in Himalayan Rivers (CI2HR) (NMHS, GoI, 2020-2023)

The Himalayan Mountain belt is a freshwater hub, and the terrain in these regions has potential for hydropower generation. The Himalayan catchments are the next big venture for hydropower generation and water security investments. New plans for hydropower projects always raise environmental concerns. The Himalayan region is also known for its rich natural resources and varied terrestrial and aquatic ecosystems. The Himalayan diversity needs to be looked at with special attention concerning sustainable development in the future. However, most of the Cumulative Impact Assessment (CIA) studies in India have only been evaluated based on hydrological approaches. Some recent CIA studies have advancements in habitat simulation, including regional aquatic life forms, however, not enough to complete the picture. Regardless of recognising ecosystem components as different aspects under consideration, the existing practices are still not based on it. This proposal is focused on developing a standardized evaluation of CIA methodologies by understanding underwater and landscape micro-environments and impacts from hydrological extremities.

Objectives:

- To conduct Morphometric analysis of Kameng (Arunachal Pradesh) and Rispana (Dehradun) and Nayar River Systems using remote sensing and GIS techniques.
- To manufacture low-cost robotic technology with sensors and communication system for measuring micro-environment underwater and nearby land surface ecology for inaccessible river reaches
- To conduct physical hydraulic experiments for underwater micro-environment characterization by measuring parameters (velocity, turbulence, temperature and dissolved oxygen (DO)).
- To improve Building Block approach of CIA by using long term hydrologic dataset and ecological relationships for Himalayan Rivers.
- To develop a Network Approach of CIA by considering landscape connectivity and impact rating in Himalayan Catchments.
- To develop a decision support system with CIA concepts, hydrological models and hydraulic models for end-users.

Achievements:

1. Sensor-based paired air-water temperature monitoring networks are established in the western Nayar, and Ganga Rivers to decipher the relationship between air-water in the Nayar basin.

2. The near-surface temperature lapse rate was analyzed using the MODIS LST temperature data for the two stations in the western Nayar Valley. A nominal variation in the TLR was observed for 2001 and 2021, as the mean yearly TLR ranges between 4.0°C/Km to 4.5°C/Km, lower than the reported annual TLR of 5.5°C/Km in Himalaya. The maximum TLR was observed during the summer season, and the minimum was recorded in the winter months with a bi-modal distribution of average monthly TLR as observed from Nepal Himalaya(Table 6).

3. A good correlation between the nighttime average monthly air and average monthly water temperature is observed in the western Nayar Valley with a r-squared value of 0.66. However, poor correlation was observed between monthly and daytime average monthly air temperature data and water temperature data.

Table 6: Monthly and Seasonal lapse rate (in °C) between the selected two stations of the Western Nayar sub-basin using MODIS-LST data

	Monthly TLR (°C/100m)		Seasonal TLR (°C/100m)		
	Year 2001	Year 2021		Year 2001	Year 2021
January	-0.028	-0.048	Summer	-0.524	-0.510

February	-0.061	-0.078	Monsoon	-0.665	-0.793
March	-0.303	-0.295	Post-Monsoon	-0.545	-0.163
April	-0.508	-0.587	Winter	-0.096	-0.057
May	-0.738	-0.749			
June	-0.547	-0.411			
July	-0.630	-0.833			
August	-0.582	-1.099			
September	-0.783	-0.447			
October	-0.686	-0.210			
November	-0.405	-0.117			
December	-0.199	-0.044			
Average TLR	-0.456	-0.410			

Pine and Oak system of Himalaya: water, climate and plant Biodiversity (NMHS, GoI, 2020-2023)

The present research work was conducted in Kosi watershed. Kosi is a Himalayan River which originates from Koshimol near Kausani and flows on the central part of Almora and the western part of Nainital district. The proposed study will be helpful to prepare a regional database of both angiosperms as well as gymnosperms. This study will update the actual localities of many plant species which were not recorded with their correct localities in previous studies. The grid-based study of local plant diversity of Almora & Nainital will emphasize the diversity, distribution and their resource use pattern in the study area. The study of regeneration pattern of the vegetation of the area will give a clear-cut picture of the future prospective of the whole study area. The distribution of plant diversity (Angiosperms and Gymnosperms) in Kosi watershed studied and analysed on the basis of grid approach. In view of better coverage, we have prepared 10 x 10 km grid map (100 Km^2) of Kosi watershed which was divided into a total of 33 grids. Out of 33 grids, Almora region covers 21 grids with a total area of 1094.32 sq.km. and Nainital covers 12 grids with a total area of 773.68 sq.km. Each 10x10 km grid was divided into 2x2 km for refining the documentation on plant diversity and soil characteristics.

Objectives:

- Assessment of Pine and Oak Forest distribution under a warmer climate over Himalaya
- Assessment of hydrological budget of Pine – Oak dominated watersheds and future scenarios under a warmer – climate
- Assessment of micro climate variability of Pine - oak dominated forest and future changes under a warmer climate
- Assessment of eco- hydro- climatological processes with information theory- based process network and understanding resilience under shock

Achievements:

1. Out of two watershed area of 1867.6 km^2 about 1288 km^2 has been assessed. (Remaining area was lying under Corbett National Park thus we didn't get the permission from PCCF for field activities in the respective area). Plant species richness and distribution including soil results of completed area are available (Fig. 49 & 50).

2. Out of total covered area 752 km^2 of area Pinus roxburghii was found to be the dominant species which is about 58 % of total covered area, however Oak covers an area of 240 km^2 which is about of 18.66 % of total covered area, in 144 km^2 species such as *Pyrus pashia, Celtis australis, Pyrus communis, Rhododendron arboreum, Ficus palmata, Grewia optiva ,Ficus palmata, Juglans regia, Lyonia ovalifolia, Magnifera indica, Malus domestica, Melia azedarach, Myrica esculenta,Phoenix dactylifera, Prunus cerrasoides, Prunus persica, Quercus glauca*, *Toona ciliata* were other species found to be dominant. Around 152km^2 area was under agriculture land / construction.

3. Species richness in Pine dominated forests is less as compared to Oak dominated forests indicates that Oak ecosystems are richer in terms of biodiversity.

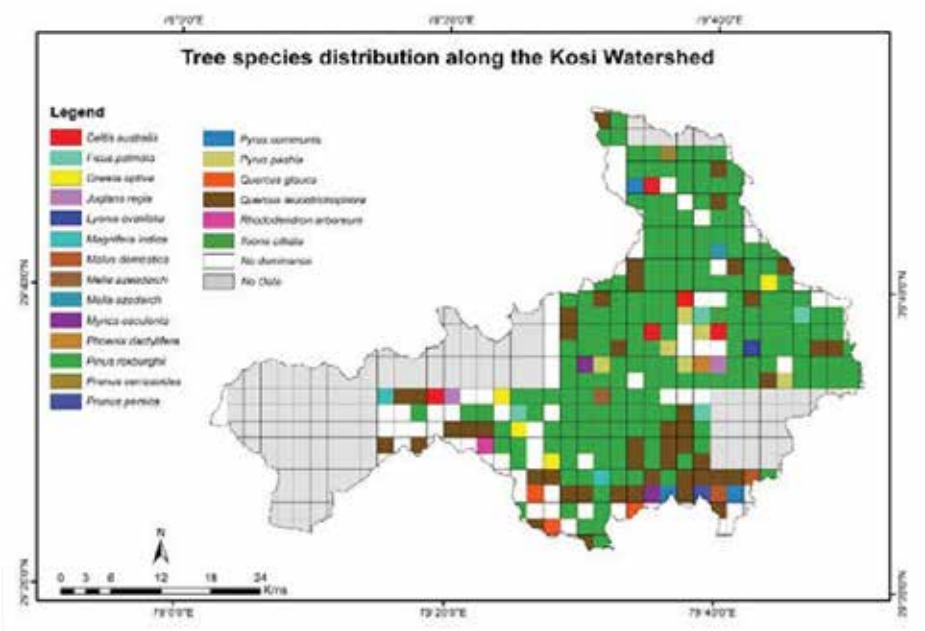


Fig.49: Grid map of Tree species diversity along the Kosi-watershed area

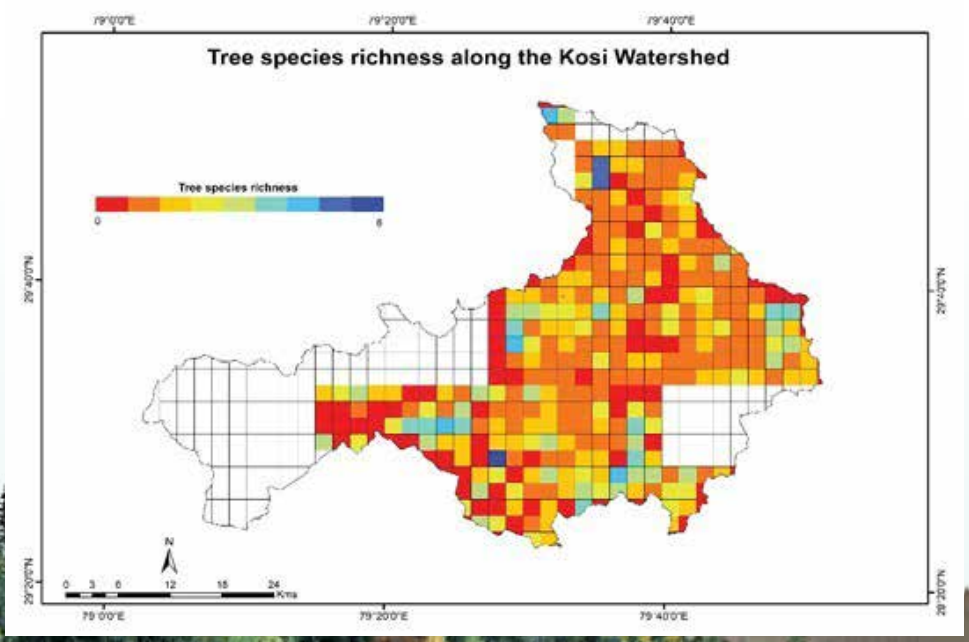


Fig. 50: Grid map representing Tree species richness along the Kosi-watershed area

Summary of the Completed Projects/ Activities

Characterization of kidney bean (Rajmahs) rhizosphere microbiome from higher altitude of Indian Central Himalaya and its field applications (NMHS, GoI, 2019-2023)

Kidney bean or Rajmah (*Phaseolus vulgaris* L.) is a high-value cash crop in the Indian Central Himalayan region. Traditionally, Rajmah is mostly grown in the hilly region of the Himalayas during the kharif season. Although Rajmah is also cultivated in the plains of India, local cultivars growing in hills are known for their premium quality, unique taste and nutritional values. Under this project, 152 Rajmah accessions from 47 hilly districts of Uttarakhand have been collected. All collected samples were identified as accessions and named after the collector's name, collection site and sequence as per the NPGR passport data format. All accessions were subjected to morphological, biochemical and genetic analysis. The major outcomes of the project are as follows:

Major Outcomes

1. Collection of total 152 Rajmash accessions from 47 sites of Uttarakhand and their accessioning using NBPGR, New Delhi.

2. Morphological assessment of 152 accessions characterized Bona B (highest weight, length and hydration capacity) as an elite accession. Biochemical parameters such as Protein was found highest in Parvada A, Bona C (26%), Carbohydrate content in (67%), Proline content in Charbang N (28 µmole/g), Methionine content in Natwar B (0.081 mg/g), AOA (DPPH assay) in Jhalla A (1.53 mg AAE/g), Total Flavonoid Content in Sankari B (40 mg QE/g) and Total Phenol Content in Natwar B (7.65 mg GAE/g). Accessions with high genetic diversity using Cp-SSR markers were Harsil & Jhalla (He=0.29) in 20 accessions, and using 20 ILP markers were Ramini & Phagti (He=0.25) among all 152 accessions. All accessions are grouped into two major populations (Fig. 51).

3. Every year, a demonstration of bioinoculants in the farmer's field was performed, and yield assessment exhibited an overall increase of 5 to 25% as compared to control/untreated samples. These findings establish them as an effective biofertilizer for high-altitude Rajmah crop cultivation.

4. Three workshop/training programs have been organized under the NMHS project to generate awareness among farmers regarding the use of bioinoculants to promote the cultivation of high-altitude Rajmah with the great participation of 134 farmers (24 men & 110 women).

Fig. 51: On field demonstration sites (Ringi, Tapovan, Lata, Triyuginarayan and Tolma) initiated for organic farming of Rajmah crop in Garhwal, Uttarakhand

SIKKIM REGIONAL CENTRE (SRC)

Sikkim state supports rich floral and faunal diversity varying in different eco-climatic ranges (300m to 8685m). There are high endemic and threatened species covering diverse ecosystems and habitats that represent the uniqueness of biodiversity. Local people are largely depended on natural resources for their livelihood. Endowed with rich natural resources, Sikkim Himalayan region forms a part of the Himalayan global biodiversity hotspot. This region is exceptionally rich in diversity and endemism and harbours wealthy floral and faunal diversity, wetlands, glaciers, river, cultural diversity and indigenous knowledge of ethnic communities. However, due to its fragile ecology and disaster-prone features, environmental issues of the region are at the forefront of the scientific debate. Further, over-extraction and utilization of the natural resources demand immediate measure to reverse the trend of degradation. Besides, it also needs strengthening, participatory management, livelihood enhancement, self-sufficiency, policy review/analysis and capacity building. Considering the above mentioned priorities of the Sikkim state, Sikkim Regional Centre of the Institute has been working on environmental and developmental issues of the Sikkim Himalaya which include entire Sikkim state and West Bengal Hills. Main thrust areas of Sikkim Regional Centre are (i) Biodiversity safeguarding at ecosystem, species and genetic level, including ecosystem services, (ii) Natural resource use, management, and sustainability, (iii) Geo-environmental assessment of land hazards and mitigation strategies, (iv) Assessment of climate change impacts and vulnerability on critical ecosystems, (v) Enhance implementation of strategies through participatory planning and policy analysis.

Assessment of Managed Spring Recharge as a Sustainable Solution to Water Scarcity in Sikkim Himalaya: Adaptation to Climate change (MoEF&CC, GoI, 2020-2023)

Mountain springs, the primary source of water for rural households in the Himalayan region, are drying up due to increased water demand, land use change, and ecological degradation. With climate change and rising temperatures, a rise in rainfall intensity and reduction in its temporal spread, and a marked decline in winter rain, the problem of dying springs is being increasingly felt across the Indian Himalayan Region. Many artificial recharge schemes have been implemented to augment groundwater resources. The technical, societal, economic and environmental impacts of these schemes are seldom evaluated in detail and thus, their effectiveness is often difficult to quantify. The aim of this project is to have a systematic assessment of traditional and advanced spring recharge schemes, Cost Benefit Analysis (CBA) to evaluate the socio-economic profitability of the spring recharge activities, and their effectiveness as a sustainable solution for water scarcity. The outcomes of the study will aim to provide an assessment of post implementation sustainability of spring recharge schemes/activities leading to policy level planning for effective implementation of the spring recharge in Himalaya.

Objectives:

- To document good practices of water conservation in Sikkim Himalaya as an adaptation to climate change
- To study water balance (demand - availability) and water governance of selected spring sheds and analyse factors of spring outflow drying
- To assess effectiveness and cost benefit of managed spring recharge experiments in Sikkim Himalayan region

Achievements:

1. Through a household survey, 13 major indigenous soil and water conservation practices for Punzitar village and 14 for Alley village (the two pilot study villages in South Sikkim district) have been documented . These indigenous practices were validated on the field for their effectiveness towards soil and water conservation.

2. The water balance (demand-supply) and governance of the study villages has been studied. It was found that per capita domestic water consumption was higher than the prescribed value of 55 liter per capita per day (lpcd) under Jal Jeevan Mission (JJM), Govt. of India and less than the value (150 lpcd) stated under World Health Organization (WHO) (Table 7). To ascertain the change in water volume with seasons, seasonal spring discharge data of two springs Gaddi khola and Chipcheydhara within the study area in south Sikkim has been collected. The analysis of the data showed maximum discharge in post-monsoon season for both the springs with a value of 40 lpm and 66 lpm, respectively.

3. It was observed that rainfall over the study sites has decreased during 1990- 2020. The validation of people's perception on climate change with the observed rainfall data of Sikkim found that the perception was in line with the climate trend of a decreased rainfall, with a declining rate of 3.23 mm/year in annual rainfall (Fig. 52), 1.84 mm/year in winter rainfall, 7.31 mm/year in monsoon rainfall and 0.94 mm/year in post monsoon rainfall. Whereas, the rainfall during pre-monsoon season has increased by a rate of 8.99 mm/year.

Table 7: Per capita domestic water consumption for the study sites

Village Name/ study sites	Per household average water consumption (lit/day)		Per Capita water consumption (lpcd)		Minimum Standard by WHO (lpcd)	Minimum Standard by Jal Jeevan Mission (lpcd)
	Mean	Std deviation	Mean	Std deviation		
Alley	423	132	80	6	150	55
Punzitar	367	139	71	11	150	55

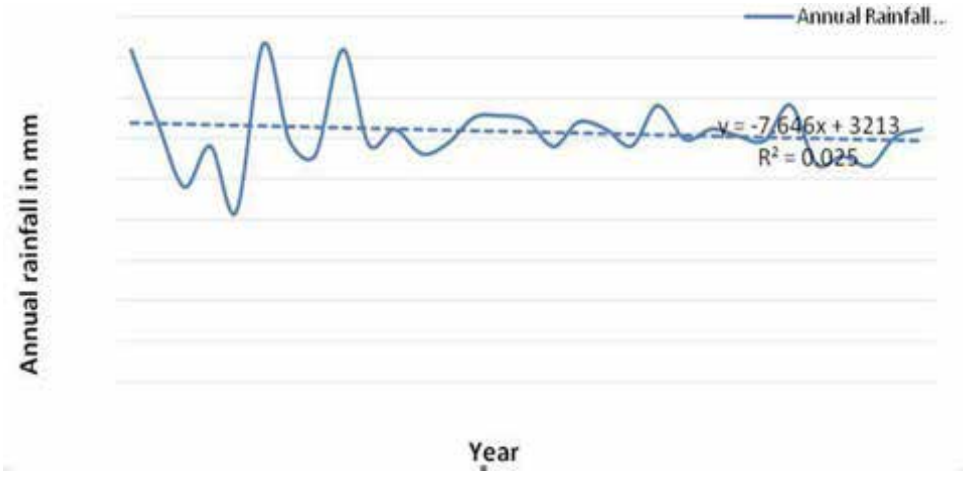


Fig. 52: Temporal variation in annual rainfall distribution in Sikkim (1990-2020)

Summary of the Completed Projects/ Activities

Khangchendzonga Landscape Conservation and Development Initiatives (KLCDI) - India (ICIMOD, 2017-2023)

The Khangchendzonga Landscape (KL) represents a highly complex and diversified system in terms of biological, cultural and physical attributes leading to a richness of bio-physical and life supporting values ranging well beyond its physical boundaries shared by Bhutan, India and Nepal (26°21'40.49" to 28°7'51.25" latitudes and 87°30'30.67" to 90°24'31.18" longitudes), covering total area 25,085.8 km^2 (56% India; 23% Bhutan and 21% Nepal). The KL offers life support systems to over 7.2 million people (87% in India; 11% in Nepal and 2% in Bhutan). The Indian part of KL covers an area of 14126.36 km^2 (districts Alipurduar, Darjeeling, Jalpaiguri, and Kalimpong) from 40 to 8586 m asl (26°29'13.56" to 28°7'51.6" latitudes and 87°59'1.32" to 89°53'42.96" longitudes). The implementation plan of KLCDI in India started with an overarching vision "The Khangchendzonga landscape represents the biological, social and cultural entity, which is continue celebrated by the community living in the landscape through equitable access and conservation of natural resources" which directed the broad objectives as i) enhance well-being of women, men, and children, ii) improve ecosystem management and conservation through inclusive and equitable benefit sharing of natural resources, community-based approaches, and economic valuation and incentive mechanisms, iii) strengthen local and national level mechanisms for evidence-based decision-making through long-term environmental and socio-ecological monitoring, and iv) strengthen regional cooperation for transboundary landscape management.

The above-mentioned objectives approved under the programme (LoA 2017 between NIHE and ICIMOD), several activities have been carried out in the KL-India by the Sikkim Regional Centre of the Institute in collaboration with the local partner organizations and concentrated in the identified three pilot sites i) Dzongu (Lepcha reserve associated with UNESCO World Heritage site, i.e. Khangchendzonga National Park), ii) Barsey-Singalila (Transboundary location connected with Nepal) and iii) Bandapani (Transboundary location connected with Bhutan). Under livelihood diversification and economic development component, promotion of agro-horti technologies and organic farming; support dairy technology and enterprises; solid waste management and community-based ecotourism development; promotion of marketable productions (e.g., mushroom; bamboo; nettle fiber, etc.); and livelihood and value-chain services were initiated. To improve management of ecosystem services within and outside protected areas, assessment of demand and supply of fodder and forage species; mitigation action plan for human-wildlife interfaces; inventorization of forest genetic resources; conservation and restoration of *Paris polyphylla* (Satuwa); and strengthen the Yak (*Poephagus grunniens*) and SIRI cow (*Bos indicus*) stakeholders networks were carried out. Long-Term Environment and Socio-ecological database development (LTESM) was aimed to establish three permanent sites at i) Laven, Dzongu (1 ha plot)-monitoring social, biological & weather data; ii) NVNP, West Bengal as Maling bamboo (*Yushania maling*) experimental plots (3 plots of 1 ha each)-monitored biological, soil, and weather data; and iii) Gorkhey forest village- social-economic data. Also, the KLCDI-India included regional cooperation among participating regional member countries on transboundary landscape management in KL through synergy and sensitizing the key stakeholders; cross-learning exposure and expedition; and participation and interaction. The Major achievements of the KLCDI-India are as bellow:

1. Integrated Livelihood Model (ILM) was successfully demonstrated and replicated by implementing capacity building, interventions, exposure visits, and monitoring events in components (Table 8).

2. Songbing was popularized as an ecotourism destination and eco-trail (Lingdem to Songbing), and the local organization i.e., Songbing Tourism Development & Management Committee (STDMC), Dzongu was strengthened for implementing the community based ecotourism (CBE) model in Dzongu, e.g., Songbing Ecotourism & Cultural festival (Fig. 53).

3. The cultivars (Dzongu Golsey, Sawney, Seremna, Ramsey, and Varlangey) of large cardamom (*Amumum subulatum* Roxb.) were prioritized for

better productivity using twelve morphometric traits, including eight yield-related traits for Sikkim, and the Dzongu Golsey, Sawney, and Seremna cultivars recommended for below 1500m elevation while Varlangey and Ramsey for above 1500 m elevation (Fig. 54).

Fig. 53: Promotion of Lapcha culture during Songbing Ecotourism & Cultural festival

Table 8: Skilled development of the local community in different components and direct beneficiaries under KLCDI-India

SN	Components	Participants	Beneficiaries/obtained
1.	Off-season vegetables; agro-horti; yacon and nakima farming, etc.	165	14
2.	Dairy development	45	45
3.	Ecotourism	160	26
4.	Organic farming	145	46
5.	Mushroom cultivation	6	6
6.	Bamboo based craft making	18	7
7.	Nettle fibre & product making	24	15
8.	Poultry farming	20	20
9.	Large Cardamom entrepreneurship	22	2
10.	Yak & SIRI cow rearing	25	20
11.	Solid waste management	185	18* (villages)
12.	COVID 19 relief	0	64
	Total	**815**	**265**

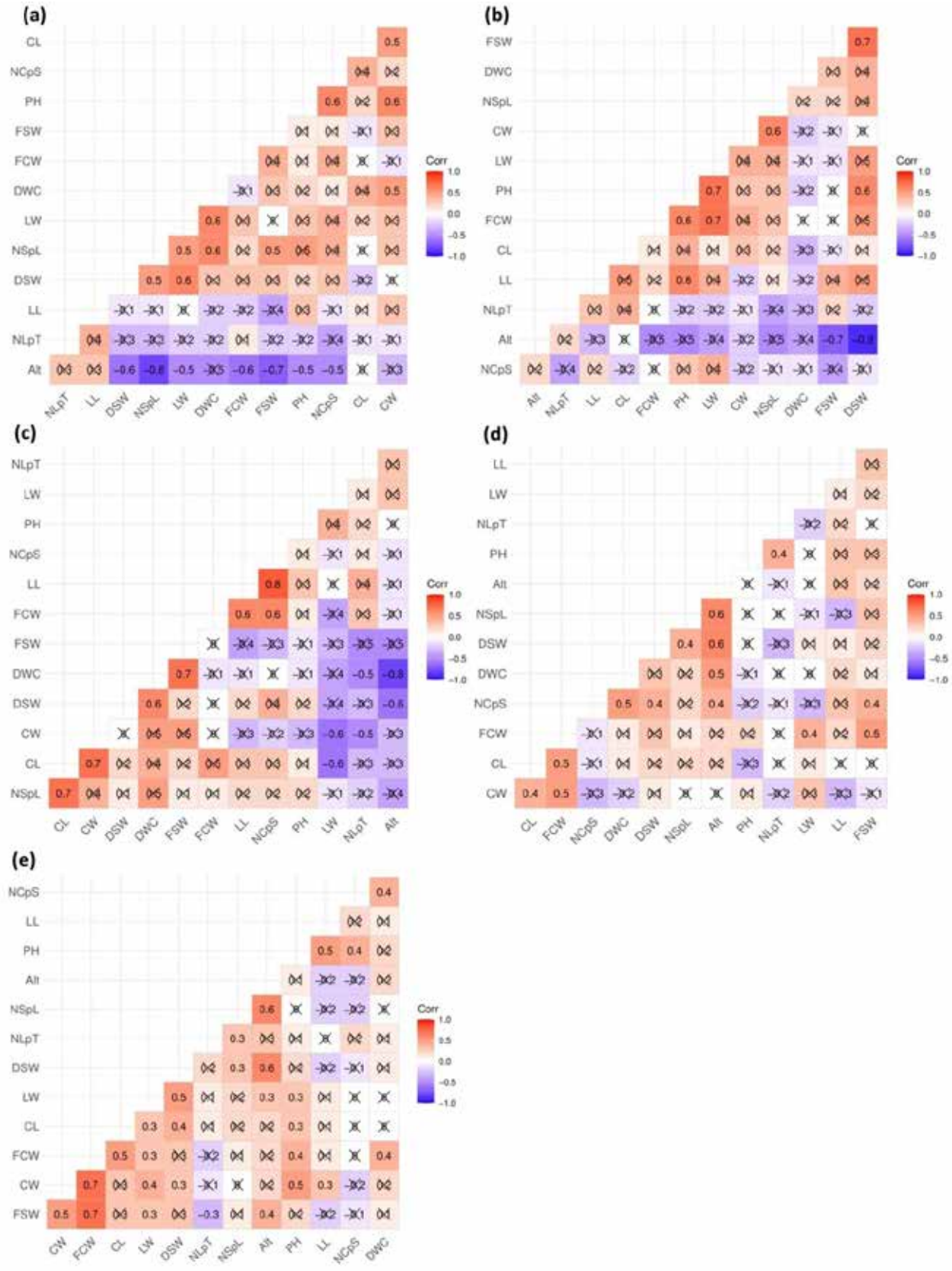


Fig. 54: Correlation between twelve morphometric traits and elevation in five cultivars of the large cardamom. (a) Seremna(b) DzonguGolsey (c) Sawney (d) Ramsey (e) Varlangey. Note: Alt = elevation/elevation, PH = plant height, NLpT = number of leaves per tiller, LL = leaf length, LW = leaf width, NCpS = number of capsules per spike, CL = capsule length, CW = capsule width, FCW = fresh capsule weight, DCW = dry capsule weight, NSpL = number of seeds per locule, FSW = fresh seed weight, DWC = dry seed weight.

Vegetation & Socio-Economic Survey for Netaji Subhash Chandra Bose University of Excellence (NSCBUoE), Chakung, Soreng, Sikkim (Department of Education, Government of Sikkim, Gangtok, 2021- 2023)

Netaji Subhash Chandra Bose University of Excellence (NSCBUoE) has been planned to be established at Chakung, Soreng by the Government of Sikkim (GoS). For the establishment of the University of Excellence, approx 57.54 acres of land was delineated and allotted by GoS for the construction and development of necessary infrastructures (e.g. administrative buildings, classrooms, laboratories, residential complexes, hostels, recreation complexes, etc.) this would occupy nearly 30 acres of land. The delineated land falls under private and Government land (Reserve Forest). While making constructions for the establishment of the University, conservation of existing natural resources (e.g. water bodies, diverse flora & fauna, medicinal plants, and other sensitive vegetation) is very important. Hence, there was a need for a detailed assessment of the existing plant diversity of the proposed site and their importance for the surrounding communities for the project's effective planning process and implementation.

The site is located at a very high water scarcity zone with low agricultural productivity wherein, the income diversification of the community is driven mainly by on/off farm activities. More than 50 medicinally important plant species were found in this region. The site of NSCBUoE Campus harbors total of 344 plant species belonging to 273 genera and 94 families, of which, 53 are represented by tree species, 44 shrubs, 218 herbs, 23 climbers, 3 liana and 3 species by bamboos. Among 94 families, 40 have single species each, 15 families have two species each, and nine families have three species each. Asteraceae (38 species) was the most spacious family, followed by Fabaceae (20), Poaceae (20) and Orchidaceae (16). In terms of IVI, the most dominant species were: *Schima wallichii* (41.24), *Engelhardia spicata* (22.54) and *Cryptomeria japonica* (19.56). Of all, 43 species exhibited an Importance Value of 1 or less, which are rare and have conservation concerns. The stand density was 912.10 individuals ha^{-1} and the basal area was 18.84 m2 ha^{-1}. The girth class distribution of stems of dominant species was plotted in 20 cm wide intervals for nine girth classes wherein, the lower gbh class (10-<30 cm) was observed as the most prominent, which shows that the forests have good regeneration potential. Based on the report's outcomes, some substantial recommendations were suggested for maintaining socio-ecological balance in-and-around the campus area leading to the region's sustainable development. The key outcomes of the project were as follows:

1. Maize crop was the most common crop grown by the community in the region (40.77%) followed by ginger (23.08%), vegetables (13.85%), pulses (6.92%), large cardamom (4.62%), potato (3.08%) and Orange (2.31%) (Fig. 55).

2. Total of 10 important tree species of this region were reported for the region as per the high dependency of the community (Table 9) to meet firewood, fodder and timber demand. As per the community perspectives, two species i.e., *Smilax zeylanica* (Kukur Daino) and *Stephania hernandifotia* (Tamarkey), were to be considered for conservation in the forest.

3. Recommended conservation measures based on community consultation identified the current issues and future interventions (Fig. 56).

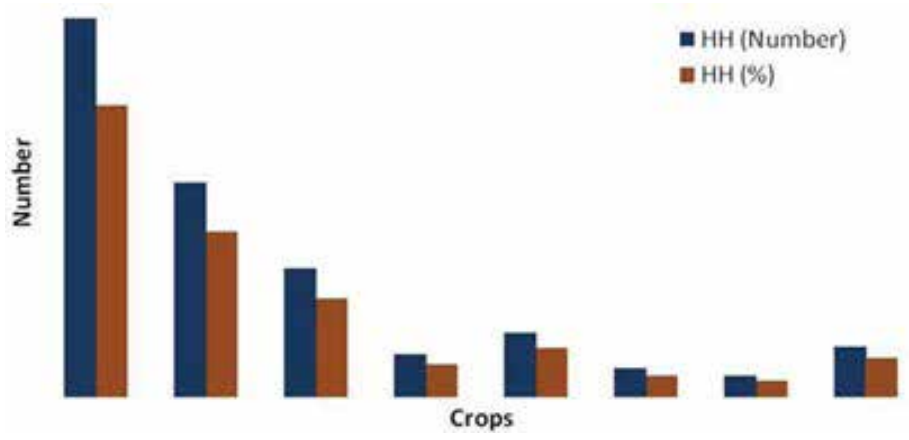


Fig. 55: Crop diversity in chakung region

Table 9: Dependency of the communities on trees

S.No.	Scientific Name	Local Name	Habitat	Uses
1.	*Schima wallichii*	Chilawney	Temperate, Sub-tropical altitudes	Fodder
2.	*Terminalia myriocarpa*	Panisaj	Temperate, Sub-tropical altitudes	Firewood, fodder, timber
3.	*Alnus nepalensis*	Uttis	Temperate, Sub-tropical altitudes	Timber, firewood
4.	*Criptomeria japonica*	Dhuppi	Temperate, Sub-tropical altitudes	Timber
5.	*Erythrina arborescens*	Phaledo	Temperate, Sub-tropical altitudes	Firewood
6.	*Macaranga* sp.	Malato	Temperate, Sub-tropical altitudes	Firewood
7.	*Michellia* sp.	Rani Champ	Temperate altitudes	Timber, fodder, firewood
8.	*Castanopsis tribuloides*	Kattus	Temperate, Sub-tropical altitudes	Fodder, firewood, timber
9.	*Cinnamomum bejolghota*	Mallagiri	Temperate, Sub-tropical altitudes	Fodder, firewood, timber
10.	*Machilus* sp.	Kaulo	Temperate, Sub-tropical altitudes	Fodder, firewood, timber

Fig. 56: Community consultation at Chakung for the establishment of BSCBUoE

Establishment of Nature Learning Centre, Sikkim (NMHS, GoI, 2019-2022)

Sikkim state is located in the adobe of the Eastern Himalayan biodiversity hotspot. However, there is an imperative need to educate and create awareness among diverse stakeholders towards nature conservation. Keeping in view that initiatives towards nature conservation are scanty, fragmented, and isolated, a Nature Learning Centre (NLC) was established at Pangthang campus of NIHE in Sikkim. The major activities of the NLC include, the development of nature conservation model and knowledge products, capacity building of stakeholders on nature conservation; promotion of citizen science approach for conservation education; and create a cadre of nature enthusiasts in the state through capacity building. With these broad objectives, Him-NLC Sikkim was established at Sikkim Regional Centre (SRC), Pangthang in collaboration with the Forest and Environment Department, Government of Sikkim. The Arboretum of SRC has been developed as a nature interpretation and learning centre and named "Prakritikunj". Various models of nature conservation and interpretation have been developed and made functional, such as Orchid trail and Orchidarium, Rhododendron trail, permanent study Plot, Fern trail, Herbal garden, waste management and water harvesting models, multipurpose plant nursery, open amphitheatre, gardens of valuable crops like Tea (*Thea chinensis*), Nakima (*Tupistra clarkei*), Ground apple (*Smallanthus sonchifolius*), etc. A total of 51 tree species belonging to 37 genera and 29 families with a density of 1580, 3984 and 7624 individual ha^{-1} of adult, sapling and seedling, respectively were recorded from Prakriti-kunj. A permanent study plot, with a size of 90 x 50 m^2 has been established (Fig. 57) with an aim to (i) Inventorize the flora and imparting knowledge on vegetation assessment, (ii) Long term phenological study of the tree species, (iii) Plant biomass study, (iii) Carbon stock estimation, (iv) Soil and litter analysis (Fig. 2). This facility is used by various stakeholders especially college and school students as field-based laboratory for training, capacity building and practical on vegetation analysis and phyto-sociological surveys. Further, the Prakriti-kunj serve as carbon sink (approximately 295 tonnes ha^{-1}) more than the state average and that of the most temperate forest of Sikkim. Orchids and Rhododendron being the most sensitive groups of plants and major attraction and important element of biodiversity in Sikkim, these two group of plants have been emphasized for conservation. Orchidarium and orchid trail holds more than 120 species and 2 hybrids belonging to 47 genera of epiphytic (89) and terrestrial (29) orchids of Sikkim Himalaya which accounts for 21% of the species of the state. NLC Sikkim has recorded two new species for the state of Sikkim viz. *Taniophyllum glandulosum* and *Thrix spermumformosanum*. Orchids in Orchidarium and the orchid trail are placed in a suitable substratum and all the species have been tagged with name plate, photo tags with QR code facilities for better understanding and interpretation for visitors. Similarly Rhododendron trail holds 13 species from Sikkim Himalaya which accounts for 36% of the species in Sikkim. *Rhododendron species in the trail are Rhododendron arboreum, R. barbatum, R. ciliatum, R. dalhousieae, R. falconerii, R. grande, R. griffithianum, R. hodgsonii, R. lepidotum, R. leptocarpum, R. maddeni, R. thomsoniiandR. triflorum*. Besides orchids and *rhododendron*, NLC has conserved 40 species of rare and threatened medicinal plants of Sikkim belonging to 25 families, 35 genera. Documentation of butterflies of the SRC has been done, wherein a total of 60 butterfly species belonging to six families were observed. Through NLC-Sikkim 8 training programmes (303 beneficiaries), 12 exposure visits (408 beneficiaries), 3 nature camps (135 beneficiaries) and 12 awareness workshops (605 beneficiaries) and sensitization programs were organized. As an outcome and impact 22 students were developed as Para-conservationist to act as ambassadors of nature conservation and selected models are replicated in Eco-clubs of a few schools. Five local farmers have been trained and supported as a participatory approach for livelihood generation through organic farming of vegetables and floriculture. Different knowledge products in the form of booklets, fliers, posters, tags, information boards, etc for dissemination and a better understanding of the biodiversity are developed through NLC.

Major Outcomes

1. Documentation of flora and fauna (butterflies) and establishment of permanent study plot inside prakritikunj with seasonal and annual observation of vegetation parameters (Fig. 57)

2. Establishment of orchidarium, orchid trail, rhododendron trail, fern trail, herbal garden, and other facilities like pathways and amphitheatre (Fig. 58)

3. Functional models of water conservation and spring rejuvenation, waste management, and multipurpose plant nursery established

4. Environmental awareness was raised through extension and outreach activities (8 training programmes, 12 exposure visits, 3 nature camps and 12 awareness workshops) and knowledge products.

5.A network of students and teachers has been created connecting students and eco-club In-charge of four schools and one college.

Fig. 57: The long term monitoring sites established inside prakritikunj

Fig. 58: An Orchidarium established at SRC

NORTH EAST REGIONAL CENTRE (NERC)

North-East India is well-known for its rich floral and faunal diversity and covers parts of two global biodiversity hotspots, namely, Himalayan and Indo-Burma. Agriculture and allied activities were the primary sources of livelihood for indigenous communities residing in the region. The region is also rich in bio-resources, which are utilized and managed by the communities for different purposes using their inherent traditional knowledge. Gradually, the region's biodiversity and traditional knowledge and practices of the region are under threat of extinction due to modernization, conversion to unsustainable land uses, developmental activities, climate change and other natural and anthropogenic factors. To address these issues, the NERC's main R&D functions are (i) conservation of biological diversity (ii) sustainable socio-economic development and livelihood security (iii) adaptation/ mitigation of climate change impacts, (iv) ecotourism (v) low-cost rural technologies and (vi) networking and collaborations with other Institutes/ organizations. Currently, the NERC is running 4 in-house and 2 externally funded projects. To fulfil common R&D goals as well as to organize different activities/ events, the NERC also collaborates with other State Government Departments and academic and research institutions, including Rajiv Gandhi University (RGU), Arunachal Pradesh, Mizoram University, Nagaland University, Manipur University, Arunachal Pradesh State Council for Science & Technology, Department of Environment, Forest, and Climate Change, Govt. of Arunachal Pradesh; Botanical Survey of India-APRC, Zoological Survey of India-APRC, Arunachal State Science Centre, etc. The NERC initiated the establishment of the Nature Learning Centre at Itanagar in collaboration with the Department of Environment, Forest, and Climate Change, Govt. of Arunachal Pradesh. During the reporting year (2022-23), nearly 35 nos. of trainings, awareness and capacity building programmes, webinars, field demonstrations, etc. have been conducted for diverse stakeholders, including line departments, CBOs, Gram Panchayat leaders, local NGOs, women farmers, students and teachers from different parts of Arunachal Pradesh and others north-eastern states.

NORTH-EAST REGIONAL CENTRE (NERC)

The North-East Regional Centre (NERC) of G.B. Pant National Institute of Himalayan Environment has been functioning from Itanagar, Arunachal Pradesh since 1997 (previously in Nagaland since 1989). The entire NE region is known for its rich diversity of flora, fauna, socio-cultural, linguistic and ethnic communities. The local communities possess rich indigenous knowledge in utilising the natural resources around them for their sustenance. Unfortunately, the region's rich biodiversity is currently facing various threats including degradation, deforestation, settlement expansion, indiscreet hunting, therefore, warranting to develop viable, replicable and effective community-based resource management initiatives to conserve it. To conserve biodiversity as well as ensure sustainable utilization of the resources, the NERC has been working on the following focal research areas (i) People-centered land use models for shifting cultivation, (ii) Indigenous knowledge systems and natural resource management options for tribal communities, (iii) Biodiversity and Wildlife conservation through community-based natural resource management, (iv) Water security through spring rejuvenation, (v) Appropriate low-cost technologies for improved livelihood in NE region, (vi) Environmental assessment of developmental initiatives in NE region, and (vii) Planning and Development of rural life in North East India. The R&D activities of the Centre aim to fulfil the following objectives: (i) conduct in-depth research and development on various environmental issues in North-East India; (ii) identify and strengthen local knowledge of the environment through interactive networking and strengthen regional relevance research in scientific institutes, universities / NGOs and voluntary organizations working in the North-East Indian region; (iii) demonstrate appropriate technical packages and delivery systems for sustainable development in Northeast India in line with local aspiration; and (iv) environmental awareness building to local people of North-East India through training, demonstration and knowledge products.

Summary of the Completed Projects/ Activities

Landscape Initiative for Far-Eastern Himalayas (HI-LIFE), India (ICIMOD, 2018-2024)

The Landscape Initiative for Far Eastern Himalayas (HI-LIFE) is a collaborative effort between ICIMOD and the three countries - China, Myanmar, and India, to promote regional collaboration on various trans-boundary issues and challenges facing conservation and development in the landscape to achieve twin objectives i.e., Biodiversity Conservation and Sustainable Development. The HI-LIFE landscape is recognized as a "Centre of Plant Biodiversity" and "Eastern Asiatic Regional Centre for Endemism". The landscape extends from the Nujiangriver and Gaoligongshan Nature Reserve of China (22%) to the Namdapha National Park of India (12%) in the east with the Hkakaborazi National Park, the Hponkanrazi Wildlife Sanctuary, and Hukaung Valley Wildlife Sanctuary of Myanmar (66%) in between covering an area of 71,452 km^2. However, the richness of the region's biodiversity and significance is comparatively below par among conservationists and policy makers due to less research exploration work and inaccessibility of the region. The HI-LIFE landscape is reported to be facing several threats such as intense farming systems, encroachment of forest land area, unregulated tourism, hunting, developmental projects, unplanned land use, and climate change. Effective conservation measures must be taken up through developing a proper knowledge base, filling informational gaps, and prioritizing areas for further interventions in making the trans-boundary landscape useful in biodiversity conservation and managing endemic species. To implement HI-LIFE in the Indian part, a Regional Workshop on 'Planning technical trans-boundary collaboration for landscape management' was held in Myanmar to further discuss country-wise activities. For the Programme Implementation (2018-2019) under Hi-LIFE in India, a meeting of the Arunachal Pradesh 'State Level Coordination Committee (SLCC)' was organized to develop and endorse the priority activities that need to be initiated in Indian part. After thorough investigation and numerous consultations, Namdapha National Park/Tiger Reserve and its adjoining areas in the Changlang district of Arunachal Pradesh were approved as the project site under HI-LIFE programme. A Letter of Agreement (LoA) was thereafter signed between NIHE and ICIMOD with a vision towards resourceful execution of management plans along with ecosystem goods and services conservation in Far-Eastern Himalayan Landscape. This would further help in improvising the local inhabitant's livelihood status; thereby improving ecological integrity, economic growth and socio-cultural flexibility towards ecological deviations. The HI-LIFE programme has succeeded in promoting sustainable tourism development, sustainable use and equitable access to natural resources for reduction of poverty, trans-boundary cooperation in managing National parks and science, policies and their implementation, ecosystem services, livelihoods, and climate change impacts, encouragement of regional data sharing, and strengthen partnerships for trans-boundary collaboration. However, effective conservation measures are necessary to mitigate the various threats that the HI-LIFE landscape faces. As per sectors adopting the landscape approach include agricultural development, natural resource management, rural development, and water resources and watershed management. The project executed to facilitate stakeholder meetings and jointly develop plans for ecosystem management in pilot areas, updated information on the biodiversity of Namdaapha National Park, and review the Eco-Tourism Policy of Arunachal Pradesh.

Major outcomes

- The project involved developing 5 homestays in M'Pen II and Lama villages with basic facilities and running water to provide better comfort for tourists. Adventure tourism facilities were also provided to 2 SHGs, including Rafting boats and Angling rods for a total of 20 beneficiaries. Picnic spots and viewpoints were constructed with huts and signboards to promote the homestays and enhance the area's natural beauty (Fig. 59).
- A book on threatened and endemic birds, scientific articles on mammals were published. Developed knowledge posters and maps on species diversity and habitats for wider dissemination. The project also provided information on market rates of locally cultivated and non-cultivated food items and developed a report on crop diversity. The project recorded 16 wild edible plant species and 25 varieties of paddy in the Indian HI-LIFE region with information on economic, medicinal, and traditional values that could be an alternative

source of food and nutrition security in the future.

- Keeping HI-LIFE vision in concern, 20 nos. of meetings, trainings/workshops and awareness programmes were conducted during the tenure along with developing an "Integrated Ecotourism Model" in the selected project site.

Fig. 59: Promoting ecotourism through ecosystem models

Understanding the process of change in Far-Eastern Indian Landscape linking with Conservation and Management (Mountain Division, MoEF&CC, 2018-2022)

The Far-Eastern landscape, while rich in its natural resources, is also equally known for its extreme vulnerability to changing faces of development and global climate. There are numerous conservation and developmental challenges. Agriculture expansion and illegal trade of wild life are on the rise, mainly manifested by acute poverty. Other challenges include limited conservation and development investments and inadequate capacity and skills of communities and climate change. There is a need for collaborative efforts to support the conservation of complex biodiversity and address poverty through conservation-linked developmental strategies. The objective of this study was (i) to develop baseline database on socioeconomic status, ecosystems and cultural diversity of the landscape including drivers of change and (ii) to study the land use /land cover change, climate change and other dynamic systems of the landscape. During the project period, a detailed study on handloom and handicraft of different communities living in the study area was conducted focusing on the income generation. Handicraft making is integral part of local community in the society and almost all the households are practicing it for some purpose (own use or income generation). The study reported that although bamboo is still available in abundance, cane, an important and durable item for handicraft making, is vanishing slowly. This can be seen as a change which is affecting livelihood of the local people. Study was also done on religious beliefs and festivals of the local community to understand their linkages with conservation as a traditional practice. The local biodiversity of canes, bamboos, palms and perennial tree species are invaluable in making various handicraft, utensils, tools and technique used for various purposes. Different sizes and shapes of handicraft products, various kinds of baskets, cane vessels, a wide variety of cane elaborately woven brassier of cane and fiber, bamboo mugs with

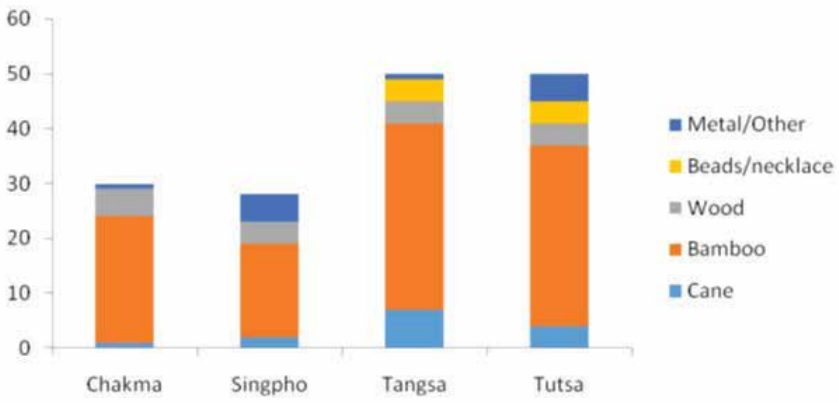


Fig.60: Different Plant based product used by Tatsa, Tangsa, Chakma and Singpho tribes in handloom and handicraft preparations

carvings, etc. They have mastered the technique of basketry, and the designing of such items among the villager has been found to be entirely need based, practical and are aptly suit to their socio-cultural and geo-geographical landscape. An awareness Workshop on "Promotion of local Handicraft for Sustainable Livelihood" was conducted at the M'Pen II Village, Changlang, Arunachal Pradesh on 18th January, 2023 with local tribes. A total 21 people participated in the programme.

Major Outcomes

- Documented the handloom and handicraft, which are mainly prepared produced by the natural sources by four different communities, i.e. Tutsa (49 Nos.), Tangsa (48 Nos.), Chakma (30 Nos.) and Singpho (28 Nos.) at fringes of Namdapha National Park, Arunachal Pradesh (Fig. 60)

- The cost-benefit assessment based on local people's interview informed that it took a significant efforts and time of a skilled person to make a particular handicraft. For example, it took 2-3 man-days to prepare a simple bamboo basket (locally known as 'Bareng') and it is sold in Rs. 400.00 only in the market. So, the practitioners not even getting their labor cost. This is discouraging to the local people and now the practice is declining with time

LADAKH REGIONAL CENTRE (LRC)

Ladakh became a Union Territory on the 31st of October 2019. Renowned for its remote mountain beauty and distinct culture, Ladakh UT is a unique landscape with an entirely different climate, sociological characteristics and environmental conditions. Ladakh Regional Centre has been established with a realization that the Trans-Himalayan landscape with most of its area lying above 3,000 m asl presents unique ecological, environmental and socio-cultural characteristics evolved over the harsh climate of the region in terms of extreme cold, minimal rain (90-100 mm annual) and very sparse vegetation. This landscape, most often, is also termed a cold desert. The region is endowed with a rich diversity of culture, unique biodiversity elements and significantly large wetlands/water bodies (lakes). Although in these areas' communities have adapted to extremely harsh climates and resource-poor living conditions, they face numerous challenges. Especially under changing climate scenarios, where impacts are expected to be more intense in higher altitudes, the Trans Himalayan landscapes and people will likely face more severe challenges. These challenges call for a better understanding of its landscape components and developing strategies and implementation plans for addressing environmental conservation issues and people's livelihoods in a changing climate. The following objectives have been targeted for the center – (i) to promote alternative and innovative livelihoods for climate change vulnerable cold-desert communities, (ii) to facilitate conservation of critical/important cold desert habitats and biodiversity, (iii) to strengthen and establish approaches for addressing issues of water scarcity, and (iv) to foster climate-smart communities in the trans-Himalayan landscape.

Addressing Water Scarcity Using Artificial Ice Reservoirs through People's Participation (NIHE, LRC In-House, 2021-2023)

Ladakh has a fragile Trans-Himalayan ecosystem having limited precipitation, thus, commonly described as a 'cold desert'. Almost, all the water requirements of the region are met by glacial meltwater originating from the huge glacial deposits in the region. The availability of snow melt water in streams is not synchronized with sowing and field preparation time. Ladakh with scanty rainfall and a shift in snowmelt, water availability is more critical for the sustenance of agricultural activities. Rapidly developing tourism activities along with expanding urbanization and fast-changing lifestyles have resulted to an increase in water consumption. Thus, efforts are made to assess water resources in Ladakh region, and to meet the water demand for irrigational and domestic purposes, Ladakh Regional Centre adopted a People's Participatory Approach in creating artificial ice reservoirs in the high-altitude villages where acute water shortage was identified by the villagers and planners. This approach is an adaptation strategy using traditional/local knowledge of water needs in the face of climate change.

Objectives:

- Geospatial assessment of water resources in Ladakh region
  - I. Assessment of glacier mass balance in the Ladakh region
  - II. Evaluation of long-term meteorological drought persistence and predictability in Ladakh and J&K UTs
- To demonstrate a participatory approach for providing solutions to water scarcity at micro-catchments of Trans-Himalayan Ladakh using artificial glaciers

Achievements:

- The estimation of the mass balance of 3500 km^2 of glacierized area in Ladakh showed the mean mass balance rate for Western Ladakh was 0.37 ± 0.09 m w.e. a^{-1} during 2000-2017. For Eastern Ladakh, the mean region-wide glacier mass balance rate was 0.21 ± 0.07 m w.e. a^{-1} during 2000-2020.

- The comparative analyses of frequencies of short-term droughts (STD), medium-term droughts (MTD) and dry years (DY) between Ladakh and J&K UTs indicated that the frequencies of STD, MTD and DY years are lower (0.09±0.03 and 0.13±0.03), and almost comparable (0.35±0.10 and 0.36±0.12) and higher (0.53±0.11 and 0.50±0.14) in Ladakh UT than J&K UT, respectively.

- An artificial glacier was constructed through a participatory approach at the Ursi village (76.89°E, 34.21°N) of the Upper Indus valley of Ladkah UT in view of significant water scarcity

in the region. The total volume of the ice reservoir as on 19th April 2023 was estimated to be approximately ~16000 m^3, translating into a total water equivalent of 1.6 ×107 litres. The melt water now supports drinking and domestic use to 19 households having a total population of 130 persons. It also supports agroforestry at around ~20 ha area. The physical properties (EC and pH) of spring water before and after ice reservoir showed good water quality (EC-242 µS/cm, pH- 7.5; before ice reservoir) and (EC-260 µS/cm, pH- 7.7; before ice reservoir). The EC and PH of the ice reservoir itself were measured to be 271 µS/cm and 7.2, respectively, (Fig. 61).

Fig. 61: Field photographs showing development and monitoring of the artificial ice reservoir at Ursi village, Leh

Rural Technology Center-Leh (In-House, 2022-2023)

After evaluating various low-cost, simple rural technologies, Hon'ble Executive Councillor (Agriculture), Ladakh Autonomous Hill Development Council (LAHDC) -Leh suggested a demonstration cum training facility for the local people and others visiting the Leh town. LAHDC-Leh provided ~0.25 ha of land with fencing to develop a "Rural Technology Centre (RTC)" within the Council Secretariat Complex for various purposes. After removal of pandemic (Covid-19) restrictions, work was started and RTC was made functional by the Ladakh Regional Centre on 19 August 2021. Initially, the area was highly degraded barren land filled with flood debris of Ladakh disaster 2010. Subsequently, through various interventions and re-habitation mechanisms, Rural Technology Center (RTC) emerged as a knowledge center for education and awareness to harness rural livelihood opportunities through natural resources. Currently, RTC is attracting various stakeholders i.e., policymakers, farmers, entrepreneurs, students, academicians, etc. RTC hosts a variety of technological demonstrations, natural products, and local plants for education and awareness purposes.

Objectives:

- Development and demonstration of simple rural technologies for knowledge dissemination and wider adoption by the people
- Capacity building of different stakeholders through research/training/hands-on practices

Achievements:

- Various low-cost technologies (i.e., low-cost portable poly-house, low-cost solar- powered hydroponic technology, shaded low-tunnel, bio-composting units, drip-irrigation, integrated pest and nutrient management, intensive crop cultivation, integrated mushroom cultivation with vegetable, etc.) were demonstrated at RTC for farmers, students, new entrepreneurs, researchers, etc., and 301 stakeholders visited RTC during August 2022 to March, 2023.

- Under the low-cost Solar Powered Hydroponic Model, target vegetables and medicinal plants' of were quantified. A total of 494.89 g of tomato/plant and 1022.78 g of cucumber/plant

Fig. 62: Winter cultivation under modified low-cost earthen brick-based polycarbonate greenhouse: Subplot (a) shows the structure of low-cost earthen brick-based polycarbonate greenhouse, (b) shows establishment of AWS under green house, (c and h) show the plant growth performance, (d) shows lettuce growth through hydroponic, (e) shows the microgreens, (f-g) show sapling production of ornamental plants under floriculture i.e., marigold, petunia, etc., (h) show the mushroom cultivation

were harvested from the hydroponic model. Moreover, 131.57 g lettuce/plant and 113.41 g mint/plant were harvested after 30 days of sowing/ plantations (Fig. 62).

- A modified low-cost earthen brick-based Polycarbonate Greenhouse (18 ft x 32 ft x 10 ft, (Fig. 62a) was designed and established at RTC in collaboration with LAHDC-Leh, for winter cultivation, including leafy & fruity vegetables, floriculture, mushroom and micro-greens. The yield and the growth data of plants are still under process, although the physical growths of plants are shown in (Fig. 62 c-h). The thermal performance of the Polycarbonate Greenhouse during winter was estimated by comparing air temperature, relative humidity, and photosynthetically active radiation (PAR) in and outside the system. The results have shown significantly higher air temperature, relative humidity and PAR in peak winter months of January to March 2023.

Natural Resources-Based Livelihood Options and Off-Farm Employment in Rural Landscape of Ladakh (In-House, 2022-2023)

In the high altitudes of Ladakh (usually above 3000m asl) the growing season for plants is restricted between April to September; thus, agriculture is confined to five to six months of Summer. However, Ladakh is largely devoid of natural vegetation (often referred as Cold Desert). Some of the natural and planted vegetation (i.e., Seabuckthorn, Fescue grass, Salix, Poplar, etc.) are available at many places, and cultivation of Apple and Apricot is common. Various local products from the natural and planted vegetation are in use primarily for self-consumption, and few selected products have begun commercialization on a smaller scale. In view of the prospects of widespread commercialization of nature-based products, this proposal aims at developing the capacity of the local villagers for nature-based product commercialization and hands-on training for value addition techniques.

Objectives:

- To develop local resource-based entrepreneurship through capacity building
- To create off-farm livelihood employment opportunities using local resources

Achievements:

1. Among 15 villages within the Leh districts of Ladakh UT, a total of 7 villages (Ursi, Saspol, Taru, Matho, Martselang, Khatpoo and Tarchit) were identified for targeted training and capacity-building programmes (Fig. 63)

2. A total of 9 trainings for mushroom cultivation through simple low-cost inputs in 7 different villages and 2 in RTC were provided. A total of 121 villagers have participated in these training programmes.

3. A training for the preparation of locally made powdered soup and its value addition was provided at the LRC-RTC. The training was attended by 24 women from the upper Leh area.

4. A total of 2 hands-on basket-making trainings were conducted in Matho and Martselang villages, wherein 28 women attended a 10-day programme for promoting the use of eco-friendly products for reducing single-use plastics. The eco-friendly products were made from locally available plant materials from Malchang (*Salix alba*), Selchang (*Salix tetraspermia*), Tsipskyan (*Festuca arudinacece)*.

Fig. 63: Glimpses of training programmes organized at different villages in the Leh district

Carrying Capacity Estimation of Tourism in Leh Town Complex in Ladakh (Mountain Division, 2022-2024)

Tourism is considered among the most dynamic economic activities that generate a flow of tourists, jobs and important revenue for the states that capitalize on their resources through investment. It is also one of the most effective tools for the sustainable development of economies and local communities. Tourism has both positive and negative impacts on the lives of local communities. The support of the local people is immediately gained due to the positive economic effects that occur when tourism develops in a region. If the development is not sustainable, the negative socio-cultural and environmental impacts that may arise, even if the positive economic impacts are high, may cause the local people to withdraw their support for tourism. In 2020, the Ladakh UT Administration and NIHE organized a summit, "Carbon Neutral Ladakh - A New Beginning", at Leh, which extensively deliberated on developmental needs and possibilities for Ladakh. Considering the heavy tourist influx in Ladakh and the pressure on resources, a need was felt for carrying capacity estimation to meet the developmental goals and address various challenges. With this background, this study aims to assess Leh Town's tourism carrying capacity to provide baseline information and strategic suggestions to formulate policies and action plans for sustainable tourism development in the Union Territory of Ladakh.

Objectives:

- To understand the role of tourism, perception mapping of diverse stakeholders in Leh town, and identification of critical factors for the sustainability of the town and its environment
- To develop a geospatial database, using crowdsourcing, for spatial planning and management in vital sectors of Leh town
- To analyze the carrying capacity of tourism on the basis of critical factors identified and with respect to sustainability of the natural environment of Leh town
- To provide a framework for action plans and guidelines for sustainable tourism in Leh and Ladakh region

Achievements:

1. As per the available tourist inflow in Ladakh over the years, it is noted that the tourism industry in Ladakh is 48 years old. From 1974 till 2022, around 36,11,674 tourists have visited Ladakh, comprising 9,09,002 foreigners and 27,02,672 home tourists.

2. The Trans-Himalayan region of Ladakh was opened to tourists in 1974. Civil aviation started in 1986 and has shown tremendous growth. Ladakh has a short tourist season lasting 4-5 months, thus the number of flights during this period reaches up to 19 in a day.

3. In 2022, there were 4273 inbound flights to Leh, and the majority were during summers (65% of the total inbound).

4. Total air travelers (in bound and out bound) in 2022 were 11.6 lakhs. The analysis of tourist inflow data also showed a positive impact of tourist inflow on accommodation units, consisting of Guest Houses, Homestays, Hotels, Hostels, etc.

5. Till December 2022, a total of 308 hotels, 710 guest houses and 561 homestays were registered at the tourism department, Leh. Moreover, the influx of tourists is also associated with a high degree of waste generation; thus, its improper disposal has affected the overall town's environment and aesthetic value.

Preparation of Peoples Biodiversity Registers for Municipal Areas of Ladakh: Leh and Kargil (Urban Local Bodies – Ladakh, 2022-23)

Union Territory of Ladakh is a high-altitude desert region located in the northernmost part of India. Despite its harsh and seemingly inhospitable climate, Ladakh has a unique and diverse range of flora and fauna, many well-adapted to the region's extreme conditions. Recognizing the importance of Ladakh's biodiversity, proper documentation of floral and faunal diversity needs to be carried out by preparing a People Biodiversity Register (PBR). In the present study, Ladakh Regional Center focuses on preparing PBR for Municipal areas of Ladakh: Leh and Kargil in collaboration with the Municipal Committee Leh (MCL) and Municipal Committee Kargil (MCK).

Objectives:

- To create Biodiversity Management Committee (BMC) at the Municipality level

- To collect floral and faunal data (including a review of literature on natural resources and direct field observations) at the ward and household level
- To analyse and validate biodiversity data in consultation with experts and BMCs, and preparation of comprehensive checklists of species
- To prepare the People's Biodiversity Register (PBR) as per the standard prescribed format

Achievements:

1. A Biodiversity Management Committee for Municipal Committee Leh (MCL) is formed under Section 41 (1) of the Biodiversity Act 2022 and Rule 22 of Biological Diversity Rules 2004.

2. Municipal Committee Leh has 13 wards. As per the Census India 2011, MCL has a population of 10754 of which 6524 are males and 4230 are females.

3. In the preliminary filed survey, from September to November 2022, for collecting the forest diversity of Municipal Committee Leh, 06 shrubs species, 30 herbs, 09 grasses, 01 climber, 11 medicinal plants, 4 timber plants, 87 birds, 10 mammals, 45 insects, 3 fishes, and 01 reptiles were identified and described by the local inhabitants.

4. The preliminary inventory of Agro-biodiversity of Municipal Committee Leh, 08 agriculture crops (01 rabi, 03 kharif, and 04 fodder), 108 horticulture plants (10 fruit plants, 26 vegetable plants, 40 floriculture plants, and 32 ornamentals plants), 08 cultivated medicinal plants, 10 animal husbandry livestocks (09 animals and 01 bird) were identified (Fig. 64).

Fig. 64: Representative flora and fauna of Municipal Committee – Leh, Ladakh UT

Summary of the Completed Projects/ Activities

Characterizing Patterns and Processes of Alpine Ecosystem in Indian Himalaya with Special Emphasis to Kumaon, Uttarakhand Alpine 2 (SAC, ISRO, 2019-2023)

Mountains reflect a huge diversity of flora and floral communities within a small geographical distance. Elevation-related environmental factors like increasing solar radiation, decreasing surface area, less carbon dioxide partial pressure, and less temperature are vital forces of species composition and community patterns in mountain ecosystems. Plants are shifting from their actual ranges to higher elevations and also to a wide range of taxonomic groups and geographical locations due to climate warming. From the last three to four decades, an unusual trend in climate warming (1.2°C per decade at high elevations) has been observed in the Himalayas, and these trends are expected to have significant effects on plant species distribution patterns. Climate warming in the Himalayas has led to a shift in timberline. A transition zone between alpine pastures and the end of a continuous temperate forest ecosystem is known as a timberline ecotone. With this view, the following objectives were framed to study the alpine ecosystems of Kumaon Himalaya:

- Understanding the alpine ecotone structure and function through space-based and *in-situ* observations

- Assessment of nutrient dynamics, physiognomy, and ecophysiology along an elevational gradient in alpine treeline ecotone

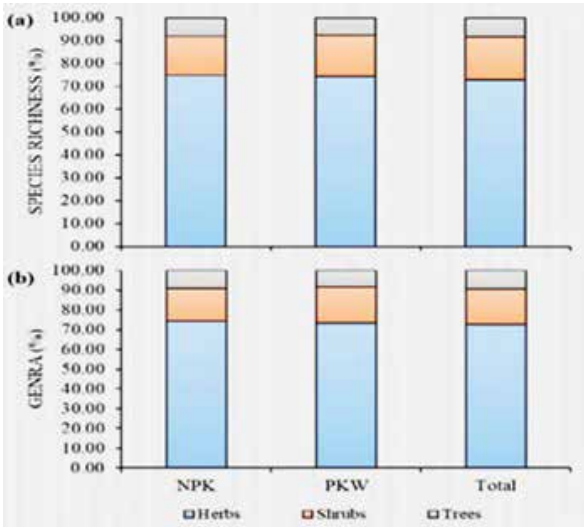


Fig.65: Proportional distribution of (a) Species &; (b) Genera in different life forms

For the present study, two HIMADRI summits situated in the Bageshwar district of the Kumaun Himalaya viz. Nan-Pakhwa (NPK) and Pakhwa (PKW) were selected, and floral diversity through the transect method was conducted. A total of 96 plant species were recorded from target sites. Of these, the greater share (72.92%; 70 spp.) was of herbs, followed by shrubs (18.75%) (18 spp.) and trees (8.33%) (8 spp.) of the total floral species richness. Herbs shared a greater proportion of species richness in both of the study sites (PKW74.36%, NPK- 74.71%) followed by shrubs (PKW- 17.95%, NPK- 17.24%) and trees (PKW7.69%, NPK- 8.05%) (Fig. 65).

Soil microbial biomass carbon (SMBC) ranges from 203.76 to 490.52 mg g-1 at NPK site, the lowest value was reported at BT plot and highest AT plots; at PKW site SMBC ranged from 262.93 to 592 mg g-1 at BT and AT plots, respectively. Soil microbial biomass nitrogen (SMBN) ranges from 97.06 to 104.61 mg g-1 at NPK site, with the lowest value at BT and highest at AT plots, respectively.

Similarity indices of herb, shrubs and trees showed that the flora above treeline plots and lower treeline plots of NPK and PKW had the least similarity. Meanwhile, high similarity was reported between herbs of AT plots of both sites i.e., in meadows, nearly similar herb species composition was recorded at both study sites. In the case of shrubs and trees, more similarity was observed between treeline and BT plots of NPK and PKW sites, respectively. Overall, higher mean soil moisture and water holding capacity were recorded at PKW site compared to the NPK site. Total organic carbon and total nitrogen content showed an increased concentration at higher plots and an increasing trend with elevation. The mean value of these parameters was reported to be higher at the PKW site. Total phosphorus content showed an inverse relation with elevation and hence lowers with increasing elevation. On moving from treeline to meadows, its concentration decreases overall, in the NPK site, it was reported higher than the PKW site. The total concentration of potassium increases with elevation, and its concentration increases from below treeline to above treeline. Soil microbial biomass carbon and nitrogen also showed an increasing trend with elevation, like total organic carbon and total nitrogen. Overall, higher soil microbial biomass carbon

and nitrogen were reported from PKW site. Leaf trait data of four dominant tree species were calculated, and varying trend of leaf traits was reported in both sites. A positive correlation was reported between chlorophyll a, b, and leaf dry matter content. Leaves of *A. spectabilis* were reported with the highest leaf water content and total carbon content. Leaves of *Q. semecarpifolia* were reported with the highest specific leaf area, leaf dry matter content and total nitrogen content. The highest chlorophyll content was reported for the *R. barbatum* followed by *R. arboreum*. The fluctuating trend of leaf traits was reported in both sites without any elevation linkage.

Major outcomes

- At the above treeline plots of the NPK site, a total of four tree species in different forms were reported, of which two species, viz. *Rhododendron arboreum* and *Qurecus semecarpifolia* were reported in all three forms.

- Soil moisture and water holding capacity showed similar trends and increase with increasing elevation, i.e., increases on going from below treeline to above treeline plots in both study sites.

MOUNTAIN DIVISION REGIONAL CENTRE (MDRC)

Considering the importance of the Himalayan region as a unique treasure of environmental goods and services and a rich repository of biodiversity, including cultural and ethnic diversity, and realizing its sensitivity to natural disasters and climatic and anthropogenic perturbations, MoEF&CC has established a dedicated unit as "Mountain Division" as 5th unit of NIHE with in the MoEF&CC to address specific issues of the mountain ecosystem in an integrated manner within divisions of the MoEF&CC, across the relevant key Ministries, and with NGOs and Academia to ensure conservation of mountain ecosystem and sustainable development of the mountain regions. The envisaged broad objectives of the Mountain Division are i) To contribute to the sustainable development of mountain ecosystems in an integrated manner within divisions of the ministry and across the key ministries; ii) To sharpen focus on mountain issues by bringing in "Mountain Perspective" across policies, programmes, missions and schemes; iii) To foster linkages between upstream and downstream regions by influencing policy & planning based on mutual dependence; iv) Develop a suitable framework of incentives for providers of ecosystem services. To achieve the objectives of the division, the following project-based studies are launched through Himalayan Research Fellows and Associates.

Assessment of Managed Spring Recharge as a Sustainable Solution to Water Scarcity in Sikkim Himalaya: Adaptation to Climate Change (Mountain Division, 2021-2024)

Mountain springs, the primary source of water for rural households in the Himalayan region, are drying up due to increased water demand, land use change, and ecological degradation. With climate change and rising temperatures, rise in rainfall intensity and reduction in its temporal spread, and a marked decline in winter rain, the problem of dying springs is increasingly felt across the Indian Himalayan Region. Many artificial recharge schemes have been implemented to augment groundwater resources. The technical, societal, economic and environmental impacts of these schemes are seldom evaluated in detail and thus, their effectiveness is often difficult to quantify. This project aims to systematically assess traditional and advanced spring recharge schemes cost-benefit Analysis (CBA) to evaluate the socio-economic profitability of the spring recharge activities and their effectiveness as sustainable solutions for water scarcity. The outcomes of the study is expected to provide an assessment of post-implementation sustainability of spring recharge schemes/activities leading to policy-level planning for effective implementation of the spring recharge in the Himalaya.

Objectives:

- To document good practices of water conservation in Sikkim Himalaya as an adaptation to climate change
- To study water balance (demand - availability) and water governance of selected spring sheds and analyze factors of spring outflow drying
- To assess the effectiveness and cost benefit of managed spring recharge experiments in Sikkim Himalayan region

Achievements:

1. 13 major indigenous soil and water conservation practices for Punzitar village and 14 for Alley village (the two pilot study villages in South Sikkim district) have been documented (Fig. 66; 67).

2. The water balance (demand- supply) and water governance of the study villages has been studied. In both the villages, current per capita domestic water consumption was higher than the value prescribed under Jal Jeevan Mission (JJM) of 55 liter per capita per day (lpcd).

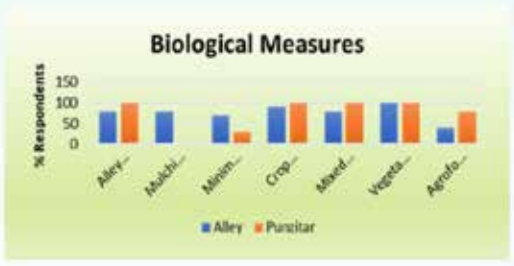


Fig. 66. Structural measures

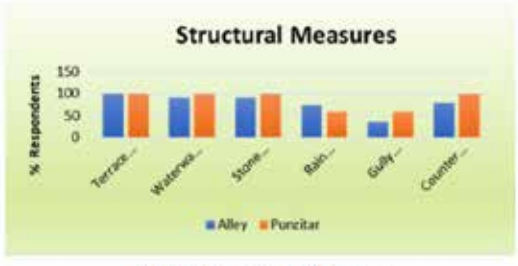


Fig. 67. Biological Measures

Policy imperatives of socio-economic development related environment-friendly rural technologies promoted by NIHE across the IHR: Prospects and constraints (Mountain Division, 2022-2024)

Over the years, the need for an integrated and sustainable approach to livelihood improvement through Natural Resource Management in the Himalayas has been realized. In this context, the Institute established a Rural Technology Complex (RTC) in 2001-02 at its HQs Kosi-Katarmal, Almora and also such RTCs in the Regional Centers of the NIHE across IHR, where some relevant R&D-based mountain-specific rural technologies were demonstrated for training and capacity building of rural people/farmers and other stakeholders for their large-scale replication across the IHR. In this process, feedback from the stakeholders was taken regularly since the early years of the RTC set-up to improve these technologies. However, there is a need to analyze these feedback forms to draw inferences to improve our methods/approach further. The project aims to identify issues influencing the interests of stakeholders towards the adaptability of different environment-friendly, low-cost, livelihood-enhancing technologies promoted by the RTC of NIHE over the last three decades and progression and performance after the implementation of these technologies for the policy imperatives through the assessment of feedbacks, ground truthing and validation of activities.

Objectives:

- Synthesize scientific basis and efficacy of various R&D-based rural technologies popularized and up-scaled by RTC in achieving environmental conservation and socio-economic development of rural people of IHR involving field-checks among the selected stakeholders those who have adopted these technologies
- Identify conceptual and implementation pitfalls in these technologies to achieve envisaged goals
- Scoping of institutionalization and scaling up of these technologies through rural development schemes / programmes of State / Central Govt. with policy imperatives for the region

Achievements:

1. Analysis of the feedback forms available at RTC (NIHE), since its establishment (2001-02), has been conducted. The highest number of farmers wanted to adopt protected cultivation (>90%), followed by bio-briquetting (>80%), bio composting (>60%) and Integrated Fish Farming (IFF) (>60%). A relatively lower percentage of farmers preferred to take up mushroom cultivation, vermicomposting, beekeeping and poultry farming.

2. More than a hundred beneficiaries from Uttarakhand have been selected for post-implementation feedback, and so far, 55 beneficiaries of Almora, Bageshwar, Pauri, and Chamoli districts and four line Departments have been approached for analysis for feedback which is being analyzed. The present status of analysis has revealed that all the respondent has adopted protected vegetable cultivation (100%), followed by cash crop cultivation, poultry farming, IFF and beekeeping. This is attributed to minimising the risk of crop failure due to the continuous threat to field crops by wild animals like monkeys, wild boars, etc.

3. Scientific validation of a few technologies such as protected cultivation, organic farming and IFF adopted by the stakeholders in the last decade is also being done through validation and documentation along with analysis by visit of farms of targeted farmers to upscale and popularize the suitable technologies (Fig. 68).

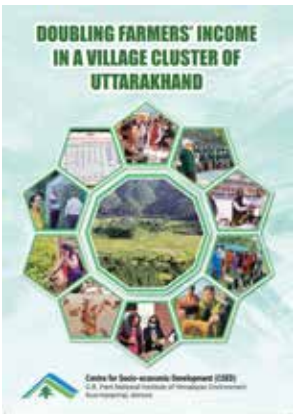


Fig. 68: Training programs and manual on Doubling Farmer's Income in a Village Cluster of Uttarakhand

Springs Ecosystem in Uttarakhand Himalaya: Boundary Protocol for Rejuvenation Policies (Mountain Division, 2022-2024)

Spring is one of the most important sources of fresh water. The Indian Himalayan region is the source of millions of springs and many big and small rivers in this region. People in the Himalayas heavily depend on the springs for household, livestock and irrigation water needs. Various studies conducted in the last few decades have reported that the discharge of the springs, in general, has declined, and the quality of water has also degraded due to the changing rainfall pattern and human interferences and activities. Most of the perennial springs have now turned seasonal, and many have dried up. This is not only a matter of concern for recharge of the spring but is also important in terms of the spring's ecosystem. With the changing and declining water discharge pattern, the ecosystem dependent on spring is also degrading. Springs have been scientifically understudied and overlooked. In the past few decades, much has been done to rejuvenate springs in different areas, but literature and reports on the ecological importance of springs still remain absent. Ministry of Jal Shakti, GoI, has released a framework document to set a policy pathway for spring rejuvenation; however, the aspect of the spring ecosystem is not considered. Some springs have the potential to support an entire ecosystem, but the springs have been studied in view of the anthropocentric approach. A healthy spring possesses great potential for a thriving, healthy ecosystem. This study focuses on the restoration of spring-dependent ecosystems and its dynamics.

Objectives:

- Collection and compilation of spring ecosystem information and activities of different regions of Uttarakhand Himalaya
- To develop a RS/GIS based protocol to delineate the spring ecosystem boundaries based on the ecosystem functions and services
- To recommend a Decision Support System (DSS) that would help in appropriate policies for enhancing the productivity of a spring ecosystem with regard to socio-cultural services

Achievements:

1. In order to develop a RS/GIS-based protocol to delineate the spring ecosystem boundaries based on the ecosystem functions and services, the annual recharge using the water balance method and surface water estimation using SMAP has been estimated (Fig. 69).

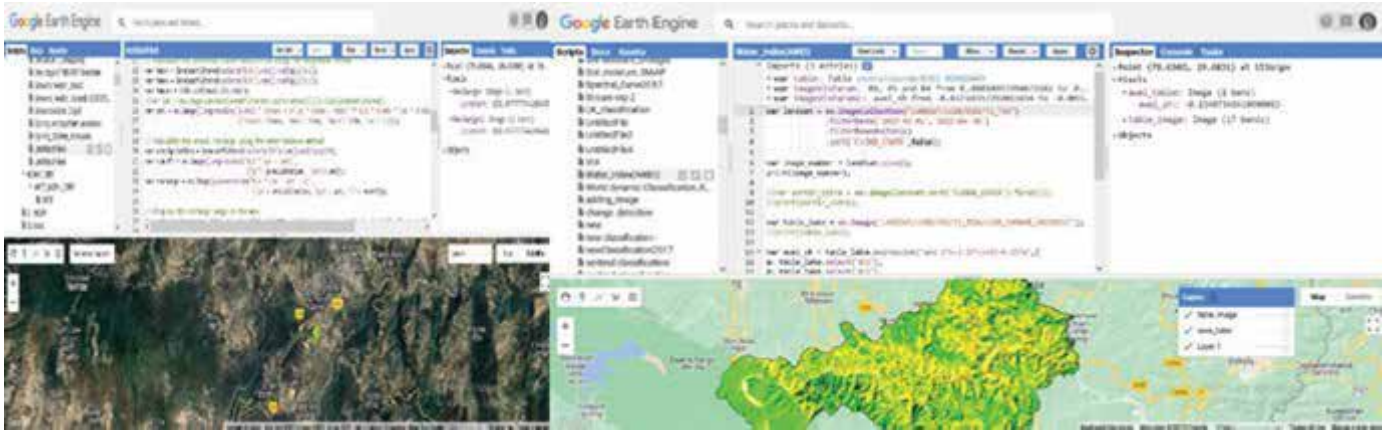


Fig. 69. Surface water estimation using SMAP and Annual recharge using the water balance method

Carrying Capacity Estimation of Tourism in Leh Town Complex in Ladakh (Mountain Division, 2021-2024)

The tourism industry is one of the fastest-growing sectors across the globe. During the last few decades, remarkable growth has been seen in the global tourism industry. Ladakh is no exception to this global trend, where the influx of tourism has increased manyfold during the last few decades. The year 2021 has made history of surpassing all previous records of tourist arrivals in the region with 3.1 Lakh tourists. Every place has a carrying capacity in terms of the number of tourists it can serve without compromising the quality of tourism and the local environment. For the sustainability of tourism, each tourist destination must have its carrying capacity assessed to check exploitation. Therefore, the proposed study is planned to understand the role of tourism, perception mapping of diverse stakeholders in Leh Town, and identification

of critical factors for the town's sustainability and its environment. In this study, a geospatial database using crowd-sourcing for spatial planning and management in vital sectors of Leh Town will be developed to support the decision-making process and for planning and management. A status report on the carrying capacity of tourism on the basis of critical factors will be developed with an orientation towards the environmental sustainability of Leh town. The output of the project is expected to provide a framework for the action plan and guidelines for sustainable tourism in the Ladakh region to achieve environmental sustainability in tourism and allied sectors of the Leh town complex.

Objectives:

- To understand the role of tourism, perception mapping of diverse stakeholders in Leh town, and identification of critical factors for sustainability of town and its environment
- To develop a geo-spatial database, using crowd sourcing, for spatial planning and management in vital sectors of Leh Town
- To analyze carrying capacity of tourism on the basis of critical factors identified, and with respect to sustainability of natural environment of Leh town
- To provide framework for action plan and guidelines for sustainable tourism in Leh and Ladakh region.

Achievements:

1. A geospatial database of public facilities, hotels, guesthouses and homestays surrounding Leh town was prepared (Fig. 70).

2. Database for number of tourists (Domestic and International) visiting Leh during 1974-2022 per year was prepared; till date, around 36,11674 tourists had visited Ladakh, which comprises 909002 foreigners and 2702672 domestic tourists.

3. Linear enhancement in the number of accommodations, which includes hotels, guesthouses and, homestays, and tourist inflow, was noted.

4. The monthly total solid waste generation in Leh Town was computed from April 2021 to February 2022. The peak solid waste generation (~142 Qt) was noted in July 2021; however, the peak tourist inflow (94740) was noted in September 2021 (Fig. 70).

Fig. 70. Map of Public facilities in Leh and Tourist flow (Domestic and Foreign) in Ladakh from 2021-2022

Biodiversity Policy Landscape in Indian Himalayan Region (IHR) for Conservation, Sustainable utilization and Community Livelihoods (Mountain Division, 2022-25)

Biodiversity-rich landscapes like the Himalayas provide an array of livelihood opportunities to the millions of people living in its periphery and beyond. In a conservation context, people's dependence on the natural ecosystems of the landscape warrants the inclusion of livelihood consideration as well. Therefore, the concept of livelihood enhancement, livelihood diversification, and alternative livelihood needs to be a part of conservation projects or policies. Considering this, the present study is proposed to analytically review the existing policy arena along the biodiversity landscape in the Indian Himalayan Region (IHR) along with documentation of successful bio-resource-based livelihood models.

Objectives:

- Collection and compilation of National and State level policy documents w.r.t. biodiversity conservation
- Analysis and synthesis for development of National and State level policy chapters through review and consultative workshop
- Documentation and analysis of successes stories on bio-resources based enterprises through individual consultation
- Recommendation for strengthening the policy landscape

Achievements:

1. 41 National policies /rules w.r.t. Biodiversity Conservation collected & compiled (Fig. 71)
2. 114 State policies /rules w.r.t. Biodiversity Conservation collected & compiled
3. Success stories (06) identified and documentation framework prepared
4. Stakeholder's consultations (04) held for documentation of best practices of Biodiversity conservation in Pithoragarh

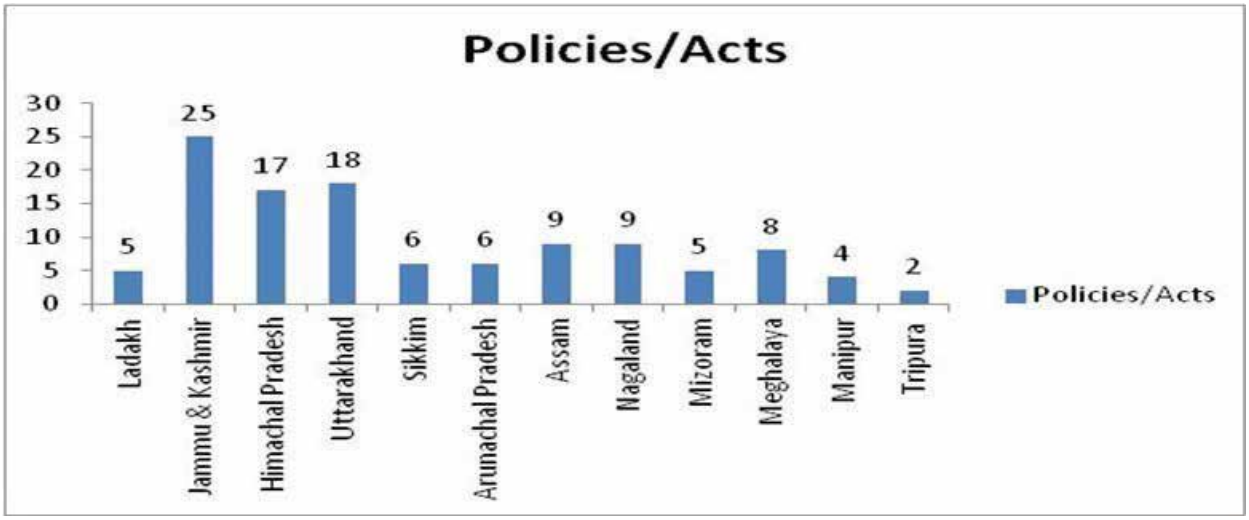


Fig. 71. Policies/Acts 10 States and 2 UT

Understanding the Process of Change in Far-Eastern Indian Landscape Linking with Conservation and Management (Mountain Division, 2019-2023)

The Far-Eastern landscape, while rich in its natural resources, is also equally known for its extreme vulnerability to changing faces of development and global climate. There are numerous conservation and developmental challenges. Agriculture expansion and illegal wildlife trade are on the rise, mainly manifested by acute poverty. Other challenges include limited conservation and development investments and, inadequate capacity and skills of communities and climate change. Collaborative efforts need to support the conservation of complex biodiversity and address poverty through conservation-linked developmental strategies. The proposed study will help in understanding the various drivers of change (land use, climate, social, etc.), formulating comprehensive planning for sustainable landscape development, and ensuring adaptation to climate change and the well-being of people. The study will also help in formulating plans/policies for sustainable livelihood development. It also envisages addressing poverty and climate change threats through designing good practices and technology transfer among the local communities and strengthening policy environment through state and national policy analysis.

Objectives:

- To develop baseline database on socioeconomic status, ecosystems and cultural diversity of the landscape including drivers of change
- To study the land use /land cover change, climate change and other dynamic systems of the landscape

Achievements:

1. Documented the handloom and handicraft, which are mainly produced by the natural sources by four different communities (i.e. Tutsa (49 Nos.),

Tangsa (48 Nos.), Chakama (30 Nos.) and Singpho (28 Nos.)) at fringes of Namdapha National Park, Arunachal Pradesh (Fig. 72).

2. The cost-benefit assessment based on local people's interviews informed that a skilled person took significant effort and time to make a particular handicraft. For example, it takes 2-3 man-days to prepare a simple bamboo basket (locally known as 'Bareng'), and it is sold for Rs. 400.00 only in the market. So, the practitioners are not even getting their labour cost. This discourages the local people, and the practice is declining with time.

3. A training cum Awareness Workshop on "Promotion of local Handicraft for Sustainable Livelihood" was conducted at the M'Pen II Village, Changlang, Arunachal Pradesh on 18th January 2023 with local tribes. A total of 21 persons were participated in the programme.

Fig. 72: Different Plant based product used by Tatsa, Tangsa, Chakma and Singpho tribes in handloom and handicraft preparations

APPLICATION OF R&D OUTPUTS IN DEMONSTRATION AND DISSEMINATION

Environmental Information, Awareness, Capacity Building and Livelihood Programme (EIACP) Centre on Himalayan Ecology at the Institute HQs (MoEF&CC, GoI, 1992 - Long Term Scheme,)

EIACP Centre on Himalayan Ecology formerly known as Environmental Information System Centre on Himalayan Ecology (ENVIS) was set up in the Institute in the financial year 1992-93 as a part of ENVIS network in India by the Ministry of Environment, Forest & Climate Change (MoEF&CC), Govt. of India; the nodal agency in the country for collecting and collating all available information from 60 ENVIS Centres nationwide to provide national scenarios to the international set up, INFOTERRA Programme, of the UNEP.

Objectives:

- To collect, collate, compile and build qualitative and quantitative database of information related to various aspects of Himalayan Ecology
- To disseminate all available information, free of cost, to various stakeholders/users including all the District Information Centres (operating in the Himalayan states of the country), EIACP Centres / Nodes and other user agencies/groups through print and electronic media
- To develop, up-grade and maintain EIACP website at the headquarters of the Institute

Achievements:

- The Centre collected, collated and synthesized the quantitative and qualitative databases on various aspects of Himalayan Ecology from authentic data sources covering important segments, e.g., demography, literacy, land, water, agriculture, horticulture, forest cover, protected areas, weather profiles, etc. and also compiled data on subject experts and important web links related to Himalayan Ecology.

- EIACP Centre also published ENVIS Bulletin Himalayan Ecology (Vol. 29, 2021) on the theme of Ecosystem Restoration in Himalaya. In addition, four thematic ENVIS Newsletters Vol. 18(1-4), 2021 on (i) Biodiversity Conservation Research in IHR: A futuristic view for solutions, (ii) Ecosystem Restoration, (iii) Community Driven Environmentally Sustainable Village Programme, and (iv) Dynamics of Timberline in the Himalaya were published. A Book entitled "Katarmal Gram ki Jaiv-Vividhta" as an outcome of Preparation of People's Biodiversity Register under GSDP course was also published and released during Annual Day of the Institute on 10 September 2021.

- The Centre conducted two certificate courses on Green Skill Development Programme (GSDP) namely (a) Value Addition and Marketing of NTFPs (Animal Origin): Wild Bee Keeping and Processing, and (b) Bird Identification and Basic Ornithology. Total 60 trainees from 13 districts of Uttarakhand were trained through these GSDP courses following national standards set by EIACP Secretariat, MoEF&CC.

- EIACP Centre conducted a meeting in Supi village, Kapkot sub division, Bageshwer District adopted under Community Driven Environmentally Sustainable Village Programme (CESVP) Saansad Adarsh Gram Yojana (more details: http://gbpihedenvis.nic.in/csevp.html.)

Integrated Eco-development Research Programme (IERP) in the Indian Himalayan region (MoEF&CC, GoI,1992- Long Term Scheme)

Ministry of Environment, Forest & Climate Change (MoEF&CC), Government of India entrusted the responsibility of Integrated Action Oriented Research, Development and Extension Programme (named as Integrated Eco-development Research Programme - IERP) in the IHR to the Institute in 1992. Through this scheme the Institute extends R&D support to Universities, R&D organizations and NGOs working in the IHR under two broad thrust areas (i.e., Technology Development and Research for Integrated Eco-development, and Technology Demonstration Extension) covering 4 thematic areas (viz; land and water resource management, biodiversity conservation and management, environmental assessment and climate change and socio-economic development) of the Institute. IERP has set-out a format (Hindi/English) and guidelines for applying under this scheme by various stakeholders across the IHR.

Objectives:

- To provide extramural funds to different Universities/Institutions/NGOs/Voluntary agencies for the support of location-specific R&D activities in the IHR
- To develop scientific capabilities in the IHR and strengthen infrastructure for environmental research
- To develop and execute coordinated programmes as per R&D needs of the IHR

Achievements:

- A total of 369 R&D projects have been supported by IERP so far to various Universities, Institutions, NGOs and Government organizations across IHR; out of them, 337 projects have been successfully completed.

- Currently, 32 R&D projects are under various stages of implementation, covering 7 States (namely, Assam, Arunachal Pradesh, Meghalaya, Mizoram, Sikkim, Tripura and Uttarakhand).

- Regular monitoring of project activities is carried out, and feedback is received from project implementing agencies and communicated to project PIs.

Central Laboratory Services

The institute has centralized facilities for physicochemical, biological, and heavy metal analysis of fresh and wastewater, soil and plant products. Quantification of organic compounds (mainly volatiles) of water, soil and plant samples is done using a Gas chromatograph (Chemito, Ceres 800plus), elemental analysis (carbon, hydrogen, nitrogen, and sulphur) of solid samples is carried out using CHNS analyzer (Elementar, Vario EL-III). The heavy metals in the liquid samples (such as water, digested soil and plant samples) are detected through an Atomic Absorption Spectrophotometer (Varian AA280Z, equipped with graphite tube atomizer). Along with this, the central facility is equipped with various other minor instruments such as UV-VIS spectrophotometer (Shimadzu), flame photometer (Systronics), digestion systems (Pelican, India), extraction units (MAC, India), etc. The Institute has extended these services to other organizations (NGOs and Government Organizations) on a payment basis. Individuals (researchers and villagers) are also using the facility for sample analysis. In the financial year 2022-23, the Institute collected Rs. 82,246 /- as a Central laboratory service charge from different organizations including two public organizations, three NGOs, and two requests from individuals. The Central Lab has also facilitated Institute research work (In-house and externally funded projects) in sample analysis using AAS, GC & CHNS (Fig. 73).

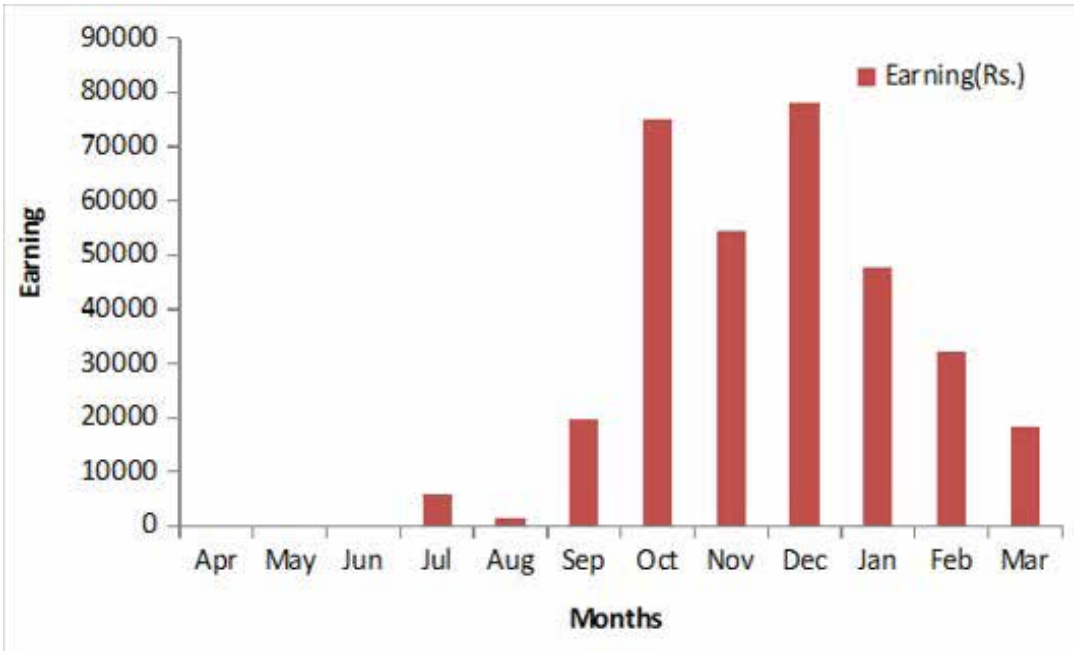


Fig.73: Month wise Income generated through sample analysis

MISCELLANEOUS ITEMS

SCIENTIFIC PUBLICATIONS

1. SCIENTIFIC JOURNALS:

INTERNATIONAL

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INDEPENDENT AUDITOR'S REPORT

To
The Members of
G.B. Pant National Institute of Himalayan Environment

Opinion

In our opinion and to the best of our information and according to the explanations given to us, the financial statements of **G.B. PANT NATIONAL INSTITUTE OF HIMALAYAN ENVIRONMENT (A Institute of Govind Ballabh Pant Himalaya Paryararan Evam Vikas Society)** for the year ended **March 31, 2023** are prepared, in all material respects, in accordance with The Law of India.The said account gives the information required and gives a true and fair view in conformity with the Accounting Principles generally accepted in India.

(a) In the case of Balance Sheet, of the State of Affairs of the Institute as at 31st March 2023.

(b) In the case of Income and Expenditure Account the Income / expenditure for the Year ended on that date.

(c) In the case Receipt and Payment Account the Receipt and Payment on Cash and/or Bank account during the Year ended on that date.

Bases of Opinion

We conducted our audit in accordance with Standard on Auditing (SAs). Our responsibilities under those Standards are further described in the Auditors's Responsibilities for the audit of the Financial Statements section of our report. We are independent of the Institute (Govind Ballabh Pant Himalya Paryavaran Evam Vikas Societys) in accordance with the Code of Ethics issued by the Institute of Chartered Accountants of India (ICAI) together with the ethical requirements that are relevant to our audit of the financial statements and we have fulfilled our other responsibilities in accordance with these requirements. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our qualified opinion.

Key Audit Matters

Key audit matters are those matters that, in our professional judgement were of most significance in our audit of the financial statements of the current period. These matters were addressed in the context of our audit of the financial statements as a whole, and in forming our opinion thereon, and we not provide a separate opinion on these matters. In addition to the matters described in the basis of Qualified Opinion section we have determined the matters described below to be the key audit matters to be communicated in our report.

Key Audit Matters	Auditor's response
None	None

Anil Shalini & Associates DELHI FRN 009960C Chartered Accountants

1

Emphasis of Matters or Other Matter

Institute has ordered for procurement of Scientific Equipment from abroad against which in the books of the Institute Rs. 2,59,19,380.56 is outstanding in the Head of Current Assets (FDR's & LC Margin). These outstanding pertain to (FDR's & LC Margin) against which Scientific Equipment have already been received, so this amount should be booked in fixed assets and total current assets balance to be reduced to that extant.

Institute has not booked bank charges debited by bank related issuance of pass book etc. since past years with contention that they have requested to bank to waive the same being Government Institute, we are of the view that same should be booked in the Books of Accounts as these are outstanding since long time.

Responsibility of Management and Those Charged with Governance for the Financial Statements

Management is responsible for the preparation of these financial statements that give a true and fair view of the financial position, financial performance, Receipt & Payment of the Institute in accordance with the accounting principles generally accepted in India, Including the Accounting Standards prescribed by the Institute of Chartered Accountants of India. This responsibility also includes maintenance of adequate accounting records in accordance with the provision of the Act for safeguarding of the assets of the Society and for preventing and detecting fraud and other irregularities, selection and application of appropriate implementation and maintenance of accounting policies, making judgements and estimates that are reasonable and prudent, and design, implementation and maintenance of adequate Internal Financial Controls, that were operating effectively for ensuring the accuracy and completeness of the accounting records, relevant to the preparation and presentation of the financial statement that give a true and fair view and are free from material misstatement, whether due to Fraud or Error.
In preparing the financial statements, managements is responsible for assessing the Institute's ability to continue as a Going Concern, disclosing, as applicable, matters related to going concern and using going concern basis of accounting unless management either intends to liquidate the Institute or to cease operation, or has no realistic alternative but to do so.
Those Charged with Governance are also responsible for overseeing the Institute's financial reporting process.

Auditor's Responsibility

Our responsibility is to express an opinion on these financial statements based on our audit. We conducted our audit in accordance with the Standards on Auditing issued by the Institute of Chartered Accountants of India. Those Standards require that we comply with ethical requirements and plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedures selected depend on the auditor's judgement, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to the Societies preparation and fair presentation of the financial statements in order to design audit procedures that are appropriate in the circumstances. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of the accounting estimates made by management, as well as evaluating the overall presentation of the financial statements.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

Report on Other Legal and Regulatory Requirements

a. We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purpose of our audit;

b. In our opinion proper books of account as required by law have been kept by the society so far as appears from our examination of those books maintained at Head Office at Kosi- Katarmal, Almora.

c. The Balance Sheet, Income and Expenditure Account, dealt with by this Report are in agreement with the books of account maintained by the Society;

d. In our opinion, the Balance sheet, the Statement of Income and Expenditure and the Receipt and Payment account comply with the Accounting Standards referred to in Societies Act 1860.

e. Observation reported in previous period audit report corrected to the extent not reported hereinabove.

Date: 25.06.2023

Place: Almora

For Anil Shalini & Associates
(Chartered accountants)

25/6/2023

Anil Kumar Shukla
FCA, DISA
M NO.075418
FRN. 009960C
UDIN: 23075418BGWZUV6781

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G.B.PANT NATIONAL INSTITUTE OF HIMALAYAN ENVIRONMENT
KATARMAL, KOSI (ALMORA) UTTARAKHAND
BALANCE SHEET AS ON 31ST MARCH 2023

PARTICULARS	SCHEDULE	CURRENT YEAR (₹)	PREVIOUS YEAR (₹)
LIABILITIES			
CORPUS / CAPITAL FUND	1	3,88,65,555.82	2,39,17,363.46
RESERVE AND SURPLUS	2	37,73,99,228.50	37,49,15,263.25
EARMARKED / ENDOWMENT FUNDS	3	-	-
SECURED LOANS & BORROWINGS	4	-	-
UNSECURED LOANS & BORROWINGS	5	-	-
DEFERRED CREDIT LIABILITIES	6	-	-
CURRENT LIABILITIES AND PROVISIONS	7	25,45,64,071.63	26,20,63,391.65
TOTAL		**67,08,28,855.95**	**66,08,96,018.36**
ASSETS			
FIXED ASSETS	8	37,73,99,228.50	37,49,15,263.25
INVEST. FROM EARMARKED/ENDOWMENT FUND	9	1,11,92,560.18	68,76,296.82
INVEST. OTHERS	10	-	
CURRENT ASSETS , LOANS, ADVANCES ETC.	11	28,22,37,067.27	27,91,04,458.29
MISCELLANEOUS EXPENDITURE			
TOTAL		**67,08,28,855.95**	**66,08,96,018.36**
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES & NOTES ON ACCOUNTS	25		

AUDITOR'S REPORT
As per our separate report of even date annexed.
For: Anil Shalini and Associates
CHARTERED ACCOUNTANTS

(Anil Kumar Shukla) 25/6/2023
FCA PARTNER
M.NO.075418
FRN: 009960C

DATED : 25.06.2023
PLACE : KOSI- KATARMAL, ALMORA
UDIN: 23075418BGWZUU6788

25/6/2023

(Prof. SUNIL NAUTIYAL)
DIRECTOR

(DR. MITHILESH SINGH)
D.D.O

(L. M.S. NEGI)
ACCOUNTS OFFICER

Anil Shalini & Associates * DELHI FRN: 009960C * Chartered Accountants

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G.B.PANT NATIONAL INSTITUTE OF HIMALAYAN ENVIRONMENT
KATARMAL, KOSI (ALMORA) UTTARAKHAND
INCOME & EXPENDITURE A/C FOR THE YEAR ENDED 31ST MARCH 2023

PARTICULARS	SCHEDULE	CURRENT YEAR (₹)	PREVIOUS YEAR (₹)
INCOME			
Income from Sales/Services	12	4,53,459.00	3,24,946.00
Grants/Subsidies(net off exp)	13	29,24,49,568.93	23,91,10,125.72
Fees/Subscriptions	14	-	-
Income from Investment	15	-	-
(to the extent of depreciation & WDV of asset sold)		-	-
Income from Royalty, Income from Inv. Publication etc.	16	-	-
Interest Earned	17	2,35,030.00	5,23,667.00
Other Income	18	89,43,603.36	1,03,52,833.64
Increase (decrease) in stock of Finished goods and work in progress)	19	-	-
TOTAL (A)		**30,20,81,661.29**	**25,03,11,572.36**
EXPENDITURE			
Establishment Expenses: a) Institute	20	15,16,34,888.00	12,97,67,657.00
b) Projects		2,82,33,879.00	2,18,57,861.00
c) F.C (Projects)		19,07,078.00	8,32,159.00
Administrative Expenses :a) Institute	21	6,70,39,760.73	5,18,90,810.46
b) Projects (As per Annexure)		3,25,76,037.20	2,19,82,565.26
c) F.C (Projects)(As per Annexure)		22,45,411.00	68,35,354.00
Expenditure on Grants, Subsidies etc.	22	88,12,515.00	59,43,719.00
Interest			
Depreciation (Net Total at the year-end-as per Sch. 8)		3,78,09,941.74	3,92,22,252.49
TOTAL (B)		**33,02,59,510.67**	**27,83,32,378.21**
Balance being excess of Income over Expenditure (A - B)		**(2,81,77,849.38)**	**(2,80,20,805.85)**
Transfer to special Reserve			
Transfer to/ from General Reserve			
BAL.BEING SURPLUS TRF.TO CORPUS FUND (Other Income)		**(2,84,12,879.38)**	**(2,85,44,472.85)**
BAL.BEING SURPLUS TRF.TO CORPUS FUND (Corpus Interest)		**2,35,030.00**	**5,23,667.00**
Add: Transferred from General Reserve Fixed Asset Fund		**3,78,09,941.74**	**3,92,22,252.49**
Interest income of other Saving Accounts.			
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	25		

AUDITOR'S REPORT
As per our separate report of even date annexed.
For: Anil Shalini and Associates
CHARTERED ACCOUNTANTS

28/6/2023

(Anil Kumar Shukla)
FCA PARTNER
M.NO.075418
FRN: 009960C

DATED : 25.06.2023
PLACE : KOSI- KATARMAL, ALMORA
UDIN: 23075418BGWZUU6788

(Prof. SUNIL NAUTIYAL)
DIRECTOR

(DR. MITHILESH SINGH)
D.D.O

(L. M.S. NEGI)
ACCOUNTS OFFICER

G.B. PANT NATIONAL INSTITUTE OF HIMALAYAN ENVIRONMENT
KOSI-KATARMAL, | ALMORA | UTTARAKHAND
RECEIPTS & PAYMENTS A/C FOR THE YEAR ENDED 31ST MARCH 2023

RECEIPTS	CURRENT YEAR	PREVIOUS YEAR	PAYMENTS	CURRENT YEAR	PREVIOUS YEAR
I. Opening Balance			I. EXPENSES		
a) Cash in hand	1,59,812.56	1,04,070.70	a) Establishment Expenses		
	-	-	i) Institute	12,08,13,491.56	12,39,43,120.15
b) Bank Balance		-	b) Administrative expenses	-	
	-	-	a) Institute	3,83,32,193.00	4,19,99,554.83
i) In current accounts	-	-	b) R&D/ Rent expenses	2,87,06,971.73	81,83,202.60
ii) In deposit accounts (Corpus Fund)	58,70,296.82	1,75,24,901.27	c) Payments for current liabilities	2,72,71,072.00	41,24,841.00
iii) Savings accounts	19,70,96,538.02	12,65,58,337.18	C. Capital expenditure	-	
c) Advances & Others	7,27,29,956.21	7,75,16,197.40	a) Purchase of Fixed Assets	1,00,26,179.00	66,35,750.00
(As per annexure - Attached)	-	-	b) Expenditure on Capital Work in Progress	1,50,00,000.00	1,00,00,000.00
F.C. ACCOUNT	-	-	c) Acquirement of land (Lease money)	-	-
A) Cash in hand	0.33	4,026.33	II Payments made against funds for various proj.	-	-
b) Cash at bank	44,87,658.62	37,68,774.03	Expenditure State govt. projects		
c) FC Advances	9,15,331.00	13,13,331.00	a) Capital	2,02,07,728.00	1,01,77,183.00
II. Grants Received	-	-	b) Revenue:	-	
a) From Government of India	24,00,00,000.00	24,00,00,000.00	Establishment exp	2,82,23,879.00	2,15,07,861.00
i) Institute & IERP	-	-	Administration exp	3,25,76,037.20	2,13,35,986.31
Contribution corpus from CPF	26,88,050.00	25,11,503.00	Expenditure FC projects	-	-
b) From Other agencies	15,82,44,512.00	6,54,89,650.00	a) Capital	-	3,85,430.00
c) From other sources (from FC)	38,27,566.70	59,79,452.41	b) Revenue:	-	-
III. Income on Investments from	-	-	Establishment exp	19,07,078.00	8,33,188.00
a) Corpus Fund(Received from Institute)	-	-	Administration exp	23,76,083.00	17,04,683.80
IV. Interest Received	-	-	IERP grant released	88,12,515.00	59,43,715.00
a) On Bank deposits savings a/c		-	III Investments and deposits made	-	-
b)On term deposits a/c	-	-	Pension trust unit of corpus fund	26,58,050.00	7,05,90,759.61
c) Loans, Advances etc	-	7,027.00	IV Refund of Surplus money/Loans	-	-
d) Interest income Corpus Fund	2,30,030.00	5,13,661.00	a) To the Government of India	-	-
V. Other Income	-	-	b)To Others/ security / caution money	-	
Received in Corpus Fund	40,81,233.36	65,96,546.28	Refund to MoEF&CC (IERP/MCA)	-	
(As per annexure Attached)	-	-	V Other payments	-	-
VI. Amount Borrowed	-	-	Other Payment to Instt. FC Proj	-	-
VII. Any other receipts	53,18,829.05	40,81,233.36	Outgoing Balance (FC)	-	-
Interest Received in SNDS Payable to Government	-	-	Payment of Current Liabilities	-	-
	-	-	Refund of EMD		
Other Receipt FC a/c	-	-	Fund transfer to Corpus fund	40,81,233.36	65,96,546.28
a)Performance Guarantee	-	-	VI Closing balances	-	-
b) Receipts Current Liabilities	-	-	a) Cash in hand	1,13,436.02	1,59,812.56
c) IERP grants refunded by grantee Org.	-	-	b) Bank Balance	-	
d)Construction Fund	-	-	i) In Current account		
e) Corpus Fund PDFS	-	-	ii) In deposit accounts (Corpus Fund)	1,11,02,560.18	58,70,296.82
f) Caution Money		-	iii) In savings accounts	17,88,42,506.04	19,70,96,538.02
g) Security Deposit		-		-	-
h) EMD		-	C) Advances and others	9,82,41,804.59	7,27,29,956.21
i) Royalty	-	-	FC Project	-	
j) Sales Tax / GST	-	-	a) Cash in hand	-	0.33
k)Service Tax/GST	-	-	b) Bank Balance	40,27,149.32	44,87,658.62
	-	-	c) Advances and others	9,15,331.00	9,15,331.00
	-	-	Adjustment of previous year closing Advances	37,417.48	91,648.45
	-	-			
	-	-			
	-	-			
	-	-			
TOTAL	63,45,39,814.72	57,26,41,552.86	TOTAL	63,45,39,814.72	57,26,41,552.86

AUDITOR'S REPORT

As per our separate report of even date annexed.
For: Anil Shalini and Associates
CHARTERED ACCOUNTANTS

20/11/2023

(Anil Kumar Shalni)
FCA PARTNER
M.NO.073418
FRN: 009960C

DELHI FRN: 009960C

DATED : 25.06.2023
PLACE : KOSI-KATARMAL, ALMORA
UDIN: 23075418BAGWZUV6788

(PROF. SUNIL NAUTIYAL)
DIRECTOR

(Dr. MITHILESH SINGH)
D.D.O

(R.S. NEGI)
ACCOUNTS OFFICER

6 6

G.B.PANT NATIONAL INSTITUTE OF HIMALAYAN ENVIRONMENT
KOSI- KATARMAL, (ALMORA) UTTARAKHAND
SCHEDULES FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2023

PARTICULARS	CURRENT YEAR (₹)		PREVIOUS YEAR (₹)	
SCHEDULE 1-CORPUS / CAPITAL FUND :				
Balance as at the beginning of the year				
Opening Balance of Corpus Fund:	2,39,17,363.46		3,08,94,764.45	
Add : Interest & Other income Trf. From Income & Exp. a/c (Corpus Fund)	2,35,030.00		5,23,667.00	
Add : Contribution towards Corpus / Capital Fund	26,58,050.00		25,11,903.00	
Add: Transferred from General Reserve Fixed Asset Fund	3,78,09,941.74		3,92,22,252.49	
Less: Transferred to Pension Trust	26,58,050.00		(2,66,90,750.63)	
Less: Payment of 7th Pay Commission arrear (partially)	-		-	
Less: Payment of sale of vehicle to MoEF&CC	-		-	
Less: Bank Charges	-		-	
(Merger of endowment fund)	-		-	
Add/(Deduct) tf. From Income & Expenditure A/C	(2,84,12,879.35)		(2,85,44,472.85)	
Add: Intrest income from Previous Year	-		-	
BALANCE AT THE END OF THE YEAR		**3,88,65,555.82**		**2,39,17,363.46**

PARTICULARS	CURRENT YEAR (₹)		PREVIOUS YEAR (₹)	
SCHEDULE 2-RESERVE & SURPLUS :				
1. CAPITAL RESERVE :				
- AS PER LAST BALANCE SHEET	-		-	
- ADD : ADDITION DURING THE YEAR	-		-	
- LESS: DEDUCTION DURING THE YEAR	-		-	
	-		-	
2. REVALUATION RESERVE :				
- AS PER LAST BALANCE SHEET	-		-	
- ADD : ADDITION DURING THE YEAR	-		-	
- LESS: DEDUCTION DURING THE YEAR	-		-	
	-		-	
3. SPECIAL RESERVE : (CONSTRUCTION FUND)				
AS PER LAST BALANCE SHEET	11,38,17,203.00		11,21,97,203.00	
ADD : ADDITION DURING THE YEAR	1,00,00,000.00		16,20,000.00	
- LESS: DEDUCTION DURING THE YEAR	-		-	
(Adjustment)		12,38,17,203.00		11,38,17,203.00
	-	**12,38,17,203.00**		**11,38,17,203.00**
4. GENERAL RESERVE : (FIXED ASSETS FUND)				
- AS PER LAST BALANCE SHEET	26,10,98,060.25		27,31,60,904.74	
- ADD : ADDITION DURING THE YEAR	3,02,93,907.00		2,71,59,408.00	
- ADD : ADJUSTMENT DURING THE YEAR	(0.01)		-	
- Add: ADJUSTMENT OF PREVIOUS YEAR	-		-	
ADD: (Trf. From const fund a/c)				
- LESS: ADJUSTMENT DURING THE YEAR	-		-	
(WDV of asset sold during the year)	-		-	
Add: Transferred to Corpus Fund	3,78,09,941.74		3,92,22,252.49	
(Depreciation FOR 2022-23)				
		26,35,82,029.50		**26,10,98,060.25**
TOTAL (1 + 2 + 3 + 4)		**37,73,99,228.50**		**37,49,15,263.25**

Anil Shalini & Associates
DELHI
FRN: 009960C
Chartered Accountants

G.B.PANT NATIONAL INSTITUTE OF HIMALAYAN ENVIRONMENT
KOSI-KATARMAL, (ALMORA) UTTARAKHAND
SCHEDULES FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2023

SCHEDULE 3-EARMARKED / ENDOWMENT FUND :

PARTICULARS	Corpus FUND	CURRENT YEAR (₹)	PREVIOUS YEAR (₹)
(a) Opening balance of the fund			
(b) Additions to the funds	0.00	0.00	0.00
i. Donations/grants	0.00	0.00	0.00
ii.Income from invest made on account of funds	0.00	0.00	0.00
iii. Other additions	0.00	0.00	0.00
TOTAL (a + b)	**0.00**	**0.00**	**0.00**
(c) Utilization/Expenditure towards objectives of funds			
i. Capital Expenditure			
Fixed Assets	0.00	0.00	0.00
Others	0.00	0.00	0.00
Total	**0.00**	**0.00**	**0.00**
ii. Revenue Expenditure			
Salaries, Wages and allowances etc.	0.00	0.00	0.00
Rent	0.00	0.00	0.00
Other Administrative expenses	0.00	0.00	0.00
Total	**0.00**	**0.00**	**0.00**
Funds merged with corpus Fund as per Governing Body Decision:	**0.00**	**0.00**	**0.00**
TOTAL (c)	**0.00**	**0.00**	**0.00**
NET BALANCE AS AT THE YEAR-END (A+B-C)	**0.00**	**0.00**	**0.00**

SCHEDULE 4 SECURED LOANS AND BORROWINGS:

PARTICULARS	CURRENT YEAR (₹)		PREVIOUS YEAR (₹)	
1. Central Government		0.00		0.00
2. State Government (Specify)		0.00		0.00
3. Financial Institutions				
a) Term Loans	0.00		0.00	
b) Interest accrued and due	0.00	0.00	0.00	0.00
4. Bank:				
a) Term Loan				
Interest accrued and due	0.00		0.00	
b) Other Loans (specify)	0.00	0.00	0.00	0.00
5. Other Institutions and Agencies		0.00		0.00
6. Debentures and Bonds		0.00		0.00
7. Others (Specify)		0.00		0.00
TOTAL		**0.00**		**0.00**

SCHEDULE 5 - UNSECURED LOANS AND BORROWINGS :

PARTICULARS		PREVIOUS YEAR (₹)
1. Central Government	0.00	0.00
2. State Government (Specify)	0.00	0.00
3. Financial Institutions	0.00	0.00
4. Banks:	0.00	0.00
a) Term Loans	0.00	0.00
b) Other Loans (specify)	0.00	0.00
5. Other Institutions and Agencies	0.00	0.00
6. Debentures and Bonds	0.00	0.00
7. Fixed Deposits	0.00	0.00
8. Others (Specify)	0.00	0.00
TOTAL	**0.00**	**0.00**

Anil Shalini & Associates
DELHI
FRN: 009[illegible]C
Chartered Accountants

G.B.PANT NATIONAL INSTITUTE OF HIMALAYAN ENVIRONMENT
KOSI-KATARMAL, (ALMORA) UTTARAKHAND
SCHEDULES FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2023

SCHEDULE 6 - DEFERRED CREDIT LIABILITIES:

PARTICULARS	CURRENT YEAR (₹)		PREVIOUS YEAR (₹)
a) Accep. secured by hypothecation of Cap. Equip. and other assets		0.00	0.00
b) Others		0.00	0.00
TOTAL		**0.00**	**0.00**

SCHEDULE 7 - CURRENT LIABILITIES AND PROVISIONS:

PARTICULARS				PREVIOUS YEAR (₹)
A. CURRENT LIABILITIES				0.00
1. Acceptances				
2. Sundry Creditors:				
a) For Goods			0.00	
b) Others (capital goods)			0.00	0.00
3. Advances Received:				
project grant (As per **Annexure "A"**)	19,06,56,385.85		17,18,69,686.71	
govt grant (R & D etc) (**Annexure "A1"**)	(4,97,99,589.10)		(3,72,62,063.36)	
govt grant (const fund)	-	14,08,56,796.75	-	13,46,07,623.35
4. Interest accrued but not due on:				
a) Secured Loans/ borrowings				
b) Unsecured Loans/borrowings				
5. Statutory Liabilities:				
a) Overdue				
b) Others				
6. Other current Liabilities (As per **Annexure "B"**)		3,05,09,457.88		3,25,03,791.30
TOTAL (A)		**17,13,66,254.63**		**16,71,11,414.65**
B. PROVISIONS				
1. For Taxation		-		-
2. Gratuity		4,50,98,625.00		5,24,09,088.00
3. Superannuation / pension		-		-
4. Accumulated Leave Encashment		3,80,99,192.00		4,25,42,889.00
5. Trade Warranties/ Claims		-		-
6. Others		-		-
TOTAL (B)		**8,31,97,817.00**		**9,49,51,977.00**
TOTAL (A + B)		**25,45,64,071.63**		**26,20,63,391.65**

Anil Shalini & Associates
DELHI
F.R.N:
009980C
Chartered Accountants

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Institute Faculty

S. N.	Name	Designation	Area of Specialization
1	Prof. Sunil Nautiyal	Director	Natural resource management & conservation
2	Er. Kireet Kumar	Scientist-G	Environmental Engineering; Hydrology
3	Dr. J.C. Kuniyal	Scientist-G	Development Geography, Waste Management, Aerosols Climatology
4	Dr. I.D. Bhatt	Scientist-F	Plant Physiology, Physiochemistry
5	Dr. Paromita Ghosh	Scientist-F	Plant Science; Soil Science
6	Mr. M.S. Lodhi	Scientist-E	Environmental Assessment
7	Mr. A.K. Sahani	Scientist-E	Social Science; Anthropology
8	Dr. S.C. Arya	Scientist-D	High Altitude Ecology
9	Dr. Mithilesh Singh	Scientist-D	Plant tissue culture; Bioprospecting
10	Dr. K.S. Kanwal	Scientist-D	Strategic Environmental Assessment
11	Mr. Ashutosh Tiwari	Scientist-D	Remote Sensing & GIS
12	Dr. Sumit Rai	Scientist-C	Soil Science; Soil & Water Conservation
13	Dr. V.E. Gosavi	Scientist-C	Hydrology; Watershed Management
14	Dr. Harshit Pant	Scientist-C	Forest Ecology
15	Dr. Shailaja Punetha	Scientist- C	Agriculture; Horticulture
16	Dr. Kapil Kesharwani	Scientist- C	Cryosphere; Atmospheric and Environmental Science
17	Dr. Aseesh Pandey	Scientist –C	Biodiversity Conservation; Alpine ecology; Phytochemistry; Conservation Education
18	Dr. Suresh Kumar Rana	Scientist-B	Biogeography; Evolutionary Ecology; Bio curation
19	Dr. Subodh Airi	Sr. Technical Officer (II)	Forest Ecology; Biotechnology
20	Mr. Om Prakash Arya	Technical Officer	Biotechnological Application

Garhwal Regional Centre

21	Dr. K. C. Sekar	Scientist-F	Plant Taxonomy; Animal Taxonomy
22	Mr. S. Tarafdar	Scientist-E	Weather & Climate Change; glaciology; Hydrology
23	Dr. Arun Kumar Jugran	Scientist-D	Plant Biotechnology
24	Dr. Kusum Pandey	Scientist –C	Hydrophonic Culture; Protected Cultivation; Soft Computing; Natural Resource Management
25	Dr. Lakhpat Singh Rawat	Technical Assistant (II)	Socio-Economic Development

Himachal Regional Centre

26	Er. R. K. Singh	Scientist-F	Information Technology
27	Mrs. Sarla Shashni	Scientist-D	Rural Entrepreneurship and Small Business
28	Dr. Renu Lata	Scientist-D	Environmental Governance & Policy; Environment Impact Assessment & Management
29	Dr. Kesar Chand	Scientist –C	Climate Change; Environmental Pollution & Disaster Management
30	Dr. Manish Tripathi	Scientist-B	Lichen (Taxonomy, Ecology and Bioprospection); Resource Governance
31	Dr. Kishore Kumar	Technical Officer	Pollination Biology; Conservation Education

Sikkim Regional Center

32	Dr. Rajesh Joshi	Scientist-E	Mathematical Modelling
33	Dr. Sandeep Rawat	Scientist –C	Biodiversity Conservation; Conservation Genetics; Biochemical and Nutritional Analysis
34	Dr. Mayank Joshi	Scientist –C	Tectonic Geomorphology
35	Dr. K.S. Gaira	Technical Assistant (II)	Biodiversity Conservation

North-East Regional Centre

36	Dr. Devendra Kumar	Scientist-D	Climate Change
37	Dr. Wishfully Mylliemn-gap	Scientist-C	Climate Change and Environment Pollution
38	Smt. Tridipa Biswas	Scientist –C	Cartography
39	Dr. Sivaranjani S (SSS)	Scientist-C	Carbon flux; Carbon Sequestration; Carbon credit
40	Dr. Mriganka Shekhar Sarkar	Scientist-B	Ecology, Genetics

Ladakh Regional Centre

41	Dr. Subrat Sharma	Scientist-F	Agro Ecology; Remote Sensing/ GIS
42	Dr. Sandipan Mukherjee	Scientist-D	Climate Change; Ecosystem Services
43	Dr. Purushottam Kumar Garg	Scientist –C	Biogeography; Evolutionary Ecology; Bio curation
44	Dr. Ajay Kumar Gupta	Scientist-C	Climate Change Risk; Vulnerability and Adaptation Assessment; Forest Carbon Estimation
45	Dr. Lalit Giri	Technical Assistant (II)	Biotechnology

Institute Supporting Staff

Headquarters

S. N.	Name	Designation
1	Mr. Sajeesh K. P.V.	Admin. Officer
2	Mr. Surya Kant	Finance officer
3	Mr L.M.S. Negi	Accounts Officer
4	Mr. S. Higgins	Sr. Technical Officer (I)
5	Mr. Mahesh Chandra Sati	Technical Officer
6	Mr. K.N. Pathak	Sr. Technician (I)
7	Mr. Govind Singh	Technician (I)
8	Mrs. Sarita Bagdwal	Stenographer
9	Mr. Jagdish Kumar	Stenographer
10	Mrs Mamta Higgins	O.S.
11	Mr Heera Singh	O.S.
12	Mr. K.K. Pant	U.D.C.
13	Mrs. Hema Pandey	U.D.C.
14	Mr. Mayank Verma	UDC
15	Mr. Atul Bisht	L.D.C.
16	Mr. Vipin Chandra Sharma	L.D.C.
17	Ms. Vaishali Rani	LDC
18	Mr. Sanjeev Kumar Arya	Driver
19	Smt Ganga Joshi	Group 'C'
20	Mr. Gopal Singh Bisht	Group 'C'
21	Mr. Govind Singh Malwal	Group 'C'

Garhwal Regional Centre

22	Mr. D.P. Kumeri	UDC
23	Mr. M.P. Nautiyal	Lab/Field Assistant/House-keeping
24	Mr. R.C. Nainwal	Lab/Field Assistant
25	Mr. R.P. Sati	Lab/Field Assistant

Himachal regional Centre

26	Mr. Daulat Ram	Group 'C'
27	Mr. Ajay Pawar	Group 'C'
28	Mr. Jagdish Kumar	Driver

Sikkim Regional Centre

29	Mr. Jagnnath Dhakal	Lab/Field Assistant
30	Mr. P.K. Tamang	Lab/Field Attendant (II)
31	Mr. R.K. Das	LDC
32	Mr. Musafir Rai	Group 'C'
33	Mr. Shyambir	Group 'C'

North-East regional Centre

34	Mr. Sandeep Kumar	LDC

Ladakh Regional Centre

35	Ms. Stanzin Zangmo	LDC

Scientific Advisory Committee (SAC) of NIHE

Chairman

1. **Dr. Eklabya Sharma**
   Block 1/3A, Silver Oaks Apartment
   Mallaguri, Siliguri, West Bengal-734003

Thematic Experts

2. **Dr Arun Kumar Saraf**
   Professor (High Academic Grade)
   Department of Earth Sciences
   Indian Institute of Technology
   Roorkee -247 667

3. **Prof. Rajive Mohan Pant**
   Vice-Chancellor
   Assam University (A Central University)
   Silchar-788011, Assam

4. **Dr. Sandeep Tambe, *IFS***
   APCCF, Govt. of Sikkim
   Tashiling Secretariat, Gangtok,
   Sikkim-737101

Peer Institutions

5. **Director (or his nominee at Senior Scientist Level)**

   Director
   Wadia Institute of Himalayan Geology
   33, General Mahadev Singh Road,
   Sewla, Kalan, Majra, Dehradun-248 171
   Uttarakhand

6. **Director (or his nominee at Senior Scientist Level)**

   Director
   Zoological Survey of India
   Prani Vigyan Bhawan, M Block, New
   Alipore, Kolkata- 700 053, West Bengal

Institute Faculty

7. **Dr. G.C.S. Negi**
   (at Scientist-G level)

8. **Dr. Rajesh Joshi**
   (at Scientist-E level)

9. **Dr. Arun K. Jugran**
   (at Scientist-D level)

Convenor

10. **Director**
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Project Evaluation Committee (PEC-IERP)

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Professor, Department of Forestry, Mizoram University, Aizawl, Mizoram

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Dr. I.D. Bhatt, Member Secretary
Scientist – F
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About the Institute:

G.B. Pant National Institute of Himalayan Environment, Kosi-Katarmal, Almora was established in 1988, during the birth centenary year of Bharat Ratna Pt. Govind Ballabh Pant, as an autonomous Institute of the Ministry of Environment, Forest & Climate Change (MoEF&CC), Govt. of India. The institute has been identified as a focal agency to advance scientific knowledge, to evolve integrated management strategies, demonstrate their efficacy for conservation of natural resources, and to ensure environmentally sound development in the entire Indian Himalayan Region (IHR).

The Institute follows a multidisciplinary and holistic approach in all its Research and Development programmes with emphasis on interlinking natural and social sciences and particular attention is given to the conservation of fragile mountain ecosystems, indigenous knowledge systems and sustainable use of natural resources. Training, environmental education and awareness to different stakeholders are essential components of all the R&D programmes of the Institute.

G.B. Pant National Institute of Himalayan Environment,

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