ANNUAL REPORT 2024-25

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

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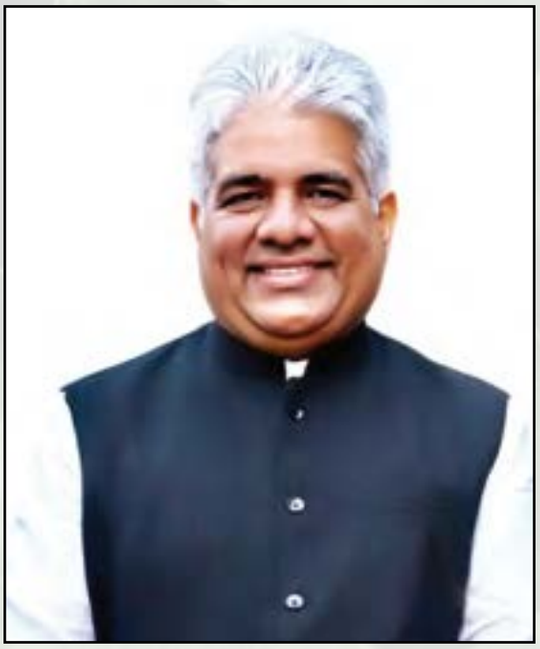

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Hon'ble Union Minister
Ministry of Environment, Forest & Climate Change
Government of India

Sh. Kirti Vardhan Singh
Hon'ble Union Minister of State
Ministry of Environment, Forest & Climate Change
Government of India

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FOREWORD

G. B. Pant National Institute of Himalayan Environment (GBP-NIHE), an autonomous institute under the Ministry of Environment, Forest and Climate Change (MoEF&CC), is a leading R&D organization dedicated to promoting sustainable development in the Indian Himalayan Region (IHR) by way of making a balance between physical, biological and social system. Serving as the focal agency for Himalayan environmental research, the Institute advances scientific knowledge, develops integrated management strategies, and demonstrates practical models for natural resource conservation and environmentally sound development in the IHR. GBP-NIHE follows a multidisciplinary and holistic approach, integrating natural and social sciences in its research programmes. Its work is implemented through four thematic centres; namely Land & Water Resource Management (CLWRM), Socio-Economic Development (CSED), Biodiversity Conservation & Management (CBCM), Environmental Assessment & Climate Change (CEA&CC), and six regional centres located in Ladakh, Himachal Pradesh, Uttarakhand (Srinagar), Sikkim, and Arunachal Pradesh, addressing local R&D needs across the IHR. Through its decentralized structure and partnerships, the Institute delivers science- and nature-based solutions for key environmental and developmental challenges. Its contributions in resource management, climate resilience, and sustainable livelihoods are widely recognized at regional, national, and global levels.

During 2024–25, the Institute achieved significant research and development milestones across the Indian Himalayan Region (IHR). Of 61 ongoing projects, 15 were successfully completed with impactful outcomes. A science-based framework and ecosystem health indicators were developed for spring rejuvenation, enabling effective monitoring and replication across the IHR. Studies on glacier mass balance, velocity, and retreat rates in Uttarakhand, Ladakh, and Sikkim strengthened insights into glacier–climate interactions. A Standard Operating Protocol for Passive Solar-Heated Buildings was developed for Ladakh, suitable for similar cold Himalayan regions. Analysis of 1,852 extreme climate events (1980–2024) showed floods as the dominant hazard, responsible for 79% of total fatalities. Socio-ecological improvements were achieved in the Jyoli eco-smart village cluster, benefiting 245 households through 10 rural technologies. The pteridophyte database expanded to 1,025 taxa, while long-term ecological monitoring revealed site-specific vegetation shifts in the western Himalaya. Two orchid species new to science and one new national record were reported. Establishment of Seabuckthorn processing and technology centres in Ladakh and Himachal Pradesh promoted women-led enterprises and sustainable livelihoods. Five climate-resilient frameworks were developed and validated for community adaptation. The Institute also contributed to India's first Biennial Transparency Report (BTR-1) on Himalayan biodiversity and initiated a Vetiver grass pilot study for land stabilization and restoration.

The Institute's multidisciplinary and integrated R&D efforts generated substantial knowledge outputs during 2024–25, including 136 research articles in peer-reviewed national and international journals, 44 book chapters/proceedings, 12 authored or edited books, bulletins, or monographs, 38 popular articles, and 1 policy paper/brief. In addition, four patent applications were initiated during the year. Capacity building, training, and environmental awareness continued as integral components of all R&D programmes. The Institute made a conscious effort to ensure local community participation for long-term adoption and success of interventions, reaching >4500 stakeholders through 89 outreach and training events across the IHR on key issues of sustainable Himalayan development. During the year, the Institute also received 17 externally funded projects, enabling collaborative, research-based solutions on diverse aspects of Himalayan ecosystems.

The Institute gratefully acknowledges the continued guidance and support of the Ministry of Environment, Forest and Climate Change, the Society, the Governing Body, and the Scientific Advisory Committee. The dedication of the Institute's faculty and staff has been central to these achievements. With sustained collaboration and stakeholder engagement, the Institute remains committed to advancing R&D excellence for the benefit of Himalayan communities and their environment.

Prof. (Dr.) Sunil Nautiyal
Director

MAJOR ACHIEVEMENTS

1. Developed a science-based framework using hydro-geological investigations, Analytical Hierarchy Process (AHP) techniques, and Geographic Information System (GIS) methodologies to prioritize spring rejuvenation interventions in the selected locations of Indian Himalayan region.

2. Investigated glacier dynamics (2020-24) for Chipa, Uttarakhand; Rulung, Ladakh; South Lhonak, and Changme Khangpu glaciers, Sikkim, revealing diverse location specific responses, e.g., velocity ranging from 0.001–35.9 m/year and mass balance of -0.0317 Gt and -1.83 m w.e. year^{-1}.

3. Enhanced socio-ecological conditions in Jyoli eco-smart village cluster with ten rural technologies, improving livelihood for 245 households, and systematically deployed to promote sustainable income generation and ecological resilience.

4. Developed a regional database of 1025 pteridophyte taxa in the Indian Himalayan Region, with the highest species diversity in Arunachal Pradesh (590 taxa) and lowest in Ladakh (91 taxa), representing 799 native, 99 threatened, 215 medicinal, and 12 endemic species, highlighting critical need for targeted conservation policies to protect threatened and endemic pteridophyte species.

5. Re-evaluated GLORIA site in western Himalaya, documenting a 6.3% rise in species richness, 13% vegetation cover increase, and thermophilization (D=0.035) reflecting a compositional shift toward warm-adapted species on mountain summits.

6. Analyzed long-term data from Kullu Valley (Himachal Pradesh) and Kosi (Uttarakahnd), showing seasonal aerosol variability, radiative forcing (0.5–2.5 W/m^2), temperature rise (0.02–0.04°C/year), and elevated pollutants (PM10: 50–100 µg/m^3, PM2.5: 20–50 µg/m^3, BC: 2–8 µg/m^3), urging enhanced monitoring and emission controls.

7. Introduced a Conservation Priority Index for North-East India, pinpointing key conservation zones for large-bodied (56,570 km^2), small-bodied (65,291 km^2), and threatened mammals (64,660 km^2), advocating for expanded protected areas.

8. Evaluated phytochemical diversity of selected Himalayan medicinal plants, i.e., *Hedychium spicatum*, *Allium stracheyi*, *Malaxis muscifera*, *M. acuminata*, *Polygonatum verticillatum*, *Amomum subulatum*, and other species, proposing region-specific cultivation and conservation plans.

9. Established a Seabuckthorn Processing Unit in Chamsen, Nubra, and a Technology Centre in Jahalma, Lahaul, empowering women-led cooperatives for sustainable rural livelihoods.

10. Set up the highest hydro-meteorological station at Rulung Glacier (5604 m asl) with an Automatic Weather Station and sensors, and developed five climate-resilient village models in Himachal Pradesh, Uttarakhand, and Assam using socio-ecological and geospatial data.

11. Supported India's first Biennial Transparency Report (BTR-1) on Himalayan biodiversity for UNFCCC, discovered two new orchid species *(Phalaenopsis quadridentata*, *Gastrodia indica)* and one new national record *(Cheirostylis tortilacinia)* for India's flora, developed 4 School Herbal Gardens and 110 Home Herbal Gardens in Kullu District.

12. Analyzed a 97-year *Cedrus deodara* tree-ring chronology (1928–2024) and documented 1,852 extreme climatic events (1980–2024), with floods (64.47%, 8,327 deaths) as the dominant hazard.

PUBLICATIONS

1	Peer Reviewed National & International Journals	136
2	Chapters in Books / Proceedings	44
3	Authored/ Edited / Books / Booklets / Bulletins / Monographs	12
4	Popular Articles	38
5	Policy Papers/brief	01
6	Patent Initiated	04

EXECUTIVE SUMMARY

The Institute (NIHE) aims to advance environmental conservation and sustainable development across the Indian Himalayan Region (IHR) by addressing critical environmental challenges representing physical, biological, and socioeconomic domains through an integrated, multidisciplinary approach. The Institute's research and development (R&D) mandate comprehensively encompasses the environmental complexities of mountainous ecosystems. It's guiding principles emphasize the synthesis of diverse disciplines and the generation of robust knowledge through interdisciplinary R&D initiatives. Fundamental to these initiatives is the synergy between natural, physical and social sciences, with a focus on integrating indigenous knowledge, the ecological vulnerability of mountain ecosystems, and the sustainable management of natural resources.

GBPNIHE actively incorporates stakeholder perspectives, including those from academia, policymakers, government agencies, non-governmental organizations (NGOs), community-based organizations (CBOs), and others, in design and execution of its R&D activities. The Institute prioritizes the development and dissemination of best practices, innovative technology packages, and delivery mechanisms to enhance livelihoods and promote socioeconomic progress while addressing pressing environmental concerns. Deliberate efforts are made to foster inclusive participation from diverse groups, including students, researchers, farmers, citizens, policymakers, and funding agencies, through targeted initiatives and collaborative mechanisms. Education, training, and stakeholder engagement are fundamental to all R&D programs.

The Institute's activities and functions are strategically coordinated through it's Headquarters at Kosi-Katarmal, Almora in Uttarakahnd and five regional centers, namely; Ladakh Regional Center (LRC), Leh; Himachal Pradesh Regional Center (HPRC), Kullu; Garhwal Regional Center (GRC), Srinagar; Sikkim Regional Center (SRC), Pangthang; and North-East Regional Center (NERC), Itanagar. The 6th Centre, the Mountain Division Regional Centre, is housed in MoEF&CC, New Delhi and responsible for looking into policy issues across IHR. These regional centres cater to the specific R&D needs of the respective States/ regions. Additionally, four thematic centers, Center for Land and Water Resource Management (CLWRM), Center for Socio-Economic Development (CSED), Center for Biodiversity Conservation and Management (CBCM), and Center for Environmental Assessment and Climate Change (CEA&CC) drive specialized research efforts across the IHR. During the reporting period (2024–2025), 15 of the 61 R&D projects implemented across the IHR were successfully completed, reflecting the Institute's commitment to impactful outcomes.

1. Thematic Centres

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

Land and water are among the most important life support functions of our planetary ecosystem, a key policy objective for sustainable development. Aligning with this very important aspect, the Center for Land and Water Resource Management (CLWRM) carried out its R&D activities with the vision of integrated land and water resources management to support sustainable development in IHR in mission mode to develop action plans for sustainability in IHR. During the reporting year (2024-25), the centre addressed various issues pertaining to land and water resources through in-house and externally funded projects. The major in-house activity of the center was focused on spring rejuvenation. Out of a total of 6523 springs, 6407 spring datasets were uploaded on the HIMAL portal (https://nmhs-himal.gov.in) after necessary checks and corrections for wider stakeholder use. The centre also developed a science-based framework for prioritizing spring rejuvenation interventions using hydro-geological investigation, AHP techniques, and GIS-based methodologies. The spring rejuvenation activity was implemented in Almora, Champawat, and Rudrprayag districts of Uttarakhand state, Kullu, Mandi, Lahual and Spiti districts of Himachal Pradesh, and South Sikkim district of Sikkim state. The spring-ecosystem health indicators of the springs were also quantified using multiple statistical and hydrological indicators to study the pre- and post-impact assessment of spring rejuvenation intervention, which suggests some significant stability in spring discharge by indicating lesser values of variability indices of selected springs and increasing lean season discharge of some springs. With this experience and expertise, the centre also contributes to the technical committee of the Spring and River Rejuvenation Authority (SARRA) in Uttarakhand for implementing springshed management work in Uttarakhand and its monitoring and evaluation. Further, centre also continued the assessment of Glacier-Climate functional relationships across IHR through long-term network observations of Chipa glacier, Uttarakhand; Rulung glacier, Ladakh; and South Lhonak glacier, Sikkim. The important work of glacier mass balance and velocity estimation was completed in the reporting year using field-based observations and satellite imagery. Towards the efforts of sustainable urban-rural resilient development, the Passive Solar-Heated Building (PSHB) project conducted a comprehensive analysis for estimating the construction cost of a PSHB building in Stok (Leh and Ladakh). A database of thermophysical properties of building materials used in the construction of PSHBs was created. Overall, the study provided a knowledge repository, simulation models of PSHBs for different regions, field demonstration models, and developed SOPs. Upon receiving directions from the MoEF&CC, the centre has also initiated a pilot study for field-based application and testing of Vetiver grass *(Chrysopogon zizaniodes)* in the Indian Himalayan Region. This scientific study has a long-term focus on the potential use of Vetiver in land stabilization and restoration of degraded land, prevention of soil erosion, groundwater recharge, and sustainable livelihood. The Vetiver plantation is being carried out in Uttarakhand, Himachal Pradesh, Arunachal Pradesh, Sikkim, and West Bengal states. Centre also conducted various trainings and awareness programmes, community-led spring rejuvenation work, and meetings where multiple stakeholders were reached and sensitized on springshed management, water scarcity, and land management.

ii) Centre for Socio-Economic Development (CSED):

The Centre for Socio-Economic Development (CSED) is implementing grassroots-driven research with the integration of ecological restoration, sustainable livelihoods, and community empowerment in the IHR. Guided by a systems approach, CSED blends scientific research with traditional knowledge to create resilient solutions for mountain communities. During 2024–25, the Centre achieved notable impact across multiple thematic areas, reinforcing its commitment to inclusive and sustainable development. Livelihood enhancement through poultry farming reached 120 households across six villages of Jyoli village cluster (Almora) supporting earnings of ₹8.77 lakh. Villages like Kujyari and Jyoli emerged as key contributors, demonstrating a small-scale poultry model leading to improved income and nutrition. Towards pine needle biomass briquetting and green skills development, 59 households produced 1,080 bio-briquettes and 239 rakhi and aipan crafts, collectively earning ₹26,900. Villages such as Bisra and Kaneli showed high production. A livelihood diversification survey

in Barshu (Rudraprayag) revealed that 73.17% of households had multiple income sources, and 65.85% were aware of alternate options such as beekeeping and mushroom cultivation. During the reporting year CSED conducted 10 training programs reaching 690 individuals. These sessions focused on sustainable livelihoods, human-wildlife conflict mitigation, and circular economy principles, equipping participants with practical skills and adaptive strategies. Agricultural diversity remained a cornerstone of food security and ecological balance in the region and villagers cultivated a range of crops including kodo millet, wheat, mustard, barley, pulses, and oilseeds. Innovations in protected cultivation, particularly polyhouses proved highly profitable. Spinach cultivation within polyhouses earned up to ₹30,000 per unit, outperforming polytunnels in both growth rate and income, showcasing the potential of climate-smart agriculture. Ecotourism development in Jaubari (Sikkim) added a new dimension to livelihood diversificationwherein a 3.6 km eco-trail was established. This initiative fostered environmental education and opened avenues for nature-based tourism, aligning conservation goals with community benefit. CSED also advanced its work in climate-resilient agriculture through biochemical and molecular analyses. These studies identified nutrient-rich landraces of French bean, horse gram, and soybean, suitable for organic farming in hilly terrains. Promoted through targeted training, these varieties enhance crop quality, climate adaptability, and food security in the higher Himalayan region. The Centre continues to serve as a catalyst for change, translating research into action and empowering communities to shape their resilient futures.

iii) Centre for Biodiversity Conservation and Management (CBCM)

The Centre for Biodiversity Conservation and Management (CBCM) continues to address the pressing challenges threatening Himalayan biodiversity, characterized by its exceptional richness and uniqueness. During the reporting period , CBCM implemented a range of research and development initiatives aimed at conserving plant biodiversity, promoting sustainable resource utilization, and enhancing rural livelihoods across the Indian Himalayan Region (IHR). These efforts particularly focused on strengthening biodiversity databases, developing propagation techniques, promoting the cultivation of medicinal plants, restoring degraded ecosystems, and assessing climate change impacts on forest resources and plant diversity. The centre developed *in-vitro* propagation protocols for *Gentiana kurruoo*, *Polygonatum spp.* and *Rheum australe Allium stracheyi*, and *Rheum australe*, characterized the genetic diversity of *Allium stracheyi* using ILP markers, optimized seed germination protocols of five high-value medicinal plants in Sikkim, mapped eight biodiversity-rich areas in Uttarakhand, and conducted a value chain analysis of medicinal plants in Uttarakhand. The centre prepared Chapter IV of India's Biennial Transparency Report (BTR-1) for UNFCCC and Chapter III of the Fourth National Communication (4NC), focusing on Himalayan plant biodiversity vulnerabilities and adaptation strategies. Long-term ecological monitoring data indicated a signal of early warning in the high-altitude flora in the western Himalayan region. The centre strengthened agri-horticulture systems by promoting the cultivation of medicinal plants in 14 villages of Chaudas area, Pithoragarh district, and 6 villages in Almora district, by engaging over 300 farmers. The centre has promoted an ecosystem-based approach for springshed management in Sikkim, Uttarakhand, and Arunachal Pradesh to enhance biodiversity resilience. Creation of an integrated Himalayan Biodiversity Information System (HBIS), curating data on mammals, plants, and other taxa at the village level across 135 districts, and assessing IUCN Red List assessments are also being initiated by the centre. Conservation of endemic and threatened Himalayan species is the core programme of the centre, which involves conserving those species through development of germplasm repositories at different locations. The centre also maintained different apple germplasm in two locations, Surykunj and the Government Horticulture Garden Chaubatia, Uttarakhand. The centre conducted various seminars, workshops, training, and meetings on diverse themes of Himalayan biodiversity, and also celebrated the important national/international days to build the capacity of a wider range of stakeholders.

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

Centre for Environmental Assessment and Climate Change (CEA&CC) is committed to address the pressing environmental and climate-related challenges of the Indian Himalayan Region (IHR). In recent

times, climate change has emerged as a critical threat to the fragile mountain ecosystems of the Himalayas, where even a modest warming of 1–2°C is projected to significantly impact biodiversity, ecosystems, and the livelihoods of communities dependent on natural resources. Recognizing this vulnerability, CEA&CC conducts multidisciplinary research to assess climate impacts, build adaptive capacities, and integrate climate considerations into regional development planning. The Centre's key areas of focus include climate vulnerability mapping, the development of adaptation strategies, public awareness campaigns, and the promotion of citizen science. Through in-house project, the centre has developed a climate vulnerability framework for the IHR, created the HIMCARES dashboard as a decision-support tool, and conducted over 65 training and awareness programmes, reaching nearly 2,800 participants. The centre has also contributed to disaster risk reduction by analyzing historical climate extremes and documenting over 1,700 events across the IHR, supporting the formulation of risk-informed policies. Long-term studies on aerosols and air pollutants in Himachal Pradesh and Uttarakhand have revealed increasing concentrations of black carbon and surface ozone linked to tourism, biomass burning, and urbanization, with implications for climate, glaciers, and public health. The centre analyzed long-term data from Kullu Valley (Himachal Pradesh) and Kosi (Uttarakahnd), showing seasonal aerosol variability, radiative forcing (0.5–2.5 W/m^2), temperature rise (0.02–0.04°C/year), and elevated pollutants (PM10: 50–100 $\mu g/m^3$, PM2.5: 20–50 $\mu g/m^3$, BC: 2–8 $\mu g/m^3$), urging enhanced monitoring and emission controls. The Centre has also studied soil microbial dynamics across alpine treelines and plant biodiversity under climate change as part of national missions, such as NMSHE. These findings inform conservation planning, sustainable land use, and forest resource management.

2. Regional Centres

i) Ladakh Regional Centre (LRC)

The Ladakh Regional Centre is mandated to undertake in-depth research and development studies on water, biodiversity, and socio-ecological issues of the trans-Himalaya region, with a focus on developing and demonstrating suitable technological packages for the region. Consequently, in-house activities of the Centre during the year 2024-25 were focused on the integration of science and society to study and address the water issues in Ladakh; conservation and phytochemical evaluation of indigenous medicinal plants of the region for commercial viability using low-cost techniques; and promotion of nature-based solutions through targeted training for off-farm employment. The in-situ assessment of artificial snow reservoirs (snow barrier bands) was carried out in Tarchit Village, Ladakh, using advanced GPS and measurement tools. The maximum capacity of the reservoir was estimated at 18.29 million litres of water. Daily monitoring of nine springs surrounding the Leh town indicated variable discharge ranging from 104.6 lpm to 0.82 lpm. The hydroponic experiments at the RTC with Rheum tibeticum and Inula racemosa treated with MeJA showed significant enhancement in phenol content and antioxidant activity under hydroponic conditions, especially at 500 µM concentration. The centre also organized training and livelihood programs in six villages, including three mushroom cultivation workshops (40 participants) and two basket-weaving sessions in the Changa and Kharu villages of Leh (30 women). One training session on the Seabuckthorn product value addition was also held in Chamshen, with 26 women in attendance. Under a National Mission on Himalayan Studies (NMHS) funded project, a low-cost, solar-powered hydroponic prototype using treated wastewater was installed at the FSTP site of the Municipal Committee, Leh. It supported the cultivation of tomatoes, lettuce, cucumbers, and mangos, utilizing 15,000 L/month of treated water. A patent (Application No. 202511020347) was filed for this wastewater hydroponic system. The NABARD-funded project resulted in extensive ecological surveys in Nubra Valley, which showed Hippophae rhamnoides dominating the riverbanks, coexisting with species such as Salix and Ephedra. Female plants outnumbered males (71:29), and average berry yield was ~1 kg/plant. A Seabuckthorn Processing Unit was inaugurated in Chamshen, Nubra, to promote the economic security of rural women under this project. A set of spectral vegetation indices was developed for Changthang grasslands using satellite imagery under the National Agricultural Science Foundation (NASF) project on grasslands. Mapping and productivity of grassland analysis revealed a positive decadal trend in net primary productivity, with an annual increase of ~2% from 2014 to 2024. The year 2024-25 witnessed the establishment of one of the highest hydro-meteorological stations in the country at the forefield of Rulung Glacier, Ladakh, at an altitude of 5,604 meters above sea level (asl), marking a significant milestone in glacier resource investigation in the region. Two researchers from the Centre also received first prize in Agrithon-2024, sponsored by the DST, Government of India, at Leh, Ladakh, in the Crop and Horticulture Farming theme.

ii) Himachal Pradesh Regional Centre (HRC)

During the reporting year 2024-25, a disaster inventory of flood events was prepared for the years 1995-2020 and 2023. Thematic maps of the Flood Hazard Susceptibility Model have been prepared, which include morphological criteria and hydrological criteria. Flood hazards and their impacts in the upper Beas basin have been investigated through extensive field surveys in flood-affected villages of Beas and the Parvati Valley. The People's Biodiversity Registers (PBRs) have been updated for Kullu district and Una district. A long-term monitoring is continuing through the environmental observatory for various gaseous air pollutants, including Sulphur Dioxide, Carbon dioxide, Carbon monoxide, Surface Ozone, and OH, among others, for the Kullu Valley. The Aerosol optical depth (AOD) measurement for the Kullu Valley indicates the dominance of anthropogenic interferences in the surrounding environment. The groundwater recharge potential was evaluated in Kullu, Lahaul Valley, and Mandi District using GIS, remote sensing, and multi-criteria approaches. The stable isotope analysis (δ18O and δD) of spring samples confirmed the rainfall as the primary recharge source, and field interventions were implemented in the Barot and Seraj valleys using bio-engineering intervention techniques, including native tree plantations (e.g., Quercus leucotrichophora), check dams, contour trenches,

and percolation pits for rejuvenation of the spring. Spring rejuvenation activities were also implemented in Yangrang village of Lahaul valley by constructing 52 contour trenches and 12 percolation pits, based on geological and topographic suitability. Post-intervention monitoring recorded an increase in spring discharge from 65.2 to 68.1 liters per minute in the same year, demonstrating an initial promising clue of spring discharge enhancement due to the recharge structures in the Yangrang springshed. Further, one hundred fifty women members (from Women Self-Help Groups, Mahila Mandals, etc.) from different regions of the Lahaul valley have been supported in the development of seabuckthorn-based small enterprises and the establishment of one Technology Centre in Jahalma Village. Efforts are also underway to secure the Geographical Indication (GI) certification for Seabuckthorn from the Lahaul region. A primary survey under the In-house project community-driven eco-smart model village covered 1992 households of 11 districts of Himachal Pradesh. 598 stakeholders have been trained on various low-cost rural technologies through 17 training cum capacity capacity-building programmes. A climate vulnerability framework identified the most vulnerable regions and communities within Himachal Pradesh. Developed Herbal Gardens in 4 schools of the Kullu district and distributed over 400 saplings of medicinal plants. 110 Home Herbal Gardens have been developed at different villages of the Kullu district and documented field-based information on ethnobotanical knowledge and plant utilization patterns among indigenous communities across 16 villages of Thirthan Valley, Himachal Pradesh. A comprehensive physico-chemical analysis was conducted for permafrost thawed water and active layer soil samples collected from permafrost sites across different locations of Leh, Ladakh, at different periods. The center organized around 60 training and capacity building programme in this reporting year on different thematic aspects of the projects in various districts/regions of Himachal Pradesh.

iii) Garhwal Regional Centre (GRC)

The R&D activities for the reporting year were focused on the assessment and management of spring ecosystems, creation of community-driven eco-smart model villages to support climate-smart communities, development of biodiversity databases, assessment of genetic diversity, establishment of propagation protocols, and conservation of MAPs. A comprehensive household survey encompassing 160 respondents across eight villages in the Barsu cluster of Rudraprayag district revealed significant climate-related socio-ecological stress characterized by sharp declines in crop yields, drying springs, reduced snowfall, an earlier onset of summer and monsoon, and increased drought frequency. Encouragingly, 73.9% of households adopted Integrated Farming Systems (IFS), organic pesticides, and apiculture to enhance resilience and sustainability. On the biodiversity front, genetic diversity in *Allium stracheyi*, a high-value Himalayan species, was assessed using ILP markers. Parallel conservation efforts led to the development of efficient in-vitro propagation protocols for *Allium stracheyi* and *Rheum australe*. A comprehensive database of pteridophytes in the Indian Himalayan Region (IHR) was compiled from 367 research studies, documenting 1025 taxa (106 genera, 19 families). The study found that the species richness was highest in Arunachal Pradesh (590 taxa) and lowest in Ladakh (91 taxa). The study also recorded 799 native species, 99 threatened taxa, 215 medicinally important ones, and 12 endemics, mostly confined to the eastern Himalayas. In the hydrological domain, a network of monitoring stations was set up along the Nayar River, from its headwaters to its confluence with the Ganga River. Data collected in the river basin revealed a consistent coupling of air and water temperatures across elevation gradients, and the water temperature patterns closely mirrored air temperature trends, indicating the river system's thermal sensitivity to climate change. In contrast, the Ganga River exhibited narrower temperature fluctuations due to regulated flows, highlighting an altered thermal regime. Agricultural sustainability was further explored through rhizobacterial profiling in common bean (Rajma) cultivation across Chamoli and Pithoragarh districts. A total of 54 Rhizobium-like bacterial isolates were obtained from root nodules. A focused vegetation and resource-use survey was conducted in and around Badrinath, including Mana Village and Vasudhara Falls, across three elevation zones. Resource-use patterns were documented using open-ended questionnaires, while ecological data were collected through quadrat based vegetation analysis, supporting conservation planning and sustainable ecotourism strategies. The tourism-driven resource dynamics in the region was assessed using the secondary data from the District Tourism Department..

iv) Sikkim Regional Centre (SRC)

The Sikkim Regional Centre has been undertaking research and development activities on environmental, ecological, and social aspects in Sikkim, West Bengal hills, and Meghalaya states of Northeast India. During the year 2024-25, activities of the Centre were majorly focused on spring rejuvenation and water security, improving livelihood and ecological security, fostering climate smart communities, biodiversity conservation, ecological dynamic and ecosystem health of high altitude wetlands, promoting natural resource base integrated livelihood approaches, scaling ecosystem-based approaches for climate adaptation and biodiversity resilience, earthquake hazards assessment, propagation protocol and agro-techniques development, genomic resource creation, genetic and chemical characterization of medicinal plants, development of a hydroponic system for commercial crops, and valuation of ecosystem services of managed aquifer recharge through the implementation of 4 In-house projects, 8 externally funded projects, and 1 fellowship programme. Under the In-house projects, classification of agro-climatic zones of Sikkim based on elevation and geographical characteristics, baseline data of springs(geo-tagging and physical parameters), monitoring of spring discharge of the intervene springs, collection of baseline datasets, development of resource-use maps of villages, implementation of low-cost technological interventions for improving livelihood status of rural communities, technical support and inputs in facilitating PBR, strengthen the propagation protocol for RET & high-value plants and strengthening of ex-situ conservation site were carried out. Under the High-Altitude Wetlands project, mapping and spatio-temporal analysis of water spread, climatic variables, in situmeasurements of hydrological parameters, and analysis of floral diversity, soil carbon, and sediment flux were carried out for Tsomgo and Hanspokhari wetland (Sikkim), Tso Moriri wetland (Ladakh), and Bhekkal Tal (Uttarakhand). Under the DST-STI hub project, germplasm of Amomum subulatum was characterized based on essential oil composition and morphological parameters. Also, prepared various value-added products from Yacon, Mandarin, and Dale chilli. More than 2000 seedlings of *Amomum subulatum* and *Capsicum annuum* were produced through seed germination protocols. Under the ICIMOD-funded HiREAP project, detailed spring inventory geo-tagging, discharge measurement, quality assessment, elevation, and household dependency were carried out. Based on the vulnerability assessments, two springs, viz., Takibong dhara and Khaptwa dhara, have been identified for interventions. Under the DBT-funded project, geographic variation in the essential oil of *Hedychium spicatum* was investigated, and high diversity was recorded in eastern Himalayan populations. Under the CCRAS-RARI funded project, a literature review of orchid propagation was carried out, and non-targeted metabolite profiling of Crepedium acuminata was performed in methanol and ethyl acetate extract. Further, different types of hydroponic models were developed for commercial crops, and based on the performance of different crops, the best model type, nutrient solvents, and supporting materials were identified under the NABARD-funded project. The Mountain Division Fellowship program validated the good practices of soil and water conservation practices adopted by communities and prepared a framework for economic valuation and cost-benefit analysis of managed aquifer recharge. Under the DST-funded project, river basins of the Shillong Plateau were delineated, and based on geomorphic indicators, various tectonically active regions were identified. The SRC organized various training programme and workshops on diferent thematic areas to build capacities and skills of different stakeholders.

v) North East Regional Centre (NERC)

The North-East region is a critical ecological and socio-economic zone and is facing multifaceted challenges. During the year 2024-25, the NERC has undertaken various R&D programs in alignment with the Institute's mandates as well as priority areas of the north-eastern region of India. The NERC is currently implementing 13 R&D projects, of which 9 are externally funded and 4 In-house projects. As a contribution to state government priorities, NERC is conducting 3 Social Impact Assessment studies of proposed Hydro Electric Projects (HEPs) in Arunachal Pradesh, i.e., Kalai-II HEP (Anjaw district), Kamala HEP (Kamle, Kra Daadi and Kurung Kumey districts), and Naying HEP (Shi-Yomi and Siang districts). Under the NMSHE Task Force-3 project (Phase-II), mapped the temporal changes in Land use/land cover (1991–2021) for north-eastern region of India and analysed forest fragmentation, revealing ~9% forest cover loss—particularly in Assam, Manipur, and Meghalaya—with significant changes in AREA, PERIM, and SHAPE ($p < 0.05$). As part of the ICIMOD-supported

project on Scaling Ecosystem-based Approaches, hydrogeological surveys in Lower Subansiri, Arunachal Pradesh, delineated a 350-hectare recharge zone for Siya Piro Spring. Baseline data on spring discharge, water quality, and ecological conditions were collected, and village surveys highlighted strong community dependence on this vital water source. In the SBIF CONSERW project, 535 scat samples were collected across seven Protected Areas (PAs) for tiger genetic analysis. Spatial modeling using 18 environmental variables and 510 human-elephant conflict points helped to identify conflict hotspots in the Brahmaputra floodplain. The High-Altitude Lake (HAL) Tenbawa project in Sikkim initiated a bibliometric analysis of research on high-altitude wetlands, and three major research clusters were identified: climate impacts, human influences, and ecological studies, which revealed a shift in concerns toward tourism and human pressures, underscoring the need for integrated conservation strategies. Under the Nature Learning Centre Project, two orchids species were reported as new to Science: (i) Phalaenopsis quadridentata from Arunachal Pradeshand (ii) Gastrodia indica from Sikkim, and documented one new record of orchid *(Cheirostylis tortilacinia)* for the flora of the country. Several training and capacity-building programs were also conducted under these projects to create a cadre of para-hydrologists, para-taxonomists, and change leaders in the fields of green livelihood interventions and biodiversity conservation. During the reporting period (2024-25), NERC collaborated with various academic and research Institutes across the northeastern region and organized nearly 26 events, including workshops, training programs, and awareness programs, as well as celebrations of National and International days.

vi) Mountain Division Regional Centre (MDRC)

The “Mountain Division” Regional Centres of GBP-NIHE housed at 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 broad objectives of the Mountain Division are to: i) contribute to sustainable development of mountain ecosystems in integrated manner within divisions of the ministry and across the key ministries; ii) sharpen focus on mountain issues by bringing in “Mountain Perspective” across policies, programmes, missions and schemes; iii) 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, various projects were implemented though MDRC. To address climate-induced disasters and policy issues, a total of 1,777 Extreme Climate Events (ECEs) were recorded between 1980 and 2019, resulting in 9,505 fatalities, with an average mortality rate of 5.35 deaths per event. Additionally, between 1970 and 2023, a total of 252 cloudburst events were documented in the IHR, with the highest occurrences in Uttarakhand (98 events) and Himachal Pradesh (81 events), predominantly occurring within the 1,000–2,500-meter elevation range. The carrying capacity of Leh town was assessed at 12 key tourist sites using surveys and official data. Three types of capacities were calculated: physical carrying capacity (PCC), real carrying capacity (RCC), and effective carrying capacity (ECC). Findings show a daily PCC of 91,717 visitors, while RCC-factoring in environmental and infrastructure constraints is just 5,052 visitors/day. The ECC, which includes management capabilities, stands at 4,331 visitors/day. Estimation of Ecological Carrying Capacities Index (ECCI) values was calculated using the ECC per year and population data for Leh town. Based on the ECCI value of 2.85, Leh town currently has the sustainable capacity to support its population. Towards addressing the spring recharge as a sustainable solution to water scarcity, sixteen indigenous climate adaptive practices of soil and water conservation (both traditional and modern) practiced by communities in Sikkim were documented as structural (e.g., terraces, contour bunds), biological (e.g., vegetative barriers, agroforestry), and fertility management (e.g., farmyard manure) and their effectives, replicability and scalability. Per capita water availability at the study in Sikkim was found below WHO’s standards (150 lpcd) in Alley (81 lpcd), Bul (88 lpcd), and Punjitar (74 lpcd) villages; however, these values were above the national benchmark set under the Jal Jeevan Mission (55 lpcd). A multi-dimensional framework for the evaluation of the effectiveness and cost-benefit of managed spring recharge interventions was developed in the project, covering provisioning, regulating, socio-cultural, and supporting services. Significantly higher SOC stocks in spring intervention sites, as compared to the non-spring intervention sites were observed in Sikkim Himalaya.

1. INTRODUCTION

In 2024–25, the Institute carried out a broad range of R&D activities focused on environmental conservation and sustainable development across the Indian Himalayan Region (IHR). These activities were coordinated through its headquarters at Kosi-Katarmal (Almora, Uttarakhand) and supported by Regional Centres located in Kullu (Himachal), Srinagar-Garhwal (Garhwal, Uttarakhand), Pangthang (Sikkim), Itanagar (Arunachal Pradesh), Leh (Ladakh), and the Mountain Division Centre at MoEF&CC in New Delhi. The central focus of the Institute's research has been to develop and apply region-specific solutions for environmental issues and sustainable development across the IHR. These efforts involved field demonstrations, stakeholder engagement, and in-depth studies on the mountain region's biophysical and socio-economic challenges. Key areas of research included natural resource conservation, traditional knowledge documentation, biodiversity protection, livelihood enhancement, climate change mitigation strategies, and the use of biotechnology for conserving vital plant species. The Institute's R&D work was funded through core financial support from the Ministry of Environment, Forest and Climate Change (MoEF&CC), Government of India, as well as through nationally and internationally sponsored projects. The Institute also supports partner institutions across various Himalayan states through the Integrated Eco-development Research Programme (IERP) and the National Mission on Himalayan Studies (NMHS).The Scientific Advisory Committee (SAC) regularly evaluates project progress and provides strategic direction for new research initiatives. Implementation is carried out through four Centres of Excellence: the Centre for Land and Water Resource Management (CLWRM), Socio-Economic Development (CSED), Biodiversity Conservation and Management (CBCM), and Environmental Assessment and Climate Change (CEA&CC). Additionally, region-specific issues are addressed by six dedicated Regional Centres, including those in Ladakh, Himachal, Garhwal, Sikkim, the North-East, and the Mountain Division in Delhi.This report presents highlights of the key outcomes from ongoing and completed projects during the reporting year. Detailed documentation will follow for stakeholders' reference, with a focus on informing policy responses to critical regional environmental challenges. The report also summarizes academic engagements and includes the financial statement for 2024–25. The Institute welcomes constructive feedback further to enhance the quality and impact of its R&D efforts.

2. MAJOR EVENTS

Inception Workshop-cum-Project Advisory Committee Meeting of HAW Project

The inception workshop cum PAC meeting of the High-altitude Wetland (HAW) project was organized during 10-11 May 2024 in Gangtok. A field visit to Tsomgo and Hanspokhari wetlands was conducted for site reconnaissance and to build a shared understanding of the study sites. On the second day, the PAC meeting was held, during which the advisory committee and six partnering institutions discussed activities, approaches, study plans, knowledge product development, and policy linkages. The PAC for HAW project emphasized the ecological importance, vulnerability, and community engagement for management of wetlands. Standard methods for data collection, guidelines for measuring carbon emissions, and hydrology and mapping tools to manage and protect wetlands were co-designed.

International Day for Biological Diversity

The Institute, at it's headquarters in Almora and across its regional centres, organized various activities to commemorate the International Day for Biological diversity on 22 May 2024, under the theme "Be Part of the Plan". At NIHE-HQs, the Centre for Biodiversity Conservation and Management (CBCM) organized exposure visits, interactive sessions, and several competitions for school children. The LRC celebrated the day at Government High School Nimmo, Leh, Ladakh, reinforcing the importance of biodiversity conservation and environmental stewardship. The celebrations commenced with a plantation drive, followed by a painting competition on the Biodiversity of Ladakh, fostering creativity and awareness among young minds. The HPRC celebrated the day with students from Academic Hills School, Shamshi; Bharat Bharti School, Dhalpur; Cambridge International School, Mohal; DAV, Mohal; JNV, Bandrol; and OLS, Kullu. The event organized a declamation and drawing-painting competition on the theme of the International Day for Biodiversity 2024. An exposure visit to the Institute's facilities was also organized for the students. A training-cum-awareness program on Biodiversity Conservation was organized by SRC for Penlong Secondary School, Lingdok Senior Secondary School, and Government Senior Secondary School Bojoghari. The NERC celebrated the day in Itanagar, Arunachal Pradesh, to raise awareness among local communities about their roles and responsibilities in achieving global biodiversity conservation targets. Knowledge was also imparted on various topics relevant to the IBD theme, such as the biodiversity framework, SDGs, and biodiversity monitoring through different tools, including Remote Sensing and GIS.

Visit by the Joint Secretary, MoEF&CC

Ms. Nameeta Prasad, Joint Secretary, Ministry of Environment, Forest and Climate Change, Government of India visited Sikkim Regional centre of the Institute on 25th May 2024 and chaired a Scoping meeting organized at SRC campus for planning and development of the National Museum on Natural History (NMNH) regional museum galleries in collaboration with NIHE, BSI, ZSI, GIZ, EIACP. During her visit to the institute's headquarters in Almora during 21-22 June 2024, she interacted with the institute faculty and inspected various facilities of the institute. During her visit to the institute's living laboratory, 'Surya-Kunj', she planted a tree under the 'Ek Ped Maa Ke Naam' initiative of the Government of India. Likewise, on 23rd September 2024, during her visit to the Ladakh Regional Centre of the Institute, she inaugurated the "The Seabuckthorn Processing Unit" at Leh.

Swachhata Hi Seva Campaign

Under the Swachhata Hi Seva Campaign, a series of awareness programs and cleanliness drives were conducted in various villages of the Hawalbagh block, Almora from May 28, 2024 to June 5, 2024. The NERC organized a cleanliness drive at the Rural Technology Centre, Itanagar on 20th September 2024 to promote cleanliness and waste management, aligning with the national initiative for a cleaner India. On 16th September 2024, the NERC celebrated World Ozone Day under the theme "Montreal Protocol: Advancing Climate Action" by organizing an awareness and cleaning drive at the Senki River bank in Chandranagar, Itanagar, Arunachal Pradesh. The program was organized to raise awareness among local residents about the importance of a clean environment and the dangers of indiscriminate waste disposal to aquatic life and the water quality of the river. Similarly, a cleanliness drive was conducted at Sangestar Lake (3,700m) on September 25, 2024.

The Ladakh Regional Centre spearheaded the campaign from September 17 to October 2, 2024, undertaking a series of outreach programs and cleanliness drives in and around Leh City, Ladakh UT. This initiative aimed to promote environmental awareness and encourage sustainable waste management practices within the community. Throughout the campaign, three structured outreach programs engaged residents, students, and stakeholders, fostering discussions on waste segregation, plastic pollution, and eco-friendly alternatives. Parallel to these educational efforts, cleanliness drives were carried out across key locations, mobilizing volunteers to remove waste and restore public spaces. The collected waste primarily consisted of plastic waste, wrappers, discarded glass bottles, and other non-biodegradable materials. By integrating education, action, and community involvement, the campaign reinforced the institute's commitment to sustainable environmental stewardship. The SRC, on the occasion of World Wetlands Day conducted a cleanliness drive to raise awareness and maintain the ecological integrity of Tsomgo Wetland in Sikkim on 2 February 2025.

World Environment Day

On the occasion of World Environment Day the HQs and regional centre of the institute organized an outreach programme at Government High School, Kaneli as a pre-event celebration (May 26 - June 5, 2024). The Centre for Socioeconomic Development organized a one-day training workshop on the subject of technical transfer related to livelihood development through the sustainable use of natural resources in the Himalayan region at the Rural Technology Centre of the Institute in conjunction with the Indian Council of Forestry Research and Education, Dehradun.The center for Biodiversity Conservation and Management celebrated World Environment Day 2024 under the theme "Land restoration, desertification and drought resilience". A series of awareness programmes in the nearby villages of Almora and Surya-kunj from 28 May to 5 June 2024. Additionally, a land restoration campaign was organized in the Kaneli, Bisra, and Jyoli villages of Hawalbagh block, and plantation of medicinal plant species (Van Haldi, Rosemary) was carried out on fallow agricultural land,followed by a one-day awareness program at G.I.C. Majhkhali.

The LRC celebrated World Environment Day (WED) in Leh, Ladakhfrom May 26 to June 5, 2024. Commencing the celebration, a consultation workshop on 'Participatory approach for village Water Resource Management' was organized on 28th May 2024 at Government High School Igoo, Leh, Ladakh in collaboration with Acres of Ice. The second event was organized at the Municipal Committee Leh Faecal Sludge Treatment Plant Site on 31st May 2024 wherein a dedicated visit of Assistant Section Officers from different Ministries of Govt. of India was made to the site and the officers were apprised of the various benefits of the utilization of treated wastewater and hydroponic cultivation towards drought resilience. The third and concluding event, organized in the Conference Hall of LRC, NIHE, Leh, took place on 5th June 2024 in the form of popular lectures. The keynote lecture was delivered by Shri Sonam Lotus, Scientist-E and Head, Met Centre, Leh, India

Meteorological Department, Ladakh and the program was presided over by Shri Dhawan Kumar Rawat, IFS, and Wildlife Warden, Ladakh. All the participants in all three events essentially took the Mission LiFE pledge. Collectively, more than 150 individuals participated in a two-week-long celebration of World Environment Day. The HPRC, Mohal, Kullu, selected four Government Senior Schools in Kullu, GSSS, Dhalpur-Kullu, GSSS, Bhunter, GSSS, Bajura, and GSSS, Nagwain to raise awareness by organizing different activities during 28 May to 04 June 2024, such as declamation, drawing and painting, and quiz competition. A total of 15 students from each school participated in these activities.The NERC observed the day by organizing anevent at Ganga Lake, Itanagarin collaboration with the Department of Environment, Forest, and Climate Change (DoEFCC), Government of Arunachal Pradesh. A plantation drive was conducted on the periphery of the lake. A total of 50 participants joined the event, including officials from the DoEF&CC, Arunachal Pradesh, and scientists and research scholars from GBPNIHE-NERC, Itanagar.

Scientific Advisory Committee meeting

The XXXII Scientific Advisory Committee (SAC) meeting was organized at GBPNIHE HQs Almora (June 19-20, 2024). On the first day of SAC a Knowledge Sharing Day was organized during which faculty members from Thematic Centres and Regional Centres delivered presentations on new thematic programs under their respective Centres. It was followed by group discussions. During the Knowledge Sharing Day, all scholars of the institute, along with the scientific faculty, participated. On the second day (20th June 2024) the SAC reviewed the ongoing scientific progress of the Institute. The meeting was organized under the chairmanship of Prof. D.S. Rawat, Hon'ble Vice Chancellor, Kumaun University, Nainital. Among the SAC members, Dr. S.P. Aggarwal, Director, North East Space Application Centre (NESAC), Prof. (Dr.) Anil K. Gupta, Head of Division International & National Cooperation, National Institute of Disaster Management (NIDM), Ministry of Home Affairs, Govt. of India, Prof. R. Uma Shankar, Head, Bioscience and Bioengineering, Indian Institute of Technology Jammu, Dr. Purvaja Ramachandran, Acting Director, National Centre for Sustainable Coastal Management (NCSCM) , and Dr. Lalit Sharma, representative from Zoological Survey of India were present.

Ladakh Agrithon, 2024

The Centre actively participated in Ladakh Agrithon 2024 on June 28, 2024, at the University of Ladakh (UoL). The event, organized by the DST-Technology Enabling Centre of the University of Ladakh, featured seven distinct themes aimed at fostering innovation in agriculture and allied sectors. Among the key highlights, Ms. Jigmet Chuskit Angmo and Mr. Mohd Hussan, Junior Project Fellows at LRC-NIHE secured first prize in the Crop & Horticulture Farming theme. Their oral presentation, titled "Transforming Agriculture in Ladakh. Wastewater Hydroponic for Sustainable Crop Cultivatio" showcased groundbreaking approaches to sustainable agriculture in Ladakh's challenging environment. The award included a cash prize of Rs. 20,000 and certificatio of recognition validating efforts in promoting eco-friendly and innovative farming techniques.

Training on Mushroom Cultivation at Border Village of Ladakh




The Ladakh Regional Centre organized a hands-on training program on mushroom cultivation at Ayee Village, situated near the Siachen Base Camp, on 19th July 2024. The initiative aimed to enhance livelihood opportunities and address nutritional deficiencies in the region. A total of 15 villagers, including 09 women and 06 men, actively participated in the event. The training focused on equipping the community with essential skills in mushroom cultivation, offering a sustainable and locally adapted approach to food security. Experts guided the attendees through practical demonstrations, emphasizing low-cost techniques suitable for Ladakh's cold desert conditions.

Training Programme on Cultivation and Post-Harvest Management and Marketing of Aromatic Plants

Five-day training programme was organized on cultivation and post-harvest management and marketing of aromatic plants funded by Mehak Scheme of Horticulture Department, Swarghat Block, District Bilaspur, Himachal Pradesh from July 29to August 2, 2024 at HPRC Mohal Kullu, Himachal Pradesh. 50 male and female farmers of Swarghat development block participated in the programme. On the first day, farmers were introduced to the Institute by Er. RK Singh, Regional Centre Head and Scientist F followed by information about the programme and Mehak scheme by Dr. Sarla Shashni, Scientist E and convener. During the five-day programme, various scientists delivered lectures on topics related to aromatic plants, aiming to educate participants about the types of aromatic plants, particularly those found in Himachal Pradesh, their cultivation techniques, harvesting and post-harvesting methods, as well as management and extraction of essential oils. Farmers were made more aware of the importance of climate-smart aromatic plant farming in today's context. Lectures and information were also provided by various agencies related to aromatic plants on various topics, including value addition, packaging, labeling, and marketing. Farmers were made aware about how aromatic plants have now emerged as a good source of livelihood. During these five days, they were also taken to field to visit institutions such as Kanha Aromatics, Himalayan Essential Unit, Nature Learning Centre, and HPMCto gain practical knowledge.

Governing Board Meeting

The Institute organized the 46th meeting of the Governing Body of G.B. Pant National Institute of Himalayan Environment (NIHE) on July 31, 2024, under the Chairpersonship of Ms.Leena Nandan, Chairperson, Governing Body NIHE, and Secretary, MoEF&CC, Govt. of India. During the meeting Shri Pravir Pandey, Additional Secretary and Financial Advisor, MoEF&CC (Member), Smt. Nameeta Prasad, Joint Secretary, MoEF&CC(Member), Shri Hem Pande, Dwarka, New Delhi (Member), Shri B.M.S. Rathore, Bhopal, M.P. (Member), Dr. Susan George, Scientist-E (Mountain Division), MoEF&CC (Special Invitee),, and Prof. Sunil Nautiyal, Director, NIHE (Member Secretary) were present.

Establishment of One of the Highest Hydro-meteorological Stations of the Country in Ladakh

The Ladakh Regional Centre established one of the highest hydro-meteorological stations of the country, marking a significant milestone in glacier resource investigation on 1st August 2024. The Automatic Weather Station, positioned at an altitude of 5600 masl on the forefield of the Rulung Glacier, is accompanied by a meltwater discharge measurement site equipped with advanced sensors to record water level fluctuations automatically. These in-situ measurements, including glacier, weather, and hydrological data, provide crucial insights into the state and fate of Ladakh's glacier wealth. The establishment of this high-altitude monitoring station reinforces NIHE's commitment to climate resilience and sustainable research, ensuring robust data collection for future glacier conservation and environmental policy development in the Indian Himalayan Region.

Economic Valuation of Springshed Management in the Indian Himalayan Region: Assessing Effectiveness for Restoration and Enhancing

The Institute organized a two-day workshop on "Economic Valuation of Springshed Management in the Indian Himalayan Region: Assessing Effectiveness for Restoration and Enhancing Climate Resilience" from 6-7 August 2024. The workshop, supported by the International Centre for Integrated Mountain Development (ICIMOD), Nepal, brought together leading experts, resource persons, and practitioners in springshed management from various institutes and regions across India. The primary focus was to discuss approaches for the economic evaluation of springshed management, particularly in terms of its effectiveness in restoration efforts and its role in enhancing climate resilience within the fragile ecosystems of the Indian Himalayan Region. The workshop aimed to evaluate the socio-economic and ecological profitability of the springshed management activities, exploring their viability as sustainable solutions to water scarcity in the region. Additionally, the discussions focused on how key variables, such as population growth and water consumption patterns, impact profitability indicators like net present value (NPV) and internal rate of return (IRR) under varying demand scenarios.

Annual Day Celebration

The headquarters of the Institute and it's Regional Centres celebrated the 36th Annual Day on 10th September 2024. On this occasion at the Institute's HQs Kosi-Katarmal Almora, Hon'ble Minister of State in the Ministry of Road Transport and Highways Shri Ajay Tamta was the Chief Guest and Ms. Nameeta Prasad, Joint Secretary, Ministry of Environment Forest and Climate Change (MoEF&CC) was the Guest of Honour of the programme. The 30th Pandit Govind Ballabh Pant Memorial Lecture was delivered by Prof. Zafar Ahmad Reshi, Kashmir University, Srinagar on "Guardians of the Peaks: Confronting the Green Invaders of the Himalayan Highlands". Similarly, the LRC celebrated its Annual Day function in Leh, and the 5th popular lecture was delivered by Shri Sonam Lotus, Head of the Met Centre Lab at the India Meteorological Department, Leh, on "Climate Change & Water Issues in Ladakh". GRC celebrated the function in Srinagar, and Padma Shri Dr. Kalyan Singh Rawat, Founder of Maiti Foundation, delivered a popular lecture.

The HRC of the Institute celebrated the day at Mohal, Kullu, Himachal Pradesh, and Dr. Devina Vaidh, Additional Director, Regional Horticulture and Training Station, Bajora was the keynote speaker of the day and delivered lecture on Enhancing Livelihood in the North-Western Himalayan Region through Sustainable Horticulture Practices". SRC celebrated the annual day in its campus at Pangthang, Sikkim. On this occasion, 11th Himalayan Popular Lecture was delivered by Prof. Niladri Bag, Dept of Horticulture, Sikkim University, on "*In vitro* technology for the production of cash crops of Sikkim Himalaya and bio-control measures to improve cardamom cultivation in organic farming". The event was presided over by Shree P.N. Lepcha, Honourable Minister, Science & Technology, Environment & Forest, and Mines & Geology, Government of Sikkim. The North-East Regional Centre of NIHE celebrated the day in Itanagar and organized the 11th Pt. Govind Ballabh Pant Himalayan Popular Lecture delivered by Prof. Tomo Riba, Hon'ble Vice Chancellor Arunachal Pradesh University, Pasighat, on the topic "Traditional Ecological Knowledge among the shifting cultivators of Arunachal Pradesh, India". The Chief Guest on the occasion was Prof. Saket Kushwaha, Hon'ble Vice-Chancellor, Rajiv Gandhi University, Arunachal Pradesh.





Brainstorming Session on Identifying the Key Issues and Challenges on Environmental Aspects for the North-Eastern region of India

On 10th September 2024, the North-East Regional Centre of NIHE organized a "Brainstorming Session on Identifying the Key Issues and Challenges on Environmental Aspects for North-Eastern region of India" in collaboration with the Department of Environment, Forest & Climate Change, Govt. of Arunachal Pradesh; Botanical Survey of India, Arunachal Pradesh Regional Centre and Zoological Survey of India, Arunachal Pradesh Regional Centre. The event saw participation from scientists and faculty members from various organizations, including BSI-APRC, ZSI-APRC, GSI, National Centre for Sustainable Coastal Management (NCSCM), Chennai, SFRI, State Biodiversity Board, SRSAC, Himalayan University, NERIST, Urban Development & Housing dept., Tourism dept., Centre for Earth Sciences & Himalayan Studies, NEIST-Itanagar, NIT-AP, and other line departments of Arunachal Pradesh.

Green Skill Building Programs

The institute organized various green skill development programs across the IHR. A two-days training and skill-building program on "Himalayan farming: towards economic prosperity through high value crops" was conducted under the In-house project at Jyoli village cluster (Almora) on 12th-13th September 2024, covering 78 stakeholders. Additionally, a green skill was developed for 53 beneficiaries from the Jyoli village cluster, which covers 6 villages, utilizing pine needle-based biomass briquettes. An eight-day (6-23 March 2025) Green Skill Development Programme on 'Ecotourism Enterprises and Climate Change Adaptation' was organized by SRC in collaboration with Diocesan Integrated Society for Holistic Action and Kalimpong Horticulture Society at Kalimpong. The training programme emphasized the importance of ecotourism as a viable economic alternative that fosters environmental stewardship, enhances community participation, and contributes to sustainable development. Thirty unemployed youth from Dzongu, Kabi (Mangan), and Tsomgo were trained in eco-friendly tourism, biodiversity conservation, and climate adaptation strategies. The programme was combined with theory, field visits, and hands-on training on sustainable hospitality, waste management, and community-led conservation.

Hindi Pakhwada and Workshop

On the occasion of Hindi Diwas (14 September 2024) all the officials and employees of the institute and regional centers took an oath to promote and increase use of Hindi official activities, and to make employees aware about working in Hindi in official matters. Additionally, a Hindi Pakhwada was organized in the institute from September 14 to September 28, 2024. During the Hindi Pakhwada, various competitions, such as quiz, translation (from Hindi to English), noting and drafting, essay writing, computer typing in Hindi, and standard spelling were organized. The employees of the Institute participated enthusiastically in these competitions. At the end of the Hindi Pakhwada, the winners of competitions were awarded with cash prizes and certificates.

Workshop on Enhancing Climate Change Resilience in the Himalaya

The Ladakh Regional Centre, in collaboration with NIHE-HQs, organized a brainstorming session on "Enhancing Climate Change Resilience in the Himalaya: Integrating Biodiversity, Water Resources, Sustainable Tourism, and Livelihood" on 19th September 2024 in Ladakh. The event aimed to foster strategic discussions and innovative solutions for climate resilience in the Himalayan region. The inaugural session was presided over by Ms. Nameeta Prasad, Joint Secretary, Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India, while Adv. Tashi Gyalson, Hon'ble Chief Executive Councillor of LAHDC-Leh, served as the Chief Guest. Shri Stanzin Chosphel, Hon'ble Executive Councillor of LAHDC-Leh, Ladakh UT, attended as the Guest of Honor, alongside Prof. S.K. Mehta, Vice Chancellor, University of Ladakh, as the Special Guest. Following the inauguration, two technical sessions were organized, allowing in-depth discussions among representatives from various esteemed organizations across Ladakh regional centers and NIHE. Experts deliberated on holistic strategies for environmental sustainability, emphasizing community-led conservation, adaptive water resource management, eco-tourism development, and climate-resilient livelihoods. The session strengthened collaborative efforts in addressing climate challenges while bridging scientific insights with regional development policies, ensuring a more resilient and sustainable future for the Himalayas.

Training for Senior Indian Forest Service (IFS) Officers on "High Altitude Wetland and Peatland Management"

The North East Regional Centre (NERC) of the NIHE and National Centre for Sustainable Coastal Management (NCSCM), Chennai jointly organized 5-day compulsory Training for Senior Indian Forest Service (IFS) Officers on "High Altitude Wetland and Peatland Management" from 23rd to 27th September 2024 at Tawang, Arunachal Pradesh in collaboration with Department of Environment Forest & Climate Change, Govt. of Arunachal Pradesh. During the training, a cleanliness drive was conducted under the Swachata Hi Seva Campaign at Sangestar Lake (3,700m) on September 25, 2024, with the theme "Swabhav Swachhata-Sansakar Swachhata." The event was jointly organized with the Indo-Tibetan Border Police (ITBP) and recorded participation from 72 officers and staff. On the same day, "Ek Ped Maa Ke Naam" Campaign was organized by NIHE, NCSCM, and Arunachal Pradesh Forest Department at Tawang. A total of 94 participants, including the Hon'ble MLA of Tawang, senior IFS officers, staff from NIHE, NCSCM, the Arunachal Pradesh Forest Department, and NCC, participated in the campaign.

National Wildlife Week

To celebrate National Wildlife Week, the Institute organized various events from 2nd October to 8th October 2024 under the theme "Human-Wildlife Co-existence". At the institute's headquarters, the center for Biodiversity Conservation and Management (CBCM) organized a series of programs i) brainstorming session on Human-Wildlife Co-existence, wherein Prof. Sunil Nautiyal, Director of the Institute, Mr. Bhuvan Nautiyal, a social worker, Mr. Tapas Mishra, range officer, Dr. I.D. Bhatt, Head CBCM, officials from the forest department, scientists and researchers took part, ii) lecture on Human-wildlife co-existence with special reference to the Himalayan region by Mr. Tapas Mishra citing his experiences, he talked about management strategies to co-exist with the surrounding wildlife, iii) nature walk of Binsar Wildlife Sanctuary iv) community awareness programs at Dhaulchina, Almora,and v) Institute level photography competition. A total 70 participants (31 female, 39 male) participated in the events.

A one-day program on April 10, 2024, was organized by HPRC at Government Senior Secondary School, Bhuntar, Kullu, Himachal Pradesh. To mark the occasion, Essay Writing and Drawing Competitions were organized under the theme for the year 2024. A total of 26 girls from the GSSS, Bhuntar participated in both events. The GRC organized a one-day workshop at Govt. Inter College Khandah, Pauri Garhwal, in which 60 students (Male-34; Female-26) from classes 9–12 participated. The SRC organized a one-day awareness workshop on 'Wildlife Conservation through Co-existence', emphasizing the growing importance of digital technology in wildlife conservation efforts, enabling better understanding and protection of biodiversity. Participants were guided on bird photography during an onsite exposure visit to document local bird species. A photography competition was organized to document the wildlife of Pangthang digitally. Approximately 30 participants were present in the event. The NERC organized a two-day awareness program on "Nature Conservation" from 7-8 October, 2024. On the first day, an awareness programme, followed by a Quiz and Photography competitions, was organized at Himalayan University, Jollang, Itanagar, for university students. On the second day, Nature Camp and field visit for students was organized at the Itanagar Biological Park. A total of 120 students actively participated in the events.

The Special Campaign 4.0

Active participation of the Institute along with Regional Centres in Special Campaign 4.0 for institutionalizing Swachhata and Minimizing Pendency in Government offices. The campaign was successfully organized by LRC from October 2 to October 31, 2024, with a dedicated focus on cleanliness and environmental responsibility. This campaign aimed to enhance public awareness about waste management and promote sustainable practices across different sites in Leh. During the campaign, multiple cleanliness drives were conducted daily. For instance, on October 16, 2024, a drive was carried out at the Rural Technology Centre, emphasizing the importance of maintaining clean and eco-friendly workspaces. The following day, October 17, 2024, another drive took place in the Office Corridor, reinforcing institutional commitment to cleanliness. On October 21, 2024, the initiative culminated in a large-scale waste collection drive across multiple locations involving a team of nine participants. These efforts successfully gathered plastic waste, e-waste, and other types of refuse, helping to reduce environmental pollution and encourage responsible waste disposal in Leh.

Workshop on Cultivation of high-value medicinal plants for livelihood enhancement

Garhwal Regional Centre, G.B. Pant NIHE, Srinagar Garhwal, organized a two-day workshop on "Cultivation of High-Value Medicinal Plants for Livelihood Enhancement" at Ghandiyalka village, Barsu cluster, Rudraprayag, on 8–9 October 2024. Led by Dr. A. K. Jugran, the workshop aimed to empower villagers to increase their incomes through the cultivation of medicinal plants. Highlighting the growing market demand, participants were sensitized to the economic and conservation benefits. Over 400 kg of Hedychium spicatum tubers and seedlings were distributed and demonstrated. A total of 47 farmers benefited, with 15 farmers initiating cultivation across 10 Nali areas.

Awareness Campaign on Solid Waste and Algae Management

The SRC organized an awareness campaign on solid waste and algae management at Tsomgo High-Altitude Wetland on October 21, 2024 in collaboration with the Indian Army and the Tsomgo Pokhari Sanrakshan Samiti. Approximately 40–50 stakeholders, including Army personnel, TPSS members, Forest Department officials, and local groups, participated. The event included hands-on algae removal and awareness sessions on sustainable waste disposal and eco-friendly tourism. Stakeholders pledged joint responsibility to clean algae annually and manage solid waste five times a year. The campaign fostered strong community-government partnerships to protect the lake's biodiversity and ecological integrity through continued awareness and collaboration.

Nature Camp

On 24 October 2024, the North East Regional Centre of GBPNIHE organized a Nature Camp for school students at the Itanagar Biological Park. The program was conducted under the NMHS-funded Him-Nature Learning Center (Him-NLC) project, jointly implemented by the Department of Environment, Forests and Climate Change, Government of Arunachal Pradesh, and GBPNIHE–NERC. This event aimed to educate young minds about the importance of biodiversity conservation and foster a deeper connection with the natural world. The event saw active participation from around 50 students of Gellam Memorial School, Itanagar.

Homestay Steering for Ecotourism Management

SRC organized a five-day Training-cum-Exposure workshop on Homestay Steering for Ecotourism Management at Assam Lingzey from 24 to 28 October 2024 in collaboration with Mutanchi Lom Aal Shezum-Dzongu. A total of 24 participants from Dzongu and Kabi blocks attended the workshop. The program aimed to foster sustainable livelihoods through ecotourism, with a focus on empowering the Lepcha community by enhancing their skills in homestay operations and sustainable tourism practices.

Himalayan Glacier Monitoring and Training Workshop (HIMTRAIN)

The Ladakh Regional Centre in collaboration with IIT Indore and IRD-France, successfully organized the "Himalayan Glacier Monitoring and Training Workshop (HIMTRAIN)" at IIT Indore, Madhya Pradesh, from November 11-15, 2024. This initiative was conducted under the Young Team Associated with IRD (JEAI)-France and NMHS-Glacier projects, focusing on advancing research and capacity-building in Himalayan glaciology. The HIMTRAIN Workshop offered a unique blend of theoretical knowledge and practical tutorials, equipping participants with essential skills for cutting-edge research in glaciology while supporting water resource management and planning. The workshop witnessed active participation from 24 research scholars representing prestigious institutions across India. Their engagement in intensive discussions, hands-on tutorials, and expert-led sessions reinforced the workshop's impact, fostering collaboration among early-career researchers and strengthening the scientific understanding of Himalayan glaciers.

Awareness Training and Consultation Workshop for Yak Herders on Tsomgo Lake High-Altitude Wetland Conservation

An awareness-cum-training workshop for yak herders on the conservation and management of High-Altitude Wetlands was organized on 29 November 2024 at Tsomgo Lake, by SRC. The workshop highlighted the region's unique biodiversity and the vital role of yak herders in its protection, as well as eco-friendly measures of yak herding, waste management, and the impacts of climate change, encouraging sustainable practices. The workshop fostered awareness, developed conservation strategies for Tsomgo Lake, and strengthened collaboration among the community, scientists, and authorities. Active participation from yak herders and Pokhari Sanrakshan Samiti members lead to the success of the programme.

Training on Natural Resources-based Livelihood Program

The Ladakh Regional Centre, in collaboration with the Ladakh Autonomous Hill Development Council (LAHDC)-Leh, conducted an eight-day Natural Resources-based Livelihood Training Program from December 5 to 12, 2024, at Changa Village, Ladakh. The event aimed to empower local communities by promoting sustainable resource management, eco-friendly practices, and entrepreneurial skills. A total of 20 participants from Changa Village were trained in nature-based craftsmanship, focusing on weaving baskets and decorative products using Festuca grass and twigs of Silex species. The training emphasized the significance of traditional knowledge, economic diversification, and environmental sustainability. During the closing session, Dr. Sandipan Mukherjee, Head of LRC-NIHE, emphasized the program's commitment to promoting nature-based entrepreneurship and off-farm employment in Ladakh, thereby ensuring long-term economic resilience. The event culminated in a product showcase, where participants exhibited their handmade goods, gaining confidence in sustainable livelihood opportunities and reinforcing their role in local economic development.

International Mountain Day-2024

Under the theme of International Mountain Day 2024, "Mountain solution for a sustainable future-innovation, adaptation, and youth, the Institute organized a seminar 'Mountain solutions for a sustainable future: Success stories from the Himalaya' on 11th December 2024 at institute headquarter delivered by Prof. Durgesh Pant, Director General UCOST, Dehradun. Similarly, the LRC organized a lecture on "Biodiversity Research, Trends of Vegetations, and Climate Change Impact in the Mountain – A case of Himalaya. The NERC organized a lead talk on the theme by Dr. S D Gurumayum, Head of the Zoological Survey of India, Arunachal Pradesh Regional Centre, Itanagar.

One-day training workshop with Students & Teachers on Biodiversity Conservation through Student Participation

The Garhwal Regional Centre in collaboration with INYAS and the Indian National Science Academy (INSA), New Delhi, organized a one-day workshop on "Biodiversity Conservation through Student Participation" at G.I.C. Phata, Rudraprayag, Uttarakhand, on 30th December 2024. A total of 119 students from class 9 to 12 attended the training. The workshop aimed to raise awareness about biodiversity, ecosystems, and conservation strategies. Highlights of the event included expert lectures, interactive sessions, quiz and insights into biodiversity conservation efforts.

GESI responsive Regional Training on Spring shed Management (29 January to 01 February 2025)

A regional training on "GESI responsive Regional Training on Springshed Management" was conducted by NIHE in collaboration with ICIMOD and SRHU from 29 January to 1 February 2025 at SRHU, Dehradun. The goal of the event was to build interdisciplinary knowledge and practical skills for springshed management in the HKH region, focusing on hydrogeology, climate, and governance. It also aimed to assess the impacts across various contexts and promote innovative, climate-resilient, and cost-effective water supply technologies suitable for mountainous areas.

Awareness programmes on Deforestation and Climate Change Adaptation

An awareness programme on 'Deforestation and Climate Change Adaptation: Ensuring Sustainability in the Himalayas' on 11th February, 2025 was organized by North-East Regional Centre of NIHE at Vivekananda Central School (VCS), Itanagar, Arunachal Pradesh. The programme, which attracted 150 attendees, including students and faculty members, aimed to educate them on the causes, impacts, and mitigation strategies related to climate change, with a particular focus on deforestation.

Training Workshop Remote Sensing and Machine Learning Tools to Support Monitoring Wetland Dynamics

A four-day training workshop on "Remote Sensing and Machine Learning Tools to Support Monitoring Wetland Dynamics" was jointly organized by the GBPNIHE-SRC and IIT Kharagpur from 14 to 17 February 2025 at IIT Kharagpur, West Bengal. The workshop aimed to equip participants with practical knowledge of satellite data processing and machine learning applications for monitoring wetland ecosystems. Sessions included hands-on training in QGIS, Google Earth Engine, and land cover classification techniques. A total of 25 researchers from different institutes (NIHE, IIT Lharagpur, Sikkim University, ZSI, NCSCM, Symbiosis University, Kumauan University) participated in the training workshop.

Springshed Management and Climate Adaptation: Strategies for Sustainable Development in the Indian Himalayan Region

NITI Aayog, under the State Support Mission, in collaboration with the G.B. Pant National Institute of Himalayan Environment (NIHE) and the International Centre for Integrated Mountain Development (ICIMOD), organized a National Workshop on "Springshed Management and Climate Adaptation: Strategies for Sustainable Development in the Indian Himalayan Region" on 17 February 2025 at Haytt, Dehradun. The program was chaired by Shri. Pushkar Singh Dhami, Hon'ble Chief Minister of Uttarakhand. The workshop aimed to highlight deliberations on various perspectives, including challenges and opportunities of springshed management at the national and state levels, and explored ways to make spring revival part of the policy-science-practice interface agenda for long-term sustainability. More than 100 participants representing ministries, state governments, NGOs, research institutions, and communities participated in the workshop.

Training programme on Ecological Niche Modeling: Techniques and Applications for Biodiversity Conservation

A three-day training programme titled "Ecological Niche Modelling: Techniques and Applications for Biodiversity Conservation" was conducted by the North East Regional Centre of NIHE from 19 to 21 March 2025. The program attracted over 35 participants from various organizations, universities, and research institutions. The primary objective of the training was to enhance participants' proficiency in current ENM methodologies, tools, and software, with a particular focus on species distribution modeling. The training sessions included in-depth instruction on utilizing R Studio as a programming environment and MaxEnt as a tool for species distribution modeling, equipping participants with essential knowledge and skills for biodiversity conservation research.

Training programme on Mountain Hive: Sustainable Beekeeping in the Garhwal Himalaya

Under In-house Project-3, the Garhwal Regional Centre of NIHE, organized a two-day demonstration programme on "Mountain Hive: Sustainable Beekeeping in the Garhwal Himalaya" at Barsu, Ghandiyalika, and Khyarki villages in Rudraprayag district during March 25-26, 2025. The event aimed to promote sustainable livelihood opportunities through beekeeping and raise awareness of its economic and ecological benefits. The workshop focused on modern beekeeping practices, honey production, and pollination services, highlighting their role in enhancing agricultural productivity and farmers' incomes.A total 6 bee boxes with hives were distributed to the stakeholders. A total of 38 farmers and stakeholders benefited from the program, gaining hands-on experience and technical knowledge to implement beekeeping as a sustainable income-generating activity successfully.

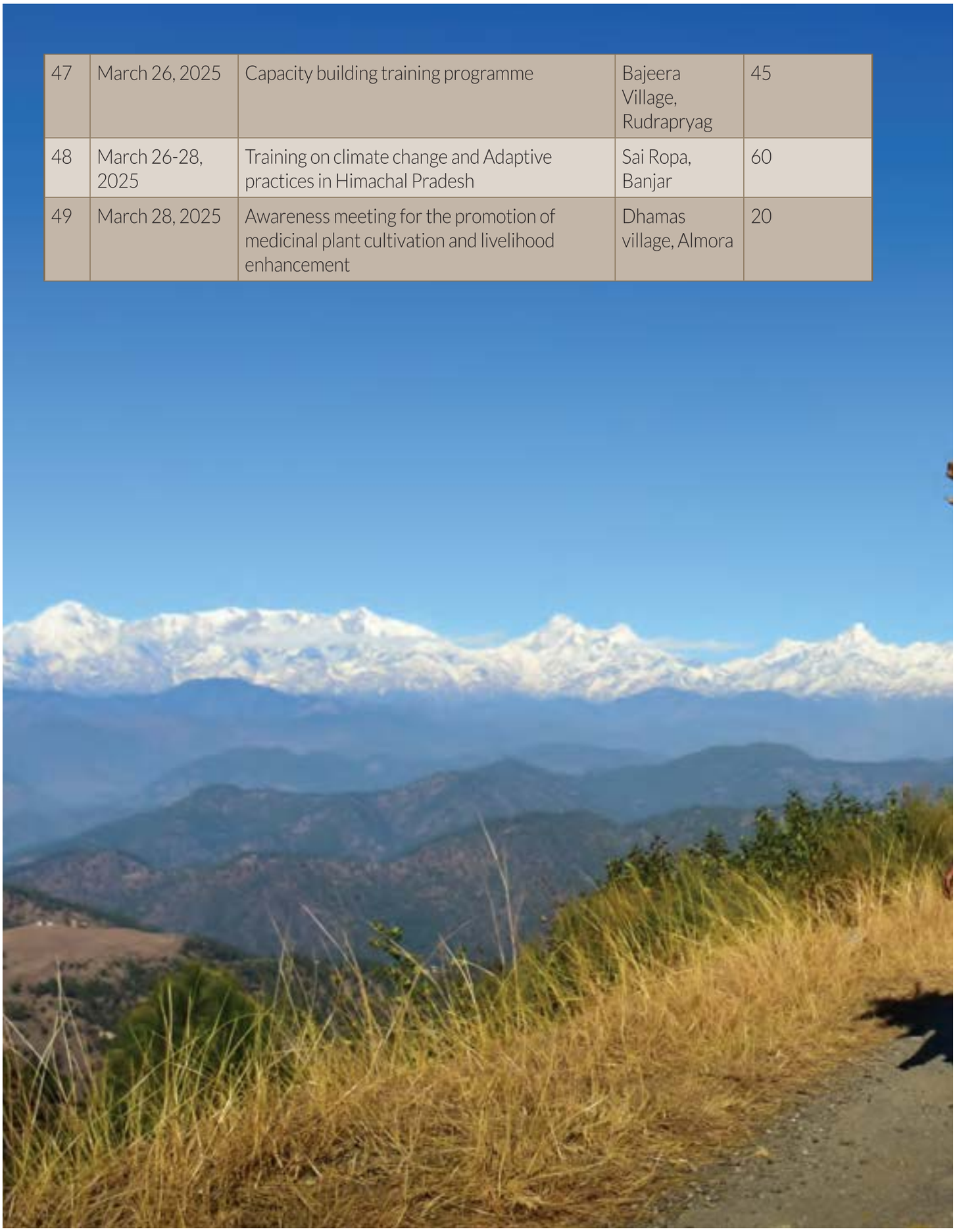
Summary of Some Important training/Webinars/Web Meetings Organized by the Institute

S.N.	Date	Title of events	Venue	Total Participants
1	May 21, 2024	Life Mission awareness programme	NIHE, HQ	21
2	May 22, 2024	Role of people's participation in conservation and management of biodiversity to adopt a healthy & sustainable lifestyle	NIHE, HRC	80
3	May 28, 2024	A plantation drive and pledge in celebration of World Environment Day	NIHE, HQ	29
4	May 27 -17 June 2024	A Research Placement Programme for students of Bath Spa University and the University of Cumbria, UK England	NIHE, HQ	17
5	June 03, 2024	Workshop on hazard and vulnerability assessment of Phojal area towards flash floods	NIHE, HRC	58
6	June 03, 2024	One day Workshop on UGC-UKIERI HiFlo-DAT	NIHE, HRC, Mohal, Kullu	39
7	July 01, 2024	Biodiversity Conservation Education and Development of School Herbal Gardens	Dhalpur, Kullu	300
8	July 15, 2024	National Hindi Workshop - Environmental Issues, Challenges and Solutions in the Indian Himalayan Region	NIHE, HRC	80
9	July 16, 2024	A plantation drive and pledge	NIHE, HQ	26
10	July 17, 2024	Celebration of LokparvHarela through mass plantation	NIHE, HQ	100
11	July 20, 2024	Biodiversity Conservation Education and Development of School Herbal Gardens	Bhuntar, Kullu, HP	240
12	July 19-22, 2024	Awareness on Biodiversity Conservation	North Bengal	210
13	July 24, 2024	Capacity building among stakeholders for the conservation and rejuvenation of springs	Rangway, Lahaul Valley, Himachal Pradesh	20
14	July 24, 2024	Capacity building on conservation and rejuvenation of water springs	NIHE, HRC	20
15	July 25, 2024	Capacity building among stakeholders for the conservation and rejuvenation of springs	Lapshak, Lahaul Valley, Himachal Pradesh	15

16	July 28, 2024	Community participation programme for spring rejuvenation intervention work	Yangrang, Lahaul Valley, Himachal Pradesh	43
17	August 05, 2024	Field demonstration of high-value medicinal plant cultivation for livelihood enhancement of farmers	Triyuginarayan	30
18	August 08, 2024	Workshop on Creation of an integrated database of the Himalayan biodiversity for mainstreaming in policy to meet national commitments	NIHE, HQ	33
19	August 28, 2024	Biodiversity Conservation Education and Development of School Herbal Gardens	Sultanpur, Kullu, HP	70
20	August 28, 2024	Community consultation on Awareness and Participatory Rural Appraisal at Korzok village, Tso Moriri, Changthang District, Ladakh	Ladakh	38
21	August 28, 2024	Workshop on wetland conservation	Korzok village, Ladakh	30
22	September 14, 2024	Plantation activity at Suryakunj and establishment of “Matravan”	NIHE, HQ	64
23	September 20, 2024	Inauguration of Seabuckthorn Processing Unit in Chamshen	Chamshen, Siachen Valley, Ladakh	28
24	September 22, 2024	Workshop on Conservation and Management Planning of High-Altitude Wetlands	Sikkim	41
25	September 23-27, 2024	Training on Cultivation, Post Harvest Management and marketing of Aromatic Plants	NIHE, HRC	50
26	September 27, 2024	Biodiversity Conservation Education and Development of School Herbal Gardens	Cambridge International School, Mohal, Kullu, H.P.	60
27	October 09-10, 2024	Awareness on Climate Resilient Crops in Himachal Pradesh	Bathad, Tirthan Valley, Himachal Pradesh	30
28	October 16-18, 2024	Training on Environmental Monitoring Climate Change in Relation to Biodiversity, Environmental Awareness and Disaster Management	Sainj, Kullu, HP	45
29	October 18-21, 2024	Awareness on Biodiversity Conservation	Mechuka	210
30	November 11, 2024	Awareness and promotion of medicinal plant cultivation in villages	Khoont village, Almora	41

31	November 18-22, 2024	Training on Cultivation, Post Harvest Management and marketing of Aromatic Plants	NIHE, HRC	38
32	December 6-7, 2024	Indian Honeybee Keeping Management for Sustainable Development	NIHE, HRC	20
33	December 11-13, 2024	Training on Sustaining Ecosystems: A Path to Resource Security and Resilience Sub-Theme: Water Resources, Socio-economic Development, Biodiversity Conservation, Disaster Management and Clean Air	HPRC	45
34	December 11-13, 2024	Training on Sustaining Ecosystem: A Path to Resource Security and Resilience	NIHE, HRC	65
35	December 28-29, 2024	Training on Enhancing Financial and Accounting Expertise	NIHE HQ	32
36	January 20, 2025	Scoping Workshop on Strengthening R&D collaboration Between G. B. Pant National Institute of Himalayan Environment and National Centre for Sustainable Coastal Management	NCSCM	40
37	January 27, 2025	Biodiversity, Climate Change and Local Knowledge: A collaborative Vision for Sustainable Development	NIHE, HRC	30
38	January 28-29, 2025	Awareness on Biodiversity Conservation	Seijosa	182
39	January 29-30, 2025	Training on climate resilient practices in Himachal Pradesh	KVK, Bajura, Kullu	50
40	February 02, 2025	Capacity Building & Awareness Programme on Protecting Wetlands for Our Common Future	Tsomgo Wetland	34
41	February 11-12, 2025	Cultivation of cash crop plants for livelihood enhancement	Rudraprayag	46
42	February 14, 2025	Training-cum-awareness on Parahydrology with Special Reference to Spring Rejuvenation	Lempia village, Arunachal Pradesh	31
43	February 22–23, 2025	Workshop on Developing Action Plan for Springshed Management	Kalimpong	29
44	March 03-07, 2025	Training on Climate-Resilient Beekeeping: Empowering Women and Youth for Sustainable Livelihoods through Integrated Farming	Old Ziro, Arunachal Pradesh	15
45	March 22, 2025	Workshop on vetiver farming techniques	NIHE, HRC	
46	March 21, 2025	Flood hazard management and vulnerability assessment	NIHE, HRC	60

47	March 26, 2025	Capacity building training programme	Bajeera Village, Rudrapryag	45
48	March 26-28, 2025	Training on climate change and Adaptive practices in Himachal Pradesh	Sai Ropa, Banjar	60
49	March 28, 2025	Awareness meeting for the promotion of medicinal plant cultivation and livelihood enhancement	Dhamas village, Almora	20



CENTRE FOR LAND AND WATER RESOURCE MANAGEMENT (CLWRM)

Land and water are the two major components of the Ecosystem and provide the basis for the life forms to thrive. Therefore, the Institute, since its inception, has taken the lead not only to study the key components of Land and Water Resources of IHR but also for its management. This inevitable urge to carry out in-depth research in the field of Land and Water resources of IHR resulted in the establishment of a dedicated Centre for Land and Water Resource Management (CLWRM) in 2017. Over the years, the Centre has undertaken extensive research in the field of mountain hydrology including springs, water resource augmentation, urban sprawl studies, glacier dynamics and hydrometeorology, geo-tectonics and landslide restoration, catchment area treatment, soil and water conservation technologies, etc. have been implemented to address pertinent issues of land and water resources in the Indian Himalayas. 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 (In-house Project, 2020-2025)

Natural water springs are the primary freshwater sources for nearly 40 million people across the Himalaya. Springs varies in terms of flow, water chemistry, geomorphology, and ecology, and holds socio-cultural and economic importance. However, the problem of drying of springs resulting in substantial alterations to spring ecosystem structure and functions. Being the most structurally complex, ecologically, and biologically diverse ecosystems, it has been observed that the interactions of dependent ecosystem services in springs are hardly documented or studied in the Himalaya. Hence, the study has been undertaken with two-fold objectives: (i) to provide a better understanding of the functioning of spring ecosystems through the development of spring-ecosystem assessment and management protocols, and (ii) to enhance water security through the revival of springs using the Jal Abhayaranya concept. This transformative project is currently under implementation in four IHR states through four regional centres of the Institute: Uttarakhand (Almora, Champavat, Rudraprayag, and Pauri districts), Himachal Pradesh (Kullu and Mandi districts), Sikkim (South Sikkim district), and Arunachal Pradesh (Lower Subansiri district).

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

1. The spring inventory datasets of 6407 springs across IHR (out of total spring inventory of 6523 springs), were uploaded on HIMAL portal (https://nmhs-himal.gov.in) after necessary checks and corrections for wider stakeholder use. For the delineation of spring ecosystem boundary and identification of area/sites for potential rainwater harvesting structures to recharge the spring, a methodological framework was developed using eigenvectors of eight different thematic layers derived under the AHP framework, combining hydrogeological and GIS-based methodologies for springshed management (Fig. 1). It established a solid foundation for prioritizing interventions, including afforestation, soil moisture retention measures, and in-situ recharge structures.

2. The spring flow or health of spring discharge was quantified viz., Flow variability (Q10/Q90), Low flow variability (Q50/Q90), Spring variability index (Cv), Meinzer's discharge class (V), Maillete's spring variability class (M), Seasonality Index of discharge (SI) and Asymmetry of discharge (Ca), and annual Water Quality Index (WQI); and following standard statistical and hydrological analysis of selected springs under study. For example, Spring variability index (Cv) of one of the springs of Mandunga village cluster, M01D, before pre-intervention was 64.73, and changes to 53.95 after post-intervention, suggests some significant stability by indicating lesser values of indices.

3. In strengthening the bio-engineering interventions, this year, a total of 150 recharge structures, mostly trenches, and toe trenches, were dug and desilted to facilitate rainwater harvesting and groundwater recharge in the Jyoli village cluster, Almora. The pre and post-impact analysis of engineering intervention on springs were studied using Meinzer's discharge class, hydrograph analysis, Flow Duration Curve (FDC) curves and its associated discharge variability indices, viz., Q10 and Q90, and Master Recession curves (MRCs), to ascertain the impact and variability of spring discharge in the monitoring period and demonstrates the efficacy of the planning and management of spring interventions work in the selected study sites.

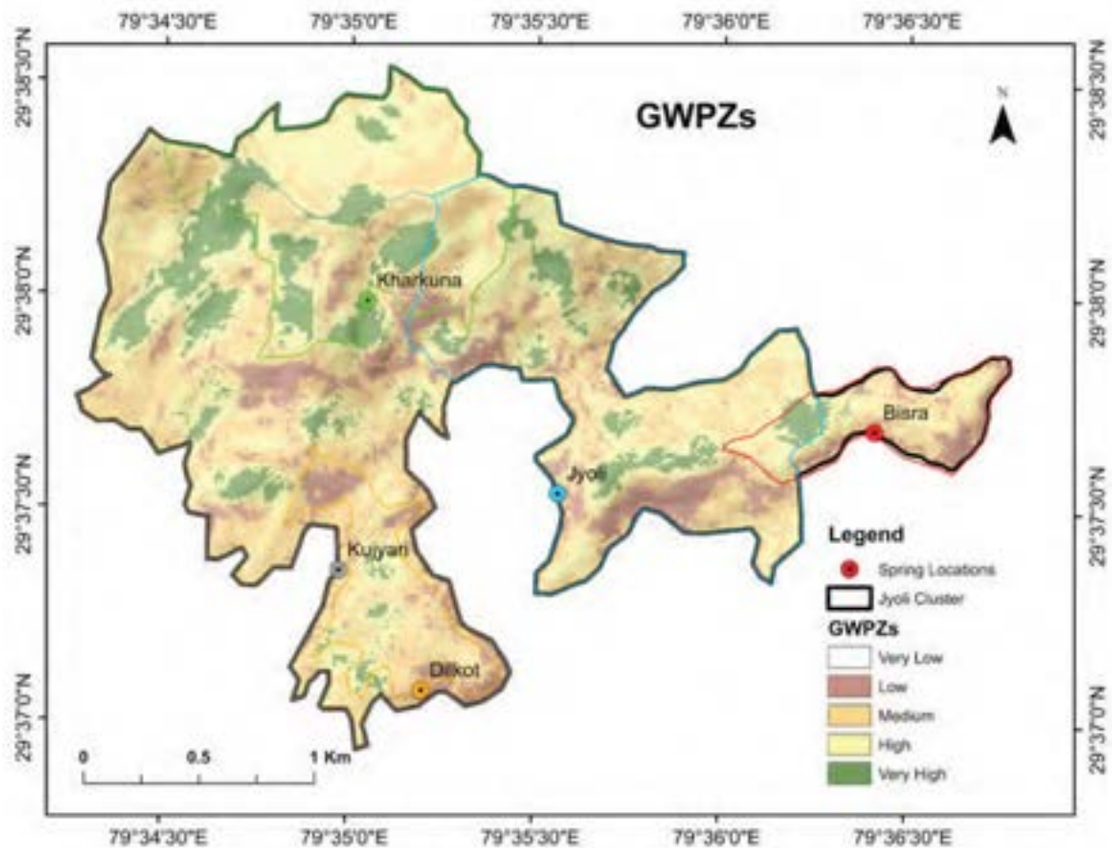


Fig. 1 Groundwater Potential Zones (GWPZs) at Jyoli spring cluster, Almora, Uttarakhand

Assessment of Glacier-Climate Functional Relationships across the Indian Himalayan Region through Long-Term Network Observations (NMHS, 2023-2026)

The project is aimed to long-term monitoring of glacier mass balance, hydrometeorology with black carbon, meltwater, and sediments properties of three ungauged glaciers of Jammu and Kashmir, Uttarakhand, and Sikkim so that the multi-component glacier observations could be used for developing glacier-climate response function preferably through network approaches and spatially distributed glacier mass balance and ice-flow models. The novelty of the proposal is the application of an information theory-based network approach to developing functional relationships between glaciers and climate feedback. Furthermore, the observations are expected to be disseminated through GIS and web-based resources of CDMA, as well as NIHE. These glaciers were chosen in a manner that not only represents the different geographic zones but also the different climatic zones where the various behaviors of glacier response have been reported over the last few decades. This will contribute towards establishing representative/benchmark glaciers across the IHR, with networks for long-term monitoring, data generation, and a glacier-climate response model to enhance the understanding of glacier behavior in the near future.

Objectives

- Assessment of glacial dynamics, changes in the glacial morphometry and mass balance using space-based resources and field measurement.
- Identifying changes in the glacier hydrodynamics and glacier melt-water chemistry using in-situ observations.
- Investigating glacial mass balance as a response to changing climatic parameters using functional relationships through real-time and memory-based networks for understanding the glacial-climate functional relationships.

Achievements

1. Glacier mass balance for Chipa glacier (2000-2010, 2010-2020, 2020-2024) was calculated using the Geodetic method (also known as DEM differencing method). Further, the velocity of the Chipa glacier was also derived using the temporal Sentinel-1 datasets for pre-monsoon, monsoon, and post-monsoon time periods for the years 2017 to 2024 (Fig. 2 & 3).

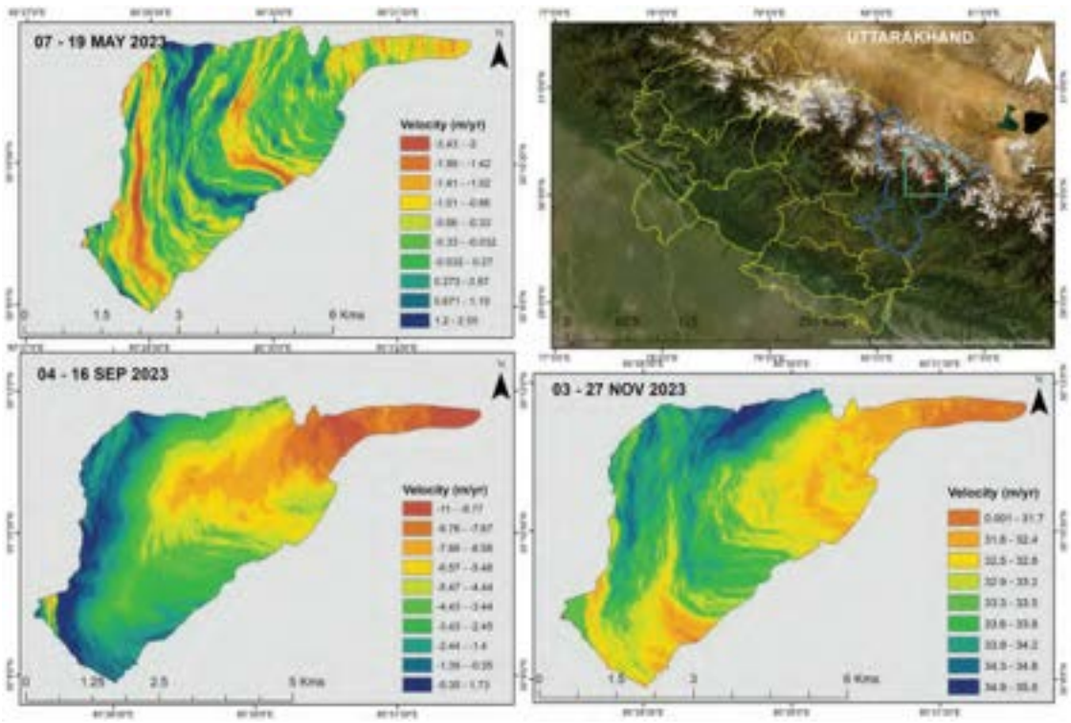


Fig. 2 Chipa glacier velocity derived using InSAR method

2. SAR-based Rulung Glacier (Ladakh) velocity was determined from 2017 to 2024, and the glacier meltwater analysis of Rulung Glacier (2015-2016, 2023-2024) is completed (Table 1).

3. The Terminal Retreat rate was calculated for South Lhonak glacier using the Landsat 5 and Landsat 8 (30m) datasets. The total loss area of the South Lhonak glacier over the last three decades (1990-2020) was calculated using Landsat 5 and Landsat 8 datasets. Further, 19 Supraglacial lakes were mapped using Sentinel 2 MSI over the Changme Khangpu glacier (Sikkim). Moreover, the impact assessment of the 2023 GLOF was also conducted in the Sikkim Himalaya. The devastation due to this flood event was documented and a report was prepared.

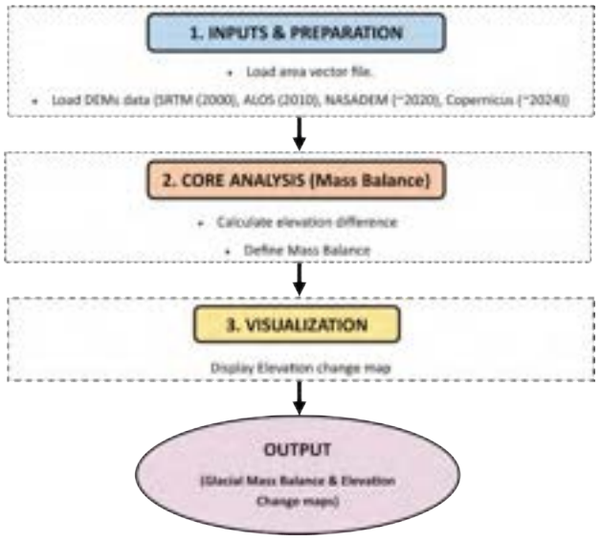
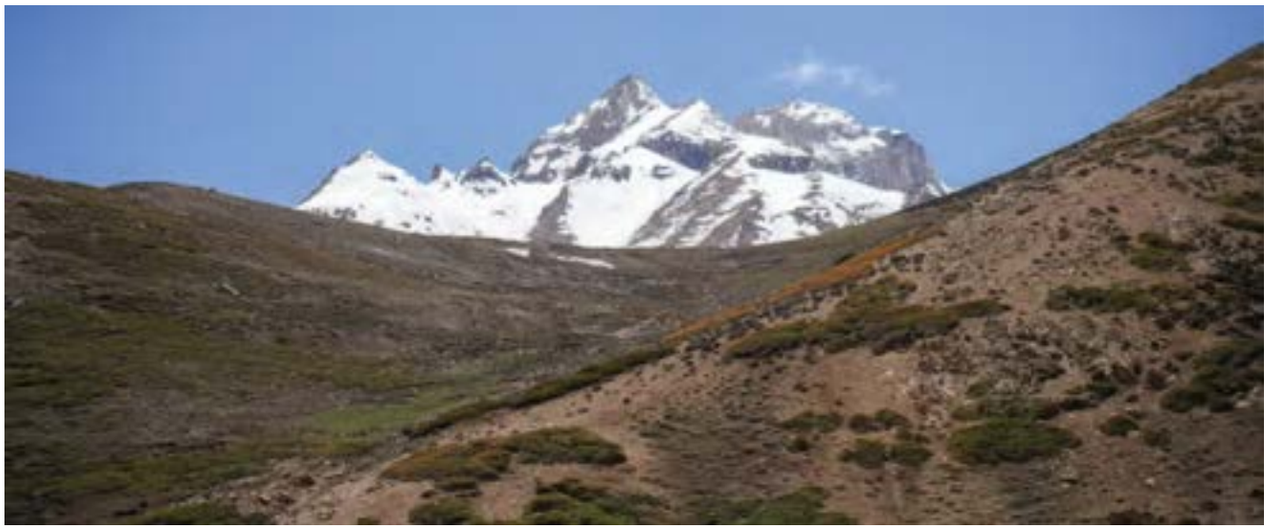


Fig. 3 Diagram of the Glacier Mass Balance analysis workflow

Table 1. The ELA and mass balance estimation of Rulung Glacier, Ladakh

Date	Year	ELA (m)	AAR	Mass Balance (m w.e. year^{-1})
19-Aug-17	2017	6017.38	56.30	-0.067
26-Jul-18	2018	5925.22	56.36	-0.065
08-Sep-19	2019	5924.09	57.91	-0.013
03-Aug-20	2020	5967.38	53.37	-0.167
22-Jul-21	2021	5936.26	59.70	0.0479
10-Sep-22	2022	5959.63	48.36	-0.337
12-Aug-23	2023	5970.38	47.79	-0.356
30-Aug-24	2024	5935.57	59.94	0.0561



Summary of the Completed Projects / Activity

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

The project was one of the first study of spring rejuvenation in cold desert area of Himachal Pradesh, wherein water security through inventory and revival of springs was attempted using hydro-geological action research and active participation of community and other relevant stakeholders during the project activities in Lahaul Valley also known as a cold desert region of Himachal Pradesh. The region remained closed due to snow for most of the time in a year; still, the region faces an acute water shortage in the summers. This is due to the reduction in snowfall, the receding of snow-covered mountains, limited groundwater recharge, and the absence of spring rejuvenation-focused policies. The project activities were carried out specifically in Yangrang, Lapshak, and Rangway villages in Lahaul Valley, integrating scientific research, participatory approaches, and innovative conservation techniques. Through a systematic approach that combined spring inventory via primary and secondary sources/surveys (190 springs), spring water quality monitoring and discharge analysis, participatory interventions, and the use of RS-GIS tools, the study provides a comprehensive understanding of the region's spring water dynamics and potential for rejuvenation. Various policies, schemes, and programs of the Government of India were studied to identify gaps specific to the management of spring, upon which possible future strategies could be built. From developing an inventory of springs, ensuring their monitoring, thematic map preparation in GIS framework, identifying groundwater recharge potential zones, carrying out field interventions for spring rejuvenation, monitoring of spring water health through seasonal water quality index, community participation and engagement with line department this action research-based Spring Revival Model (AR-SRM), was implemented in the region. To assess the water quality of the region, physicochemical analysis of water samples was conducted in 2023 and 2024 during winter (March), summer (June), and monsoon (August) at 30 springs. The Water Quality Index (WQI) indicates that all spring water quality was good to excellent. The highest value observed was 45.1 at Keylong spring; however, it was still under the permissible limit. Pearson's correlation and one-way ANOVA were applied to examine relationships among water quality parameters, which provided insights into both systematic and random influences. To develop a model to recharge the spring, a hydrogeological action research model was implemented in Yangrang village. Based on geological and topographic suitability, the interventions included constructing 52 contour trenches and 12 percolation pits (Fig. 4). A comparative analysis of seasonal measurements of spring discharge before and after the intervention was conducted to understand the impact of the intervention. It was observed that prior to the intervention, the water discharge was recorded at 65.1 liters per minute (lpm) in the 2023 monsoon, which was found to increase to 68.1 lpm for Lapkshak-1 spring in 2024, demonstrating an initial promising clue of spring discharge enhancement due to the recharge structures. Community participation played a central role in the project's implementation, including the development of the intervention model and water discharge monitoring. Capacity-building programmes during the project phase also raised awareness among local stakeholders.

In conclusion, the project successfully combined scientific assessment, technological innovation, and community participation to address water scarcity in the Lahaul cold desert area. Under the shadow of climate change and development scenarios, ensuring water security and better adaptation to climate change is a must. This project addresses the same issue in the cold desert region of Himachal Pradesh. The integration of hydrogeological research with policy insights and localized action offers a replicable model for spring rejuvenation in other water-stressed mountainous regions. Based on the experience gained through this project, a remedial and replication plan was proposed for springshed management.

Major outcomes

1. Seasonal spring water quality assessment of 30 selected springs in the region during 2023 and 2024.

2. The action research-based Spring Revival Model (AR-SRM) in Yangrang village successfully demonstrated scientific assessment, technological integration, community participation, and stakeholder engagement in springshed management, providing an initial promising indication of spring discharge enhancement.

3. Based on the present work and subsequent request from Lahaul Forest Division, Keylong, Himachal Pradesh, spring rejuvenation plan for 30 springs in each forest range (15 focused on drinking water and 15 for natural recharge of catchment and useful for plantation/nursery) was developed and submitted to the department for further replication or implementation.

Fig. 4 Recharge interventions in the springshed of Yangrang village at Lahaul Valley (pictorial view of recharge structure and community participation)

Mainstreaming passive solar heated buildings in the Indian Himalayan Region: Integrating science with traditional practices to enhance climate resilience (NMHS, 2023-2024)

Passive solar-heated buildings (PSHBs) offer a sustainable solution to the extreme cold climate experienced in the Higher Himalaya and Trans-Himalayan Regions, where temperatures drops as low as -30°C. Traditional biomass energy sources are used for heating and cooking, leading to localized carbon emissions, as fossil fuels are costly and challenging to transport due to the rugged terrain. Despite the harsh climate, Ladakh receives ample sunlight, providing an opportunity to utilize passive solar heating to meet heating needs, reduce emissions, and enhance residents' well-being. However, a comprehensive evaluation of energy-efficient passive solar-heated buildings (PSHBs) in the region is lacking, highlighting the need for sustainable building designs tailored to local conditions. This project aimed to adapt and mainstream the PSHB concepts and technologies in the Indian Himalayan Region (IHR) by studying best practices and developing solutions for identified bottlenecks. The project objectives were focused on examining the dynamics of PSHBs paradigm in the context of IHR in order to: (i) document traditional knowledge pertaining to thermal comfort, (ii) evaluate PSHBs for thermal efficacy, (iii) assess cost-benefit analysis, (iv) develop replicable designs and standard operating protocols (SOPs), and (v) promote skill development in the PSHB market by developing design thumb rules and courses for training institutions. To achieve these objectives, existing PSHBs have been identified in the different vernacular settings of the IHR. Based on the objective, methodologies, documentation of thermal practices,

material studies, and technical evaluations, including major aspects such as structural, socio-economic, and environmental considerations, were employed. Energy simulation was also carried out to evaluate thermal performance under various climate zones. As a result, the study provided a knowledge repository, simulation models of PSHBs for different regions, field demonstration models, and developed Standard Operating Procedures (SOPs). Additionally, workshops and training courses were developed to promote PSHB skills development. As an exit strategy, the project aimed to engage policymakers, local administrations, researchers, and community stakeholders to promote the adoption of PSHB in the IHR by developing region-specific policies and laws, the use of low-carbon thermal/insulation materials, advancement in research, heightened awareness efforts, and ensuring long-term sustainability and adoption beyond the project's lifespan.

Major outcomes

1. One hundred seventy-nine (179) energy-efficient space heating practices were identified through a systematic Literature review. Further, 173 passive solar representative buildings were surveyed across Ladakh (Nubra, Changthang, Zanskar, Sham Valley, Kargil, Drass), Himachal Pradesh (Lahaul-Spiti, Losar, Lalung, Demul, Kinnaur), Uttarakhand (Badkot, Rajgarhi, Jakhol, Khrasali, Lakhamandal), Sikkim (Okhare, Rebdi, Bhareng, Uttarey, Pelling), and Arunachal Pradesh (Tawang) for documentation of a knowledge repository on passive solar heated buildings (PSHB) and thermal comfort.

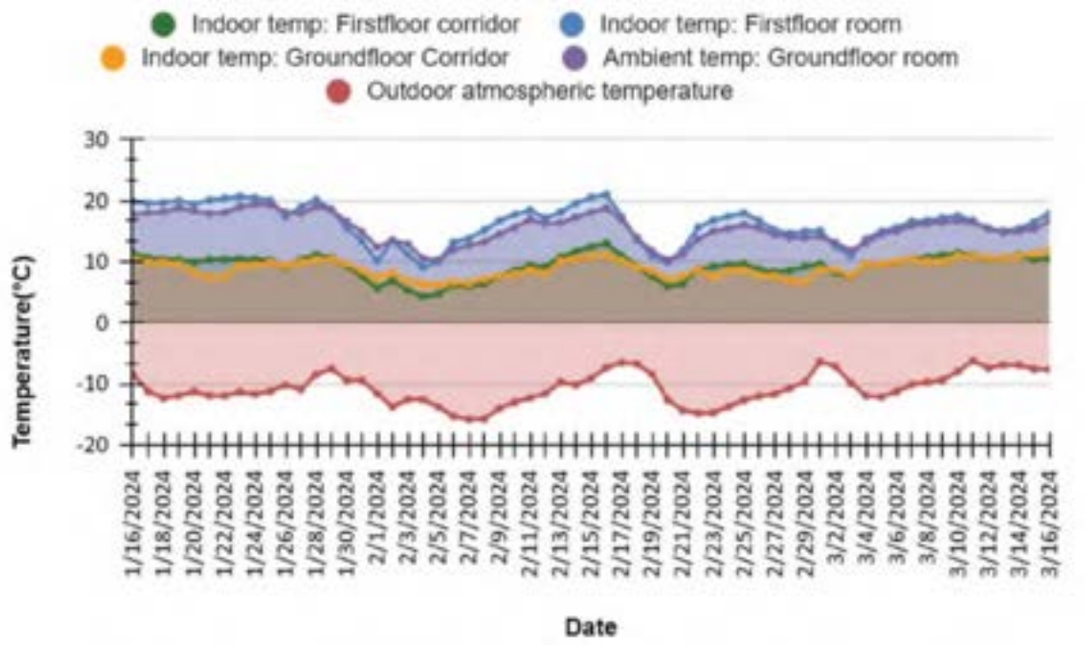


Fig. 5 Indoor temperature of all spaces v/s Outdoor atmospheric temperature measured for a PSH building located at Kargil (Ladakh)

2. Four (04) passive solar-heated building (PSHB) sites were identified in the Ladakh region (Kargil, Stok, Leh, & Khardung) for the purpose of thermal comfort monitoring. Automated Weather Stations (AWS) measuring relative humidity, atmospheric temperature, wind speed and direction, and solar net radiation were established outside these buildings. Inside the buildings, ambient temperature, relative humidity, and CO2 levels are being monitored using equipment to assess thermal comfort (Fig. 5). Further, a comprehensive analysis was conducted to estimate the construction cost of a passive solar-heated building (PSHB) at a representative site in Stok (Leh and Ladakh).

3. A database of thermophysical properties of building materials used in the construction of PSHBs was developed. Also, Standard Operating Protocol (SOP) or Guideline Standard Operating Procedure for Passive Solar Heated Buildings in the Ladakh Region was developed.

CENTRE FOR SOCIO-ECONOMIC DEVELOPMENT (CSED)

The Centre for Socio-Economic Development, established in 1988–89 as the Sustainable Development of Rural Ecosystems, envisions a future rooted in ecological, economic, and sustainable development across the Indian Himalayan Region (IHR). As a core programme of the organization, the Centre integrates scientific, technological, and community-based approaches to address critical challenges facing fragile mountain ecosystems. Its focus areas include integrated watershed management, rehabilitation of degraded lands through the use of multipurpose tree species, and the sustainable use of natural resources, aiming to enhance both environmental resilience and rural livelihoods. The Centre also places significant emphasis on socio-economic upliftment, promoting value chain and product development, ecotourism, protected cultivation, and the conservation and sustainable commercialization of medicinal and aromatic plants (MAPs). Documentation of Indigenous Knowledge Systems (IKS) and natural resource management planning form integral components of its strategy to blend traditional wisdom with modern practices.The Centre also develops quality planting material through advanced nursery techniques to support ecological restoration. Embracing the principles of a circular economy, the Centre promotes low-cost, livelihood-enhancing technologies that align with the rhythms of nature and support community self-reliance. Its work is closely aligned with national and global development agendas, particularly the UN SDGs 2030, the Sansad Adarsh Gram Yojana, and the Prime Minister's initiatives of Van Dhan, Jan Dhan, and Govardhan, which focus on forest-based enterprise, financial inclusion, and organic waste management. Through this integrated approach, the Centre continues to contribute meaningfully to sustainable mountain development and inclusive rural transformation in the IHR.

Focal areas of activities

- To promote activities that lead to ecological and economic security and sustainable development in the Indian Himalayan Region (IHR).
- Natural Resource Management for Sustainable livelihood, Technology development, and demonstration for reducing poverty and outmigration in the mountains.

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

Different approaches to village development are envisioned as "Smart Village" with a vision to transform villages into examples of sustainable development based on environmentally responsible individual and collective action for reducing the human ecological footprint and through the judicious use of natural resources. This project aims at developing 'Eco-smart Model Villages', across five representative localities in the Indian Himalaya through an innovative community-driven action process by promoting participatory planning and development strategies through a combination of natural resource management activities, services, policies, and stakeholders (including Govt. line Dept.) engagement to improve livelihood, water, and environmental status in rural areas to enhance livelihood, income and employment generation while safeguarding the ecological balance of targeted villages /village cluster employing carrying capacity concept and consequently leading to creation of an Eco- smart model village

Objectives

1. Identification of representative villages/village clusters for community-led planning process for preparation of eco-smart model village plans across the IHR.
2. Preparation of baseline datasets and resource-use maps of the target villages through stakeholder's participation.

3. Capacity building of rural communities to implement "Eco-smart model village" plans for integrated natural resource management for livelihood improvement.

4. Demonstrate and develop 'Eco-smart model villages' for enhancing livelihood, and upscaling by Govt. Line Depts. to foster ecological security in the region.

Achievements

Head Quarters:

- Monitoring and data collection for technological interventions, such as pine needle-based biomass briquetting and backyard poultry farming, in the Jyoli village cluster in Almora Fig.6b (Tables 2 and 3).

- Soil sampling was conducted in van panchayat forests of Jyoli village cluster with total 57 samples for the soil organic carbon analysis Fig.6a.

- One two-days training and skill building program on Himalayan farming: towards economic prosperity from high value crops during 12-13 September 2024 was conducted at Jyoli village cluster (Almora) covering 78 stakeholders (F=52, M=26).

Table 2. Details of the beneficiary of poultry farming and benefits accrued between September 2020 and September 2024

Village	No. of beneficiary HH	Beneficiaries (BPL/GEN)	SC/ COVID	DOC given/DOC Survival* (%)	Total production (eggs)	Total earnings (Rs.) till date
Kujyari	29	16	17	596 (224)	18400	264560
Dilkote	18	1	17	410 (295)	8470	45870
Kaneli	10	3	7	425 (284)	4586	87790
Bisra	6	6	-	375 (262)	3806	92480
Jyoli	57	27	22	1394 (640)	16790	386500
Total	**120**	**53**	**63**	**3200/53.28**	**52,052**	**8,77,200**

Fig.6 (a) Soil sampling (b) Backyard poultry farming at Eco-smart model village Jyoli

Table 3. Beneficiaries under pine needle-based biomass briquetting and green skill development

Village	No. of beneficiary HH	Bio briquettes	Rakhi/aipan	Earning incurred (Rs.)
Jyoli	08	0	25	470
Khadkuna	08	0	54	6320
Bisra	11	800	25	6600
Kaneli	11	200	30	6800
Kujyari	17	80	60	4180
Total	**59**	**1080**	**239**	**26900**

Garhwal Regional Centre

- Identified and supported income diversification strategies among rural households. Survey indicated that 73.17% of respondents had multiple income sources, reflecting a positive shift from dependence on agriculture in the Barshu area. Moreover, 65.85% of respondents showed awareness of alternative livelihood options such as beekeeping and mushroom cultivation.

- A total of 690 individuals from Rudraprayag and Chamoli were trained through 10 community sensitization programs. Training focused on sustainable livelihoods, human-wildlife conflict, circular economy, and value-added products. These efforts strengthened local capacity and empowered communities to tackle socio-ecological challenges.

- The study successfully documented the presence of 72 diverse crop and plant species in the Barsu cluster villages of Rudraprayag district (Table 4), despite the observed decline in traditional varieties of rice, wheat, and millet (Fig. 7). This comprehensive agro-diversity survey across 12 villages not only highlights the existing biodiversity but also forms a critical baseline for promoting conservation and sustainable agricultural practices in the region.

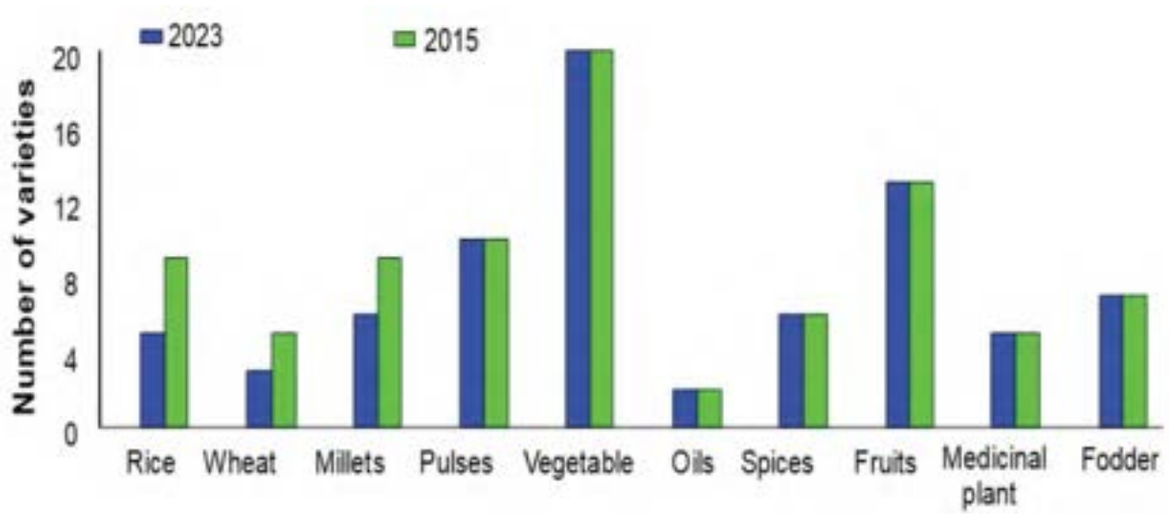


Fig. 7 Decrease in crop diversity over the period of eight years

Table 4. Major crop diversity among different studied villages of Barsu Cluster, Rudraprayag district, Uttarakhand

S. No.	Name of the Village	Crop diversity
1.	Ghandiyalika	*Paspalum scrobiculatum* (Kodo millet), *Brassica campestris* (Mustard), *Hordeum vulgare* (Barley), and *Triticum aestivium* (Wheat)
2.	Kyarki	*Paspalum scrobiculatum* (Kodo millet), *Echinochlora frumentacea* (Jhangora), *Amaranthus spp.* (Chaulai), *Triticum aestivium* (Wheat), and *Brassica campestris* (Mustard)
3.	Khedi	*Paspalum scrobiculatum* (Kodo millet), *Echinochlora frumentacea* (Jhangora), *Amaranthus spp.* Chaulai), *Triticum aestivium* (Wheat), *Brassica campestris* (Mustard), *Oryza sativa* (Dhaan), *Vigna mungo* (Urhad), *Macrotyloma uniflorum* (Gahat), *Glycine max* (Soyabean), and *Vigna unguiculata* (Lobiya)
4.	Biro	*Paspalum scrobiculatum* (Kodo millet), *Echinochlora frumentacea* (Jhangora), *Triticum aestivium* (Wheat), *Oryza sativa* (Dhaan), *Phaseolus vulgaris* (Rajma), and *Cajanus cajan* (Toor)
5.	Gwaad	*Paspalum scrobiculatum* (Kodo millet), *Echinochlora frumentacea* (Jhangora), *Oryza sativa* (Dhaan), A*maranthus spp.* (Chaulai), *Triticum aestivium* (Wheat), *Sesamum indicum* (Til),and *Macrotyloma uniflorum* (Gahat)
6.	Kothiyu	*Paspalum scrobiculatum* (Kodo millet), *Echinochlora frumentacea* (Jhangora), *Triticum aestivium* (Wheat), and *Macrotyloma uniflorum* (Gahat) were the major crops.
7.	Pokharsari	*Paspalum scrobiculatum* (Kodo millet), *Echinochlora frumentacea* (Jhangora), *Triticum aestivium* (Wheat), *Amaranthus spp.* (Chaulai), *Sesamum indicum* (Til), and *Macrotyloma uniflorum* (Gahat)
8.	Punar	*Paspalum scrobiculatum* (Kodo millet), *Echinochlora frumentacea* (Jhangora), *Triticum aestivium* (Wheat), *Amaranthus spp.* (Chaulai), and *Sesamum indicum* (Til) were the major crops

Sikkim Regional Centre

- Prepared village resource map of 10 Villages (Hee Gaoe, Hee Tamabung, Dhanbari, Bijanbari, Hee Patal, Upper Pecherek, Lower Pecherek, Majhgoan, Hee Yanthang and Bringatham) of West, East and North districts through participatory mode.

- Training programs (4 nos.) were conducted in East Sikkim and West Sikkim to inculcate awareness among villagers, especially youth and farmers, about bioresources and their documentation. A household survey of these villages indicated a varied pattern of income sources across districts. Villages in the East district show an equal distribution of income sources, while the West district relies heavily on farming, and the North district relies on labor and jobs (Fig. 8).

- A study on crop diversity and forest resource use shows that Maize is a staple crop across all target villages, while ginger and cardamom have regional prominence. Data obtained from the polytunnel and polyhouse intervention show that

coriander emerged as the most profitable crop, while spinach and celery were the fastest-growing under polytunnel cultivation.

- Polyhouses outperformed polytunnels in reducing crop maturation time during the cultivation of spinach, coriander, and fenugreek. Income and profitability from each polyhouse indicated that spinach was the most lucrative crop than others, generating up to ₹30,000 in income from each polyhouse (12 x 9 feet), followed by fenugreek and Brassica.

- To explore the possibilities of an eco-trail in Jaubari for promoting ecotourism activities in Tendong Reserve Forest, a survey was conducted to assess various features, including environmental and cultural significance. These features were evaluated in terms of altitudinal range, forest type, major fauna and flora, distance between points, and travel time. This 3.6 km long ecotrail consists of temperate forest ecosystem having adventure of watching wild animal such as barking deer, flying squirrels, bear, and wild boar under the forest of *Quercus thomsoniana*, *Quercus pachyphylla*, *Rhododendron griffithianum*, *Rhododendron arborium*, *Magnolia sps.*, *Oak sps.*, *Abies webbiana*, *Quercus lamellosa*, etc.

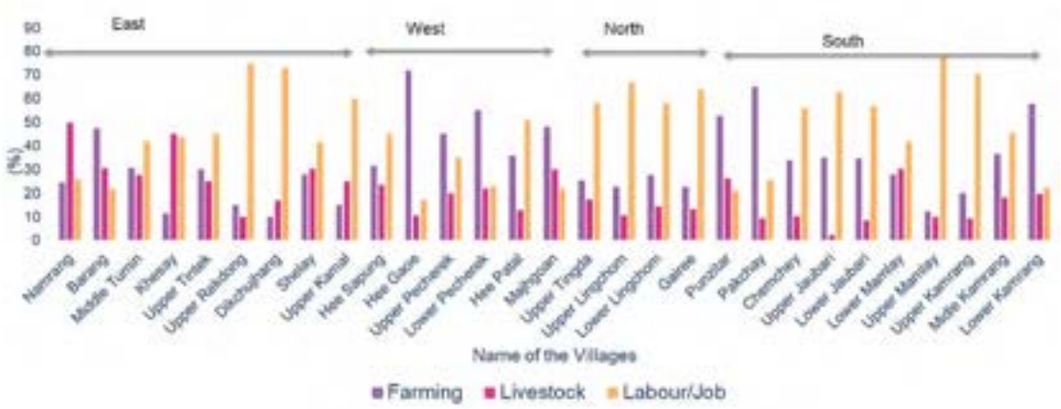


Fig. 8 Major source of income in selected villages of Sikkim

North East Regional Centre

- A three-day Training and Capacity-Building program aimed at expanding Mushroom Cultivation Units in cluster villages was conducted at Dikopita and Byapin villages in Ziro, Lower Subansiri district, Arunachal Pradesh. The program marked the third phase of cultivation for the Dikopita mushroom unit, as well as the installation of new units at Byapin and Manipoliang villages. A total of 12 participants (2 M and 10 F) engaged in the training, enhancing their skills and knowledge in mushroom cultivation to foster sustainable agricultural practices in their communities Fig. 9.

- Conducted a program focused on Dragon fruit cultivation and farm site development on 26 September 2024 in Dikopita village of Lower Subansiri district. This program was aimed at fostering sustainable agricultural practices, improving livelihoods, and promoting economic development within rural communities. A total of 8 participants (2 M and 8 F) benefitted from the training.

Fig. 9 Mushroom units at Byapin and manipoliang villages

Summary of the Completed Projects

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

Uttarakhand is known for its rich biodiversity, traditional agricultural practices, and diverse agro-ecological zones. It has a long history of indigenous crops, including a wide array of legumes that play a crucial role in sustaining food and nutritional security for local communities. However, recently, a significant decline in the cultivation of traditional legumes has been observed. This downturn is mainly due to factors such as genetic drift, environmental factors, and a growing preference for high-yielding conventional crops, which have replaced native varieties. To address this concern, a systematic effort was undertaken to collect and conserve traditional pulse landraces across diverse altitudinal ranges of Uttarakhand. This initiative involved the collection of 73 landraces of P. vulgaris from altitudes ranging between (1020-4028m), 15 landraces of M. uniflorum between (935-2102 m), and 26 landraces of G. max (823-2183 m). These landraces were sourced from major pulse-growing regions including Pithoragarh, Chamoli, Mukteshwar, Dharchula, Munsiyari, Almora, Bageshwar, and Lohaghat. After collection, these landraces were systematically segregated based on varied seed morphological characteristics and were then cultivated under similar agroclimatic conditions for morphological, biochemical and molecular characterization. The morphological study included both qualitative and quantitative parameters, such as those related to vegetative growth, inflorescence, pod characteristics, seed traits, and overall yield, which were evaluated Fig 10.

In contrast, the biochemical analysis focused on phytochemical, antioxidant, and proximate activities. From the results of morphological and biochemical estimation, it is concluded that a good diversity was found among the landraces of french beans, soybean, and horse gram. French beans collected from Dharchula, Mukteshwar and Chamoli showed significant phytochemical, antioxidant and protein content. The phenol, flavonoids, tannin, anthocyanin and antioxidant activity were found to be highest in black soybeans. The phenol, flavonoids, tannin, anthocyanin and antioxidant activity in horse gram was found good in landraces collected from Pithoragarh, Dharchula and Almora. Among these, R10, R15, R42, and R48 (French bean), H2, H4, H5, H7 and H9 (Horse gram), BS13, BS15 and YS9 (Black Soybean; Yellow soybean) were identified on the basis of yield and nutritional profiles. Furthermore, molecular characterization was also conducted to assess the genetic diversity and relatedness among the landraces. Based on this analysis, superior germplasm was identified with good adaptability and rich nutritional content, making them suitable for large-scale farming in similar regions of the state. To facilitate the promotion and adoption of these superior landraces, targeted training and extension programs were conducted at various villages of Uttarakhand. These initiatives emphasized sustainable and organic farming practices that align with the region's ecological integrity. Hence, cultivating these improved landraces under organic conditions has led to enhanced crop quality and productivity. Moreover, these landraces, being inherently suited to the local climate and resistant to various biotic and abiotic stresses, offer solutions to some of the most pressing agricultural challenges posed by climate variability. Their cultivation not only contributes to food and nutritional security but also supports the long-term goal of eco-friendly and sustainable agriculture in hilly areas.

Major outcomes

- Superior germplasm identified through molecular and morphological characterization, showing potential for improved yield and quality traits.
- High-performing varieties promoted among hill farmers for large-scale cultivation.

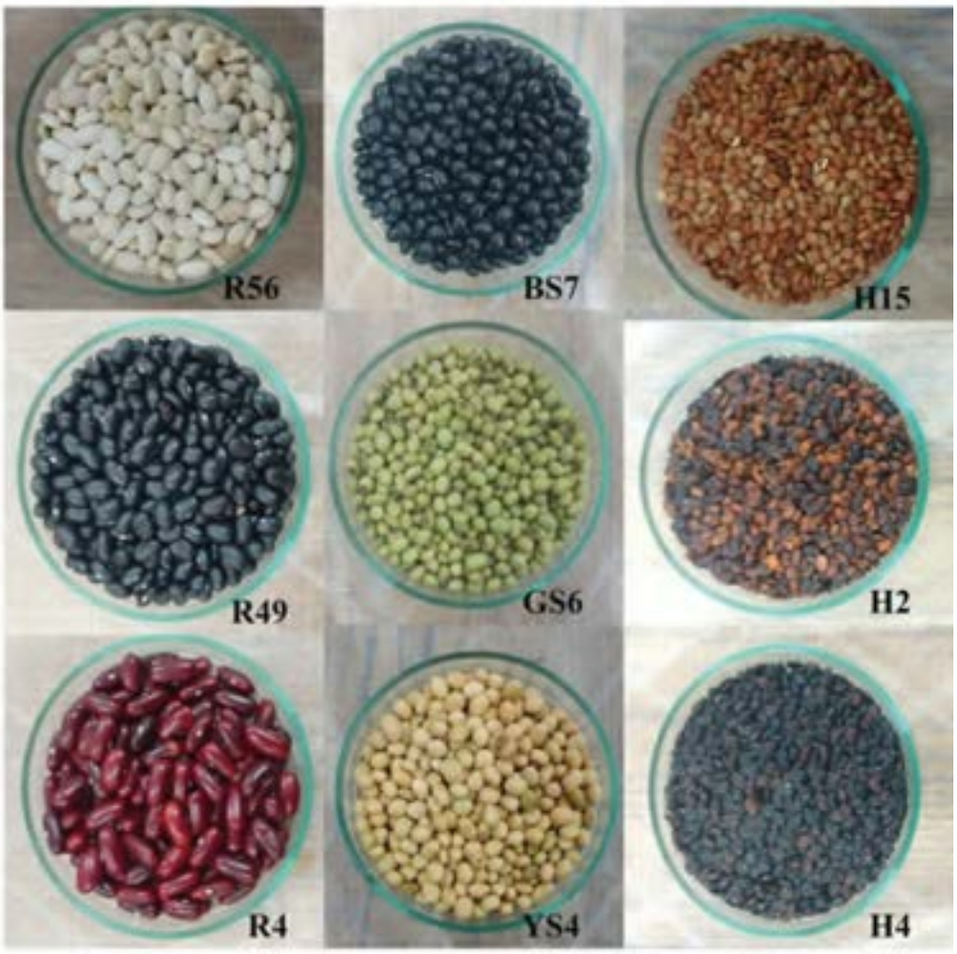


Fig.10 Illustration of some collected landraces (French bean- R56, R49, R4; Soybean- BS7, GS6, YS4; Horse gram- H15, H2, H4)

Demonstration and scaling up of Chir Pine leaves-based bio-briquettes technology to promote environment-friendly energy for employment and income generation among rural people in Uttarakhand (UCOST: 2022-2024)

In the Uttarakhand hills, over two-thirds of the village community is mostly dependent on firewood, which constitutes about 75% of the total energy consumption. In the challenging mountain terrain, the consumption pattern depends on the availability of forests in nearby areas, as well as the socio-economic conditions of the people. On average, per capita firewood consumption varies from 5 to 10 Q/yr in Uttarakhand, posing immense pressure on surrounding vegetation and leading to a loss of biodiversity and carbon sink value in forest ecosystems. In recent decades, increasing incidences of forest fires in the Chir Pine (Pinus roxburghii) dominated middle-mountain belt have further aggravated this problem. Therefore, our forests are facing the twin challenges of forest fires as well as pressure from rural people for firewood collection. The present project focuses on a large-scale demonstration of making bio-briquettes through the carbonization of dry biomass. In the presence of a binder, these can be manufactured into briquettes using an iron mold. Consequently, they can be easily produced at the household or village level using Chir-Pine needle litter, along with weeds and invasive plants, as raw materials. The objective of the project where to (i) To conduct calorimetric analysis, proximate analysis and flue gases emission quotient of bio-briquettes for the safety measure for use in rural and urban areas, (ii) To build the capacity of rural people, women's groups and weaker sections to prepare briquette charcoal from Pine-needle litter waste and weeds as alternative efficient energy source for household use, warming office complexes during winters and commercial activities in villages and towns, and (iii) To introduce and popularize cost effective energy solutions using the obnoxious Pine needles thus saving forests from biotic

pressure and creating income generating opportunities for women through sale of bio-briquettes. During the project period (i) Thirteen workshops have been conducted for fulfilling the project objectives. Total 835 people (male- 273, female- 550; SC- 229), covering 30 villages, 12 NGOs in four developmental blocks (Hawalbagh, Takula, Dhauladevi and Someshwar) of Almora district were imparted training and capacity building, (ii) Two Training of trainers sessions were conducted under the project, and six women stakeholders were trained, who are now working as master trainers for bio-briquetting, and (iii)Women and weaker sections, particularly those in the 40-50 age group, are more inclined towards preparing bio-briquettes from pine needles andprefer self-use of these bio-briquettes and sell the surplus to the market for income generation. The unemployed youth of the target region have shown interest in preparing and marketing these bio-briquettes, and have sold a significant number of them to enhance their livelihoods. The socio-economic survey outcome for the popularization of bio-briquettes as an alternative livelihood is presented in Fig 11.

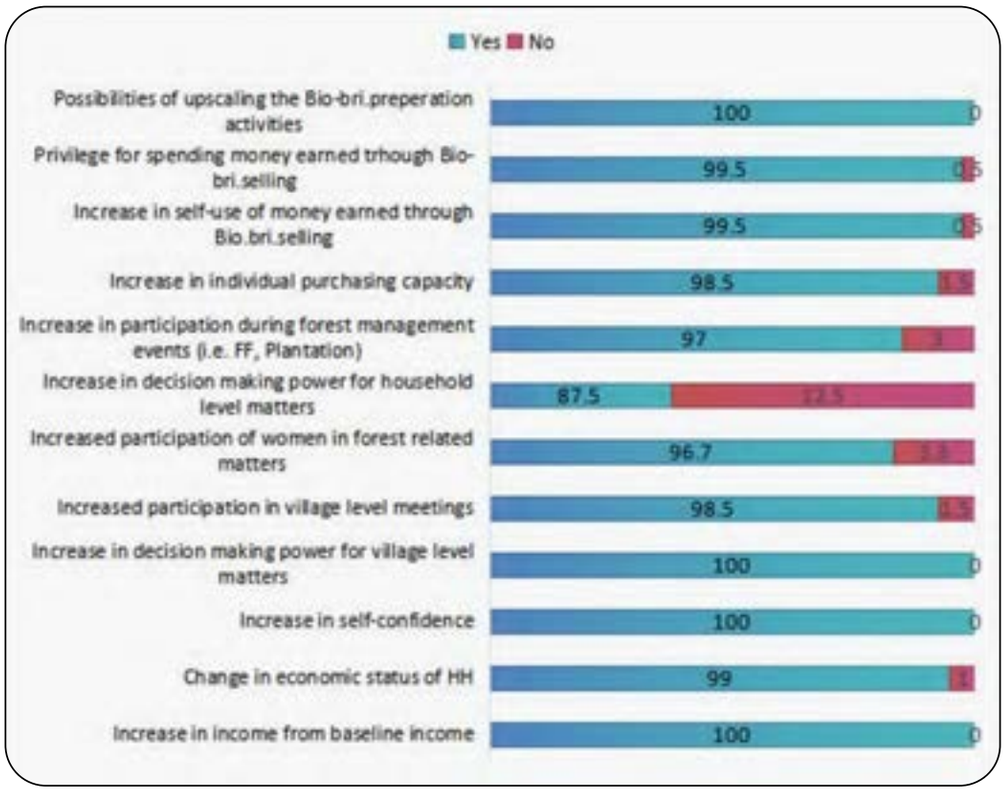


Fig. 11 Socio-economic impact of project R&D interventions on stakeholders in target village (N=100)

CENTRE FOR BIODIVERSITY CONSERVATION AND MANAGEMENT (CBCM)

The Centre for Biodiversity Conservation and Management (CBCM) is proactively working on Institute's longstanding commitment to Himalayan Biodiversity Conservation. This commitment aligns with the recently adopted Kunming-Montreal Global Biodiversity Framework (KMGBF), a landmark international agreement aiming to halt and reverse biodiversity loss by 2030. Similarly, India is developing a new National Biodiversity Strategy and Action Plan (NBSAP), which places strong emphasis on conserving Himalayan biodiversity, recognizing its unique ecological importance. CBCM not only deepens scientific understanding but also promotes conservation action and also ensures the continued flow of ecosystem services in the face of global change. The centre's activities are directly contributing to several Sustainable Development Goals (SDGs), particularly SDG 15: Life on Land, SDG 13: Climate Action, and SDG 3: Good Health and Well-being. CBCM's multifaceted approach goes beyond traditional research. It employs both in-situ and ex-situ conservation practices, fostering collaboration with a wide range of stakeholders to fulfill international and national biodiversity conservation commitments that emphasize participatory conservation models. This includes engaging rural communities in initiatives such as medicinal plant cultivation and wasteland restoration, thereby empowering them economically and socially while achieving conservation goals. CBCM also promotes the replication of successful models to ensure the widespread adoption of sustainable practices in the Himalayan region. CBCM integrates scientific knowledge into conservation decision-making at local, state, and national levels. The centre has established representative long-term ecological monitoring sites (LTEMS) to contribute to the regional analysis and long-term predictions on Himalayan biodiversity under changing climate scenarios. Centre also fosters collaboration for knowledge sharing and capacity building among a wide range of stakeholders, aligning with international commitments to collaborative conservation efforts. CBCM has also developed standardized protocols for the sustainable use of Himalayan bioresources, ensuring their access and benefits are shared responsibly. Overall, CBCM bridges the gap between scientific research, demonstration, and dissemination of on-the-ground conservation efforts in the Himalayan region. By leveraging its scientific expertise and fostering collaboration, the centre leads effective and sustainable biodiversity conservation initiatives for the unique ecological and socio-economic system of the Himalayan region.

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

Conservation and sustainable use of biological resources have become a priority for research and development. The Himalaya, one of the global hotspots, are recognized for their ecological and economic value. More importantly, the dependence of upland and downstream communities on goods and services from the Himalayas makes this region an important candidate for action, both for the maintenance and sustainable use of biological diversity. The Centre for Biodiversity Conservation and Management (CBCM) integrated Himalayan biodiversity into sustainable development initiatives to address these challenges. With a broad goal of ensuring the sustainable use of Himalayan biodiversity for human well-being and improved ecosystem health, the project aims to facilitate the formation of BMC and PBR, thereby strengthening the Access and Benefit Sharing mechanism in IHR. On the one hand, the project aims at ex-situ conservation of selected endangered plants and identifies new potential areas for conservation without Protected Areas (PA). The establishment of market value chains for selected high-value medicinal and wild edible plants, as envisaged, will help stakeholders optimize their benefits. The project aims to create a cadre of green-skilled and conservation-aware individuals for the sustainable use and long-term maintenance of Himalayan biodiversity.

Objectives

1. To facilitate BMCs and PBR formation for implementation of the biodiversity act (2002) in selected villages of IHR

2. To develop and demonstrate applicability of ex situ conservation of selected endemic and threatened plants in the IHR

3. To identify and map selected biodiversity rich areas for promotion of in situ conservation in the IHR

4. To establish marketing value chains of selected high value medicinal plants and wild edibles in the IHR

5. To engage and inspire diverse stakeholder towards biodiversity conservation through conservation education and green skill building programme

Achievements

Headquarter

- An in-vitro propagation protocol was developed for *Gentiana kurruoo* through node explant using a combination of 2 µM 2,4-D (2,4-dichlorophenoxyacetic acid) and 3 µM BAP, which were found to be effective in inducing callus formation. In addition to that, the shoot formation was achieved effectively in combination with 1.0 µM NAA+6.0 µM BAP+0.1 µM GA3.

- Documented floristic diversity and cultural significance of Hariyali Devi (Rudraprayag), Surkanda Devi (Tehri Garhwal), Nagtibba (Tehri), Banlekh-Cheerapani (Champawat) areas of Uttarakhand.

- Identified and mapped 8 biodiversity-rich areas i.e., Thal Kedar Sacred Forest, Kalamuni-Ratapani (Pithoragarh), Banlekh-Cheerapani (Champawat), Mornaula, Banari Devi (Almora), Kilbury-Pangot (Nainital), Hariyali Devi (Rudraprayag), Surkanda Devi (Tehri Garhwal), Nagtibba (Tehri) of Uttarakhand State (Fig. 12).

- Conducted a comprehensive value chain analysis for targeted medicinal plant species *(Cinnamomum tamala*, *Picrorhiza kurrooa*, *Aconitum heterophyllum*, and *Hedychium spicatum)* in Uttarakhand. The study revealed *C. tamala* (8602.22 quintals/ year) as the most traded species, followed by *H. spicatum* (428.90 quintals/ year), *P. kurrooa* (159.01 quintals/ year), and *A. heterophyllum* (59.62 quintals/ year).

- A total of 09 conservation education programs were conducted, wherein 632 participants (311 male; 321 female) participated.

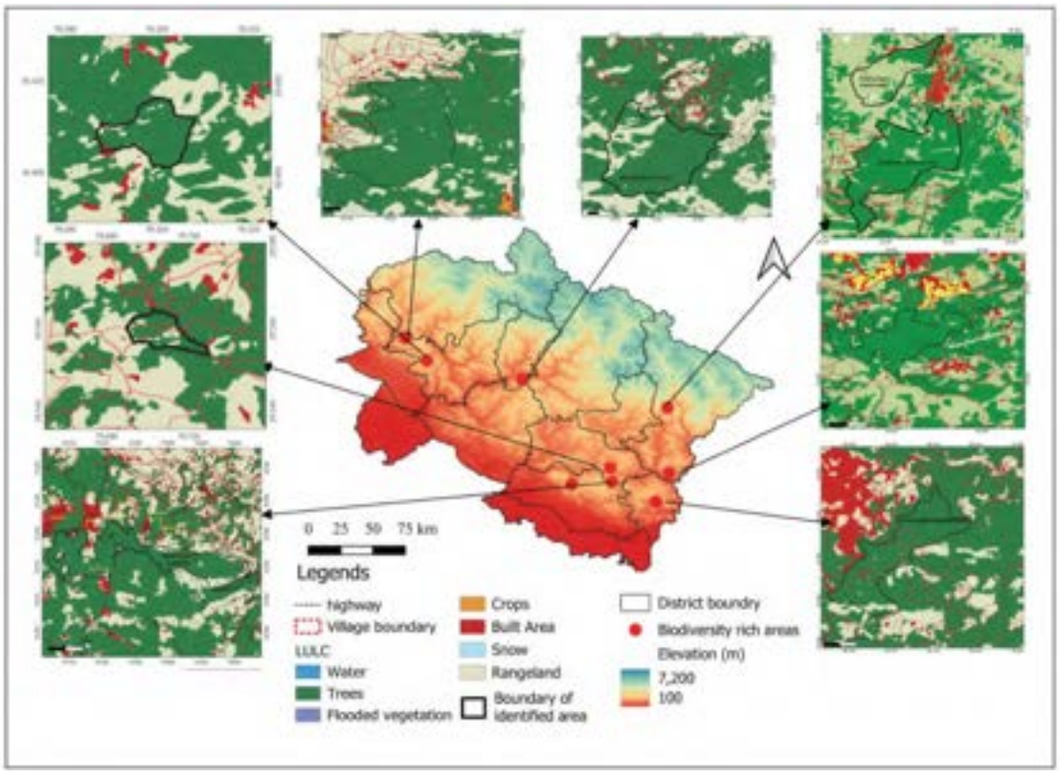


Fig. 12 Boundary demarcation of validated biodiversity rich areas in Uttarakhand

Himachal Pradesh Regional Centre

- Promoted High-value medicinal plants by providing quality planting and seed material to farmers. Seeds of *Aconitum heterophyllum (20 kg)*, *Inula racemosa*, *Saussurea costus*, *and Angelica glauca* (3 kg each) were distributed to 40 farmers in Tirthan and Banjar Valleys (Kullu district) and Saraj Valley (Mandi district) for nursery development in their fields.

- Ethnobotanical knowledge was documented across 16 villages in Tirthan Valley, Himachal Pradesh, identifying 73 plant species from 46 families. These plants are used for food, medicine, rituals, construction, and farming. Medicinal uses include tea, infusions, and poultices. The study highlights threats like deforestation and climate change, urging conservation and community involvement.

- Four Green Skill Development and Biodiversity Conservation Education Programmes were organized at various schools in Kullu districts, including 03 Govenment Senior Secondary Schools and 01 Public School. A total of 2,500 students participated in these events.

- To promote ex-situ conservation of threatened medicinal plants, four school herbal gardens were established at Govt. Senior Secondary Schools in Kullu, including Bajaura, Dhalpur, Sultanpur, and Cambridge International School, Mohal. Species planted include *Taxus contorta*, *Swertia chirayita*, *Withania somnifera*, *Ginkgo biloba*, and *Bergenia ciliata*.

- Two training-cum-awareness workshops on "Cultivation, Harvesting, and Seed Distribution of High-Value Himalayan Medicinal Plants" were organized at GBPNIHE-HRC, Mohal, Kullu, and Gushaini village in Tirthan Valley, Kullu district. Participants were educated on pre-harvesting, cultivation, post-harvesting practices, and market linkages of medicinal plants.

- Two Days Training-cum- Green Skill Workshop on "Conservation and Management of Pollinators for Biodiversity Conservation, Crop Production & Sustainable Livelihood" was organized for Disaster affected communities of the Sainj Valley in collaboration with SAHARA and People Science Institute, Dehradun, Uttarakhand.

Garhwal Regional Centre

- The genetic diversity of *Allium stracheyi* from the Uttarakhand Himalaya was successfully characterized using Intron Length Polymorphism (ILP) markers. Nine ILP primers analyzed 103 genotypes from fourteen populations, generating 29 fully polymorphic bands (100% polymorphism). High genetic diversity was observed with a mean polymorphism percentage (75.47%) and total genetic diversity (He = 0.297). AMOVA results showed greater variation within populations (88%) than among populations (12%). Moderate genetic differentiation (Gst = 0.201) and low gene flow (Nm = 1.979) were recorded. Population structure analysis (Evanno test) revealed two distinct genetic clusters (K = 2) among the genotypes.

- An efficient *in vitro* propagation protocol was successfully developed for *Allium stracheyii* and *Rheum australe* to facilitate the large-scale multiplication of these valuable species. For *A. stracheyi* tuber explants (~1 cm^2) cultured on MS medium with 6 µM BAP and 6 µM NAA achieved 88.88% callus induction with compact green callus. Maximum shoot induction (100%) with 20.7 ± 2.60 shoots and 17.06 ± 0.28 cm shoot length was observed using 4 µM TDZ. Rooting was optimized (100%) with 6 µM BAP + 6 µM NAA, producing 10.67 ± 0.88 roots and 5.43 ± 0.40 cm root length. For R. australe, seeds and leaf explants on MS medium with 9 µM BAP + 9 µM NAA achieved 100% shoot induction, with 5.78 ± 0.33 cm shoot length and 7.02 ± 0.58 leaves. Rooting (100%) with the same treatment produced 11.59 ± 0.58 roots and 5.05 ± 0.54 cm root length.

- A total of five sensitization and capacity-building training programs on "Biodiversity Conservation & Management" and "High-Value Medicinal Plant Cultivation for Livelihood" were organized for school students, teachers, and farmers. A total of 286 participants (115 male and 171 female) benefited from these initiatives, which enhanced

their awareness and skills in biodiversity conservation and sustainable livelihood practices.

Sikkim Regional Centre

- Strengthening the seed germination protocol and nursery management practices of 05 high value medicinal plants of Sikkim Himalaya for large scale plant production. Seed germination protocols were developed for the *R. arboretum*. pH of the medium (½MS without hormone was found an important factor for seed germination (55% germination) and moisture was found to be an important factor for field transfer of seed-raised seedlings of *Rhododendron dalhousiae*, and *R. arboretum*. More than 500 plantlets of these species were developed using the propagation protocol.

- Symbiotic association between the recently discovered orchid, *Gastrodia sikkimensis in bulk* and rhizospheric soils partners analyzed by targeted metagenomic approach revealed Proteobacteria (45.62%), Firmicutes (11.45%), and Planctomycetota (11.27%) as dominant bacterial communities and Basidiomycota (22.88%), Ascomycota (20.52%), and Mucoromycota (20.31%) as dominant fungal communities. At the genus level, Pseudomonas (10.04%), was dominant among bacteria, while Mucor (21.22%) displayed dominance among the fungal genera. Functional annotation of fungal traits showed the abundance of saprotrophs as their mode of nutrition for this achlophyllus species. In contrast, its soil composition revealed a richness of carbon and moisture content.

Noth-East Regional Centre

- A study on bird diversity along an urban-to-forest gradient across five districts of Arunachal Pradesh—Tawang, Shi-Yomi, Papum Pare, Kra-Daadi, and PakkeKessang—recorded a total of 219 bird species. The cultural landscape varied across these regions: Itanagar (Papum Pare) is predominantly inhabited by the Nyshi community, a hunting Tani tribe; Shi-Yomi hosts both hunting (Galo) and non-hunting (Memba) tribes; while the Monpa, a non-hunting Buddhist tribe, primarily occupies Tawang. The findings indicate a clear trend: areas with reduced hunting practices, often influenced by religious beliefs and alternative livelihood options, support higher bird diversity (Fig. 13).

- 582 people were made aware of different aspects of Biodiversity and its conservation through seven different awareness programs.

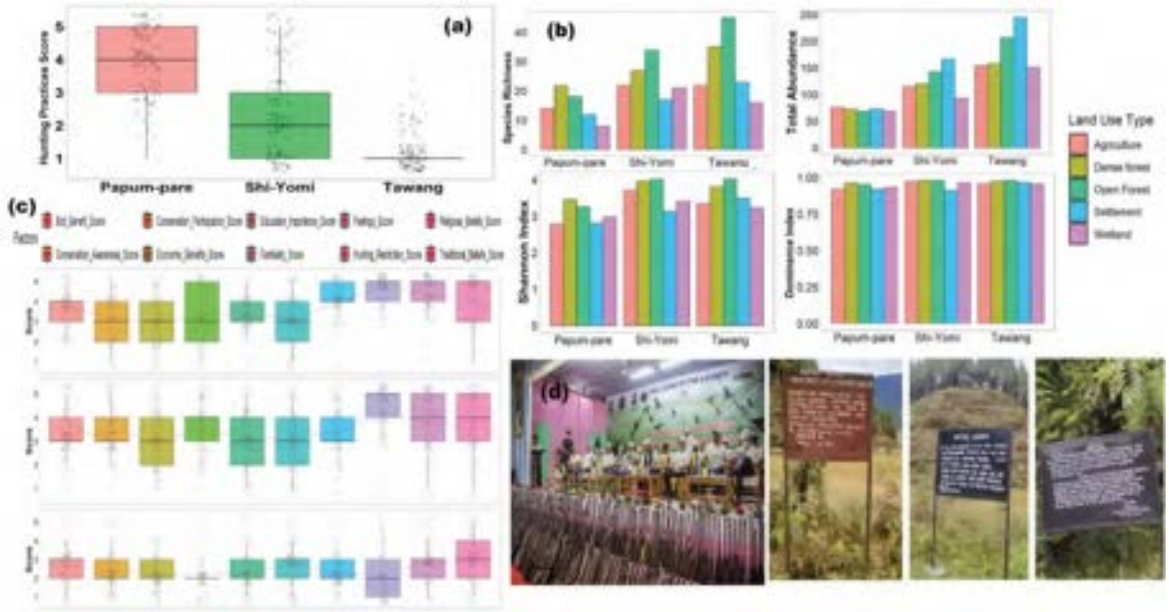


Fig. 13 Results of the impact of community perspectives, ethnozoological traditions and government initiatives on bird diversity and different initiatives by community and government to conserve bird biodiversity in Arunachal Pradesh: (a) Hunting Practice Score across the districts, (b) Diversity indices of Birds across the districts, (c) Positive Influence score across the districts, (d) Interventions by Government and community to reduce hunting.

Developing conservation strategies for harnessing pharmaceutical potential of Astavarga plants of West Himalaya (UCOST, 2023-2025)

Astavarga is an important group of medicinal plants used in various Ayurvedic formulations and has been recognized for its diverse medicinal properties in ancient Materia Medica. This group consists of eight main plant ingredients, viz. *Polygonatum verticillatum*, *P. cirrhifolium*, *Habenaria intermedia*, *Habenaria edgeworthii*, *Malaxis acuminata*, *Malaxis smuscifera*, *Roscoea procera* and *Lilium polyphyllum*. Studies have indicated that the 'Astavarga' plants are rarely available and threatened due to their frequent use since ancient times. It is often challenging to obtain materials in the required quantity. Therefore, there is an urgent need to conserve and promote these important plants to fulfill the raw material requirements and maintain the efficacy of various Ayurvedic medicines. In view of the above two Polygonatum species *(P. verticillatum & P. cirrhifolium)* were targeted for the present study. According to the CAMP report 2003 of the Western Himalaya, *P. verticillatum* is vulnerable in Jammu and Kashmir, Himachal Pradesh, and Uttarakhand, while *P. cirrhifoliumis* endangered in Himachal Pradesh and vulnerable in Uttarakhand. Studies of different regions (Alpine and cold desert) in Uttarakhand revealed a decline in population over the last 50 years and improper regeneration patterns of targeted species in the Western Himalaya.

Objectives

1. To develop propagation methods for mass multiplication of target species
2. To develop agro-technologies and initiate PPP model for the targeted species
3. To optimize the extraction procedure of bioactive compounds
4. To raise awareness and impart training on the conservation and sustainable utilization of the target species

Achievements

- Germplasm repository of three Polygonatum species of the Northwest Himalaya, including *P. verticillatum*. *P. cirrhifolium* and *P. multiflorum* has been maintained in the Surya Kunj ex-situ conservation site of the institute and germplasm from different populations are conserved therein.

- Indirect organogenesis and mass multiplication of *P. verticillatum* and *P. cirrhifolium* has been examined under different concentrations and combinations of Plant Growth Regulators (PGRs) and different explants (leaf, node, rhizome and seed) were tested. Among the tested PGRs, the maximum redifferentiation and multiplication rate was observed in leaf explants cultured under Murashige and Skoog (MS; 1968) media fortified with 3%carbon source and thidiazuron (TDZ) in combination with α-naphthaleneacetic acid (NAA).

- The vegetative propagation experiment indicated that the rhizome segments treated with pulse treatment of higher auxin concentrations (NAA, IBA and IAA) and planted in coco pit under mist chamber (humidity: 60±05%; temperature: 25± 05°C), resulted in higher sprouting percentage as compared to longer duration (i.e. 24h and 48h) treatments in *P. verticillatum*.

Development and Implementation of Working Frameworks for Climate Resilient Village: An Approach for Integrated Sustainable Rural Development (DST, 2023-2025)

The Himalaya, one of the largest and highest mountain systems on Earth, is facing the impact of global warming at a rate higher than the global average. Limited scientific evidence is available on climate-induced changes in ecosystem structure and functioning in the Himalayas, whereas such changes are severely impacting the dynamics of Himalayan ecology in an unprecedented manner. Human societies in the Himalaya are facing severe impacts in terms of alterations to their agricultural and natural ecosystems, necessitating immediate attention to adaptation and developing resilience toward

such changes. The project aims to develop village typologies to assess the vulnerability and climate resilience capacity of selected villages from different clusters in three agro-climatic zones: Lahaul and Spiti in Himachal Pradesh, Rudraprayag and Almora in Uttarakhand, and Karbi Anglong in Assam. Using data on socio-economic, and ecological parameters, the project aims to understand the severity of climate change's impact on different rural village typologies. This understanding will inform the development of a climate-resilient village framework that integrates traditional ecological knowledge and modern adaptation strategies available in the Himalayas and elsewhere.

Objectives

1. To develop typologies for rural areas with respect to selected high-level geoclimatic and socioeconomic indicators.

2. To conduct indicator-based socio economic/ socio ecological assessment.

3. To study the resource availability, use and spatio-temporal change of a village/cluster/landscape.

4. To perform need and demand assessment for basic services and infrastructure.

5. To map and plan for risk, resilience, and challenges regarding development of a village/cluster/landscape and identification of technological interventions required.

6. To study traditional ecological knowledge and identify its role in increasing the smartness of existing villages.

7. To find smart solutions to existing environmental and conservation problems in rural areas and evaluate suitability of replication of framework in villages/clusters belonging to similar typology.

8. To implement CRV interventions in two selected villages based on their needs and suitability and execute sustainability-driven exit plan.

Achievements

- Developed and validated five innovative climate resilience frameworks across three ecologically and culturally diverse Himalayan landscapes i.e. Lahaul-Spiti, Rudraprayag, and Karbi Anglong. These frameworks addressed settlement-level infrastructure gaps, vulnerability profiling using the Five Capitals Model, land-use and land-cover dynamics, and socio-perceptual insights, resulting in data-driven policy tools for region-specific adaptive planning.

- By integrating household surveys, satellite-based analysis, and hierarchical clustering, the study identified 10 distinct settlement typologies, revealing that over 60% of habitations are located in high-vulnerability zones, particularly those above 2,500m, which have limited access to healthcare, education, and early warning systems. The findings demonstrated intra-regional disparities in financial capital (up to 70% deficit) and a 70% higher vulnerability among marginalized groups, such as lower castes and women-headed households.

- Identified that villages with well-established community assets, such as self-help groups, local cooperatives, and traditional water harvesting structures—exhibited stronger adaptive capacity. These assets contributed to enhanced information sharing, collective risk management, and faster post-disaster recovery. Villages with functional community networks reported 30% higher participation in resilience initiatives, reinforcing the critical role of locally governed institutions and shared infrastructure in climate adaptation planning.

- Spatio-temporal LULC analysis (2011–2022) revealed alarming patterns: forest loss in Karbi Anglong (-11.34%), shrinking agriculture in Rudraprayag (-5.00%), and glacial retreat in Lahaul-Spiti impacting water sources. The study confirmed that Natural Capital was the most degraded across all sites, emphasizing the need for ecosystem-based adaptation. Additionally, strong social capital was associated with a 30% faster recovery and a 25% higher adoption of adaptive practices, underscoring the importance of community institutions in building resilience (Fig. 14).

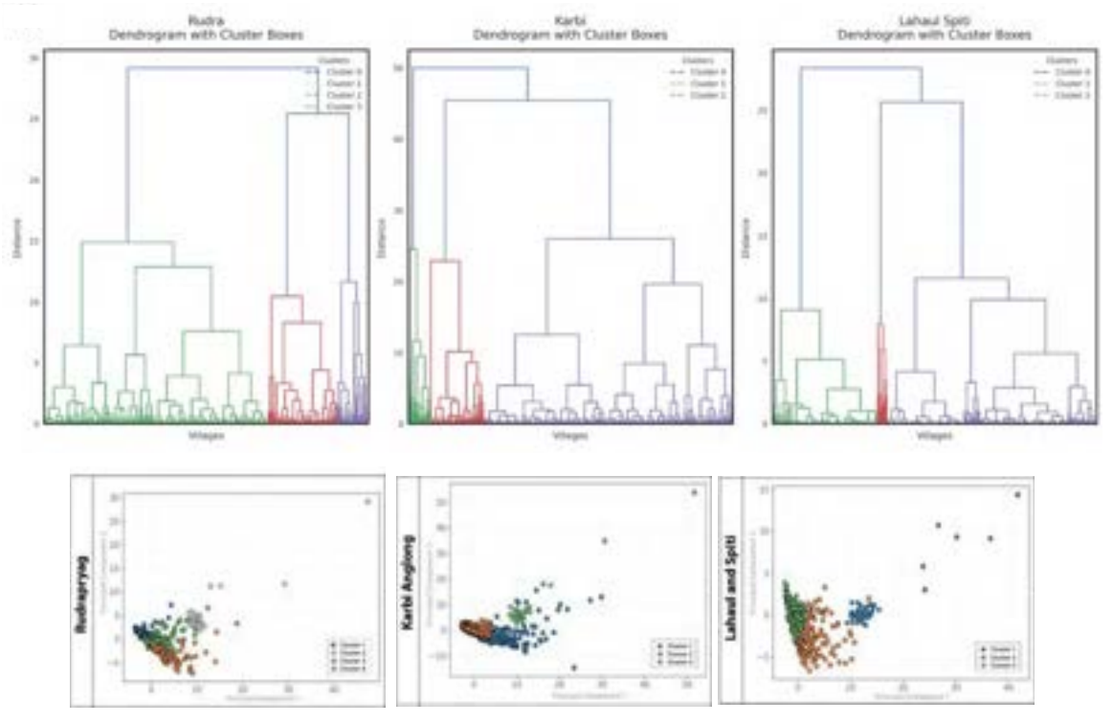


Fig. 14 Region wise cluster distribution and dendrogram of region wise cluster

Preparation of Chapter IV of India's Biennial Transparency Report (BTR-1) and Chapter III of Fourth National Communication (4NC) Impact, Vulnerability, and Adaptation for Himalayan Ecosystem focusing on plant biodiversity (MoEFCC, 2024-2026)

The National Action Plan on Climate Change (NAPCC), among other initiatives, recognizes the Himalayan ecosystem as vital for preserving the country's ecological security. Additionally, it highlights the ecosystem's intense vulnerability to both anthropogenic and environmental perturbations. The sensitivity of the region is likely to be exacerbated by the impact of climate change (CC). Recognizing the need, the Government of India (GoI) has initiated various programs through the Department of Science and Technology and the Ministry of Environment, Forests, and Climate Change to study the impact of climate change, vulnerability, and adaptation in different Himalayan ecosystems. For instance, the NAPCC sets out 'Sustaining the Himalayan Ecosystem' (NMSHE) as one of the eight area-specific missions. This mission envisages measures for sustaining and safeguarding the glaciers and mountain ecosystems. Additionally, the MoEF&CC has initiated the National Mission on Himalayan Studies to gain a more holistic understanding of the Himalayan region. The Himalayan region is highly sensitive to natural (e.g., climate change) and human-induced perturbations. The magnitude and consequences of the impacts of climate change and biodiversity loss are still poorly understood. Arguably, the future of biodiversity in the region will define the future of local communities and those dependent on it downstream. Therefore, understanding the impact, vulnerability, and adaptation to climate change on Himalayan biodiversity is urgently required to develop sound strategies for its conservation and sustainable utilization.

Objectives

1. Assessing Climate Change Impacts on Himalayan Plant Biodiversity
2. Determining plant Biodiversity Vulnerabilities in the Himalayan Ecosystem
3. Developing Plant Biodiversity-Centric Adaptation Strategies in the Himalaya

Achievements

1. Chapter IV of India's Biennial Transparency

Report (BTR-1) is prepared in consultation with ICFRE, Dehradun, and IIFM, Bhopal, and submitted to MoEFCC, GoI, New Delhi.

2. A Framework has been prepared for Chapter IV of India's Fourth National Communication (4NC) Impact, Vulnerability, and Adaptation for the Himalayan Ecosystem, focusing on plant biodiversity.

3. A comprehensive review of the literature has been conducted to assess the impacts, vulnerabilities, and adaptation strategies related to the Himalayan ecosystem, with a particular focus on plant biodiversity. Analysis of long-term herbarium records (n = 552) for 11 high-value alpine and sub-alpine medicinal plant species from the Indian Himalayan Region (IHR) using a Generalized Additive Model (GAM) revealed a significant trend of earlier flowering by 5 to 8 days (β = -0.0637; SE = 0.01721; p< 0.01) (Fig. 15).

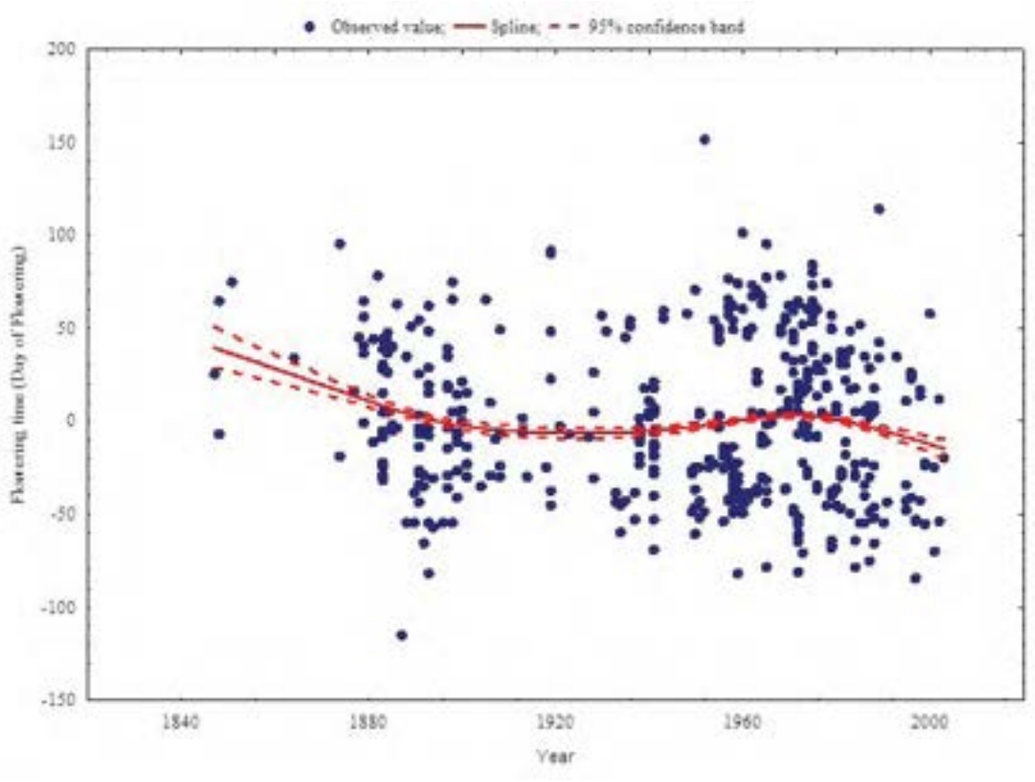


Fig. 15 Early flowering trend of 11 high-value alpine and sub-alpine medicinal plant species from IHR

Creation of an Integrated Database of the Himalayan Biodiversity for Mainstreaming in Policy to Meet National Commitments (NMHS, 2024-2027)

Biodiversity research in the Himalaya started more than two centuries ago and has spent millions of dollars, resulting in an output of more than 35,000 scientific publications. However, this vast treasure of scientific information has not yet been utilized in data-driven decision-making and policy planning broadly due to the absence of this information in a spatially explicit form. Thus, the Himalaya is often considered a data-deficient region, despite having a large volume of information on biodiversity and other related subjects. To the best of our knowledge, no efforts have been made to date to curate the available information on Himalayan biodiversity for its use in decision-making and policy. Thus, to address the existing data gaps, the proposed study aims to utilize modern tools of data and text mining, leveraging AI, ML, and LLM, for the curation of published biodiversity information in a spatially explicit manner at the village level for 135 districts and 133 Protected Areas in the IHR. This data will be further supplemented with field-based biodiversity data collected through rigorous field surveys along

the elevational gradients of five Himalayan states in India. The spatially explicit biodiversity information will be utilized to produce SEEA ecosystem accounts, IUCN Red List indexing of Himalayan species, and enhance the Environmental Performance Index (EPI) of India. The information will also be used to develop a Himalayan Biodiversity Information System (HBIS) in the form of an open-access and user-friendly web portal, a decision support system (DSS) for policymakers, and an under-friendly App for biodiversity data collection through citizen science.

Objectives

1. Biodiversity data curation at village level to develop baseline data for ePBRs, agro-biodiversity, and biodiversity profiles of all districts and PAs of IHR.

2. Biodiversity indices for improving Environmental Performance Index.

3. Conservation assessment of species for IUCN Red List Indexing

4. Ecosystem accounting using SEEA central framework

5. Development of Himalayan Biodiversity Information System (HBIS), Decision Support System (DSS), and mobile App for Central Database Management Agency (CDMA) for the Himalaya.

Achievements

- Biodiversity data for groups such as: mammals, insects, reptiles, fishes, birds, amphibians, nematodes, viruses, algae, bryophytes, pteridophytes, and higher plants (gymnosperm and angiosperms) that is available at various databases (with the exception for some publications that are not open access) is collected and curated at the state and district levels for the entire Himalayan region (including Nepal, and Bhutan).

- IUCN Red List assessment for the target 20 endemic Himalayan species is completed (Fig. 16 & 17). Of these, six species fall under IUCN Threatened Categories (Critically endangered, endangered and under vulnerable category), one under near threatened- 01, while thirteen species are categorized as data-deficit species. The categories of the species under IUCN threat categories include: (i) *Aconitum sikkimensis* [Critically endangered (D1+C2a)], (ii) *Aconitum tawangense* [Critically Endangered (C2a)], (iii) *Berberis lamberti* [Endangered (D1)], (iv) *Rhododendron rawatii* [Endangered (D1); B1ab (i, iii, v)], (v) *Saussurea obvallata* [Vulnerable (A2abcd)], and (vi) *Aconitum lethale* [Vulnerable A4cd + B2b (i-iii) c(i-ii)].

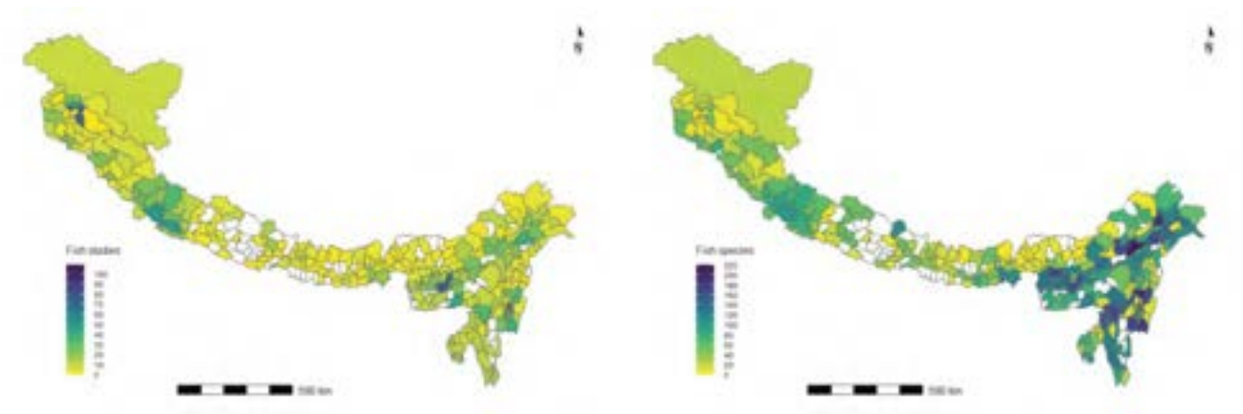


Fig. 16 Spatial distribution of studies (n=1303) on fish across the Himalayan region; and Spatial distribution of fish (n=943) species in the Himalayan region at district level.

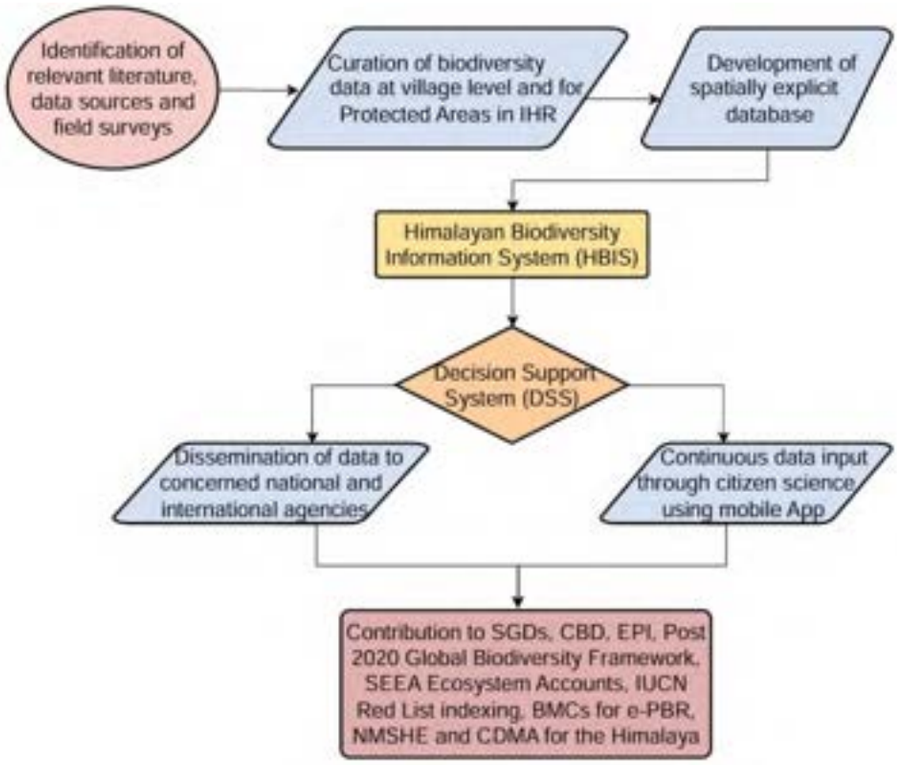


Fig. 17 Framework for implementation of the project and deliverables.

Promoting medicinal plant cultivation for conservation and livelihood upliftment of rural people in Hawalbagh and Takula Blocks of District Almora, Uttarakhand and Funding Agency (NABARD, 2024-2026)

TheHimalayanrangeisoneofthe36globalbiodiversity hotspots, known for its rich, unique, and useful biodiversity, and for providing goods and services to a large population in India. In addition, the increasing pressure of development infrastructure, concurrent habitat losses, and unscientific exploitation, coupled with growing indifference among the people, have reduced the biodiversity of the Himalaya. In recent years, there has been an increase in demand for the raw materials of medicinal and aromatic plants by pharmaceutical companies. Keeping in view the increasing demand for raw materialsfor medicinal and aromatic plants by pharmaceutical companies and the depletion of medicinal plant diversity due to various anthropogenic activities, it has become necessary that medicinal plants should cultivated so that, on one hand, they will be conserved and at the same time the livelihood of the rural people will be improved.

Objectives

1. To promote cultivation of medicinal and aromatic plants in the farmer's field.
2. To establish herbal garden/demonstrations of medicinal plants at Institute.
3. To develop market linkages for cultivated produce.
4. Capacity building and skill development of farmers on cultivation and harvest techniques.
5. To sensitize diverse stakeholders' groups towards promoting conservation of medicinal plants.

Major Achievement

- A total of 363 households were surveyed in the villages of Dhamas and Khoont. Out of these, 220 farmers expressed their willingness to cultivate medicinal plants. In Khoont village, 77 out of 129 households showed interest, while in Dhamas, 143 out of 234 households were willing

to participate in medicinal plant cultivation.

- A total of 697 *Cinnamomum tamala* saplings and 286 Rosmarinus officinalis cuttings were distributed among 112 farmers of Jyoli, Kaneli, Katarmal, and Kujyadi villages. Additionally, 21,000 rhizomes of *Hedychium spicatum* were also successfully distributed to 70 farmers of Khoont and Dhamas villages for cultivation (Fig. 18).

- Six awareness meetings were conducted in the selected villages, along with four capacity-building workshops organized at the GBP-NIHE HQ to provide technical knowledgeon livelihood genration through medicinal plant cultivation to interested farmers.

Fig. 18 Photographs plantation activities of Hedychium spicatum at Khoont village

Scaling Ecosystem-Based Approaches in the Indian Himalayan Region for Climate Adaptation and Biodiversity Resilience (ICIMOD, 2024-2025)

Amid increasing climate vulnerabilities, development pathways across the mountainous region need to be examined through both climate and biodiversity lenses. Ecosystem-based approaches can potentially address the impacts of climate change and biodiversity loss. To address these issues, HIREAP, a nine-year programme (2023-2031) of ICIMOD supported by FCDO under the CARA programme, aims to build climate resilience in five countries: Bangladesh, Bhutan, China, India, and Nepal. The programme focuses on promoting regional cooperation and collaboration to influence policy and investment, scaling Ecosystem-based Adaptations (EbAs) and actions for clean air (AfCA), while adopting a Gender Equality and Social Inclusion (GESI) framework across the following three priority sectors.

Objectives

1. To support and strengthen the scaling process of EbAs across IHR states, the project aims to:
2. Promote spring-shed management as EbA for addressing water security.
3. Implement EbA for green mountain livelihoods.
4. Utilize EbA for disaster reduction.

Achievements

- A comprehensive methodology for economic evaluation of springshed management was developed, and three sites—one each in West Bengal (through SRC), Uttarakhand (through HQ), and Arunachal Pradesh (through NERC)—were selected as pilots for research, with initial data already received from selected pilot sites.

- A comprehensive survey was initiated across three pilot sites—one each in West Bengal, Uttarakhand, and Arunachal Pradesh—covering both Eastern and Western Himalayan regions. A detailed questionnaire was developed to collect socio-

economic, ecological, and hydrological baseline data, with a focus on stakeholder dependency, biodiversity, and soil quality. Springshed boundary delineation and hydrological assessments were completed in Uttarakhand and Sikkim (Fig. 19), and, whereas geo-hydrological survey has been collected in Arunachal Pradesh (Fig. 20).

- Institutional capacity need assessment was undertaken across IHR through questionnaire surveys to identify gaps and gather socio-economic, ecological, and recharge data at pilot sites.

Fig. 19 Recharge zones delineated of the study area and geotagged locations of identified springs in Bidyang pilot site, Kalimpong West Bengal .

Fig.20 Baseline and geohyrological survey in Siya-Piro spring (Arunachal Pradesh).

National Mission for Sustaining the Himalayan Ecosystem- Task Force-3: Forest Resources and Plant Biodiversity-Phase II (DST, 2021-2026)

Mountains, particularly the Himalayas, are globally significant for their rich biodiversity and providing critical ecosystem services. Recognized as a biodiversity hotspot, the Himalayan region support over 10,000 flowering plant species, many of which are endemic and threatened. Despite their importance, biodiversity loss due to climate change and human activities is accelerating. Initiatives like the National Mission for Sustaining the Himalayan Ecosystem (NMSHE) aim to monitor and conserve this diversity through Long-Term Ecological Monitoring (LTEM) and grid-based distribution mapping. The region's forests also play a crucial role in carbon sequestration, yet they face challenges from rising temperatures, elevated CO_2 levels, and pollutants. There is a pressing need to assess species vulnerability, promote sustainable use, and strengthen conservation education. This aligns with global goals, such as SDG 15, which emphasizes the restoration and protection of terrestrial ecosystems. Conservation planning and community engagement are essential for sustaining biodiversity and supporting the livelihoods of local and downstream populations.

Objectives

1. Strengthen database on forest resources and plant biodiversity in IHR using field datasets and geospatial platform.

2. Establish effective monitoring system for plant diversity and forest resources in relation to changing climate.

3. Analyse growth dynamics and carbon exchange potential under climate change scenario.

4. Assess climate change vulnerability of ecologically and economically important plants and forests.

5. Demonstration, capacity building and sensitization in forest resources management and plant biodiversity conservation.

Achievements

- Comparative analysis of Phase I (2016) and II (2022) data from LTEM plots revealed site-specific ecological shifts, including overall increases in stem density, basal area, and tree species richness, with variable trends in shrub and herb composition, and a general decline in tree population structure across CBH classes due to both successional development and local disturbances (Fig. 21).

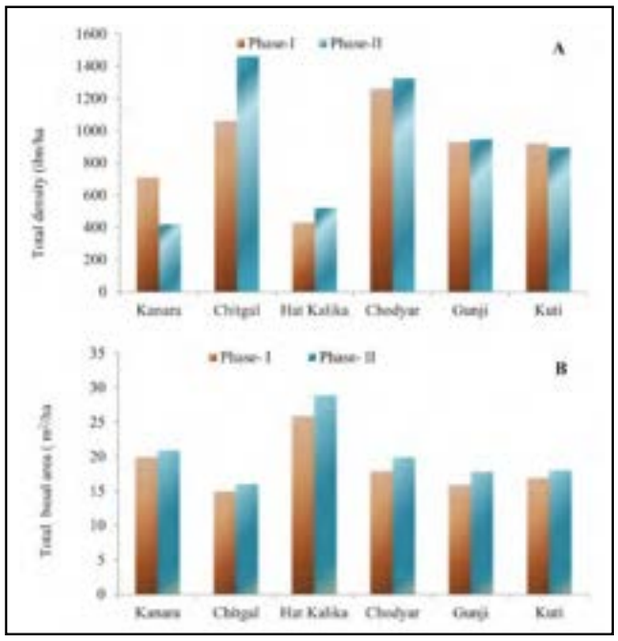


Fig. 21 Comparative analysis of ecological attributes between phases I and II in the different LTEM plots

- Vulnerability assessment across the IHR reveals that forests in the Eastern Himalayan Region (EHR) are more exposed and vulnerable, whereas the Western Himalayan Region (WHR) shows relatively higher adaptive capacity but also higher sensitivity. Forests at lower elevations experience greater exposure and vulnerability, while higher elevation forests tend to exhibit medium to low vulnerability due to climatic stability and limited anthropogenic pressure (Fig. 22).

- Under the environmental factors impact study, elevation showed a significant impact on the phytochemical content of plant species, Bergenia ciliata, Juniperus communis, and *Zanthoxylum arborum* collected from Uttarakhand. Elevation negatively influences the chlorophyll content and chemical composition of Juniper needle extracts.

Bergenin and gallic acid of *B. ciliata* are significantly positively correlated with elevation ($r=0.943$ at $p<0.05$), negatively correlated with annual mean temperature ($r=0.955$ at $p<0.05$), and positively correlated with annual mean temperature ($r=0.28$) and elevation ($r=0.091$), respectively. Linalool was significantly positively correlated with elevation ($r=0.84$ at $p<0.05$) and negatively correlated with annual mean temperature ($r=0.878$ at $p<0.05$) of Z. armatum.

- Between 1980 and 2024, Uttarakhand and Himachal Pradesh experienced significant long-term increases in air pollution. In Uttarakhand, black carbon (BC), SO2, PM2.0, and organic carbon (OC) rose at rates of 0.000896, 0.002380, 0.007050, and 0.003745 $\mu g/m^3$ per month, respectively, with episodic spikes linked to events like the April 1999 Forest fire (e.g., OC +644.29%, BC +408.57%). District-wise BC mapping revealed the highest concentrations (>2.0 $\mu g/m^3$) in the southern regions (Haridwar, Dehradun) during the period 2014–2024. In Himachal Pradesh, BC, SO2, PM2.0, and OC increased steadily at 0.000531, 0.001857, 0.004153, and 0.001921 $\mu g/m^3$ per month, respectively, with peak BC levels (1.75 $\mu g/m^3$) in Una, Kangra, and Solan during 2014–2024, reflecting persistent anthropogenic emissions and urbanization impacts.

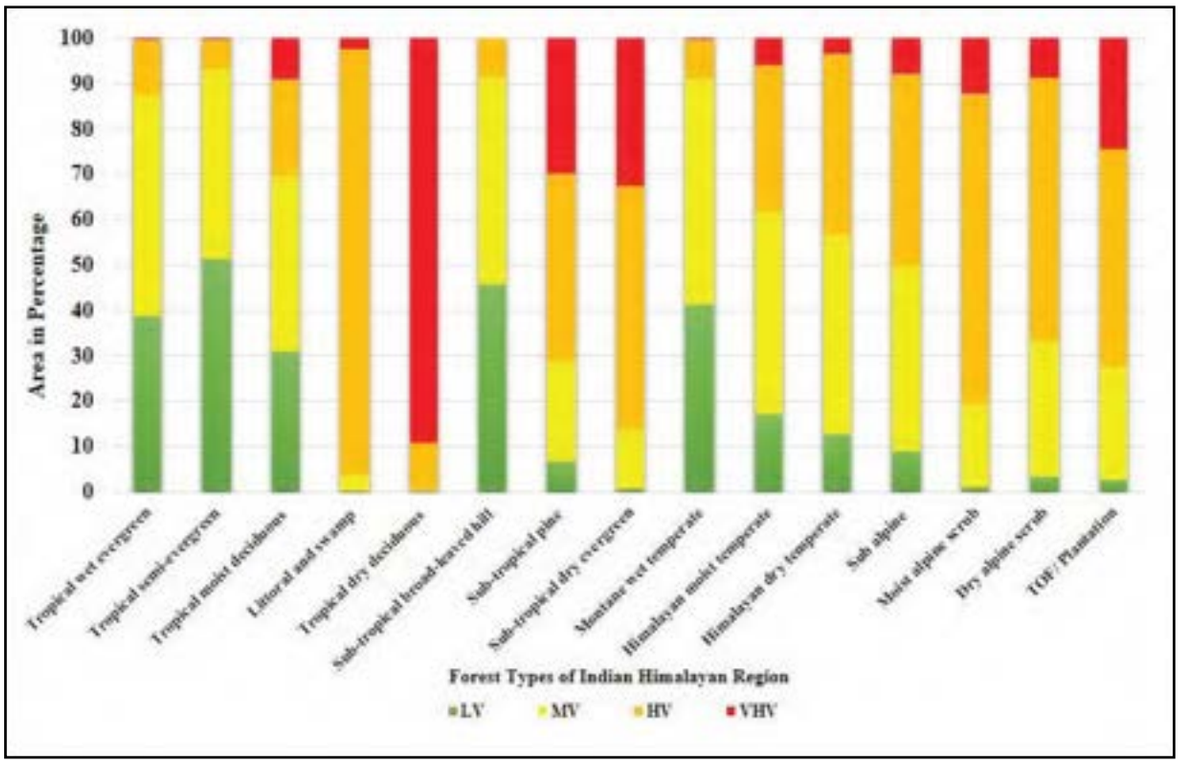


Fig. 22 Forest vulnerability classes of the IHR

(LV= Low vulnerability, MV= Moderate vulnerability, HV= High vulnerability, VHV= Very high vulnerability)

Ladakh Regional Centre

- Status report on plant distribution along the elevational gradient in Suru valley and Drass (Kargil District) was developed. Drass Valley exhibited higher floral diversity with 35 species across 16 families, while Suru Valley had 32 species from 11 families, with Asteraceae and Polygonaceae occurring across all elevations.

- Drass Valley exhibited greater species diversity and richness, while Suru Valley demonstrated a stronger relationship between species richness and elevation (Fig.23). Beta diversity of herbs increased with altitude in Suru Valley, while Drass showed an irregular pattern with a decreasing trend.

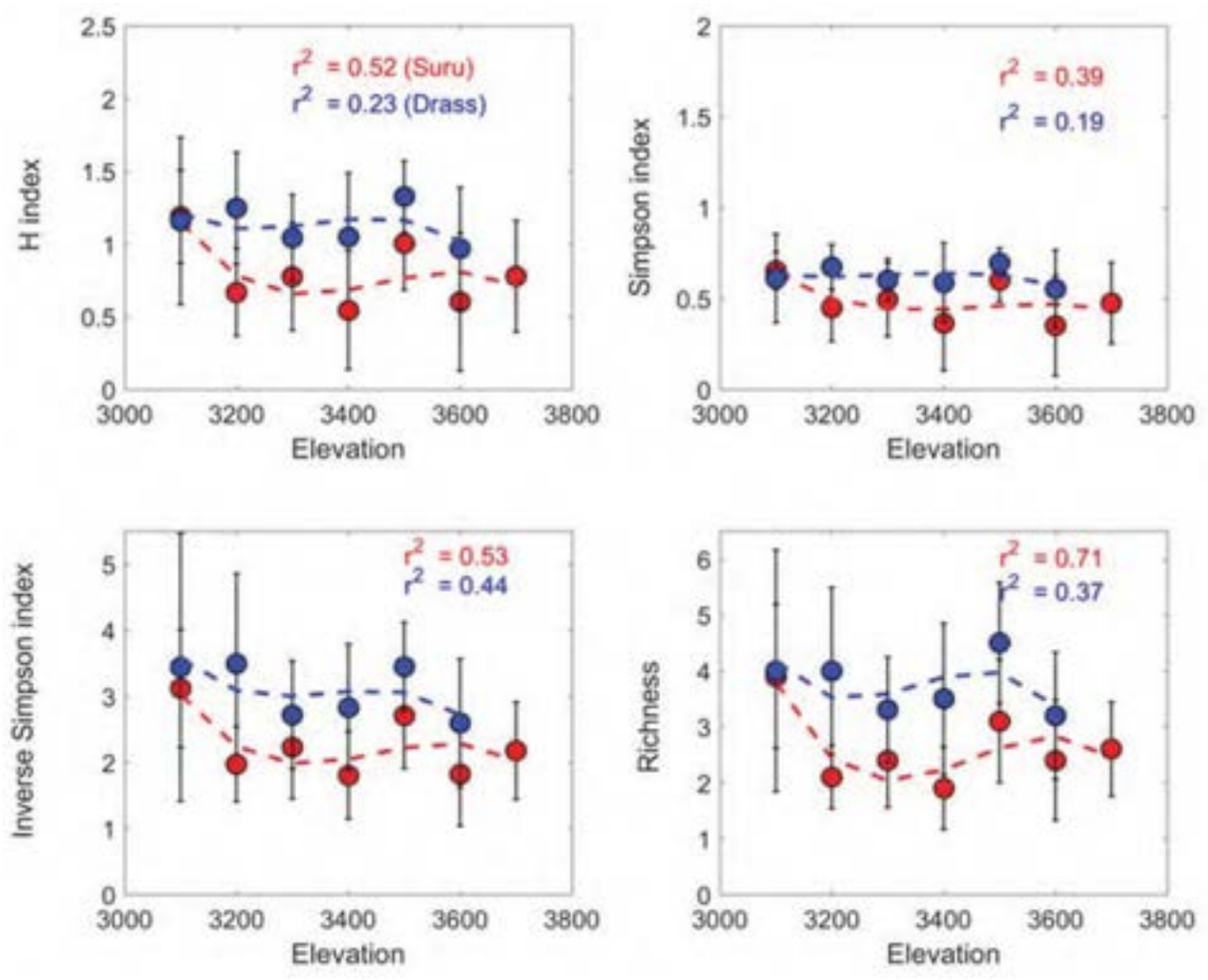


Fig. 23 Diversity indices of Drass and Suru Valley (irregular pattern with a decreasing trend).

Garhwal Regional Centre

- A database of pteridophytes (1025 taxa belonging to 106 genera in 19 families) in the IHR collated from a quantitative synthesis of 367 research studies published over the period from 1870s to 2020s. Polypodiaceae (356 taxa) was the dominant family and Thelypteris (73 taxa) was the dominant from a quantitative synthesis of 367 research studies published over the period from 1870s to 2020s. Polypodiaceae (356 taxa) was the dominant family and Thelypteris (73 taxa) was the dominant genera.

- The Jaccard similarity index (J), ranged from 0.025 (Ladakh-Mizoram) to 0.66 (Jammu & Kashmir-Himachal Pradesh). A hierarchical cluster analysis grouped states/UTs across into four clusters: (a) Jammu & Kashmir, Himachal Pradesh, Uttarakhand; (b) Ladakh; (c) West Bengal, Assam, Meghalaya, Arunachal and Sikkim; and (d) Nagaland, Manipur, Tripura and Mizoram (Fig. 24 (a)).

- A total of 799 taxa (721 ferns & 79 fern-allies) distributed 97 genera and 19 families were native to the Himalayan region. Moreover, 99 taxa were threatened, 215 were medicinal and 12 were endemic to IHR. Majority of the endemic flora were distributed in the east Himalayan regions, with Assam and Arunachal Pradesh with 5 taxa each.

- Along the elevational belt, the richness pattern of pteridophytes exhibited a hump-shaped curve with the number of taxa continuously increasing from lower elevations and attaining maximum value in mid-elevation zone, i.e., 1501-2000m (Fig. 24 (b)).

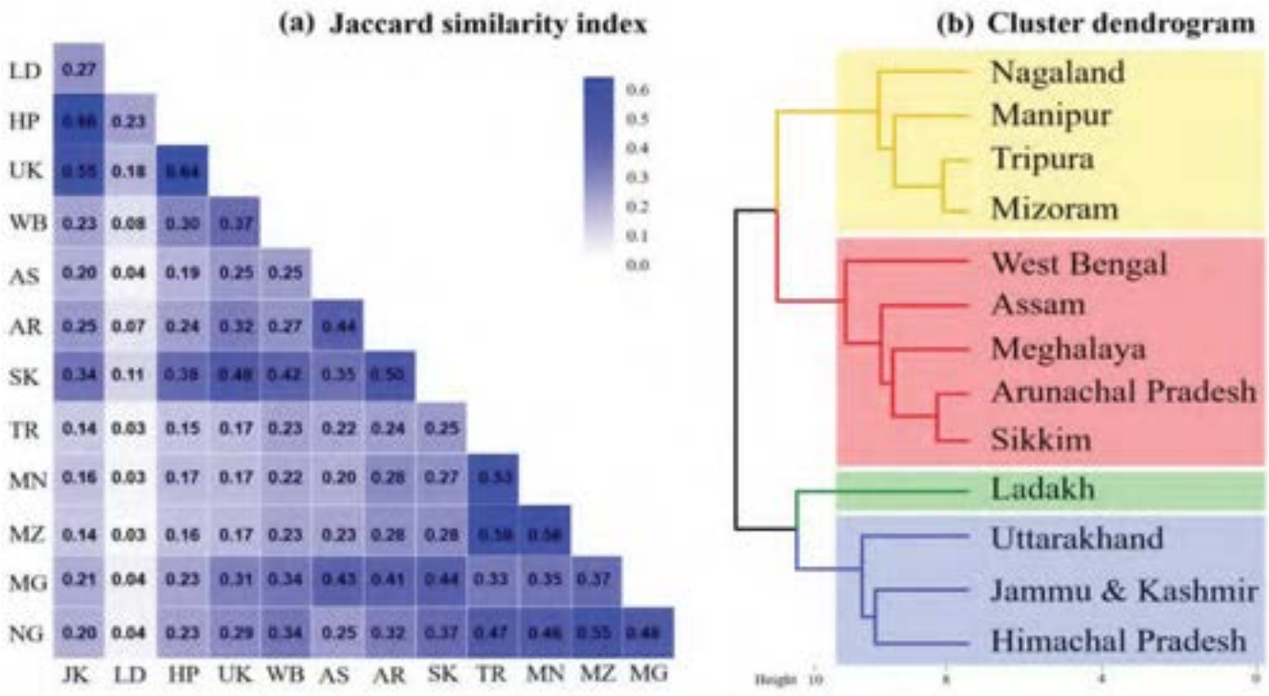


Fig. 24 (a), Heatmap showing Jaccard similarity index between states/union territories; [JK- Jammu & Kashmir; LD- Ladakh; HP- Himachal Pradesh; UK- Uttarakhand; WB- West Bengal; AS- Assam; AR- Arunachal Pradesh; SK- Sikkim; TR- Tripura; MN- Manipur; MZ- Mizoram; MG- Meghalaya; NG- Nagaland] (b), Hierarchical cluster dendrogram showing grouping of elevational zones based on the presence of pteridophytes.

North East Regional Centre

- A comprehensive review recorded 973 plant species in Arunachal Pradesh, detailing their scientific names, families, and district-wise distribution, highlighting the region's remarkable floral diversity. Among these, 220 species are endemic, underscoring the state's high conservation value. An ethno-botanical assessment identified 104 wild edible plants, with insights into their traditional uses and cultural significance. Notably, 15 species were found to possess profound socio-cultural importance among indigenous communities.

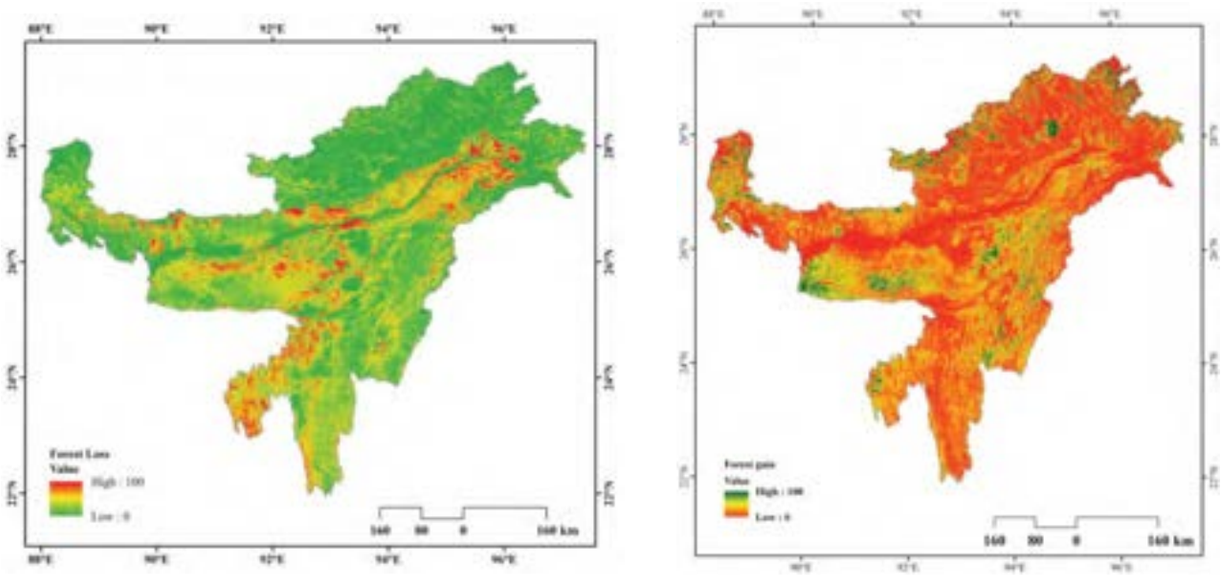


Fig. 25 Forest gain and Forest loss map of NER from 1991 to 2021.

Furthermore, representatives from 32 lower plant families were documented, reflecting a rich diversity of lower plant groups.

- Arunachal Pradesh harbors ethno-medicinal wealth. Documented 508 medicinal species across 158 families and their distribution across different altitudinal gradients of Arunachal Pradesh. A Generalized Additive Model showed medicinal plant richness peaks in tropical Himalayan zones, underscoring ecological and cultural significance.

- Remote sensing tools like Google Earth Engine and Sentinel-2 data were used to map vegetation types and assess deforestation trends over 30 years (1991–2021) for the North Eastern Region (NER) of India. Forest cover declined by ~9%, especially in Assam, Manipur, and Meghalaya (Fig. 25). Human population density, temperature rise, and low forest-to-population ratios were major drivers, while rugged terrain and high rainfall offered natural protection.

Strengthening the agri-horticulture systems for the socio-economic development of the rural communities in the Western Himalayan Ecosystem (NASF-ICAR, 2024-2027)

The Western Himalayan region is home to fragile ecosystems and marginalized rural communities that are heavily reliant on traditional agriculture for their livelihoods. However, climate variability, declining soil fertility, limited access to markets, and inadequate value chains have rendered conventional agricultural practices increasingly unsustainable. With this backdrop, the proposed project seeks to strengthen agri-horticulture systems as a sustainable and viable solution to address socio-economic challenges and enhance the resilience of rural communities in this ecologically sensitive region. This collaborative project, led by the G.B. Pant National Institute of Himalayan Environment (NIHE) in partnership with ICAR–Vivekananda Parvatiya Krishi Anusandhan Sansthan (ICAR–VPKAS), focuses on developing region-specific agri-horticultural models tailored to diverse agro-climatic conditions across selected sites in the Western Himalaya. The initiative aims to integrate medicinal plants and horticultural crops—including short-rotation species and high-value fruit and vegetable crops—to promote income diversification, nutritional security, and employment generation. By leveraging local biodiversity, traditional knowledge, and modern technology, this project aims to transform Himalayan agriculture into a resilient, inclusive, and economically vibrant system, thereby making a significant contribution to national goals of sustainable mountain development and rural livelihood enhancement.

Objectives

1. To identify the different agri-horticultural practice models adopted at regional and village cluster, and assess their feasibility in selected agri-climatic regions of Western Himalaya
2. To formulate region specific agri-horticultural farming models for enhancing the productivity, profitability and sustainability
3. To motivate diverse stakeholders for adoption of agri-horticultural model, and strengthening of market linkages by value-chain development

Achievements

- A need-based assessment survey was carried out in the eleven villages of the Chaudas valley, Tehsil Dharchula, Pithoragarh district, and documented the requirements of the villagers on bioresource based livelihood options. As a result, three potentially medicinal plant species namely *Allium stracheyi*, *Picrorrhiza kurrooa* and *Rosemarinus officinalis* were selected and identified for cultivation at farmer's fields (2200-2800 m asl).
- A total of 70 farmers from 11 villages have initiated field preparation for the cultivation of three selected medicinal plant species on 70 Nali (1.4 ha) of land following the project's intervention. Additionally, species-specific protocols were developed for selected medicinal plants, employing appropriate methods such as seed germination and vegetative propagation.
- The nursery established at Sri Narayan Ashram is being maintained for the conservation and propagation of threatened medicinal plants. Germplasm of 15 high-value, threatened Himalayan species is also maintained at the Sri Narayan Ashram, which also functions as a demonstration centre and capacity building hub for various stakeholders.

Strengthening of Lead Botanical Garden for *ex-situ* Conservation and Knowledge Dissemination on Threatened and Endemic Plants of Himalaya (Phase - III) under Assistant to Botanic Garden Programme (MoEF&CC, 2024-2027)

The Indian Himalayan Region (IHR) is a vital part of the Himalayan Biodiversity Hotspot, hosting a rich variety of medicinal and aromatic plants that are influenced by its diverse landscape, soil composition, and climatic conditions. With over 1,748 documented medicinal plant species—accounting for approximately 22% of the region's flowering plants—these species play a significant role in traditional medicine systems like Ayurveda, Unani, and Siddha while also sustaining local livelihoods. Unfortunately,

increasing exploitation poses a significant threat to many economically valuable and endangered species. In response, conservation initiatives such as the 'Surya-Kunj' botanical garden, established in 1992, aim to safeguard these plants. In 2008, recognizing the potential of 'Surya-Kunj,' the Ministry of Environment, Forests, and Climate Change, Government of India, identified it as a lead botanical garden for ex-situ conservation and knowledge dissemination on representative threatened and endemic (T&E) plants of the Central Himalaya. Over the years, various threatened and endemic plant species have been successfully preserved, reinforcing biodiversity conservation efforts and advocating sustainable resource management in the Himalayan ecosystem.

Objectives:

1. Conduct research for the development of propagation and multiplication packages for identified RET species.

2. Capacity building of diverse stakeholders for propagation, rehabilitation and recovery of RET species.

3. Development of material for environmental awareness, lectures/workshops with respect to ex-situ conservation, etc

Achievements

- Spatial presence data (148 locations) of the target species (*Asparagus curillus*, *Diploknema butyracea*, *Paris polyphylla*, *Symplocos ferruginea*, & *Zanthoxylum armatum)* were compiled from herbarium records of BSI, FRI, RARI, NIHE, WII as well as published literature to develop a comprehensive dataset for analysis and guide targeted field surveys.

- Collected the germplasm of *Diploknema butyracea*, *Paris polyphylla*, and *Symplocos ferruginea* from Pithoragarh (Munsiyari, Lilam, Ginni Bend, and Sharmoli Villages), Champawat (Ghat), and Nainital (Patwadanger) districts of Uttarakhand.

- A total of 43 seedlings were successfully developed from the collected *Diploknema butyraceae* germplasm in the net house, along with 4,000 *Zanthoxylum armatum* seedlings at Surya Kunj, Almora.

- A total of 629 students from various schools visited the Surya Kunj Lead BG, and these students were sensitized to Himalayan biodiversity conservation and management during the 2024-25 period.

Development of Genomic Resources, Elite lines, and Germplasm conservation on High-density rootstocks in Apple (DBT, 2024-2027)

The DBT-supported multi-institutional initiative aims to conserve apple genetic diversity in India. Apple (Malus x domestica), a key horticultural crop in the Himalayan states, viz. Jammu & Kashmir (J&K), Himachal Pradesh, and Uttarakhand of India. Over-reliance on a few commercial cultivars has led to reduced diversity and vulnerability to climate change and diseases. To address these issues, this project focuses on identifying elite genotypes from a novel F1 hybrid population (Red Delicious × Maharaji) for potential release as new cultivars, conserving genetic diversity through high-density rootstock plantations, and improving productivity and fruit quality to boost India's global competitiveness in apple trade

Objectives:

1. Extensive phenotyping of clonal F1 plants based on flower and fruit quality traits

2. Biochemical analysis (TSS, pH, firmness, Taste, Flavor) of F1 plants

3. Disease resistance tests on the F1 population based on phenotypic and molecular markers

4. Nutritional and nutraceutical assessment of the fruits of the F1 population

5. Material exchange, photo-documentation, and report writing

Achievements:

- Apple germplasm has been maintained at two different sites: Surya-Kunj, G.B. Pant National Institute of Himalayan Environment, Almora, and Government Horticultural Garden, Chaubatia, Ranikhet. Activities such as land preparation, germplasm maintenance (including irrigation, application of manure and fungicides, mapping, pitting, and fencing), as well as documentation of morphological and phenological parameters are being carried out in accordance with established protocols.
- A total of 69 mapping populations (305 individuals) were growing at Govt. Horticulture Garden (Chaubatia). Fifty-six apple genotypes are growing in Surya-Kunj (GBPNIHE, Almora) and the Government. Horticulture Garden (Chaubatia).
- The morphological characteristics (plant height, diameter) of apple genotypes were recorded. The minimum plant height of 45.0 cm was observed in the *Rasol Bati* variety, while the smallest stem diameter, 5.11 mm, was recorded in *Skyline Supreme*.

Understanding the impact of climate change on the birch forests of the west Himalaya (ANRF - CRG 2024-2027)

The Himalayan Birch *(Betula utilis)* is the predominant species at the treeline in the western Himalayas, an ecosystem highly sensitive to climate change. We aim to investigate birch at treelines in the Manali Wildlife Sanctuary and Sural Valley in Himachal Pradesh, which experience different climatic conditions—Manali has a summer monsoon, while Sural experiences dry summers. This research involves monitoring climate, biodiversity, and soil at the limits of the birch range. We will document phenology, herbivory, insect diversity, and insectivorous birds to explore trophic interactions. By analyzing tree cores and measuring transpiration, we will reconstruct historical climate patterns and assess biomass distribution at range limits. Tree sampling and allometric equations will be employed to determine biomass and carbon stock in relation to age. Genetic sequencing will be utilized to evaluate population structure and gene flow, revealing stress adaptations. The collected data will aid in predicting climate-induced trophic asynchrony and future effects on the western Himalayan treeline.

Objectives:

1. To document biodiversity, climate, and soil composition for long-term monitoring of the treeline ecosystem in the west Himalaya.
2. To document phenological changes and impact of herbivory in response to the changing climate.
3. To reconstruct past climate and estimate carbon stock and biomass accumulation at treeline using dendrochronology, allometric equations and transpiration measurements.
4. To conduct Genotyping-by-Sequencing

Fig. 26 Landscape of treeline and researcher setting a phenocam to monitor phenology of Birch

and transplantation experiments for understanding gene flow, population structure and adaptive plasticity of birch population in its elevational range.

Achievements:

- Recording of long-term climatic parameters initiated at lower, middle and upper elevational ranges of Betula utilis at Manali and Sural. Long-term climatic data particularly during the growing season of Birch will be utilized to investigate the interrelationships between climate and different physiological, ecological processes.

- Observation on phenology, leaf herbivory, avifaunal abundance was initiated at three elevations of the two study sites. Birch, being the flagship deciduous species on which insects emerge during the summer season, provides a food base to many passerine insectivorous birds. Thus, understanding the impact of climate on leaf phenology, insect abundance, and leaf herbivory will provide insights into the interdependence of different trophic levels (Fig. 26).

- Sampling of vegetation, soil, and plant functional traits initiated at three elevations of the two study sites. Understanding the vegetation composition at different elevations, along with the age structure, functional traits, and nutrient composition in the soil, will help in understanding how community functional diversity influences ecological interactions among species and their long-term consequences under a changing climate.

- In addition, monitoring of transpiration and genetic sequencing of the Birch population at its lower and upper elevational range limits will help in understanding the adaptive plasticity of the species towards increasing temperatures in the Himalayan treeline.

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

Climate change and other global forces are driving transformative changes in the Himalayan ecosystems. In addition to temperature changes, these changes are caused by variations in precipitation patterns, atmospheric carbon dioxide and gaseous pollutant levels, water distribution, and the frequency and intensity of extreme events. The Himalayan ecosystem exhibits varying degrees of sensitivity and response to climate change due to intricate interactions among organisms, disturbances, and other stressors. Climate change (CC) is recognized as a major global environmental challenge that will affect ecosystems in various ways and pose a threat to social and economic development in the IHR, where societies' dependence on natural resources is high. The CEA&CC addresses the Himalayan needs in these areas in alignment with the MoEF&CC and the SDGs (Goal 13), which require urgent action to combat climate change 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 resources 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 integration of community level experiences (acclimatization, adaptation, and coping mechanism) in the policy framework, and (v) collaboration with other organizations / Universities on CC projects. The objective of the CEA&CC is therefore to assess and monitor physical, biological, and socio-economic parameters for sustainable development in the IHR, and design measures for CC mitigation and adaptation by communities, as well as develop ecosystem resilience to cope with CC risks. Thus, the Centre envisions becoming a leading centre in Environmental Assessment and Climate Change research and policy advocacy on climate and environmental issues within the IHR. The mission of CEA&CC is to bridge the gap between research and practice on the impacts of CC in identified key sectors and critical ecosystems in the Himalayas.

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

Climate change is widely recognized as one of the most significant global concerns. However, its effects are particularly noticeable in the Himalayan region. This breathtaking landscape harbours invaluable ecosystems that furnish a resources and services crucial for human sustenance. In recent decades, the Indian Himalayan region has witnessed an alarming trend of accelerated warming and erratic precipitation patterns, driving a surge in extreme events. The impact of climate change is profoundly reshaping the dynamics of mountainous regions. Alterations in the water flow in mountain streams, shifts in agricultural practices, disruptions in socio-economic systems, and upheavals in the traditional livelihoods of indigenous groups. Mountain communities rely on natural resources for their survival due to limited livelihood options and inadequate social infrastructure. Under such conditions, these communities are more susceptible to the impacts of climate change. Thus, it is crucial to assess the vulnerability of communities in order to develop effective adaptation strategies in the Indian Himalayan Region. The current research Endeavour's to pinpoint the most vulnerable communities within the IHR region, aiming to bolster their resilience and adaptive capabilities against the onslaught of 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

- The climate vulnerability profile for all the

states of Indian Himalayan Region (IHR) was developed which reveals a diverse range of vulnerabilities across its states. In total, 14 districts in the north- western Indian Himalayan and 26 districts in the eastern Indian Himalayan regions fall under the highly vulnerable category.

- Exposure, Sensitivity, Adaptive capacity, Climate extreme Indices, and the Environmental Vulnerability Index (EVI) have been prepared for 13 states and union territories. The EVI is derived from 11 causative factors, including soil texture, geology, elevation, slope, forest type, road density, population density, drainage density, and land use/land cover (LULC).

- The Him CARES dashboard has been developed as an advanced decision support system to address the impact of climate change and to promote adaptive practices across the IHR. Forty seven climate adaptive practices have been documented across the IHR, encompassing key sectors such as agriculture, ecosystems, bio-resources, energy, human health, infrastructure, livelihoods, hazard and land management, waste management, and water resources (Fig. 27).

- In total, 54 awareness and 11 training programs have been conducted across the IHR, engaging approximately 2,800 participants.

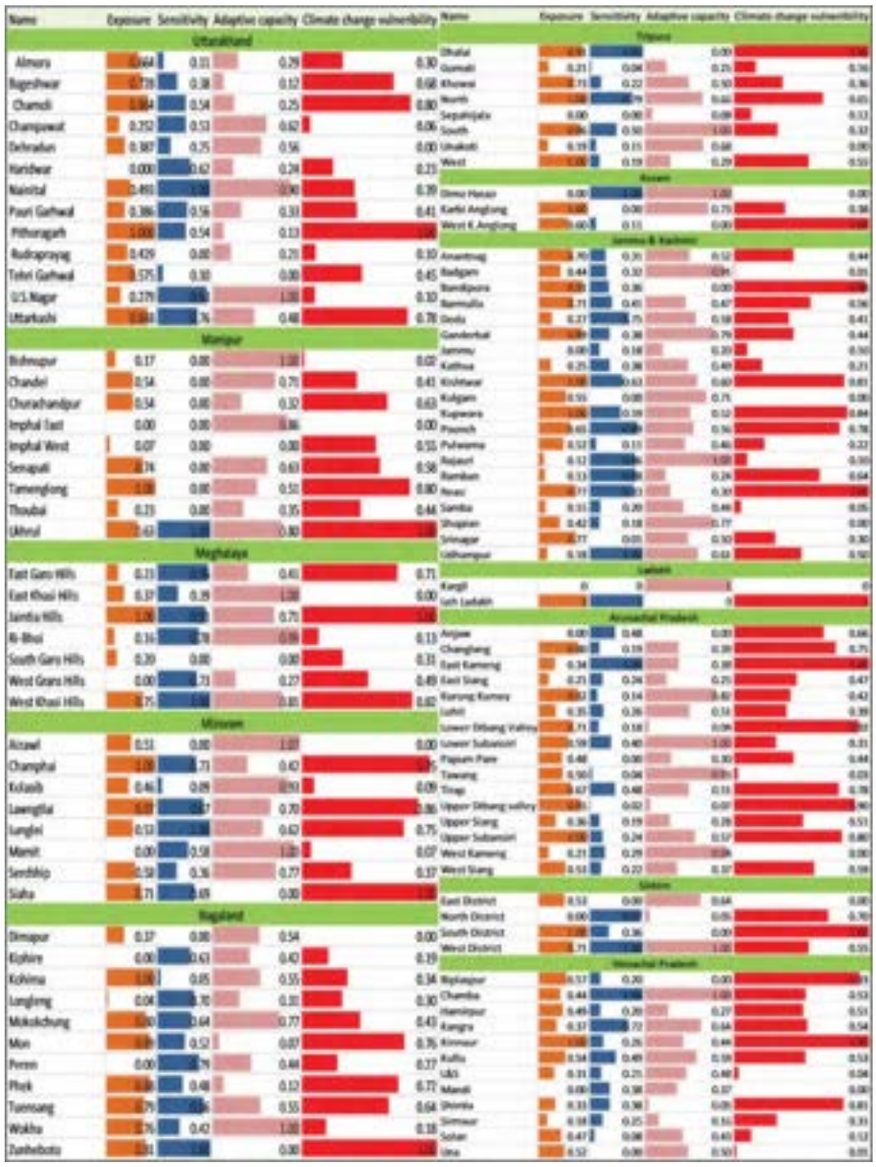


Fig. 27 State-wise Climate Vulnerability Index of the IHR

Aerosol Climatology over the North-western Indian Himalayan Region: Himachal Pradesh & Uttarakhand (ISRO-SPL, 2005-2006 Onwards)

The changing climate poses direct challenges to the Earth, amplifying issues such as deteriorating air quality, pollution, and escalating greenhouse gas emissions. Aerosol compounds in the atmosphere exacerbate these environmental issues, particularly due to rapid urbanization and industrialization in the Indian Himalaya. This intensifies the burden of human-made aerosols, impacting the local climate and glaciers. This leads to direct aerosol radiative forcing, altering Earth's radiative balance and contributing to regional climate disparities. Regular monitoring of aerosol properties, both regionally and daily is crucial for understanding their impact on the radiation balance and human health. Increases in aerosol levels accelerate processes like snowmelt and glacier retreat. Studying aerosols levels in the Himalaya provides insight into their interaction with climate and geography in this sensitive region. The present study aims to elucidate the current status of aerosol optical depth (AOD) levels in the delicate and fragile topographical region of the Himalaya, shedding light on the intricate interplay between aerosols, climate, and geography.

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

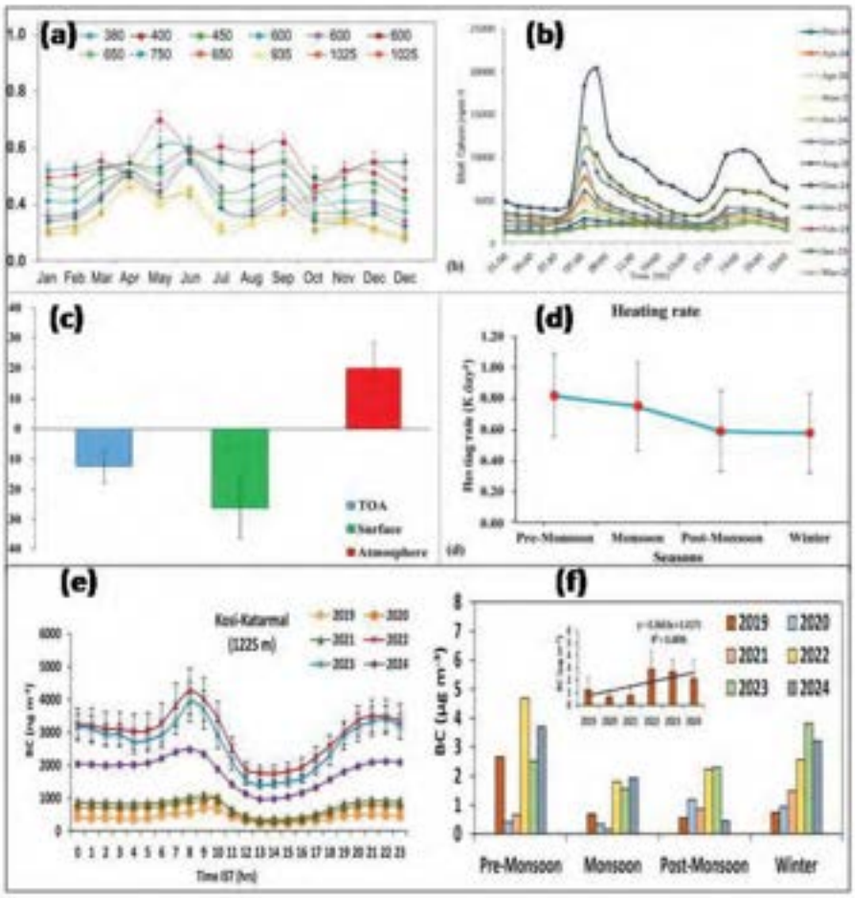


Fig. 28 (a) AOD at Mohal, (b) Black carbon at Mohal, (c) Aerosol Radiative forcing at Mohal, and (d) Heating rate at Mohal. (e) BC daily at Kosi-Katarmal (f) BC seasonal at Kosi-Katarmal.

Weather Stations (AWSs) installed at Mohal (Himachal Pradesh) and Katarmal (Uttarakhand).

- To estimate radiative forcing using different models.

Achievements

Mohal-Kullu, Himachal Pradesh:

- The mean AOD500 nm is found to have increased at Mohal during the study period of January 2024 and is highest in the summer season at all study sites, due to the higher tourist influx in the valley during this season (Fig. 28 (a)).

- The average BC from 2006 to 2024 was 2430 ± 317 ng m-3. On a yearly basis, BC concentration decreases with r = 0.069. Monthly maximum (20167 ng m-3) BC was noticed in January 2025 and a minimum (556 ng m-3) in August 2024 (Fig. 28 (b)).

- At Mohal, the instantaneous mean aerosol radiative forcing estimated using the model stood to be -17.6 ± 4.7 on the TOA, – 41.8 ± 11.2 Wm–2 on the surface and + 24.2 ± 8.02 Wm–2 in the atmosphere in 2006 to 2024. The same was estimated to be – 14.1± 5.70 Wm–2, – 31.3 ± 12.66 Wm–2 and + 17.1 ± 8.19 Wm–2 on the TOA, surface and atmosphere, respectively, in 2024 (Fig. 28 (c)).

- At Mohal, the maximum rise in temperature was noticed in the pre-monsoon season, while the minimum was in the winter season. The temperature in the valley is increasing at a rate of 0.68 K yr-1 from 2006 to 2024 (Fig. 28 (d)).

Kosi-Katarmal, Almora, Uttarakhand:

- BC concentration increased by ~78% from 2019 (1.18 µgm-^{3}) to 2024 (2.10 µgm-^{3}). Pre-monsoon BC peaks (~15.0 µg m-^{3}) are linked to biomass burning and forest fires. Temperature is moderately negatively correlated with BC (r = -0.60, p = 0.04), suggesting higher dispersion during warmer periods. Positive correlation with wind speed (r = 0.71, p = 0.01) highlights the role of atmospheric transport in influencing BC levels. (Fig. 28 (e-f))

- AOD500 exhibits a positively skewed distribution, with a mean of 0.37 and a median of 0.29. AOD500 values also show an increasing trend from 2019 to 2024. For example, pre-monsoon season AOD500 increased from 0.35 (2020) to 0.83 (2024).

- Average ARF on TOA, SFC and ATM, respectively at: Katarmal (2019-24): – 18.3 Wm–2, – 40.2 Wm–2and + 20.9 Wm–2 (heating rate - 0.6 K day-1). Atmospheric radiative forcing increased by approximately 20.26% during the fire days.

Geous Air Pollution in the Background Sites of Sprawling Urban Environment in Himachal Pradesh and Uttarakhand (ISRO, EO AT-CTM, PRL, 2008-2009 Onward)

Surface ozone, a secondary pollutant, forms when primary pollutants, such as nitrogen oxides (NO and NO2), from both natural and anthropogenic sources react in the atmosphere. Understanding the relationship between O3 and its main precursors represents significant scientific challenges. Ozone concentration depends on the absolute and relative concentration of its precursors, the intensity of solar radiation and the meteorological parameters. Analyzing these factors can enhance comprehension of local and regional level pollution. Carbon Monoxide (CO) primarily stems from biomass burning, fossil fuels combustion, and hydrocarbon oxidation from automobiles and industries. Other trace gases, such as SO_2, also react in the atmosphere and lead to the production of secondary pollutants, including PM10 and PM2.5, which adversely affect the environment.

Objectives

1. To measure the concentration of gaseous pollutants such as Ozone (O3), Nitrogen Dioxide (NO2), Carbon Monoxide (CO), Sulfur Dioxide (SO2) and Carbon Dioxide

(CO2) due to anthropogenic sources such as vehicular congestion and biomass burning as well as natural sources (dust, storm) to establish background values in the Himalayan region.

2. To observe local meteorological parameters and relate to these with gaseous pollutants and analyze in the background of long-range sources.

3. To suggest some feasible mitigating measures for implementation at the policy level.

Achievements

Mohal-Kullu, Himachal Pradesh.

- Sulphur Dioxide showed the highest average concentration in winter and the lowest in autumn and monsoon season (Fig. 29 (a)).

- Lower temperatures increased combustion, and a low level of OH increases SO2 in the region. Rainfall acts as a natural cleanser, washing pollutants out of the atmosphere. This can lead to a significant reduction in SO2 levels during the monsoon season.

- Carbon dioxide showed the highest concentration of 344.13±6.72 ppm in April, while lowest was 110.14±5.58 ppm in October 2024 (Fig. 29 (c)).

- Carbon monoxide showed the highest concentration in winter and the lowest in summer and monsoon. Carbon monoxide showed the highest average conc. of 0.56±0.06 ppm in January 2024 followed by 0.44±0.01 ppm in December 2024 and showed the lowest average of 0.16±0.01 ppm in April 2024 (Fig. 29 (b)).

- Surface Ozone showed the highest concentration of 26.17±3.86 ppb in June followed by 26.13±3.89 ppb in May 2024 and lowest at 4.52±1.71 ppb (Fig. 29 (d)).

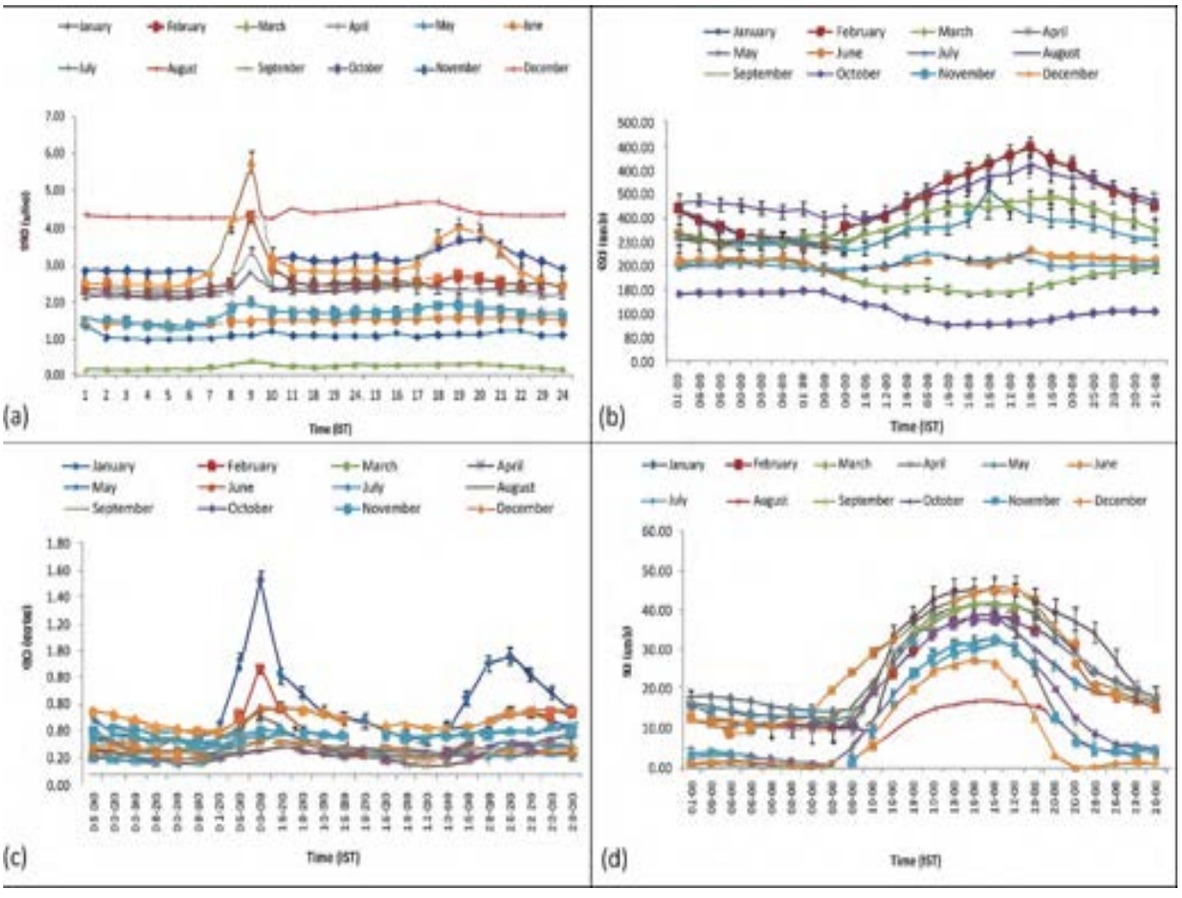


Fig. 29 Monthly diurnal variation of (a) SO2, (b) CO,(c) CO2 and (d) O3 in Kullu Himachal Pradesh in year 2024

Kosi-Katarmal, Almora, Uttarakhand:

- Highest average SO_2 (7.2 µg/m^3) and NO_2 (5.89 µg/m^3) recorded in May 2024, and peaks in winter (SO_2: 6.8 µg/m^3, NO_2: 5.5 µg/m^3) due to biomass burning and low boundary layer height.
- NO_2 and SO_2 showed negative correlation with temperature, humidity, and rainfall, while NH_3 showed positive correlation, indicating clear climate-pollutant interactions.
- All pollutants, including PM10 (max 97.3 µg/m^3), PM2.5 (max 60.7 µg/m^3), and PM1 (max 57.6 µg/m^3) remained within NAAQS limits, based on ground and satellite data (Fig. 30).
- Back trajectory analysis showed cleaner air from marine regions during monsoon, while polluted air originated from north-western India during other seasons.
- The findings support actionable steps like biomass burning control, forest fire management, and seasonal monitoring, aimed at improving regional air quality.

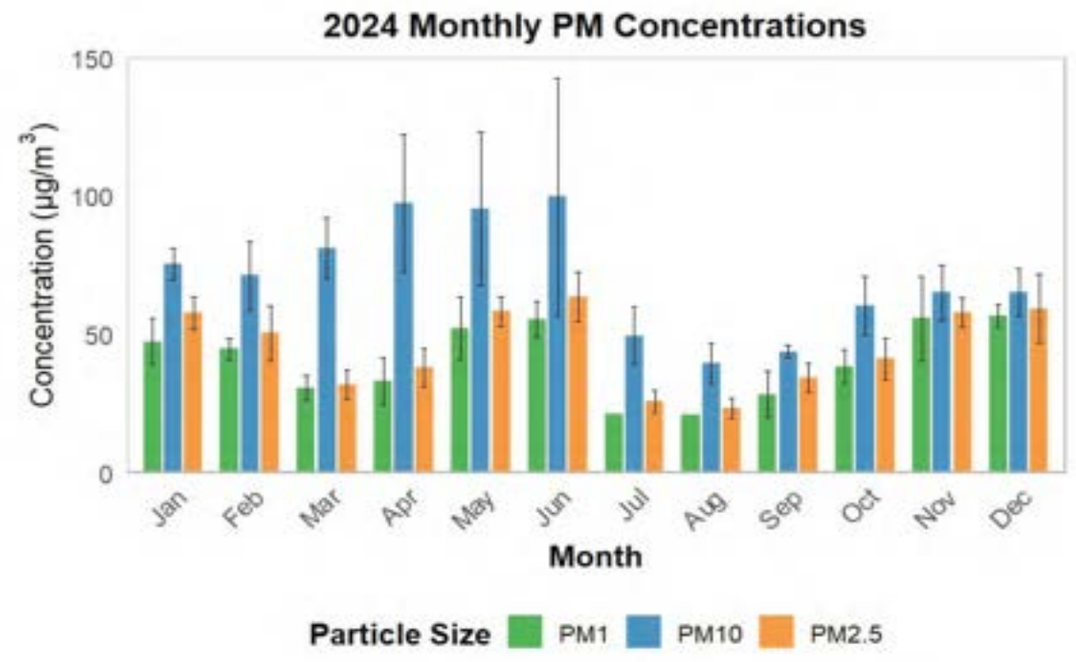


Fig. 30 Concentration of Air Pollutants at GB Pant NIHE Kosi-Katarmal Almora.

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

Soil microbial communities play a pivotal role in carbon (C) and nutrients cycling in any ecosystem, which is regulated by factors such as the quantity and quality of litter inputs, temperature, and moisture. Although microbial communities regulate important ecosystem processes, it is often unclear how the abundance and composition of microbial communities correlate with climatic perturbations and interact to affect ecosystem processes. Alpine & sub-alpine ecosystems are critically vulnerable and sensitive in the face of climate change and their carbon cycle may influence patterns of vegetation in the high-altitude environment of Himalaya. The project, therefore, attempts to fill these gaps and aims to address the influence of climate change (altitude as a proxy indicator of temperature) on microbial ecology and its role in soil carbon dynamics in major plant communities of alpine & sub-alpine ecosystems

of the Indian Western Himalaya.

Objective

1. 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.

2. To assess the rhizospheric community composition using high throughput sequencing along an altitudinal gradient (a proxy of temperature) of treeline ecotone of the Indian Western Himalaya.

3. To study the Geospatial variability of the soil microbial indices of Alpine treeline ecotone in the Western Himalayan region using a geostatistical approach.

Achievements

- Representative Treeline was selected at different elevation ranges. Pre and post monsoon sampling was performed at different elevation ranges of Darma valley Uttarakhand and Parvati Valley Himachal Pradesh.

- Soil enzyme activities exhibited seasonal and altitudinal variations across the study sites. Acid phosphatase activity ranged from 221.45 to 394.06 µg PNP/g soil/hr, with the highest values observed in meadows and the lowest in treeline areas during the pre-monsoon season of 2023. Although variations were noted across seasons and sites, no consistent spatial patterns were observed. Alkaline phosphatase activity also varied, with a general increase in meadow sites and a decrease in treeline sites from pre- to post-monsoon during 2022, while patterns in 2023 were mixed across locations. Urease activity ranged from 9.75 to 43.60 NH4+/g soil/hr, showing variable seasonal trends higher in some meadows post-monsoon, and generally lower in treelines. Dehydrogenase activity was highest in meadows during post-monsoon 2023 and lowest in treeline sites during the same season, with a general decline from pre- to post-monsoon across most sites. These observations highlight the influence of seasonal changes and elevation on soil biochemical dynamics (Fig. 31).

- Cultivable microbes have been isolated and colony forming units (CFUs) were analysed along with morphological and microscopic characterization of the isolates.

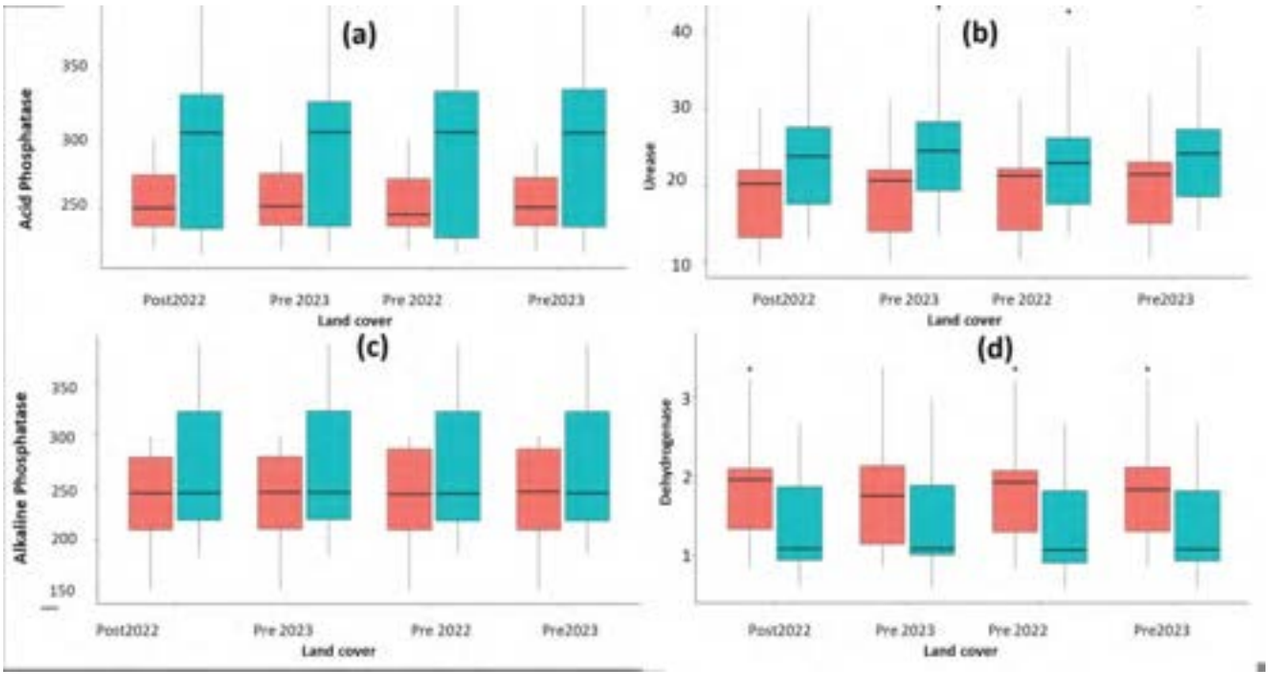


Fig. 31 Seasonal variations in soil enzyme activity along the altitudinal gradient (a) Acid Phosphatase, (b) Urease, (c) Alkaline Phosphatase (d) Dehydrogenase, of Darma valley, Uttarakhand.

Microbial Assisted Bio/Phytoremediation of Municipal Waste Dump Sites in the Central Himalaya (NMHS, 2024-2026)

The municipal solid waste management in the Indian Himalayan Region is one of the biggest challenges in terms of tackling hazardous waste which is adversely affecting the biodiversity of the region. The solid waste produced through various anthropogenic activities and their inadvertent disposal in open fields and trenches is vulnerable to environmental degradation that has not only disturbed the flora and fauna of the area but also its surroundings. Moreover, the lack of knowledge of solid waste management operations has led to an increase in soil, air and water pollution, exacerbating climate change. Thus, solid waste management is a key environmental challenge that must be tackled for sustainable development in the colder regions of the Himalayas.

Objectives

1. To identify, isolate and characterize the microbes for bioremediation potential for waste dumping sites and development of microbial consortia for bioremediation of waste dumping sites in the colder region.

2. To assess the suitable plant species and isolated microbes for the bio/phytoremediation capacity of the municipal waste dump sites.

3. To build the capacity of stakeholders w.r.t microbial assisted bio/phytoremediation eco-restoration model setup for municipal waste management.

Achievements

- Soil sampling from the experimental site (Champawat) has been done.

- The physicochemical properties of the soil, including pH, electrical conductivity (EC), bulk density, moisture content, available Nitrogen (N), Phosphorus (P), Potassium (K), organic Carbon, and Organic matter, have been determined. Analysis of the sample revealed pH from slightly acidic to slightly Alkaline (6.07–8.19), similarly EC, moisture content, BD, OM and OC levels were found to vary between 83.89–724.50 µS/cm, 5.78.28.53%, 0.55–0.99 Mgm-3, 0.62–1.95% and 1.07–3.35%.

- Soil enzyme activity, including dehydrogenase and Phosphatase has been done. Estimation revealed that highest and lowest DHA concentration showed up by A2 (77.49 µg TPF g-1 soil hr-1) and A8 (1.01 µg TPF g-1 soil hr-1) while in case of Alkaline and acidic Phosphatase conc. range vary from 6.68–24.52 µg PNP g-1 soil hr-1 and 3.93–53.87 µg PNP g-1 soil hr-1 (Fig. 32 (a-c)).

- Isolation of microbes using serial dilution and plating technique, cell morphological and colony characterization has been accomplished.

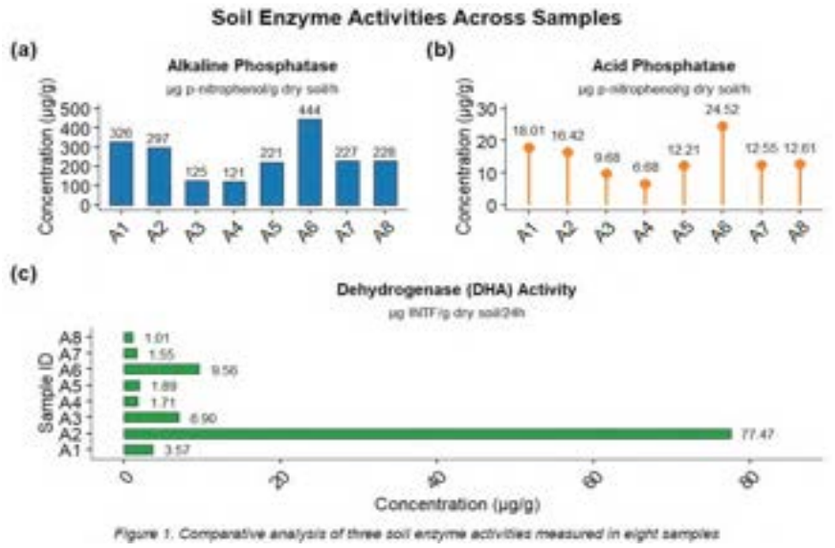


Figure 1. Comparative analysis of three soil enzyme activities measured in eight samples

Fig. 32 Enzymatic activities of contaminated soil (a) Alkaline phosphatase (b) Acid phosphatase (c) Dehydrogenase.

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 that has 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 the communities inhabiting these areas have adapted to extremely harsh climate and resource-poor living conditions, they face numerous challenges. Especially under changing climate scenarios, when impacts are expected to be more intense in higher altitudes, the Trans Himalayan landscapes and people are likely to face more severe challenges. These challenges, calls for a better understanding of its landscape components and developing strategies and implementation plans for addressing issues of environmental conservation, people's livelihoods and sustainable development under 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.

Integrating science and society to study and address the water issues in the trans-Himalayan regions of Ladakh (In-House, 2024-2025)

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 snowmelt 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 in an increase in water consumption. Furthermore, during the peak winter months, the springs form major sources of water supply for various domestic uses. Thus, the Ladakh Regional Centre has collaborated with local stakeholders to construct and assess the efficacy of the artificial snow reservoir, initiated long-term monitoring of springs that has societal implications and started the systematic documentation of the people's perceptions towards the changing spring water supply over time.

Objectives:

- Assessment of maximum and utilized potential of artificial snow reservoir and its efficacy to cater to the water needs of the downstream village
- Long-term monitoring of springs in the Leh region of Ladakh in terms of physical water properties, discharge and its social dimensions for their better management.

Achievements

- *In-situ* assessment of artificial snow reservoirs (snow barrier bands) at Tarchit Village, Ladakh was carried out during April 2024. The area of the reservoir is computed to be 39994 m2. Considering the check bands heights of 3 ft and snow/firn ideal density factor of 0.5, the maximum capacity of the reservoir is calculated as 18.29 million litre water equivalent (Fig. 33). The measured density factor of accumulated snow/firn is 0.48. Thus, the actual storage is estimated as 11.23 million litre water equivalent which is about 61% of the total capacity.
- Four springs within the Leh town were monitored at daily scale. The average discharges of springs (in decreasing order) at Chubi, Skara-II, Skara-I,

Changspa-I, Changspa-III, Changspa-II, Skara-III, Saboo-I and Saboo-II were recorded as 104.67, 34.08, 27.61, 20.84, 10.37, 5.14, 2.14, 1.57 and 0.82 lpm, respectively. We also noted that Skara Spring supports on average 30 Households per day with total potential of approx. 30000 ltrs. The Flow Duration Curve analysis shows that Skara-I (Q10/Q90= 1.36), Skara-III (Q10/Q90= 2.86), Changspa-I (Q10/Q90= 1.72), Changspa-II (Q10/Q90= 1.0), Changspa-III (Q10/Q90= 1.9), and Saboo-I (Q10/Q90= 1.37) were identified as "extraordinarily balanced." Saboo-II (Q10/Q90= 5.85) exhibited balance, while Skara-IV (Q10/Q90= 9.94) and Chubi (Q10/Q90= 6.68) were classified as "unbalanced".

Fig. 33 Field photograph showing dimensional and volumetric assessment of artificial snow reservoir (snow barrier bands) at Tarchit Village, Ladakh.

Rural Technology Center-Leh (In-House, 2024-2025)

After evaluation of 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 Leh town. For various purposes, LAHDC-Leh provided ~0.25 ha of land with fencing for developing a "Rural Technology Centre (RTC)" within the Council Secretariat Complex. After the 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 reclamation and rehabilitation mechanisms, RTC emerged as a knowledge center for education and awareness to harness rural livelihood opportunities through natural resources. At present, 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. One of the important activities of the RTC is to maintain an herbal garden with approx. 28 indigenous medicinal plants; and phytochemical evaluation of these indigenous medicinal plants for commercial viability using low-cost techniques.

Objectives:

1. To evaluate phytochemical constituents in *R. tibeticum* and *Inula racemosa* grown under RTC soil and low-cost hydroponic system.

2. To evaluate impact of elicitor on the phytochemical constituents in *R. tibeticum* and *Inula racemosa* grown under RTC soil and low-cost hydroponic system.

Achievements

- In *R. tibeticum*, hydroponic cultivation treated with 500 µM MeJA recorded the highest phenol content (3.85 mg/g DW), followed by 300 µM (3.78 mg/g

DW), showing a significant increase compared to the control. ABTS antioxidant activity was also highest at 500 µM (0.094 mg/g DW), with slightly lower activity at 300 µM (0.087 mg/g DW) and 100 µM (0.086 mg/g DW) (Fig. 34). In comparison, soil-grown plants treated with 500 µM showed lower ABTS activity (0.073 mg/g DW) than hydroponic-grown plants. In DPPH, assay showed a similar trend where 500 µM grown in hydroponic condition showed higher activity (0.012 mg/g DW) followed by 300 µM as compared to control (0.11 mg/g DW). However, FRAP showed the highest activity but with no significant difference in both the growing conditions.

- In *Inula racemosa*, the highest phenol accumulation was observed at 500 µM MeJA (2.14 mg/g DW) under hydroponic conditions, significantly higher than the control (1.14 mg/g DW), followed by 300 µM (1.18 mg/g DW). A similar trend was noted in soil-grown plants, where 500 µM treatment resulted in 1.56 mg/g DW phenol content compared to 0.92 mg/g DW in the control. In the ABTS assay, hydroponically grown plants treated with 500 µM MeJA showed the highest antioxidant activity (0.323 mg/g DW), followed by 300 µM (0.233 mg/g DW), 100 µM (0.191 mg/g DW), and control (0.125 mg/g DW). Soil-grown plants followed a similar pattern, with the highest activity at 500 µM (0.371 mg/g DW) and the lowest at 100 µM (0.186 mg/g DW).

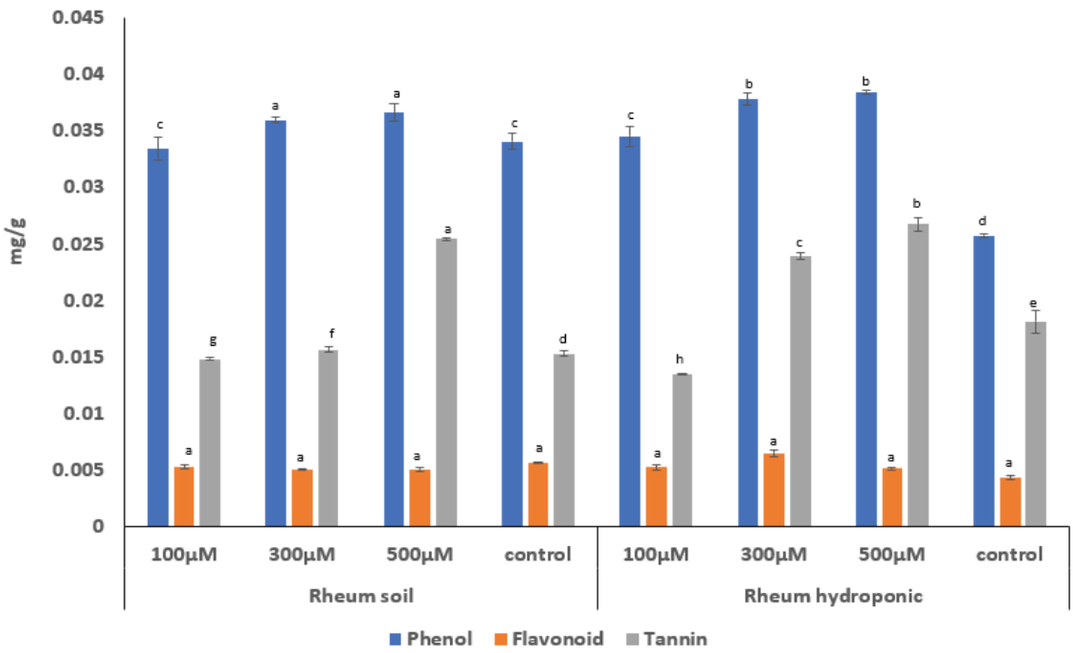


Fig. 34 Total phenol, flavonoid and Tannic Acid estimation in different concentrations of methyl jasmonate in hydroponic growing conditions of *R.tibeticum*. Data represented the mean standard error (n =3). Statistical differences are represented by Duncan multiple's range test ($p<0.05$).

Natural Resources-Based Livelihood Options and Off-Farm Employment in Rural Landscape of Ladakh (In-House, 2024-2025)

The northernmost part of India, specifically Ladakh, presents a challenging environment characterized by high altitudes exceeding 3000 meters above sea level, a dry climate with annual precipitation of 300 mm or less, and prolonged cold winters from October to March, where temperatures may drop to -40°C. The limited growing season, primarily from April to September, due to the extreme conditions poses significant constraints on agricultural activities. Despite being a cold desert region with sparse natural vegetation, Ladakh supports the cultivation of certain plants like Seabuckthorn, Salix, Poplar, Apple, Apricot, etc. in specific areas. This region, rich in plant-based natural resources, has witnessed

minimal exploration for sustainable development. The prevailing challenges include underutilization of local resources, limited entrepreneurship opportunities, and the under appreciation of women's roles in family and community management. Addressing the above issues, the study is focused to develop the capacity of the local villagers for nature-based product commercialization and hands-on training for value addition techniques.

Objectives:

1. To develop local resource-based entrepreneurship through capacity building

2. To create off-farm livelihood employment opportunities using local resources

Achievements:

- Within the Leh districts of Ladakh UT, a total of 6 villages (Sumoor, Changa, Khatpoo, Kharu, Ayee and Chamshen) were identified for targeted training and capacity-building programs. A total of 03 hands-on Integrated Mushroom Cultivation training programs were conducted with a total participation of 40 villagers (10 male and 30 female). The objective of these training sessions was to address nutritional deficiencies and to bolster livelihood opportunities within the region.

- Two hands-on basket-weaving training sessions were held over a span of 10 days in Changa and Kharu village, with participation from 10 and 20 members of Women Self Help Groups, respectively. The primary objective of these programs was to encourage the production of eco-friendly goods, thereby mitigating the usage of single-use plastics and enhancing livelihood opportunities in the area. The eco-friendly products crafted during the sessions were fashioned from locally sourced plant materials including Malchang (*Salix alba*), Selchang (*Salix tetraspermia*), and Tsipskyan (*Festuca arudinacece*). In addition, 01 value addition training programs were held at Chamshen Nubra on Seabuckthorn based products. The training was participated by 26 members of (ZAMO-40) Women Self Help Group of Chamshen Nubra.

Exploring the use of treated wastewater for vegetable cultivation through hydroponic in Ladakh UT (NMHS, 2024-2025)

The rapid expansion of urban areas strains water reserves, resulting in a surge in wastewater volumes. Consequently, there is an increasing interest in repurposing wastewater for agricultural use to alleviate strain on freshwater supplies and mitigate environmental pollution from sewage discharge. Hydroponic farming, a soilless cultivation method, emerges as a viable solution, offering numerous benefits over traditional farming methods. Despite requiring additional energy for its controlled environment and nutrient solutions, the advantages of hydroponics outweigh the drawbacks. Additionally, hydroponic systems hold promise as a wastewater treatment solution, given plants' capacity to absorb nutrients, toxic metals, and contaminants from water. Therefore, this project, supported by the NMHS, MoEFCC, GoI, is centered on utilizing treated wastewater from the Faecal Sludge Treatment Plant managed by the Leh Municipal Committee, which caters to 13 wards. Its main objective is to assess the viability of using treated wastewater for hydroponic vegetable cultivation. Through this endeavor, the project seeks to encourage the efficient utilization of urban wastewater in Leh, and provide an alternative method for vegetable production. Additionally, it aims to enhance food security in the region while addressing issues related to urban wastewater management.

Objectives:

1. To develop a solar-powered hydroponic prototype to utilize the treated water for the production of vegetables.

2. To standardize the protocol for cultivation of selected target species in Hydroponic technology utilizing the treated water.

3. To popularize the hydroponic technique by conducting various training program to local beneficiaries.

Major Achievements

- A low-cost, solar-powered hydroponic prototype was developed near the FSTP at Leh, using approx. 15,000 L/month of treated wastewater to cultivate tomato, lettuce, cucumber, and mangol. Experiments showed significant differences in cucumber growth and biomass across wastewater, nutrient solution, and soil, helping refine cultivation protocols under controlled, resource-efficient conditions (Fig. 35). results are given below:

- Cucumber plants grown in nutrient solution exhibited the greatest height (202.18 cm), while those irrigated with wastewater showed the highest stem diameter (6.39 mm), leaf number (38.82), and leaf area (68.04 cm^2). In terms of yield, nutrient solution treatment led to the highest fruit count (3.18/plant), fruit diameter (45.19 mm), and fresh weight (215.19 g), whereas wastewater-grown plants recorded the longest fruits (172.96 mm), demonstrating varied benefits across treatments.

The technology developed under this project is filed as a Patent under the Indian Patent System: Application No. 202511020347, dated 06 March 2025 – "A System for Hydroponic Cultivation Utilizing Treated Wastewater from Faecal Sludge Treatment Plants (FSTPs)".

Fig. 35 Wastewater based Hydroponic prototype for cultivation of Cucumber crops

Strengthening Ladakh's Livelihood: Empowering Women Self Help Group through harvesting and primary processing of Seabuckthorn (NABARD, 2024-2025)

Ladakh, a cold desert in northern India, is characterized by extreme climatic conditions, scarce water resources, and a fragile ecosystem. With an elevation ranging from 3,000 to 7,600 meters above sea level, the region has only 2.64% of arable land and a limited growing season from April to September. Traditional crops like wheat, barley, mustard, and vegetables, along with commercial trees such as apricot and walnut, constitute the region's agriculture. Apricot is economically significant, particularly in the Sham region, while sea buckthorn is valued for its adaptability and ecological benefits. Ladakh holds the largest seabuckthorn resource in India (13000 hac) with of Hippophae rhamnoides growing extensively in high-altitude regions. Seabuckthorn has immense medicinal value, referenced in historical texts like the "RGyud Bzi" and also used in the Amchi system of Ladakh. Its bioactive compounds make it nutritionally, medicinally and therapeutically important, especially rich in vitamins earning it the title "King of Vitamin C". Despite being a major seabuckthorn producer, Ladakh harvests only a fraction of its seabuckthorn potential due to short harvesting periods, overlapping with harvesting of other crops and inefficient methods. Women play a crucial role in seabuckthorn collection, presenting an opportunity for sustainable income generation. Addressing harvesting challenges could significantly enhance the economic and ecological benefits of this vital plant. This study assessed the distribution of *H. rhamnoides* in the Nubra Valley and evaluated the phytochemical and antioxidant properties of

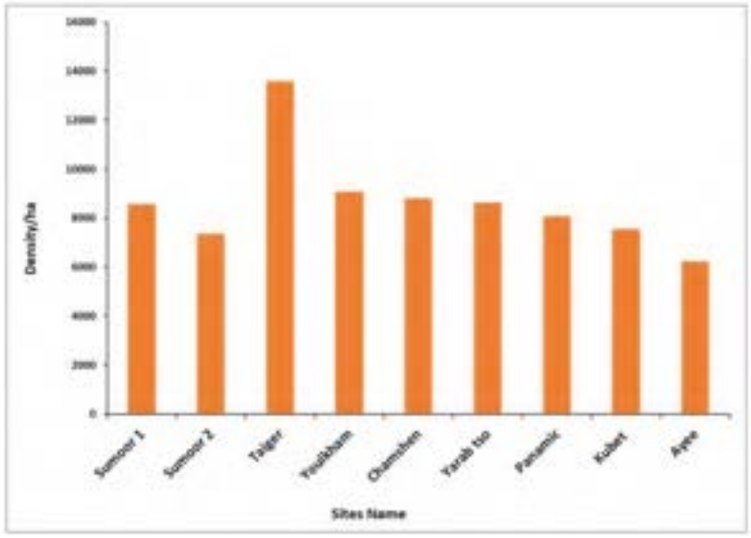


Fig. 36 Distribution of the *Hippophae rhamnoides* within the Siachen Valley. X-axis labels are indicating nearby villages where sampling quadrats were placed.

its berries and leaves across ripening stages. For ecological assessment, the Nubra River region was divided into seven 5 × 5 km² grids, with field surveys conducted in July-August 2024. Plant density, male-to-female ratios and yield of the plant were recorded and berry samples were collected at different ripening stages.

Objectives:

1. To conduct an ecological assessment of seabuckthorn berry production within specific unit areas at the selected sites.

2. To evaluate the phytochemical and antioxidant properties of berry and leaves at various stages of development to determine the optimal harvesting time for maximizing these properties.

Achievements:

- *Hippophae rhamnoides* (Seabuckthorn) dominates the Shayok River banks in Nubra Valley, coexisting with species like Salix, Myricaria, and Ephedra, with Salix showing the strongest association (Fig. 36). Its density ranges from 4,640 to 13,600 individuals per hectare, thriving mainly in sandy soils except in marshy Yarab-tso, where it forms pure stands. The female-to-male ratio is 71:29, with an average berry yield of 1.01 ± 0.29 kg/plant.

- Berry ripening leads to increased moisture (up to 84.2% in red berries) and enhanced antioxidant activity, likely due to carotenoids, ascorbic acid, and anthocyanins. FRAP and DPPH assays show maximum activity in red berries, while ABTS assay peaks in green berries. Leaf antioxidant and phytochemical levels increase with maturation, with male leaves showing higher concentrations than females.

- A hands-on training session on seabuckthorn-based products like juice and jam was conducted in September 2024 for 26 women from Chamshen Village. A seabuckthorn processing unit was inaugurated on 21st September 2024 in Chamshen Nubra, attended by officials from MoEFCC, NABARD, LEDeG, local government, and village community members.

Natural Grassland Ecosystem Monitoring System for Peninsular and Trans Himalayan India to Sustain Pastoral Communities, (NASF-ICAR, 2024-2025)

The Changthang Plateau in Ladakh is one of South Asia's most ecologically and culturally distinct regions, featuring vast grasslands, permafrost, saline lakes, and a cold, arid climate. Despite its significance, the region's grassland ecosystem remains understudied, particularly in relation to its carbon pool, grazing

capacity, and vulnerability to climate change. This project addresses these gaps through the use of remote sensing (RS) and GIS technologies to map natural grasslands and monitor vegetation dynamics over time. It also evaluates seasonal and long-term vegetation trends to assess the region's ecological shifts. The project contributes to building a scientific foundation for data-driven policy and sustainable resource management in the high Himalayas. For the first time, long-term monitoring of climate change impacts on alpine productivity in Changthang has been undertaken, offering vital insights to inform climate adaptation and mitigation strategies. This initiative aims to enhance sustainable development and resilience in this fragile landscape.

Objectives:

1. To retrieve different grassland biophysical parameters and management characteristics, such as degradation and grazing intensity, using RS-GIS and a conventional approach in the grasslands of Changthang Valley.

2. To assess the potential and effective carrying capacity of grasslands and the impact of climate change on their spatial distribution.

Achievements:

- A comprehensive set of vegetation and soil-related spectral indices was developed for the Changthang grassland ecosystem, including 11 key vegetation indices such as NDVI, EVI, MSAVI, and GNDVI, along with eight additional indices, to enable detailed analysis of vegetation dynamics and soil conditions over time.

- Grassland boundary mapping and delineation for potential grazing areas were completed using high-resolution satellite imagery, processed through Google Earth Engine (GEE) and ArcGIS platforms, providing spatial clarity on ecosystem extents and productivity zones.

- Field-based productivity sampling points were identified using Google Earth Pro, with the Net Primary Productivity (NPP) trends showing a decadal increase from 0.0516 kgC/m^2 in 2014 to 0.0606 kgC/m^2 in 2024, indicating an average annual growth rate of ~2%.

Summary of the Completed Project/ Activity

Developing New and Improved Agriculture Techniques (Mushroom Cultivation) in the GoI-UNDP-GEF SECURE Himalaya Project Landscape in the Union Territory of Ladakh, UNDP, 2023-2024

The project was implemented in the high-altitude Trans-Himalayan region of Ladakh, where traditional agriculture faces significant challenges due to harsh climatic conditions and limited food production. Recognizing mushroom cultivation as a sustainable alternative, the project aimed to enhance local livelihoods, strengthen food security, and promote environmentally sustainable practices. In collaboration with the Government of India, the United Nations Development Programme (UNDP), the Global Environment Facility (GEF), and the Ladakh Regional Centre of the G B Pant National Institute of Himalayan Environment (NIHE), the initiative introduced innovative mushroom cultivation techniques tailored to Ladakh's unique ecological and socio-economic landscape. The project focused on three remote villages—Khatpu, Hemya, and Tarchit—located in the Rong Valley of Leh district. The core objectives were to pioneer new and improved mushroom cultivation methods, establish 25 mushroom units as a base for local income generation, and conduct comprehensive training programs to build the capacity of local communities. As a result, six extensive training programs on mushroom cultivation were organized, reaching 87 farmers. Additionally, two sessions on low-cost polyhouse construction engaged 21 participants. Twenty-five mushroom cultivation units were successfully established across the three villages, with each polyhouse receiving 10 mushroom bags (approximately 4 kg each). The project yielded encouraging results, with oyster mushrooms ranging from 0.23 to 0.45 kg per bag, demonstrating strong and consistent performance across all units. In conclusion, the project effectively demonstrated the feasibility and benefits of integrating mushroom cultivation into Ladakh's farming systems. It not only introduced a novel agricultural practice suited to the region's climatic constraints but also empowered local communities through skill development and diversification of their livelihoods. The consistent yields of mushrooms and the enthusiastic participation of farmers reflect the high acceptance and scalability of this intervention. Moreover, the project contributed to the broader objectives of climate-resilient agriculture, rural income generation, and sustainable land-use practices in fragile mountain ecosystems. In the future, such models can be replicated in other ecologically similar regions of the Indian Himalayan Region, providing long-term solutions for enhancing food security, economic resilience, and environmental conservation.

Preparation of People's Biodiversity Registers (PBR) for Municipal Areas of Ladakh: Leh

The project was undertaken during 2023–24 by the Ladakh Regional Centre in collaboration with the Municipal Committee Leh (MCL), under the initiative of Urban Local Bodies – Ladakh. Located in the cold desert environment of the Union Territory of Ladakh, Leh town harbors a unique diversity of flora and fauna that has evolved under extreme climatic conditions. The region's ecological sensitivity and cultural dependence on natural resources make it imperative to document and conserve this biodiversity systematically. In response to this need, the preparation of a People's Biodiversity Register (PBR) was initiated to record and assess biodiversity at the municipal level, marking a significant step toward decentralized biodiversity governance in the Himalayan highlands. The main objectives of the project included the formation of a Biodiversity Management Committee (BMC) at the municipal level, the collection of floral and faunal data through literature reviews and field surveys at ward and household levels, validation of biodiversity data with the help of experts and BMC members, and final preparation of the PBR in accordance with the National Biodiversity Authority's guidelines. Key achievements of the project include the successful preparation and submission of the official PBR document for Leh Urban area to the Municipal Committee Leh on 30 March 2024—the first such register ever documented in the Union Territory of Ladakh. The biodiversity inventory revealed a total of 193 floral taxa, which included 27 cereals and vegetables, 9 horticultural species, 10 fodder plants, 12 weed species, 13 cultivated medicinal plants, 46 ornamental plants, 6 timber-yielding species, and 61 wild herbs and shrubs. Additionally, 29 wild medicinal plants were recorded, highlighting the ethnobotanical wealth of the region. In terms of fauna, the PBR documented 154 faunal species, comprising 10 domestic animals, 5 wild mammals, 55 bird species, 2 reptiles, 2 fish species, and 37 insect species, among others. Significantly, the assessment

revealed that 97 species (12 floral and 85 faunal taxa) are listed under various IUCN threatened categories, drawing attention to the urgent need for targeted conservation actions. In conclusion, the preparation of the People's Biodiversity Register for Leh marks a landmark achievement in initiating biodiversity documentation and conservation planning at the urban level in Ladakh. The project not only set a precedent by delivering the first formal biodiversity register for the UT but also helped in building institutional mechanisms like the BMC for long-term ecological governance. The extensive baseline data generated serves as a vital resource for informed policy-making, climate-resilient urban planning, and sustainable resource management. The inclusion of threatened species in the PBR highlights the ecological vulnerability of the region and the need for proactive conservation strategies. Moreover, the participatory approach adopted throughout the process has fostered environmental awareness and community ownership, which are crucial for sustaining biodiversity in fragile mountain ecosystems. This effort paves the way for replicating similar initiatives in other towns and villages across Ladakh and the broader Himalayan region.

HIMACHAL PRADESH REGIONAL CENTRE (HPRC)

The Himachal Pradesh Regional Centre (HPRC) caters to the need of entire Himachal Pradesh state. The focus of the centre is entire Himachal Pradesh state covering parts of north western Himalayan Bio-geographic province. The region is recognized for its ecological and economic values manifested by ecosystem integrity, adaptability and ecosystem services. Its protective and productive functions for both 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 broad objectives of the centre are as, Vulnerability assessment of biodiversity of Himalayan ecosystems in Trans and North Western Himalaya under biological, anthropogenic and climate scenarios for conservation and management; Assessment, characterization and valuation of ecosystem services and natural resource management for sustainable development of the native communities; Promoting environmentally sustainable income generating activities for livelihood enhancement and socio-economic development in the region; Development and strengthening of institutional mechanism for information sharing and capacity building of the stakeholders for environmental management; To build a body of scientific and traditional knowledge through demand driven action research and technological innovations; Development of strategies for monitoring and management of water resources, ambient air quality under climate change scenario; Assessment, monitoring and management of agricultural crops/farming systems for sustainability along an altitudinal gradient ; and Assessment and sustainable management of eco-tourism through entrepreneurship development in Himachal Pradesh.

Updation of 159 People's Biodiversity Registers (PBRs) in different districts of Himachal Pradesh (HPSBB, 2024-2025)

The Indian Himalayan Region (IHR) spans three biogeographic zones, stretching ~3,000 km and encompassing states including Himachal Pradesh. Located in the northwestern Himalayas, Himachal Pradesh covers 55,673 km^2 and is known for its rich biological diversity. However, increasing human population and anthropogenic pressures have intensified demands on its biological resources. In response, the National Biodiversity Authority (NBA) launched the People's Biodiversity Register (PBR) initiative. Following this, the Himachal Pradesh State Biodiversity Board (HPSBB) established Biodiversity Management Committees (BMCs) at various administrative levels. Technical Support Groups (TSGs) were tasked with preparing and updating the PBR. The G.B. Pant National Institute of Himalayan Environment, Himachal Regional Center, serving as a TSG, has prepared and submitted 46 PBRs for BMCs in Kullu and Mandi, one PBR for Kullu district, and five for Kullu Block (Kullu, Naggar, Banjar, Anni, Nirmand) to HPSBB. The Institute is now involved in preparing and updating 159 PBRs for Kullu and Una districts including, Municipal Councils of Kullu, Manali, Bhunter, Una, Gagret, Mehetpur and Santokgarh and Blocks of Una, Gagret and Amb.

Objectives:

1. Updation of 159 People's Biodiversity Register (PBRs) in different districts of Himachal Pradesh

Achievements

- The People's Biodiversity Register (PBR) of Municipal Council of Bhunter, Kullu and Manali in Kullu district has been updated.
- The People's Biodiversity Register (PBR) of Municipal Council of Una, Gagret, Mehatpur and Santokgarh in Una district has been updated.
- The People's Biodiversity Register (PBR) of Una

Block with total 63 Biodiversity Management Committees (BMC), Gagret Block with total 39 BMC and Amb Block with 50 BMC has been updated (Fig. 37)

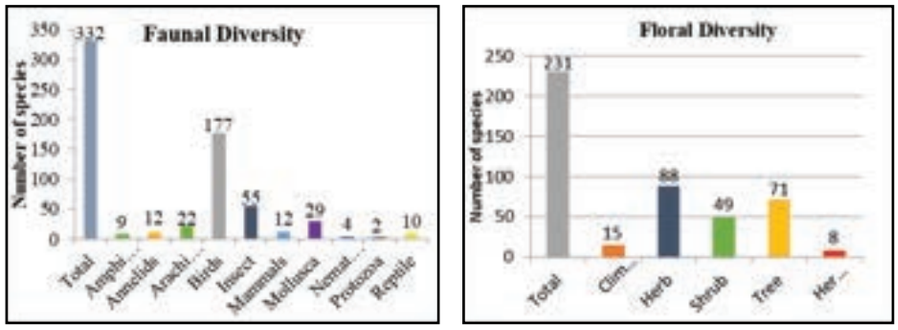


Fig. 37 Faunal and Floral Diversity of Una Muncipal Council

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

Hydroelectric projects, involving the construction of large dams, tunnels, and powerhouses, are causing several environmental problems. The approach to formulating an Environmental Management Plan (EMP) is to maximize positive environmental impacts and minimize negative ones. The suggested steps include modifications to plans, engineering designs, construction schedules and techniques, as well as operational and management practices. After selecting suitable environmental mitigation measures, the cost required for implementing various management measures will also be determined. An Environmental Monitoring Programme has been implemented to oversee environmental safeguards during both the construction and operation phases of the project. The programme aims to verify the agreement between predictions 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 and located at Neuly in Sainj Valley. It is located in the periphery of Great Himalayan National Park. The primary purpose of the EMP is to assess the environmental impacts of the project and to provide guidance on mitigating adverse impacts, their effects, and the monitoring of these effects periodically after the project becomes operational.

Objectives:

1. To assess the Soil quality, Erosion and Siltation around Sainj HEP
2. To assess the change in Migration pattern of aquatic and terrestrial fauna
3. To check the change in Landuse pattern of the Study area
4. To assess status of aquatic ecology
5. To identify the remedial issues and suggest suitable management options for the Sainj HEP

Achievements:

- Soil samples collected within a 10 km radius of the hydroelectric project site were analyzed for moisture, pH, electrical conductivity (EC), and key nutrients. Soil moisture ranged from 0.6% to 12.6%, pH from 5.32 to 7.17, and EC from 1.01 to 87 µS/cm, indicating variability in soil properties. Available potassium ranged between 310–630 Kg/ha, phosphorus between 268.8–371.84 Kg/ha, and nitrogen between 188.16–564.48 Kg/ha. Spatial distribution maps of these parameters were prepared using ArcGIS to assess their variation across the study area.
- Land Use Land Cover (LULC) classification was carried out for the years 2023 and 2024 to assess changes in land cover patterns. The analysis revealed a slight increase in water bodies, from 0.07 sq. km (0.04%) in 2023 to 0.12 sq. km (0.07%) in 2024. Bare soil areas reduced from 0.13 sq. km (0.08%) to 0.06 sq. km (0.04%). A substantial decline was observed in sparse vegetation (from

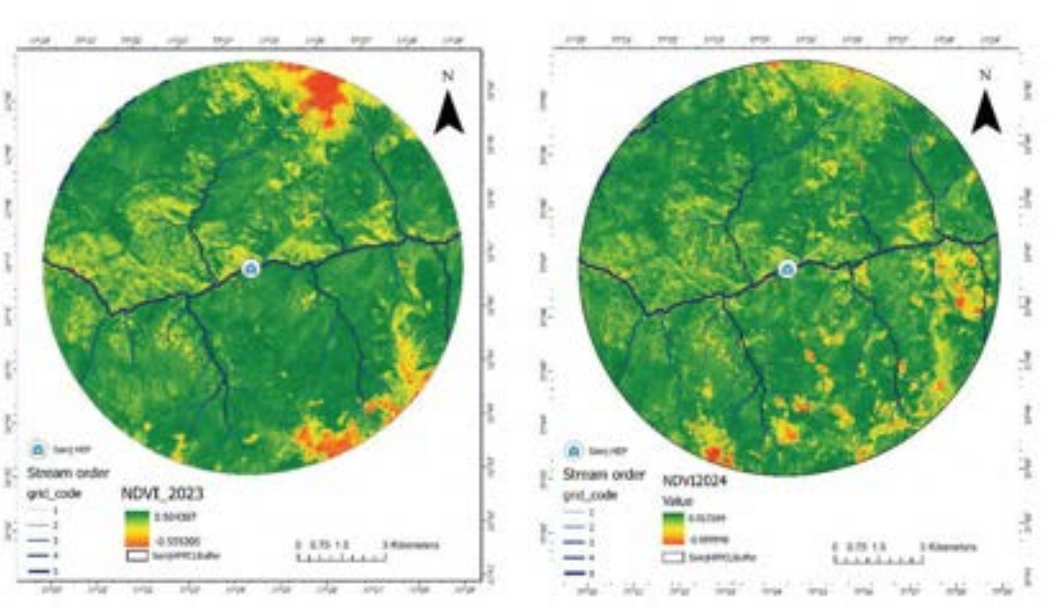


Fig. 38 NDVI maps 2023 & 2024

5.09 sq. km to 1.71 sq. km) and moderate vegetation (from 6.6 sq. km to 4.62 sq. km). In contrast, dense vegetation increased significantly from 148.84 sq. km (92.60%) to 154.23 sq. km (95.95%), indicating a positive shift toward greener land cover over the one-year period (Fig. 38). LST analysis for 2023 and 2024 shows slight changes in temperature patterns. In 2023, daytime temperatures ranged from -4.38°C to 24.99°C (average 12.83°C), and nighttime from -31.85°C to 15.50°C (average 3.13°C). In 2024, daytime temperatures ranged from -13.27°C to 27.89°C (average 13.23°C), and nighttime from -22.31°C to 15.98°C (average 4.39°C). There was an increase in variability in 2024, particularly during the day.

- A three-day capacity-building program on "Environmental Monitoring and Climate Change in Relation to Biodiversity" was successfully conducted from 16th to 18th October 2024 at Sainj, Kullu, engaging local communities. The training enhanced participants' understanding of hydropower impacts and equipped them with practical skills in environmental monitoring, disaster preparedness, and sustainable practices.

Summary of the Completed Project/ Activity

Developing Entrepreneurship and livelihood through value added products of Seabuckthorn (*Hippophae rhamnoides*) in Lahaul & Spiti, Himachal Pradesh (NABARD, 2022-2025)

The district of Lahaul & Spiti, Himachal Pradesh, nestled in the Indian Himalayan Region, presents a unique set of challenges and opportunities for livelihoods due to its rugged terrain, altitudinal gradients, and limited infrastructure. Seabuckthorn *(Hippophae rhamnoides L.)*, a deciduous shrub species native to the cold desert areas of the Northwestern Himalayan region, flourishes abundantly in Lahaul and Spiti, offering a rich array of bioactive compounds in its leaves, seeds, and berries, and also presents a promising avenue for economic empowerment. Project activity involves harnessing this resource, particularly involving women members of self-help groups, farmers, and youth. As envisioned, approximately 150 women members (Women Self Help Groups, Mahila Mandals, etc.) from different regions of the Lahual Valley have been actively engaged in the Seabuckthorn (SBT) based entrepreneurial activities. To raise the awareness and build technical capacities on various aspects of the Seabuckthorn value chain, a series of meetings and training programmes has been organised. These meeting and training programmes covered awareness about Seabuckthorn, its importance in terms of environment and economic benefits, sustainable harvesting, post harvesting handing, processing, value addition, etc. One Technology Centre has been established in the Jahalma Village of Lahual Valley to overcome the primary losses of processing and production of quality raw material. The technologies such as microwave dryer machine, fruit pulper machine, solar dryers, vacuum sealing machine, steam jacketing machine, weighing machine, etc, were installed in the centre. Five solar dryers of 5 kgs capacity were distributed among different women's groups to support decentralized processing and enhance drying efficiency. As a result, a variety of SBT based products were successfully developed which includes fruit pulp, dried berries, leaves and pomace tea, jam, juice, etc. These products were processed under hygienic conditions and also tested for quality, safety, and nutritional value.Concurrently, a preliminary marketing channel was established to facilitate product outreach and sales. Based on the feedback and demand raised by the stakeholders, a total of 1500 SBT saplings (sourced from Krishi Vigyan Kendra, Regional Station, Kukumseri) were distributed and planted by women beneficiaries from Nalda to Gondhala panchayats during 2023 and 2024. This further ensured a survival rate of approximately 70% as of August 2024.

As part of the capacity-building and knowledge-sharing component, a group of 14 women were taken on an educational exposure visit to Leh and Nubra Valley. During this visit, the participants received hands-on training in SBT cultivation, processing technologies, and business development models. The exposure visit allowed them to interact with successful entrepreneurs, gain insights into scalable practices, and enhance their understanding of enterprise management. Efforts are also underway to secure the Geographical Indication (GI) certification for Seabuckthorn from the Lahaul region. This process is being facilitated in collaboration with HIMCOSTE, Shimla. In addition to this, registration of a women-led society with the name Palden Lamo has also been completed. The process of branding and certification has also been initiated which enable the group to produce and sell food-grade SBT products legally in the broader market. As a part of project activities, the women's groups have successfully processed approximately 1000 litres of Seabuckthorn pulp, 400 kg of dried leaves, and 500 kg of dried pomace with the economic benefit of Rs. 6 Lakh approximately. These products are being marketed through various local and regional platforms, including collaborations with agencies such as Thapasu Foods LLP, Him Flavours, Jagriti, etc along with sales at regional fairs and national expos. The products have been showcased at several prominent events such as Kullu Dussehra, Shivratri Mela in Mandi, Adi Mahotsav in New Delhi, and exhibitions in Shimla, where they have received encouraging responses. In conclusion, the project has not only empowered rural women of Lahaul through entrepreneurship but also created a sustainable and scalable model. Through targeted interventions, capacity building, infrastructural support, and market integration, the initiative has laid a strong foundation for long-term livelihood security and women-led economic development in the cold desert region of Himachal Pradesh.

Major Outcomes:

- Women led SBT based enterprise in the cold desert region of Lahaul & Spiti district, Himachal Pradesh.
- Establishment of Technology Centre at Jahalma Village, Lahaul valley equipped with various technologies for the quality raw material processing.
- Development of market linkages with various local, regional and national level agencies for a sustainable value chain.

Permafrost Mapping and Characterization of Western Himalayan Region (NMHS, 2019-2024)

Permafrost, which consists of soil, rock, ice, and organic material that remains at or below 0°C for a minimum of two consecutive years, can be millions of years old. It holds preserved organic matter, plants, and animals from the last ice age. With the increase in global temperatures, the active layer above permafrost becomes deeper, resulting in a reduction of permafrost. This layer, which can range from a few centimeters to several meters in thickness, undergoes seasonal thawing and freezing, helping to regulate temperature changes and allowing for the exchange of moisture and gases. Permafrost soils are rich in organic carbon and nitrogen, which can be released as dissolved organic carbon (DOC), dissolved organic nitrogen (DON), and dissolved inorganic nitrogen (DIN) during thawing. These elements are vital for ecosystem functions and greenhouse gas emissions through biogeochemical cycling, lateral transport, and processing in aquatic environments. The breakdown of DOC produces CO2 and CH4, while DON and DIN boost primary production and decomposition. A study assessing the presence of permafrost was conducted in the Leh district of Ladakh, India, located between latitudes 32°30´N and 35°00´N and longitudes 75°50´E and 79°10´E, with altitudes ranging from 3500m to 5400 m above sea level (masl). Ladakh's distinct climate is characterized by low precipitation (115 mm on average) and significant temperature variations (-23.4 to 33.8°C). The research concentrated on the Ganglas catchment area, which includes the small Pucche glacier.This study examined the physicochemical properties of water samples from areas near permafrost in Leh, Ladakh. Samples were taken from 32 locations at altitudes between 3405-5437 m during several expeditions from 2020 to 2023. The research collected 32 permafrost-thawed water/water samples and 20 soil samples in triplicate. On-site measurements included temperature, pH, and electrical conductivity (EC) using portable instruments. Further analyses were performed in the laboratory. Results indicated surface water pH ranging from 7.11-9.72 (July-August) and 7.8-9.6 (September-October), suggesting slightly alkaline conditions. EC values ranged from 6.7-4200 µs/cm (July-August) and 17.6-4000 µs/cm (September-October). Total dissolved solids (TDS) levels varied from 4.7-2021 mg/L (July-August) and 10.87-548 mg/L (September-October). Salinity measurements ranged from 2.4-481 ppt (July-August) and 7.4-356 ppt (September-October). These parameters are essential indicators of water quality. pH affects water suitability for different uses, with 6.5-8.5 considered suitable and 7.0-8.0 optimal. EC is related to the concentration of ionized substances, while TDS reflects mineral content. Salinity influences water chemistry, density, and heat capacity. This thorough analysis offers valuable insights into the characteristics of water near permafrost in the Ladakh region.Analysis of water samples collected across two different seasons indicated variations in the levels of dissolved organic and inorganic carbon. During July and August, the Tsokar-Tsomoriri and Mahe-Samdho regions exhibited elevated Dissolved Inorganic Carbon (DIC), whereas in September and October, the Puga and Chumathang hot springs recorded higher DIC levels. Nitrogen concentrations were at their peak at the Tsokar campsite during both periods, with Tsomoriri showing the lowest levels. The Puga hot water area had the highest sodium content, while the upper Ganglas recorded the lowest. Potassium was most concentrated in Puga and least in the Pucche snout and Mahe-Samdho regions. Phosphorus levels in thawed permafrost soil varied, with the Ganglas mound and Pattern ground Ganglas areas having the highest percentages in their respective periods. Iron concentrations were at their maximum in the Warila spring area during both seasons. Zinc levels remained stable, ranging from 0-20 ppm. In most soil sampling locations, organic

carbon was the primary contributor to total carbon. The Tsokar-Tsomoriri and Mahe-Samdho areas had the highest dissolved organic carbon during July and August. Higher C/N ratios were noted in samples from the Tsokar-Tsomoriri, Mahe-Samdho, and North Pullu routes, suggesting a greater presence of peat-derived aromatic structures. Conversely, lower C: N ratios indicated a different composition of soil organic matter and an increase in microbial biomass within the active layer.

Major Outcomes:

- Generation of a comprehensive physico-chemical analysis dataset for permafrost thawed water and active layer soil samples collected from estimated permafrost sites across different locations of Leh, Ladakh, at different periods.

- Significant spatial and temporal variations in carbon (total and dissolved organic and inorganic carbon) and nitrogen (total nitrogen) concentrations across the permafrost-affected study area were observed.

- Assessment of carbon-to-nitrogen ratios in soil samples, providing insights into the composition of soil organic matter and microbial activity in the active layer of permafrost-affected areas.

GARHWAL REGIONAL CENTRE (GRC)

The Garhwal Regional Centre (GRC), Srinagar Garhwal, focuses on mountain biodiversity, biotechnological applications, water resource sustainability, restoration of degraded land, and the impacts of climate change, along with offering training and demonstration programs. Recently, the institute initiated the construction of new campus Garhwal Regional Centre at Chauras area, Tehri district, Uttarakhand. The region is recognized for sacred pilgrimage sites, which also include Badrinath, Gangotri, Hemkund Sahib, Kedarnath, and Yamunotri. Further, the region is also famous for mountaineering, UNESCO world heritage sites (Nanda Devi and Valley of Flowers), unique cultural heritages, etc. The GRC deals with need-based activities providing environmental solutions, enhancing livelihood options, model demonstration for sustainable livelihood enhancement, bioresource management, and eco-friendly tourism practices, etc. The research and development efforts of GRC are focused on the following main areas: (i) comprehending the effects of climate change on rural landscapes and adapting to them through livelihood strategies (agriculture, horticulture, pastoralism, traditional livestock husbandry, and NTFPs including MAPs); (ii) identifying sustainable tourism (rural tourism centered around nature and communities, pilgrimages, etc.); and its effects on the environment, the economy, and society; (iii) methods for assessing, using, and managing water resources; (iv) suitable technological interventions for the sustainable development of rural ecosystems; and (v) creation of genomic resources and plant propagation packages for elite identification, large-scale cultivation, management, conservation, and use of biotechnological and microbiological tools for biodiversity conservation. The GRC is also continuously contributing to the various districts, national-level programs/committees, and also helps to raise awareness on Mission LiFE and Swachh Bharat Mission among regional stakeholders.

Cumulative Impact Assessment for Cascading Interventions in Himalayan Rivers (NMHS, 2020-2025)

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

Objectives:

1. To conduct Morphometric analysis of Kameng (Arunachal Pradesh), Rispana (Dehradun) and Nayar River Systems using remote sensing and GIS techniques.

2. 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.

3. To conduct physical hydraulic experiments for underwater micro-environment characterization by measuring parameters (velocity, turbulence, temperature and dissolved oxygen (DO).

4. To improve Building Block approach of CIA by using long term hydrologic dataset and ecological relationships for Himalayan Rivers.

5. To develop a Network Approach of CIA by considering landscape connectivity and impact rating in Himalayan Catchments.

6. To develop a decision support system with CIA concepts, hydrological models and hydraulic models for end-users.

Achievements:

- A network of six to seven monitoring stations was established along the river system, extending from the headwater regions downstream to where the Nayar River joins the Ganga River. These stations were equipped with instruments (Fig. 39) to continuously measure both Air Temperature (AT) and Water Temperature (WT). This longitudinal arrangement of field-based monitoring sites was designed to assess the thermal sensitivity of the river network.

- Data collected from the monitoring network reveal distinct temperature patterns across the Nayar River basin. At higher elevation sites (above 1000 m), average air temperatures ranged from 15.32°C to 19.42°C, while downstream valley locations recorded higher temperatures between 19.37°C and 22.50°C. Water temperature measurements closely corresponded to air temperature patterns. This correlation between air and water temperatures was consistent throughout the monitoring network from the headwaters to the Nayar River confluence into Ganga River at Byashghat (Fig. 39).

- The Nayar River and its headwater tributaries exhibit a strong air-coupled thermal signature, making the entire riverine ecosystem highly vulnerable to climate change impacts. In contrast, the Ganga River displayed a narrower temperature fluctuation range (5.34 °C), indicating an altered thermal regime due to the regulated flows from reservoirs on the Bhagirathi and Alaknanda Rivers.

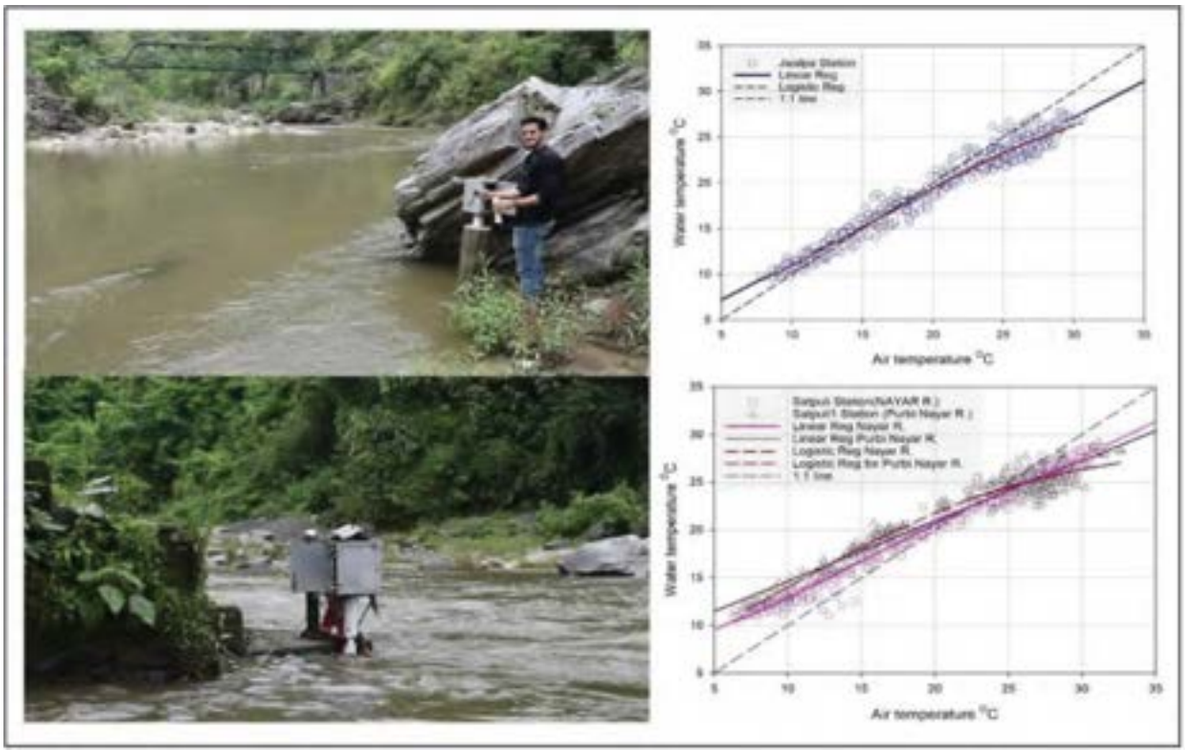


Fig. 39 Field photographs of a network of monitoring stations in the Nayar basin and linear and logistic regression analysis for air-water temperature relationship.

Characterization of rhizobia from root nodules of Himalayan Rajma and nif gene expression study to formulate bioinoculant for promoting sustainable agriculture in Uttarakhand (DST, 2024-2027)

Phaseolus vulgaris L. (common bean) is a nutritionally important legume and a vital global source of dietary protein and calories. Its short growth duration, high market value, and adaptability to diverse environments make it a preferred crop among Indian farmers, particularly in the Himalayan regions, where traditional landraces are valued for their superior taste and quality. However, in Uttarakhand, production remains insufficient to support farmer livelihoods, primarily due to challenging edaphoclimatic conditions and unproductive topography. Although common bean establishes symbiotic associations with diverse rhizobial strains, its biological nitrogen fixation (BNF) efficiency is comparatively low. Enhancing BNF through the use of efficient, competitive, and ecologically adapted rhizobial strains presents a promising strategy for improving productivity. Therefore, this study aims to (i) identify and characterize cold-adapted indigenous bean accessions nodulating with rhizobia across Uttarakhand, (ii) assess the impact of nodulation on growth, yield, and nutrition, (iii) analyze rhizospheric microbiomes and nif gene expression across different elevational zones and (iv) develop carrier-based bioformulations using promising rhizobial strains for potential field application. These efforts will contribute to sustainable agricultural practices and enhanced livelihood opportunities for farmers in the high-altitude regions of Uttarakhand.

Objectives

1. Exploration for collection of rhizobia from root nodules of cold adapted high altitude common bean germplasm, collection of soil samples and climatic data.

2. Isolation and characterization of rhizobia along with the assessment of nitrogen fixing, phosphorus solubilizing and indole acetic acid producing potential.

3. Identification and characterization of nif gene to assess the nitrogen fixation potential of rhizobia.

4. Carrier based bioformulation of promising rhizobia strain(s) for field application.

Achievements:

- Field survey was conducted across multiple elevational zones to identify common bean (Rajma) cultivation sites in Uttarakhand. Root nodules and rhizospheric soil samples were collected from eight locations—four sites each in Chamoli and Pithoragarh districts.

- A total of 54 bacterial strains were successfully isolated from the root nodules of common bean plants. Preliminary identification based on Gram staining confirmed their Gram-negative nature, supporting classification as Rhizobium species (Table 5).

- Further, biochemical characterization was conducted on all 54 isolates. Results of the catalase test showed that 35 isolates were catalase-positive, while the indole test indicated that 38 isolates were indole-negative-both traits commonly associated with Rhizobium species.

- Additionally, carbon source utilization tests were conducted on all 54 isolates using raffinose, xylose, lactose, and mannitol as sole carbon sources. Positive growth was observed in 34 isolates on raffinose, 37 on xylose, 32 on lactose, and 44 on mannitol, indicating metabolic diversity and reinforcing the identity of these isolates as putative Rhizobium associated with common bean nodules.

Table 5. Colony morphology and gram staining of isolated bacterial colonies from root nodule of common bean plant

Sites	Total isolates	Colony Characteristic	Gram Staining
Kanchoti	4	Light pink, mucoid, entire margin	Pink, small rod
Dantu	7	Light pink colonies, mucoid, entire margin	small pink rods
Sosa	4	Small colony shining light pink, less mucoid, entire margin	small pink, thin rods
Narayan ashram	7	Light pink, small isolated, yellowish colonies very less mucoid	rods dark and light pink, medium sized, thin
Lata	13	Light pink colonies, mucoid, entire margin	pink rods medium sized
Jakholi	3	Very light pink colony, highly mucoid, entire margin	Pink rod thin medium sized
Tolma	10	Light pink colony, mucoid, entire margin	Pink rods, small
Malari	6	Light pink colony, mucoid, entire margin	pink rods, medium sized

Summary of the Completed Project/ Activity

Implementing Vetiver Grass-Based Riverbank Protection in Garhwal Himalaya: A Sustainable Approach for Mitigating Soil Erosion (In-house, January to March 2025)

Towards the United Nations Decade on Ecosystem Restoration (2021-2030) goal on restoring and protecting the ecosystem of Indian Himalayan Region, this project aimed to introduce vetiver grass along the banks of river Alaknanda (one of the two headstreams of the river Ganga) to minimize the soil erosion, restore the vegetation as well as increase carbon sequestration. To achieve this, a two-day demonstration drive for vetiver plantation was organized on 24th and 25th February 2025 in Bhiri–Banswara, Rudraprayag, through community participation. A total of 42 participants from local communities took part in the drive. The initiative was coordinated by scientists from the Garhwal Regional Centre (GRC) in collaboration with community representatives from Bhiri–Banswara, Rudraprayag district, Uttarakhand. Vetiver grass was planted across a total area of 1,000 m^2. The project activities have been regularly monitored to assess progress and impact. Monitoring was carried out by the project team in collaboration with local community members.

Major outcome

1. Plantation of a 1000 m2 area with vetiver grass with the involvement of the community at degraded land in Bhiri-Banswara, Rudraprayag district.

SIKKIM REGIONAL CENTRE (SRC)

Sikkim state supports rich floral and faunal diversity varying in different eco-climatic ranges. There are high numbers of endemic and threatened species covering diverse ecosystems and habitats that represent the uniqueness of biodiversity. Local people are largely dependent 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 demands immediate measures to reverse the trend of degradation. Besides, it also needs strengthening, participatory management, enhancement of livelihood and self-sufficiency and policy review/analysis and capacity building. Considering the abovementioned priorities of the Sikkim state, Sikkim Regional Centre of the Institute has been working on environmental and socioeconomic issues of the Sikkim Himalaya and West Bengal Hills. Main action areas of Sikkim Regional Centre includes (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.

Multidimensional Assessment of Ecological Dynamics and Ecosystem Health of Selected High-Altitude Wetlands of Indian Himalayan Region (IHR) for Effective Conservation and Management planning (NMHS, 2024-2027)

High-Altitude Wetlands (HAWs) in the Indian Himalayan Region are ecologically significant ecosystems situated above 3000 meters, providing essential services such as water regulation, carbon sequestration, and biodiversity conservation. Despite their importance, these wetlands remain understudied and face increasing threats from climate change, unregulated tourism, and anthropogenic pressures. Although India has initiated conservation measures under policies like the Wetlands (Conservation and Management) Rules, 2017, key knowledge gaps persist regarding the ecological dynamics, carbon fluxes, and socio-economic dependencies linked to HAWs. The lack of integrated, long-term, and multidisciplinary studies on HAWs poses a major gap in current conservation strategies. Furthermore, growing anthropogenic pressures (e.g., unregulated tourism, road construction), climate variability, and land-use changes are threatening the ecological integrity of these fragile systems. This study addresses these gaps through a multidisciplinary approach, integrating enviornmental, ecological, hydrological, and socio-economic assessments and research. The projejct aims to provide scientific insights and practical frameworks for ecosystem health assessment to support evidence-based conservation and community-centered management of HAWs.

Objectives

1. To map and monitor the High-altitude wetlands (HAWs) using integrated remote sensing and field-based observations (spatio-temporal) on various water and sediment characteristics.

2. To understand the wetland community structure and dynamics using field and eDNA based approaches and functional traits of key biodiversity elements

3. To assess the Carbon dynamics, rate of well mixed greenhouse gas emissions and environmental parameters of high-altitude wetlands

4. To assess economical valuation and ecosystem health of high-altitude wetlands for sustainable management

5. To augment nature-based livelihood and strengthen local institution for conservation of wetland in Sikkim.

Achievements

- Integrated mapping and assessment of High-Altitude Wetlands (HAWs): satellite-based mapping and spatio-temporal analysis (including seasonal delineation, lakeboundary detection, water spread, and unsupervised classification) of Tso Moriri wetland in Ladakh, and Tsomgo, and Hanspokhari wetland in Sikkim was carried out to assess wetland dynamics over time. These analyses identified patterns of expansion and contraction influenced by climatic and anthropogenic drivers, forming a robust foundation for long-term ecological monitoring and conservation strategy development.

- Soil and sediment mineralogical characterization of HAWs: Post-monsoon analysis of soil and sediment samples from Bhekkal Tal, Hanspokhari, and Tsomgo revealed distinct biogeochemical signatures. Bhekkal Tal had moderately acidic soils with higher organic carbon (0.76–0.99%), while Hanspokhari showed elevated nitrogen and micronutrient content. Tsomgo exhibited the most acidic profile (pH 3.71–4.81) and high iron concentrations (Table 6). These findings underscore the ecological variability of HAWs and provide critical baseline data for monitoring soil health.

- Assessment of Floral Diversity and Species Richness Patterns: Floral diversity assessments across Tsomgo, HansPokhari, Tso Moriri, and Bhekkal Tal revealed significant variation in species richness.Tsomgo recorded the highest richness with 147 species, followed by Hans Pokhari (129), Bhekkal Tal (54), and Tso Moriri (47). Herbaceous plants were dominant across all sites, while tree species were absent at Tso Moriri due to its extreme altitude. Diversity indices confirmed that Tsomgo and Hans Pokhari support balanced and diverse ecosystems, while Tso Moriri showed signs of ecological stress with high species dominance and low evenness (Fig. 40).

Table 6. Soil and sediment characteristics of HAWs for post-monsoon season

HAWs	pH	EC	OC%	N (Kg/h)	P (Kg/h)	K (Kg/h)	Zn HCL (Mg/Kg)	Zn DTPA (mg/Kg)	Mn (mg/Kg)	B (mg/Kg)	Fe HCL (mg/Kg)	Fe DTPA (mg/Kg)	Cu HCL (mg/Kg)	Cu DTPA (mg/Kg)
Bhekal Tal	4.98-5.19	0.4-0.55	0.76-0.99	26.51-34.4	47.0-65.0	81.96-170.0	14.63-24.16	6.73-11.1	8.68-31.92	15.10-22.77	30.63-118.34	9.84-37.51	1.31-2.13	0.363-0.516
Hanspokahri	5.1-5.2	0.096-0.33	1.22-1.40	40.83-48.54	43.06-55.5	114.16-625.33	1.83-40.13	0.8-18.6	0.01-10.07	10.21-22.44	38.2-114.09	30.6-36.67	2.87-5.57	0.79-1.54
Tsomgo	3.71-4.81	3.71-4.81	0.99-1.23	34.25-41.54	6.9-67.23	126.73-151.16	0.93-4.53	0.36-2.03	0.01-5.95	12.07-22.10	69.45-114.71	22.32-36.87	0.403-1.91	0.106-0.526

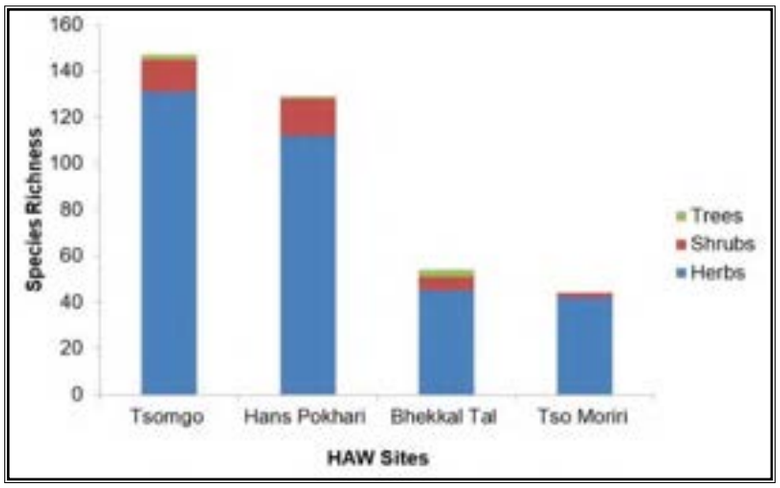


Fig. 40 Species richness of Tsomgo, Hanspokhari, Bhekkal Tal, and Tso Moriri.

Promoting natural resource base integrated livelihood approaches through Science Technology and Innovation Hub for enhancing livelihood and climate change adaptation of the Primitive tribe in Dzongu & Kabi blocks of North District, Sikkim (DST, 2024-2027)

This project aims to enhance the socio-economic well-being of tribal communities in North Sikkim through integrated livelihood approaches rooted in natural resources and traditional knowledge. Implemented in tribal-dominated areas, it emphasizes participatory planning, technology transfer, and skill building. Core interventions include propagation of disease-free large cardamom through nursery and tissue culture techniques, and value addition of Minor Forest Produce (MFP). The project also promotes ecotourism and establishes a Science, Technology, and Innovation (STI) Hub to support rural enterprises. The project focuses on diversifying rural livelihoods, empowers women and youth, and develops resilient value chains across tribal households in the region.

Objectives:

1. Identification, propagation and introduction of area-specific high yielding variety of large cardamom.

2. To augment natural resource base income opportunities, value addition, quality control and promoting local enterprise of selected underutilized crops and MFPs based products.

3. To develop and strengthen community-based integrated livelihood model for diversification and improvement in economic well-being.

4. To develop and strengthen micro & small enterprises cell for augmentation of proposed technologies and enhance skills of women and youth to perform as active economic agents.

Achievements:

- Developed yacon syrup using optimized temperature treatments, showcasing its potential as a low-glycemic natural sweetener. Yacon syrup overall performance was found excellent with treatment T1 (60°C for 60 minutes) was identified as the optimal treatment for yacon syrup, showing the highest ascorbic acid content (11.25 mg/100g), favorable pH (5.49), and relatively low moisture (6.0%) with acceptable TSS (72 °Brix). This treatment offers the best balance between nutritional quality, stability, and sweetness of yacon syrup. To minimize post-harvest losses of Dalley chilli *(Capsicum annuum)*, three drying methods were experimented: sun drying, solar kiln drying, and oven drying. Nutrient retention, moisture content, and antioxidant activity were evaluated. Among the treatments, sun drying and solar kiln drying showed excellent results in retaining nutrients and antioxidant properties while effectively reducing moisture content.

- Essential oil composition of *Amomum subulatum* (06 varieties) analyzed by GC-MS analysis revealed

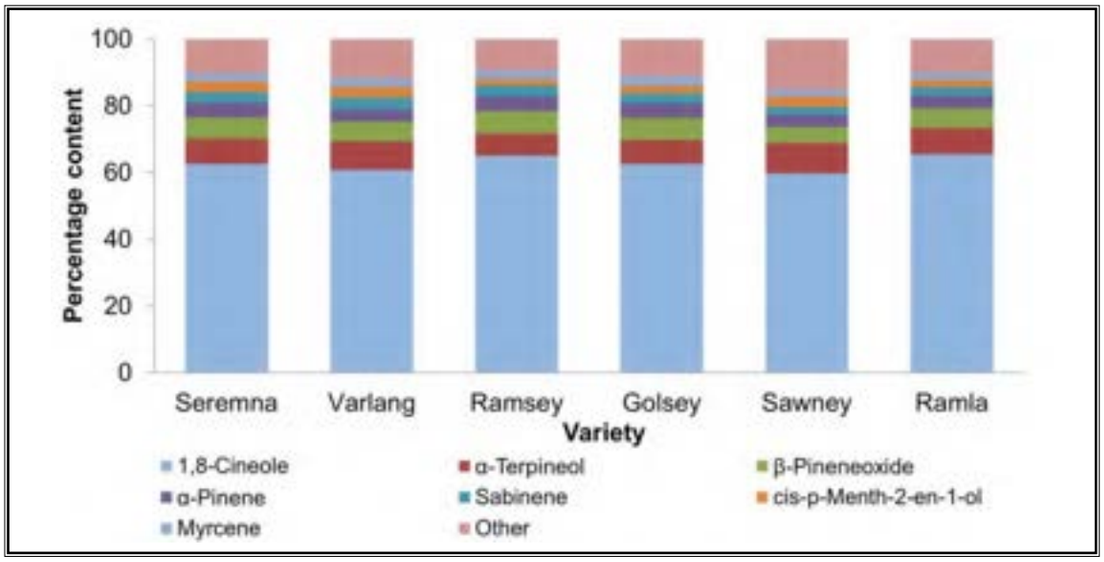


Fig. 41: Varietal difference in essential l large cardamom from Sikkim Himalaya

high variation among varieties. 1,8-Cineole was the major compound (59.66 to 65.23%) followed by α-terpineol, β-pineneoxide, α-pinene, sabinene, cis-p-menth-2-en-1-ol and myrcene. Ramsey and Ramla showed compositional similarity and Sawney was distinct from others (Fig. 41).

- Successfully produced a total of 2,000 seedlings through seed germination of six varieties of Amomum subulatum using various pre-sowing seed treatments. Additionally, germination protocols were developed for high-value cash crops of the Sikkim Himalaya, including Dalley chilli *(Capsicum annuum)* and *Dzongu orange*. For Dalley chilli, the highest germination percentage was observed with GA_3 (gibberellic acid) treatment, followed by HNO2, H2SO4, hot water, and control treatments. In the case of Dzongu orange, organic pre-sowing treatments using cow urine were applied, with the highest germination recorded at 25% concentration, followed by 50%, 75%, and control (Fig. 42).

- Skilled and trained over 160 farmers of the Lepcha tribal community through a series of capacity-building and exposure programs focused on Integrated Livelihood Models, rural technologies and innovations, homestay management for ecotourism enterprises, value addition of underutilized crops and minor forest products (MFPs), and large cardamom cultivation. These initiatives aimed to strengthen and diversify rural livelihoods and also to promote rural enterprises within the Lepcha community of Dzongu and Kabi blocks, North Sikkim.

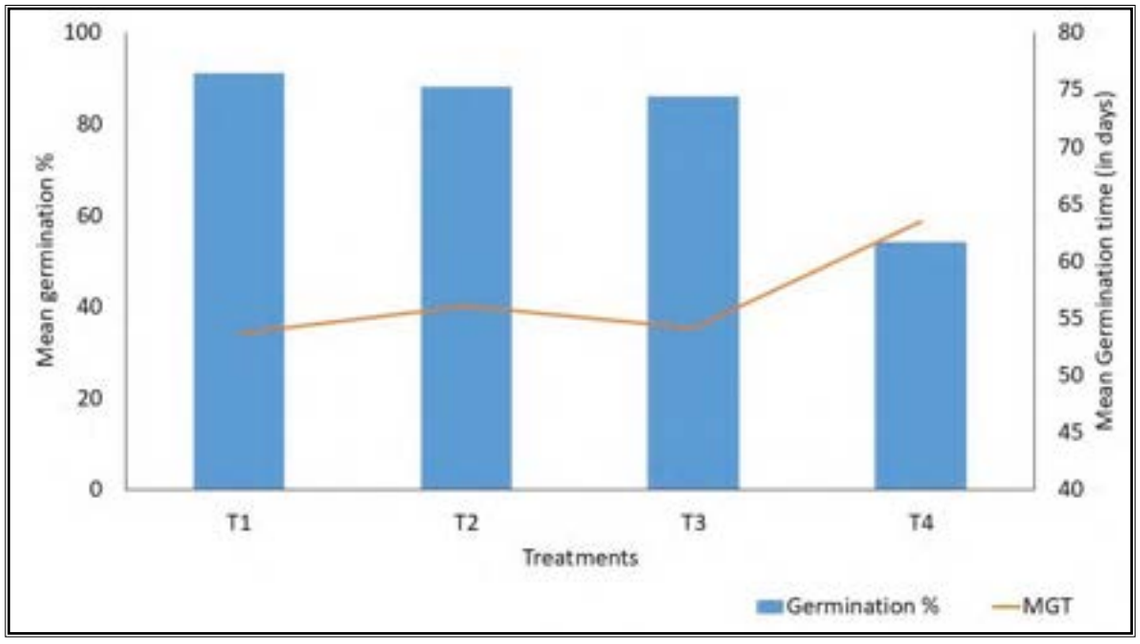


Fig. 42 Germination percentage and mean germination time of seeds of Dale chilli in different treatments of growth regulators and organic formulations.

Development of genomic resource and genetic diversity characterization to strategize sustainable cultivation and conservation of medicinally important *Hedychium spicatum* (DBT, 2023-2026)

In the adobe of rich habitats of Himalayan region, a unique biodiversity repository offers a variety of medicinal and aromatic plants to commercially used pharmaceuticals, cosmetic and nutraceutical industries. Most of the species are collected from wild habitats due to lack of quality material for cultivation. Therefore, the cultivation and conservation of these medicinal plants required application of modern tools. Modern high throughput sequence has significantly enhanced our ability to assess genomic variation for breeding efforts. These techniques are used to analyse entire genomes of non-reference

species, understand complex biological processes, characters and traits associated with quality, yield and productivity. Trait-specific functional markers developed through differentially expressed mRNAs are very informative and highly valued in molecular breeding. Also, genetic diversity studies in the global distribution range of species created information on their speciation, evaluation, and conservation.

Objectives

1. Survey and collection of natural populations of Hedychium spicatum across the geographical range in India for chemical fingerprinting and habitat prediction

2. Development of transcriptional genomic resources for elucidation of key biosynthesis pathways and genome-wide SSR markers.

3. Genetic diversity and population genetic structure assessment for identification of core populations/ elite cultivars for implantation of conservation and captive cultivation strategies.

Achievements

- Germplasm of 205 genotypes from 06 states (Uttarakhand, Himachal Pradesh, Sikkim, West Bengal, Meghalaya and Arunachal Pradesh) has been maintained in an experimental site (Herbal garden of SRC). For genetic diversity characterization, data recording at morphological and DNA level is under process.

- Essential oil of 32 genotypes was isolated and oil yield ranged between 0.42 to 1.12%. GC-MS analysis of essential oil revealed presence of 56 metabolites represented by a high compositional variation among genotypes. 1,8-cineole was found as dominant compound (27.78-81.26%) followed by linalool, β-eudesmol, α-elemol, cadin-4-en-10-ol, α-eudesmol, β-pinene and γ-eudesmol. Based on this composition 04 chemotypes were identified and chemotypes-01 represented by 1,8-cineole & linalool-rich genotypes, chemotypes-02 represented by α-eudesmol, carin-4-en-10-ol rich genotypes, chemotypes-03 represented by β-eudesmol & γ-eudesmol rich genotypes and chemotypes-04 represented by α-elemol & β-pinene rich genotypes (Fig. 43).

- Spatial transcriptome sequencing was carried out to obtain maximum genomic information of the species by sequencing RNA isolated from different plant parts (roots, rhizomes, stem and leaf) from 02 genotypes with contrasting traits. Data obtained from transcriptome sequencing provides an overview of biological, cellular, molecular functions and abundance of biosynthesis pathways. Annotations of transcripts with 05 different databases provide putative functions of 56.78% transcript by NCBI's nr, 43.84% transcript by TAIR, 40.46% transcript by Swiss-Prot and 31.58% transcript by KOG database. Due to the non-availability of genomic and transcriptomic resources in the species, a large number of transcripts (>35%) remained un-annotated.

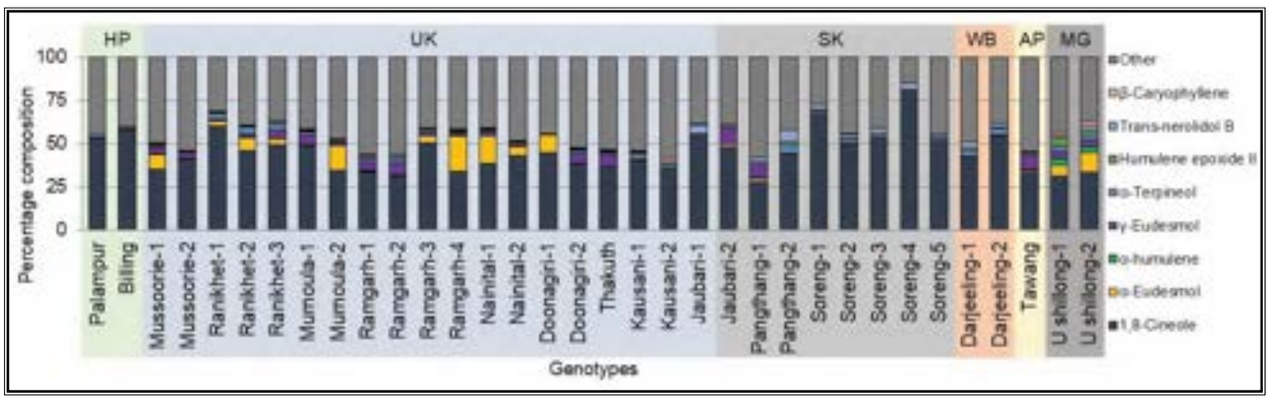


Fig. 43 Composition of essential oil isolated from different genotypes of *Hedychium spicatum* present in geographic location of Himalaya.

Development of agro-techniques for selected Ashtavarga plants (CCRAS, 2024-2027)

In the Sikkim, nestled in the eastern Himalaya biodiversity hotspot and rich cultural heritage, a diverse ecosystems support a plethora of medicinal value in traditional healthcare systems like Ayurveda, Tibetan medicine, and local tribal practices. In the traditional Indian System of Medicine, "Astavarga" plants are utilized in a variety of ways due to their therapeutic properties. NE Himalayan region is home of orchid diversity and Sikkim state harbors more than 625 species of Orchids and among these 04 species are described in Astavarga. There is an urgent need to enhancing our understanding of these medicinal plant populations, contributing to conservation priorities, develop rapid and robust propagation package for industrial need and providing a foundation for sustainable cultivation.

Objectives:

1. To assess the current status, distribution, chemical diversity of selected high-value medicinal orchid species in the Himalayan populations.

2. To develop mass scale micropropagation protocol through plant tissue culture technique for selected medicinal orchids.

3. Study the growth performance and quality parameters of tissue culture raised plants in the field.

4. To promote the cultivation of medicinal plants to the local farmer for sustainable agriculture practices.

Achievements:

- Literature survey revealed that in selected Ashtavrga orchid species, 19 articles have been published on *Habenara edgeworthii*, 15 in *H. intermedia*, 66 in *Crepidium acuminata* and 18 in *Malaxis mucifera*. Most of the studies are focused on ethno-medicinal surveys, species botany and distribution (22% each), and phytochemical characterization (17%), however very little information is available on pharmacological, propagation and genetic characterization. Overall, keyword analysis in orchid propagation indicated that mycorrhiza (206 nos.), symbiosis (201), fungi (141) and plant seeds (116) were dominating that indicating a strong emphasis on symbiotic plant-fungal relationships in the orchid propagation (Fig. 44).

- Based on primary (field visit) and secondary (literature and GBIF data) information, 14 populations of *Habenaria edgeworthii*, 17 populations of *Habenaria intermedia*, 42 populations of *Crepidium acuminatum*, and 16 population of *Malaxis muscifera* were identified from Himalaya. Population distribution indicated that the distribution of *Habenaria edgeworthii*, *Habenaria intermediais* and *Malaxis muscifera* is higher in Western Himalaya, and *Crepidium acuminatum* in Eastern Himalaya.

- Asymbiotic seed germination experiments initiated in Habenaria internedia and initial results indicated that protocorm development (60-75%)

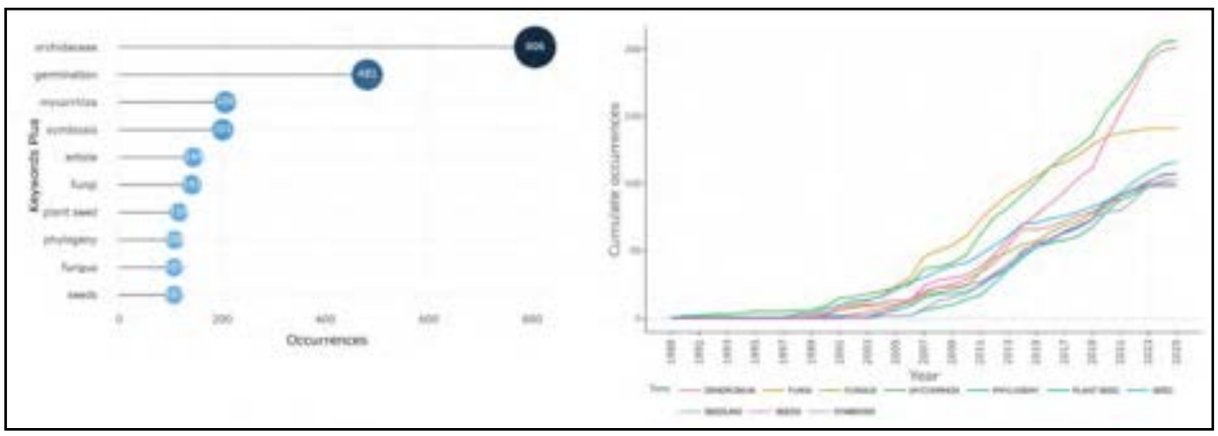


Fig. 44 Major keywords and year-wise trend of these major keywords in the area of Orchid propagation.

obtained in MS medium without supplementation of any hormone as compared to ½ MS and KC medium.

- Metabolite profiling using Orbitrap HRLC-MS/MS of different solvent extract revealed presence of 583 compounds in the rhizomes of Crepedium acuminata dominated by fatty acids, amides, phenolic compounds alkaloids, steroids, terpene esters, flavonoids and aromatic ketones.

Active Tectonic Assessment of the Dauki and Oldham Fault Zones in Shillong Plateau (India): Implications to the seismotectonics (DST, 2024-2027)

The Shillong plateau is bounded by the Himalayas to the north and the Bangladesh basin to the south. The plateau is bordered by major fault systems, notably the Dauki Fault to the south and the Oldham Fault to the north. Both of these faults played a pivotal role in its structural evolution. This region is identified as one of the most tectonically active regions in the Indian subcontinent. The region experienced an earthquake of Mw 8.1 in 1897. The region falls within Seismic Zone V of the Indian Seismic zonation map. The evolution of the present-day landscape of the Shillong Plateau has been significantly shaped by ongoing tectonic processes, including uplift, faulting, and erosion. Understanding the tectonic activity and its geomorphic expressions in the Shillong Plateau is essential for assessing the potential risks of future natural hazards. To address these issues, the following objectives have been formulated.

Objectives

1. To understand the kinematics and surface expression of Dauki Fault and Oldham Fault.
2. To assess the timing of reactivation of the Dauki and Brahmaputra, Oldham faults in the Indian part.
3. To update the seismo-tectonics of the region.

Achievements

- To assess tectonic activity, twenty-nine (29) basins of the Shillong Plateau were delineated based on drainage orientation, and various geomorphic indicators—such as river asymmetry, channel sinuosity, knickpoints, channel steepness, slope breaks, hypsometric integral, mountain front sinuosity, valley floor height-to-width ratio, basin elongation ratio, swath profiles, and the stream length-gradient (SL) index and analyzed them using a GIS platform. The results show that the eastern and southern parts of Shillong plateau have higher tectonic activities whereas the northern and western segments Shillong plateau

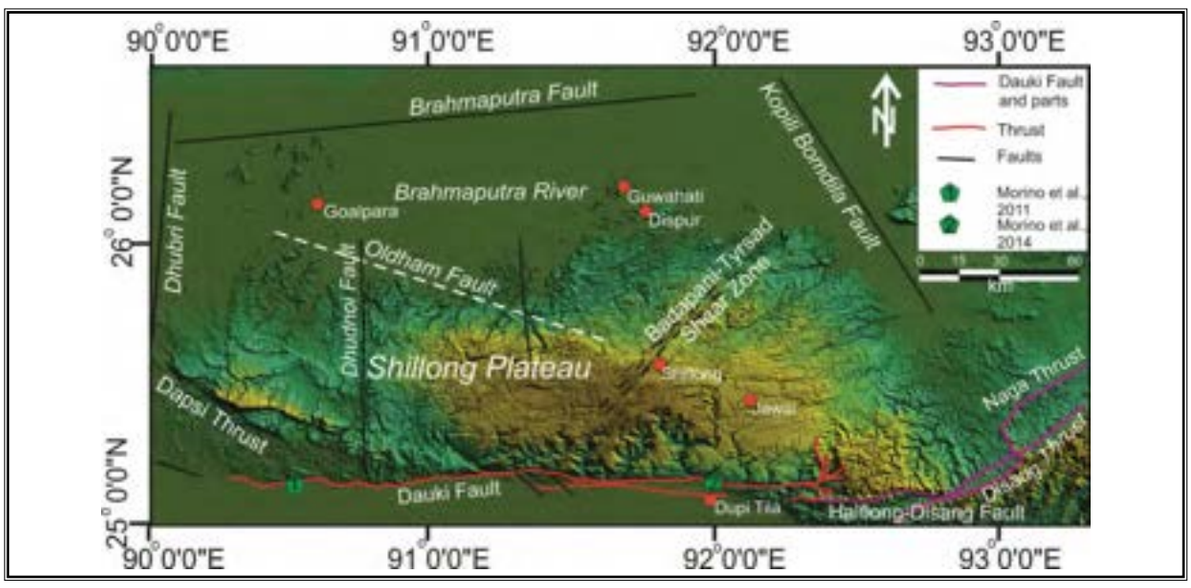


Fig. 45 SRTM image of Shillong Plateau shows various Faults present within the plateau.

show relatively less tectonic activities (Fig. 45 & 46).

- Presence of the several knickpoints, along the river courses indicate that intermittent lineaments and shear zone of the Shillong Plateau, pose significant influence on the drainage network of Shillong Plateau.
- The field study indicates that the Dauki Fault is an active fault, where the hard sedimentary rocks are thrusted on the recent fluvial sediments. The surface exposures of Oldham Fault could not be found in the study.

Fig. 46 Active segment of Dauki fault near the India-Bangladesh Border. Arrow indicates the direction of movement.

Summary of the Completed Project/ Activity

Development of hydroponic based soilless plant production system for commercial crops in Sikkim (NABARD, 2023-2025)

To feed the world's growing population, methods for sufficient food production is a challenge. Soilless cultivation might be a successful and alternative option for growing rapid and healthy plants. Hydroponic cultivation is gaining popularity due to its efficient resources management capabilities for quality food production. Various commercial crops including strawberries, leafy vegetables, tomatoes, cucumbers, peppers can be grown using hydroponics. Soil based agriculture is now facing various challenges such as urbanization, natural disaster, climate change, indiscriminate use of chemicals and pesticides which is depleting the land fertility. In Sikkim Himalaya, only 11% of the total area is available for agriculture and more than 60% of the total population depends on agriculture for their livelihood. Lack of irrigation facilities, land fragmentation, small land-holdings, soil erosion and runoff, higher investment cost, and climatic uncertainty are major challenges. Hydroponic system might be useful for many commercial leafy vegetable, fruits and medicinal plants. Keeping this in view, the project aimed, to optimization of nutrient and culture conditions for commercial hydroponic system for selected commercial crops of Sikkim, establishment of demonstration modules in different sites for targeted crop and performance of targeted crops in terms of biomass productivity and biochemical parameters, and demonstration and training of farmers for technology adaptation and cost-benefit analysis for determination of profitability of the innovation (Fig. 47).

Major Outcome

During the project 03 types of hydroponics models were developed and analyzed at SRC (including i. A-type nutrient film technique, ii. trench culture system, & iii. bag culture system) for method optimization, training and demonstration were developed. A-type Nutrient film technique performed best among the all the models in terms of yield and productivity of leafy green vegetables, tomato spinach and Swiss-chard. Also, 03 types of nutrients solutions (*i.e.*, i. commercial hydroponic nutrient, ii. Hoagland nutrient, & iii. Vermi-wash Nutrient solutions) were developed for minimizing in-put-cost and enhancing productivity. Commercial hydroponic nutrient performed well among these all and can be recommended in combination of vermi-wash nutrient solution for selected commercial crops. In organic conditions of Sikkim, Vermi-wash can be a viable option for hydroponic nutrient. Also, 03 types of substrates were developed for reducing in-put cost and increasing productivity (*i.e.*, i. coco-peat + pine needles, ii. pine needles + wooden shreds, & iii. coco-peat + perlite + vermiculite + clay balls. Among these, combination of coco-peat + perlite + vermiculite + clay balls has provided quality of produce in terms of yield and growth of spinach and Swiss-chard.

Fig. 47 In hydroponic model crops like, Brassica species (Rayi), Strawberry, Swiss Chard, Italian tomato, Cauliflower and Carrot were optimized.

NORTHEAST 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). Being part of the Himalayan and Indo-Burma global biodiversity hotspots, the NE region boasts of a rich diversity of flora and fauna, as well as rich socio-cultural diversity and traditional knowledge systems. However, this valuable natural heritage is facing growing challenges such as habitat degradation, deforestation, expanding human settlements, and developmental activities. These challenges present an important opportunity to develop and implement viable, replicable, and effective community-based resource management initiatives that both conserve biodiversity and promote sustainable use of natural resources. Since its inception, the NERC has been actively engaged in advancing scientific knowledge and conservation efforts through focused research in the following key 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) Appropriate low-cost technologies for improved livelihood in NE region, (v) Environmental assessment of developmental initiatives in NE region, (vi) Planning and development of rural life in North East India. The R&D activities of the Centre aim to fulfill the following objectives such as (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 perceptions; and (iv) environmental awareness building to local people of North-East India through training, demonstration and knowledge products.

Social Impact Assessment Studies (SIA) for Proposed Kamala Hydroelectric Project (1720 MW) in Arunachal Pradesh: Assessing Social and Environmental Consequences (GoAP, 2025)

Arunachal Pradesh, the largest state in Northeast India (83,743 km^2), has vast hydropower potential of over 27,000 MW. With a dense river network, the state is pivotal to India's renewable energy goals. The Government of Arunachal Pradesh, in partnership with public and private sectors, has signed multiple MoAs to expedite hydropower development. Among these is the Kamala Hydro Electric Project (1,720 MW), located near Tamen, spanning Kamle, KraDaadi, and portions of KurungKumey districts. Built on the Kamala River, a key tributary of Subansiri, the project aims at both power generation and flood moderation. It involves major infrastructure, including a 216m dam, tunnels, and underground powerhouses. Given the project's scale and its overlap with inhabited and ecologically sensitive areas, conducting a Social Impact Assessment (SIA) is essential for identifying and mitigating displacement risks, ensuring fair rehabilitation, and promoting inclusive development, making the project both environmentally and socially sustainable.

Objectives:

1. To conduct the Social Impact Assessment (SIA) studies for the proposed Kamala Hydroelectric Project (1720 MW) in three districts (Kamle, KraDaadi and KurungKumey) of Arunachal Pradesh.

Achievements

- Conducted stakeholder consultation meeting for initiation of Social Impact Assessment survey on February 2025 at Circle Office, Kamporijo, Kamle district. The meeting was attended by representatives from different villages and organizations including Gram Panchayat leaders, Gaon Burah/Buri, clan-based organization, community-based organizations, local citizens, as well as members of Kamla HEP Local Implementation Committee and officials from implementing agency NHPC.

- Field survey was conducted during February-March. Completed field and household survey in the all project affected villages of Kamle District, and 70 villages of Kra Daadi district. Data collected were demography of t affected villages, socio-economic profile, land use patterns, and people's perception on the proposed hydroelectric project.

Social Impact Assessment Studies for Proposed Kalai-II Hydroelectric Project (1200 MW) in Anjaw district of Arunachal Pradesh: Evaluating Socio-Economic and Environmental Implications (GoAP, 2025)

The proposed Kalai-II Hydroelectric Project (1200 MW) in Anjaw district of Arunachal Pradesh represents a significant step toward harnessing the hydropower potential of the region to meet growing energy demands. However, large-scale infrastructure projects such as this often lead to profound socio-economic and environmental changes, particularly in ecologically sensitive and culturally rich areas like Anjaw. Recognizing the need for a balanced development approach, a Social Impact Assessment (SIA) studies has been initiated to evaluate the potential impacts on local communities, land use, livelihoods, and natural resources. The SIA aims to ensure that the suggestions of affected populations are heard and incorporated into planning processes, with particular focus on displacement, livelihood disruption, and the preservation of tribal and indigenous rights. This study forms a critical foundation for preparing appropriate mitigation, resettlement, and rehabilitation strategies to ensure equitable and sustainable outcomes from the project's implementation.

Objectives:

1. To conduct the Social Impact Assessment (SIA) studies for the proposed Kalai-II HEP in Anjaw district of Arunachal Pradesh.

Achievements

- Conducted field visits and stakeholder consultations across 34 affected villages under the proposed Kalai-II Hydroelectric Project in Anjaw district. Consultations were held with all Gram Panchayat Chairpersons (GPCs), Project Affected Families (PAFs), and local administrative officials, including the Deputy Commissioner and Extra Assistant Commissioner. Primary data was systematically collected through structured survey tools and focus group discussions to capture village-specific socio-economic and cultural impacts.

- A comprehensive baseline survey was carried out between February and March 2025, focusing on land use, displacement risks, livelihood patterns, and access to common resources.

Social Impact Assessment Studies (SIA) for Proposed Naying Hydro Electric Project (1000 MW) in Arunachal Pradesh (GoAP, 2025).

Arunachal Pradesh, the largest state in Northeast India by geographical area (83,743 km^2), holds immense potential for hydropower development due to its rich river network. Recognizing this potential, the Government of India and the Government of Arunachal Pradesh have prioritized hydropower as a key area for meeting the country's growing energy demands. To harness over 27,000 MW of hydropower capacity, the state has signed multiple Memorandums of Agreement (MoAs) with various developers. The proposed Naying Hydro Electric Project (1000 MW), a run-of-river scheme on the Siyom River—a tributary of the Siang River—is planned across Shi Yomi and Siang districts. The dam site lies approximately 100 km upstream of Aalo town. With an expected generation of 3809.60 MU annually, the project is designed to utilize a gross head of 285 m over a 15 km stretch. This Social Impact Assessment (SIA) aims to evaluate the project's socio-economic implications on the local communities and stakeholders.

Objectives:

1. To conduct the Social Impact Assessment (SIA) studies for proposed Naying Hydro Electric Project (1000 MW) in two districts (Shi Yomi and Siang) of Arunachal Pradesh

Achievements

- The Social Impact Assessment (SIA) survey for the proposed 1000 MW Naying Hydroelectric Project was successfully conducted across 11 project-affected villages in Shi Yomi and Siang districts of Arunachal Pradesh. The survey captured critical socio-economic data from approximately 420 households, providing a comprehensive understanding of the demographic, livelihood, cultural, and infrastructural dynamics of the affected population (Fig. 48).
- Prior to the field survey, consultations were held with the Deputy Commissioner of Shi Yomi, the Circle Officer of Kaying, and the Director of NEEPCO to ensure administrative and logistical support. Consultation meetings were organized with the Gram Panchayat Members (GPMs), Gram Panchayat Chairpersons (GPCs), and GaonBurahs (GBs) of the affected villages to helped build community trust, ensured transparency, and facilitated smooth implementation of the SIA survey. The participatory approach adopted throughout the process ensured inclusive representation of community voices and laid the foundation for an objective and credible impact assessment.

Fig. 48 Stakeholder's consultation meeting and questionnaire survey Naying HEP affected villages.

Him-Nature Learning Centre (Him-NLC), Arunachal Pradesh (NMHS, 2023-2026)

Arunachal Pradesh is one of the seven sister states of north-east region of India located at the foothills of Eastern Himalayas, which is rich in floral and faunal diversity. However, lack of awareness on biodiversity results in management and therefore it is imperative to educate and create awareness among diverse stakeholders towards nature conservation. There have been few scanty initiatives taken by various departments towards creating awareness and sensitizing people on nature conservation; these are often isolated efforts and thus need concentrated and focused efforts through a dedicated Nature Learning Centre (NLC). Keeping in view, a NLC is being proposed to establish in Biological Park adjacent toItanagar Wildlife Sanctuary (IWS) of Itanagar town. The project mainly focuses on development of conservation sites, documentation of diversity, including the development of knowledge products for dissemination and awareness, capacity building programme for different stakeholders and the promotion of citizen science approach for conservation education.

Objectives:

1. To develop a learning and interpretation centre for the conservation of biodiversity through various interactive models.
2. To create and demonstrate the best practices for sustainable models, such as solid-waste management, water harvesting, composting, early warning disaster monitoring systems, hydroponic, and forest management practices.
3. To develop the curricula for nature-based learning for school students.
4. To encourage active conservation participation and efficient utilization and conservation management of bio-resources.
5. To promote eco-tourism for conservation of natural resources and sustainable livelihood generation, and
6. To build capacity of various stakeholders to conserve the natural resource and develop the knowledge products for dissemination and raising awareness.

Achievements

- Conducted field survey for documentation of the

Fig. 49 Awareness Programme on Nature Conservation at Biological Park, Itanagar.

faunal diversity of Itanagar Wildlife Sanctuary (IWS). So far, 31 birds, 11 reptiles, 43 butterflies and 16 amphibian species have been documented in IWS. Strengthened germplasm of 74 orchid species, which include 41 genera, in RTC of NERC for knowledge dissemination and showcasing to relevant stakeholders. Additionally, more than two hundred herbarium specimens of plant species have been prepared.

- Conducted a 2 days Nature Camp and Biodiversity Conservation awareness programme (6 Nos.) at Biological Park, Itanagar, in which approx. 650 students from different schools/ colleges/ university were participated (Fig. 49).

- Reported two orchids species new to science; (i) *Phalaenopsis quadridentata* (Fig. 50); and documented one new record of orchid *(Cheirostylis tortilacinia)* for the flora of the country and 5 plant species for the flora of Arunchal Pradesh.

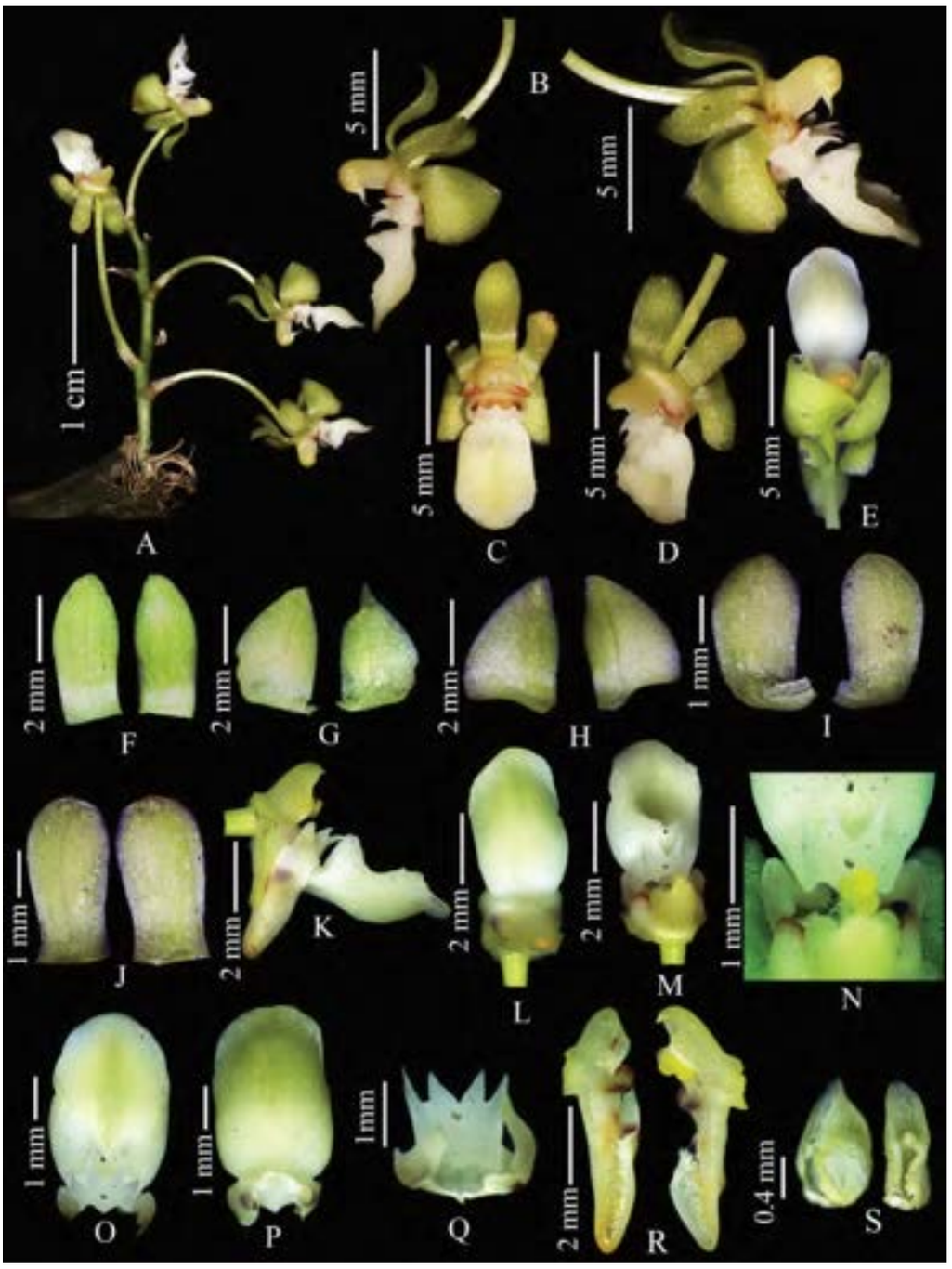


Fig. 50 *Phalaenopsis quadridentata* (Orchidaceae), a new epiphytic species from Arunachal Pradesh, India

SBIF CONSERW: Landscape Ecology and Genetics of Tigers in Northeast India (SBI Foundation, 2024-2027)

The project aims to enhance the conservation and management of tiger populations in North-East India. The project focuses on using extensive non-invasive genetic, field-sampling, and remote sensing data to estimate genetic diversity, genetic differentiation, population size, structure, and gene flow among tiger populations. It also seeks to assess demographic history, habitat quality, and connectivity of tiger conservation landscapes. The ultimate goal is to develop metapopulation conservation frameworks, identify functional corridors and bottlenecks, explore potential range expansions, and identify human-tiger conflict hotspots. This comprehensive approach is intended to inform effective conservation strategies, ensuring the long-term sustainability of tigers and their habitats in North-East India. This project adopts a non-invasive genetic approach coupled with advanced remote sensing methods to study four Tiger Conservation Landscapes (TCLs) that occur across North Bengal region, Assam, Arunachal Pradesh, and Mizoram. This research will provide the necessary regional scale analyses and perspective, and highlight the importance of tropical moist forest ecosystems and other unique habitats for understanding the ecology of tigers in the north-eastern region of India.

Objectives

1. To estimate genetic diversity, genetic differentiation, minimum population size, population structure, and gene flow and to identify migrants across various tiger populations among all the known tiger populations and habitats in north-eastern India.

2. To assess the demographic history of tigers in North-Eastern India.

3. To carry out landscape ecological analyses of the distinct north-eastern tiger conservation landscapes (TCLs) to assess tiger habitat quality, distributions, and geophysical and genetic habitat connectivity.

4. To propose metapopulation conservation frameworks for the existing TCLs, identify functional corridors and identify bottlenecks within tiger dispersal corridors for current tiger habitats, and examine possible range expansion and dispersal pathways if tiger abundance within protected habitats attains or exceeds carrying capacity.

5. To identify human-tiger conflict incidence hot-spots for the existing TCLs of North-Eastern India.

Achievements

- 535 scat samples were collected from 7 Protected Areas (PAs) & Tiger Reserves (TR) of North Bengal

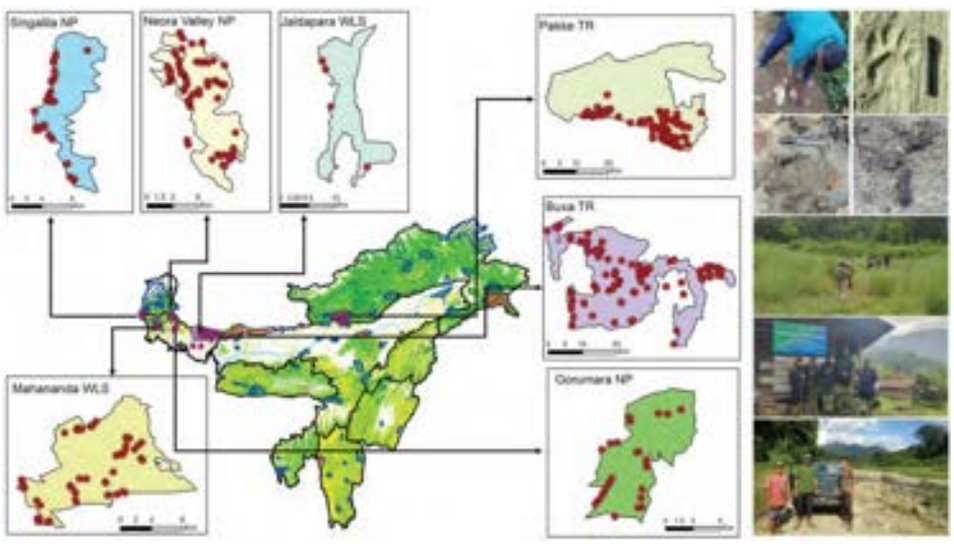


Fig. 51 Scat sampling efforts and their spatial distribution from 7 Protected Areas & Tiger Reserves of North Bengal and Arunachal Pradesh.

region and Arunachal Pradesh (Fig. 51).

- 253 school students were made aware about Biodiversity Conservation in 4 schools of North Bengal and Arunachal Pradesh.

- 18 Environmental layers were generated as predictor variables for modeling Human-Wildlife Conflict in the North East Indian region, 510 conflict points of Human Elephant Conflict were collected for Human Wildlife Conflict Hotspots analysis in Brahmaputra Flood Plain region of North East Indian region.

Assessing Health of the High-Altitude Lake (HAL) Tenbawa and Ecosystem Sustainability in Response to Changing Climate in the Lachung Valley, Sikkim Himalaya (NMHS, 2024 – 2027)

Mountain regions like the Indian Himalayan Region (IHR) are highly sensitive to climate change, with rapid glacier retreat rate, glacial lake expansion, and increased risk of Glacial Lake Outburst Floods (GLOFs). The High-Altitude Lakes (HALs) above 3000 m, especially in Sikkim, are critical ecosystems that serve as climate indicators and support unique biodiversity, endemic species, and local communities like the Drokpa or Lachungpa. Climate-induced changes such as lake water composition shifts, habitat loss, and landscape alteration, combined with anthropogenic pressures, threaten both upstream and downstream ecosystems and societies. While interventions like artificial drainage and Early Warning Systems (EWS) have been implemented elsewhere, a focused monitoring and ecological assessment of HALs like Tenbawa Lake in Sikkim is lacking. This project proposes integrated monitoring of lake volume, ecosystem health, and surrounding landscape dynamics to mitigate climate risks. It aligns with SDG 13 and India's LIFE initiative for sustainable climate resilience.

Objectives

1. Identify knowledge gaps in conserving High-Altitude Lake (HAL).

2. Quantify the role of HAL in biological assemblage.

3. Assess the risk and vulnerability of High-Altitude Lake ecosystems related to climate change.

4. Assessing ecosystem services offered by the high-altitude lakes in the Lachung Valley of the Sikkim Himalaya.

Achievements

- The preliminary finding involved a comprehensive literature review and bibliometric analysis to examine research trends, themes, and knowledge gaps related to high-altitude wetlands and its surrounding biodiversity in the Himalayan region. VOSviewer (v1.6.20) was used for bibliometric visualization, extracting 431 keywords from titles and abstracts, of which 145 met the threshold (≥5 occurrences), and 100 were selected for visualization. Using co-occurrence analysis with the association strength normalization method, keyword relationships were mapped—circle size represented keyword frequency, and proximity reflected thematic similarity. Post-processing removed irrelevant or isolated terms to refine clarity.

- The analysis revealed three major research clusters: the first (red) focused on climate-related impacts, including keywords like "climate change" and "phenology"; the second (green) on human influences, with terms such as "tourism" and "livelihood"; and the third (blue) on ecological studies, with emphasis on "conservation," "water quality," and "phytoplankton." Trend analysis from 2012 to 2024 showed a shift from climate change and conservation toward increasing concern over anthropogenic pressures, especially tourism and human activity. The research also highlights growing awareness of the socio-environmental dynamics affecting high-altitude wetlands and underscores the urgent need for integrated conservation and sustainable development strategies to safeguards the Himalayan high altitude lake biodiversity.

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, climatic and anthropogenic perturbations, MoEF&CC has established a dedicated unit as "Mountain Division" as 5th Unit of GBP NIHE within 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 sustainable development of mountain ecosystems in 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 thru Himalayan Research Fellows and Associates.

Climate-induced disasters and Policy Issues in the Indian Himalayan Region (IHR) (Mountain Division, 2024-2027)

The Himalayan ecosystem is one of the most fragile and diverse geographical entities vital for India. However, it faces vulnerability due to climate change threats, particularly in high-altitude remote locations. Risk associated with disaster events could be accentuated by natural and human-induced climate variability, compromising the local environment, ecosystem, health, and socio-economic conditions. The IHR is experiencing temperature and monsoon rainfall variability, leading to increased hydro-meteorological and climatological disaster events. This impacts both biophysical and socio-economic systems. Climate shocks increase uncertainty and risks to Himalayan community livelihoods. It is imperative to identify the potential impacts of climate extremes that may trigger or exacerbate the frequency and intensity of natural disasters in the Indian Himalayan Region (IHR). Developing sustainable and context-specific adaptation strategies is essential for enhancing the long-term adaptive capacity of Himalayan communities. This necessitates a comprehensive investigation of climate-induced natural hazards using both quantitative and qualitative approaches. Such integrated assessments will inform the formulation of a mountain-centric policy framework aimed at fostering risk-informed and resilient development pathways in the region.

Objectives:

1. Assessing the prevalence of climate related disasters in the IHR.
2. Categorization of disaster-prone areas as well as the regions specific to multi-hazard activity.
3. Developing an area-specific probabilistic disaster risk assessment and reduction policy with the help of risk assessment models.

Achievements:

- The study used secondary data derived from historical records published by the India meteorological Department (IMD) in the Disastrous Weather Events series, supplemented by peer-reviewed literature, scientific journals, and other sources on extreme climate events. The dataset covers the Indian Himalayan Region (IHR), including UTs & states such as Ladakh, Jammu & Kashmir, Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya, Assam Hills and Darjeeling Hills. In total, 1,777 extreme climate events (ECEs) were recorded between 1980 and 2019, resulting in 9,503 fatalities, with an average mortality rate of 5.35 deaths per event.

- State-level analysis reveals that Jammu & Kashmir, Himachal Pradesh, and Uttarakhand are among the most severely impacted regions, predominantly affected by floods, heavy snowfall, and cold waves. The eastern Himalayan states, particularly Assam and the hill districts of West Bengal, are notably vulnerable to thunderstorms and lightning, which contribute significantly to climate-related fatalities.

- District-level assessments highlight spatial heterogeneity in disaster impacts. In Jammu & Kashmir, districts such as Jammu, Anantnag, and Srinagar exhibit high exposure to floods and flash floods. Similarly, Shimla, Kangra, and Kullu in Himachal Pradesh are frequently affected by heavy rainfall and related hazards. In Uttarakhand, catastrophic flood events in Chamoli and Pithoragarh have led to substantial loss of life.

- Additionally, between 1970 and 2023, a total of 252 cloudburst events were documented in the IHR, with the highest occurrences in Uttarakhand (98 events) and Himachal Pradesh (81 events). These events predominantly occurred within the 1,000–2,500 meters elevation band, indicating a topographic influence on their spatial distribution.

Community based Flood Hazard Management and Vulnerability Assessment in the Upper Beas Basin, Kullu Valley, and Himachal Pradesh: A Policy Pathway for Disaster Risk Reduction (Mountain Division, 2024-2027)

The state of Himachal Pradesh, which forms a part of north-western Himalaya, is vulnerable to some 25 types of disasters/hazards such as flash floods, landslides, cloud burst etc. with varying intensity. It is caused by the extensive surface runoff on small spatial scales for short durations. Landslides, land use degradation, deforestation, growing population and economic development are also the accelerating agents in the vulnerability of hazards. However, devastating nature of the flash floods can be reduced by adopting management strategies. In mountainous terrain, it can be managed by analyzing slope dynamics, topography, climate, geomorphology, drainage characteristics and anthropogenic activities. This study has the main objective to estimate the flash flood risk levels and vulnerability of sub-watersheds within the catchment area by combining morphometric analysis with watershed geomorphologic characteristics such as stream network and relief of the watershed. These important characteristics were analyzed by integrated use of RS/GIS technology for a better understanding of hydrological processes and flooding.

Objectives:

1. To assess the flood hazard and their impacts in upper Beas basin

2. To Map the Flood Hazard Zonation in upper Beas Basin

3. To assess the Vulnerability of Floods in upper Beas basin

4. To investigate the community based approached for flood hazard management in high altitude area

5. To identify and develop the suitable flood mitigation measure options for the study area

Achievements:

- Disaster inventory of previous flood events has been prepared from the year 1995- 2020 and 2023. The accuracy of the inventory data has been validated with DDMA data source. Various thematic maps for the preparation of Flood Hazard Susceptibility Model have been prepared which includes Morphological Criteria (Elevation, Slope, Profile Curvature, and Distance from stream), Landscape Dynamics (LULC, NDVI, and Distance from road), Hydrological Criteria (Drainage Density, Annual Precipitation).

- Flood hazard and their impacts in upper Beas basin have been investigated by extensive field survey in the flood affected villages of Beas and Parvati valley. Flood Vulnerability of the village community has been assessed based on questionnaire survey at the household level (n=300). The survey collected data on Susceptibility (total family members, male-female ratio, dependency ratio, literacy), Exposure

(Proximity to the river, flood experience, property loss), Resilience (Flood risk awareness, Income source), and Mitigation (Structural improvements, role of Local authority, financial aid).

- 5 capacity building cum training programs have been organized at village level at GBP Mohal, Govt. Degree College Sainj, Gram Panchayat Palchan, and Hallan-2 in collaboration with the Panchayats, Forest Dept., JICA, NGOs etc. The total number of participation in each meetings was around 40-60 nos.

- Aspect map has been created from the Digital Elevation model of upper Beas basin on the QGIS platform. Aspect map visually represents the direction (or compass point) of a slope within a given area. Normalized Difference Vegetation Index (NDVI) is used to quantify vegetation greenness and is useful in understanding vegetation density and assessing changes in plant health. NDVI range from -1 to +1. Values closer to 1 indicate healthy, dense vegetation, while values closer to -1 indicate non-vegetated areas like water or bare soil. For the study area, Upper Beas Basin the NDVI value ranges between -0.04 to 0.43 (Fig. 52).

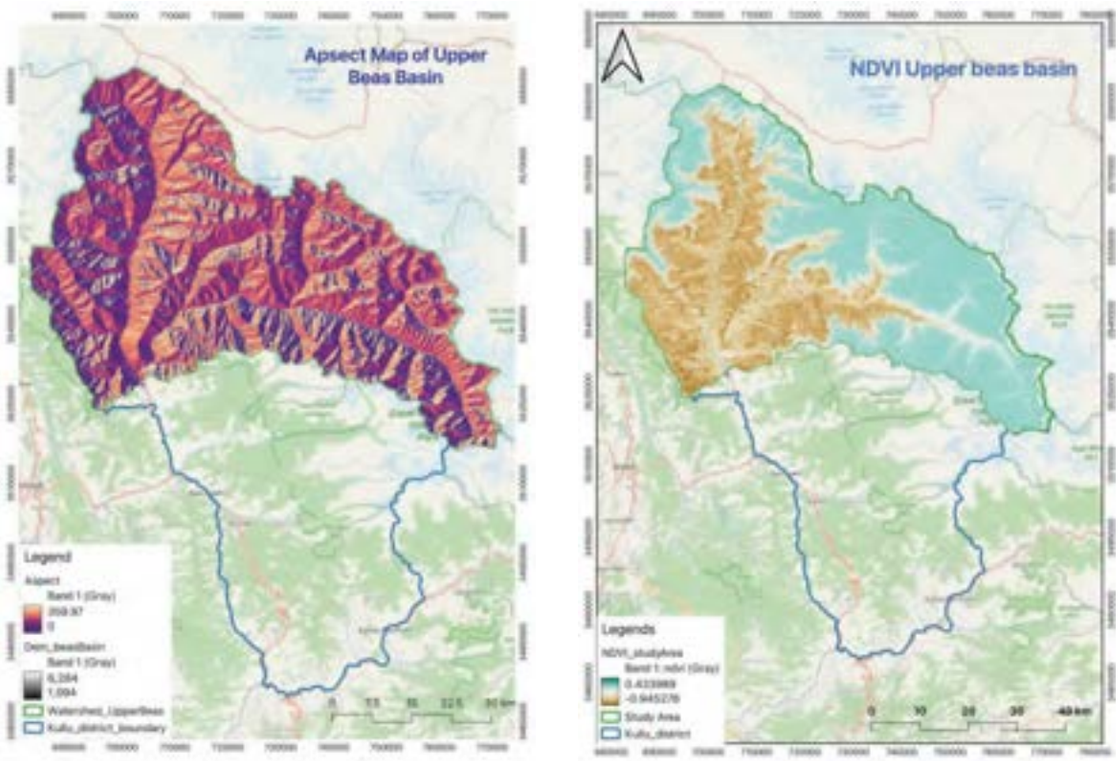


Fig. 52 Aspect and NDVI map of study area

Assessing the sustainable tourism potential in Garhwal Himalaya Uttarakhand (Mountain Division; 2023-26)

Tourism is the fastest-growing civil industry globally, with a 10–15 percent annual growth rate and a four trillion-dollar yearly outlay. In India, tourism has shown strong growth, with international tourist arrivals reaching 4.45 million and foreign exchange earnings increasing by an average of 16% every five years. In Uttarakhand, tourism significantly contributes to the economy, driven by the Himalayan landscape, pilgrimage sites like Badrinath, Kedarnath, Gangotri, and Yamunotri, and hill stations such as Nainital, Mussoorie, and Ranikhet. According to the state's draft tourism policy, 44 percent of tourists visit for religious reasons and 43 percent for sightseeing. Adventure tourism—such as trekking, rafting, mountaineering, etc.—is also emerging as a revenue source.

Objectives:

1. To study the status of tourism and its contribution to the economy in Garhwal Himalaya,

2. To assess the impacts of tourism on ecology/ environment, carrying capacity and natural resources of the area, and

3. To create awareness on tourism potential for sustainable management.

Achievements:

- As per the data received from tourism authorities, the arrival of tourists in Badrinath and Kedarnath is showing an increasing trend. In Badrinath, a total of 1,49,890 arrived in 2014 and increased to 18,33,930 in 2023. Whereas in Kedarnath, a total of 3,99,542 arrived in 2010 and increased to 18,34,429 in 2023. (Fig. 53 & 54).

- The plant diversity in Badrinath was analyzed across three altitudinal zones, namely lower (3100-3300 m, Badrinath), middle (3301-3500 m, Mana), and higher (3501–3800 m, Vasudhara) in two different categories (disturbed and undisturbed). The highest tree diversity was recorded in the lower elevation of undisturbed areas (850 ind/ha, dominated by Pinus roxburghii) and the lowest in the middle altitude (50 ind/ha, Bombax ceiba). Similarly, the highest shrub diversity was recorded in the Middle elevation of disturbed areas (387.5 ind/ha, Rosa sericea) and the lowest in the middle elevation of the undisturbed area (75 ind/ha, Rosa sericea).

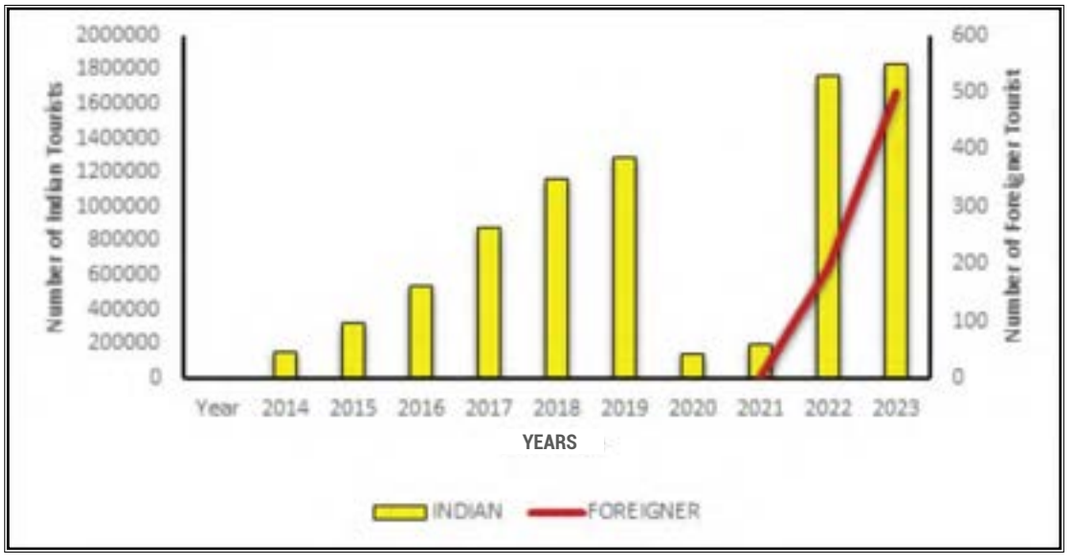


Fig. 53 Total number of tourists recorded in Badrinath from 2014 to 2023

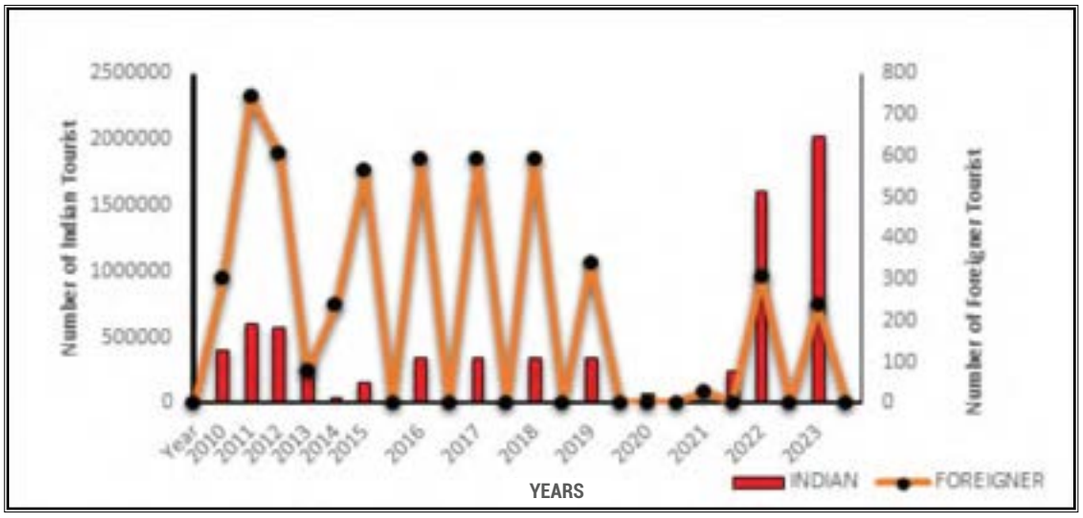


Fig. 54 Total number of tourists recorded in Kedarnath from 2010 to 2023

Summary of the Completed Project/ Activity

Biodiversity Policy Landscape in Indian Himalayan Region (IHR) for Conservation, Sustainable utilization and Community Livelihoods (Mountain Division, 2022-2025)

The Indian Himalayan region comprising 11 mountain states is a global biodiversity hotspot characterized by rich ecological diversity, endemism and cultural heritage. Despite numerous national and international commitments, biodiversity in this region faces growing threats from climate change, unplanned development, habitat loss, and policy fragmentation. Recognizing this, the project was initiated to systematically streamline the analytical review of biodiversity policy landscape in which intervention strategies for sustainable community livelihoods could be well synced with biodiversity conservation and its mainstreaming also to evaluate data on Protected Area Network across IHR States. The primary objective of the project was to analyze the existing national and state- level legislative framework and policies in IHR that supports biodiversity conservation, and to documented two success stories of ecological restoration by individuals. The aim was to further identify gaps, overlaps and opportunities for strengthening biodiversity governance through a literature review. The project focused all IHR states: Jammu and Kahmir, Ladakh, Himanchal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura and Meghalaya. In order to achieve the respected objectives of the project adopted a mixed method approach, primarily focused on secondary data analysis through a structured literature review following PRISMA (Preferred Reporting Items for systematic review and Meta analysis) method. Collection and screening of over 500 documents from government portals, academic databases were done. Extensive review on National laws such as Forests and Biodiversity acts were focused, analysis of state- specific biodiversity strategies, action plans, and policy documents were focused sources included the Ministry of Environment, Forest and Climate change (MoEFCC), National Biodiversity Authority, State Biodiversity Boards (SBBs), India Code, and peer- reviewed journals. All the database on National and State acts and policies related to biodiversity conservation were documented and analyzed in order to strengthen the policies further identification of policy gaps was carried out. Further Success stories were identified and identified success stories were documented in order to provide options for livelihood diversification and can develop potential among local people to conserve forests and uplift their economic growth and developing enterprises, documentation of suitable stories was done through survey and meetings with the respective person. The outcome of project was delivered in three phases in order to cover whole IHR, firstly Uttarakhand and Himanchal Pradesh region was focused secondly Jammu and Ladakh region then North East Himalayan regions were focused. A consolidated database of national and IHR state level biodiversity laws and policies are available. Policy gaps were identified, also project has highlighted some good practices and policies from specific states (such as Sikkim's Organic farming policy) that could be replicated in other states. Data on PAs in Each IHR State area coverage is available. Success stories documentation for successful livelihood models have been done which will be further beneficial in bringing out analysis between sustainable biodiversity use and community development. The project highlighted the importance of policy approach in IHR to address biodiversity challenges effectively. The documentation of success stories emphasized that policy impact is led by support of community led practices, also highlighted local ecological knowledge and impact on local biodiversity. The literature review provides a foundation for future interventions and policy governance for strengthening biodiversity through better frameworks.

Major Outcomes

- Comprehensive review of legal and policy Framework was done (Database on national and state level polices on biodiversity. (13 Major global conventions, 20 national acts and policies, 13 Institute missions)
- Assessment of Protected Area Network (PAN) (Database on Protected Area network (National Parks, Wildlife sanctuaries, Biosphere reserves and community reserves) of IHR region are available.
- 95 Geographical indicators products across IHR documented.

- Identification of Key gaps and issues.
- Documentation of Grassroots Success stories from IHR regions. (4 stories documented).
- Contribution to policy feedback and knowledge base.

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

Tourism has steadily increased worldwide, raising the need to manage carrying capacity to avoid environmental and socio-economic strain. Ladakh, India's northernmost union territory, known for its dramatic landscapes and cultural heritage, has mirrored this trend since opening to tourists in 1974. While the tourism boom has contributed to economic growth and infrastructure—especially in accommodations—it has also raised concerns about sustainability, particularly in Leh town, the region's capital. This study evaluates the tourism carrying capacity of Leh by assessing 12 key tourist sites using surveys and official data. Three types of capacities were calculated: physical carrying capacity (PCC), real carrying capacity (RCC), and effective carrying capacity (ECC). Findings show a daily PCC of 91,717 visitors, while RCC—factoring in environmental and infrastructure constraints—is just 5,052 visitors/day. The ECC, which includes management capabilities, stands at 4,331 visitors/day. June 2022 tourist inflow peaked at 4,238/day, approaching ECC limits. Although currently within capacity, these numbers stress the need for proactive management to control visitor numbers, reduce ecological pressures, and promote a more sustainable and enriching tourism experience in Leh.

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- June 2022 tourist inflow peaked at 4,238/day, approaching ECC limits (Fig. 55). Although currently within capacity, these numbers stress the need for proactive management to control visitor numbers, reduce ecological pressures, and promote a more sustainable and enriching tourism experience in Leh.
- Estimation of Ecological Carrying Capacities Index (ECCI) values were calculated using the ECC per year and population data for Leh town, as shown in Table 10. Based on the ECCI value of 2.85, Leh town currently has the sustainable capacity to support its population. However, in the past decade, there has been a sharp increase in infrastructure such as hotels, restaurants, settlements, and administrative facilities, which has led to the reduction of natural enclaves and an increase in ecological footprints. It is crucial to consider strategies to maintain this sustainability in the near future.
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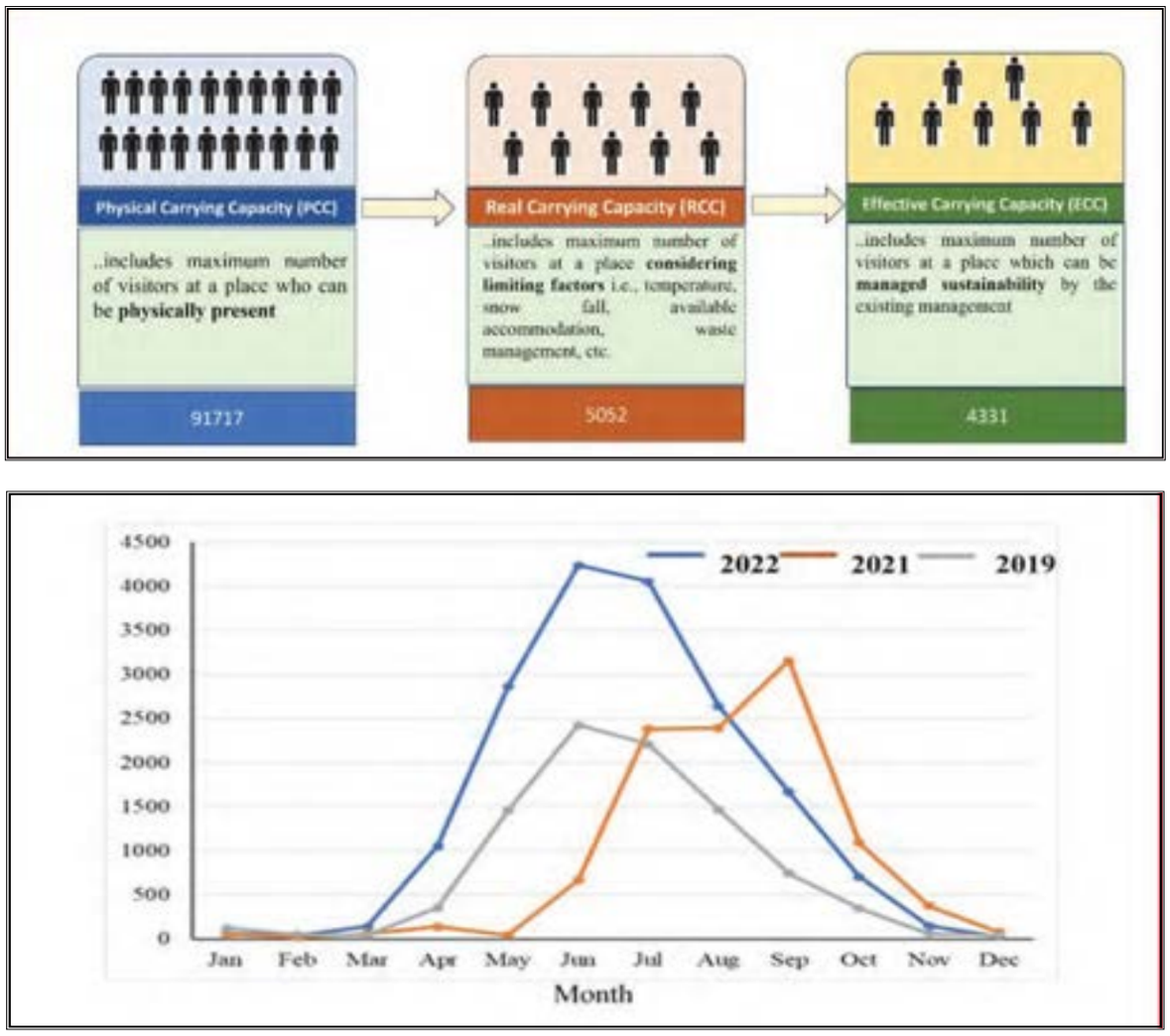

Fig. 55 Tourist flow month wise in the year 2019, 2021 and 2022 in Leh town of Ladakh

Assessment of Managed Spring Recharge as a Sustainable Solution to Water Scarcity in Sikkim Himalaya: Adaptation to Climate change (Mountain Division, 2021-2025)

Springs forms a backbone of water supply in Himalaya where more than 40 million people are supported by approximately 5 million springs for their domestic water demand. Over past few decades, these natural springs are drying up due to several reasons. Realizing the importance springs play in water security and their declining status, NITI Aayog in 2018 prepared a roadmap for revival of Himalayan springs. In recent decades, several initiatives have been made for revival of drying springs in the Himalaya. However, their benefits in terms of ecosystem services are rarely evaluated and thus their effectiveness is seldom quantified in holistic manner. For sustainable and effective planning of spring recharge, it is essential to evaluate efficacy of recharge activities. Realizing this gap, this project was initiated to assess the effectiveness of Managed Aquifer Recharge (MAR) interventions as a sustainable approach to address water scarcity in the Sikkim Himalaya region- critically dependent on natural springs. The main objectives of the study were to (i) document good practices of water conservation adopted by communities as climate adaptation strategies, (ii) Assessment

of water demand-supply balance and water governance in selected spring-shed villages, (iii) Evaluation of the effectiveness and cost-benefit of managed spring recharge interventions. The study was conducted in three water-stressed villages Alley, Bul, and Punjitar in Namchi District of Sikkim which are primarily dependent on two springs Chipchey Dhara and Gaddi Khola. These springs were augmented during 2019-2020 through MAR interventions by the Rural Development Department of Sikkim under Dhara Vikas Programme. A mixed-methods approach was applied in the study, which included household surveys to collect information on good practices of soil and water conservation, perception on climate change and its impact on springs, recharge activities, domestic water consumption, and water governance. Further, seasonal monitoring of spring discharge and water quality, ecological environmental parameters (vegetation enumeration, soil organic carbon and soil macro nutrient estimation) were carried out, and an econometric method was applied for cost-benefit analysis (CBA).

Major Outcomes

- Sixteen indigenous climate adaptive practices of soil and water conservation (both traditional and modern) practiced by communities in Sikkim were documented as structural (e.g., terraces, contour bunds), biological (e.g., vegetative barriers, agroforestry), and fertility management (e.g., farmyard manure) and their effectives, replicability and scalability was evaluated. Terraces, vegetative barriers, and crop rotation were found to be highly effective and widely replicated across all villages (Fig. 44) with no significant difference found in adoption of structural measures ($P<0.99$), biological measures ($P<0.75$), and soil fertility management measures ($P<0.87$) among the farmers of the study villages.

- Per capita water availability at the study area was found below WHO's standards (150 lpcd) in Alley (81 lpcd), Bul (88 lpcd), and Punjitar (74 lpcd) villages; however, these values were above the national benchmark set under the Jal Jeevan Mission (55 lpcd). Water distribution in the villages is managed through piped supply systems by trained local youths (barefoot engineers or Para-hydrologists). Overall, it was found the rural areas lack in strong water management and the governance system. Therefore, based on a systematic review and existing gaps, a "Socio-Ecological Climate-Resilient Governance Model" coupled with Human and Natural System is developed for spring water management aiming to strengthen water security, hydrological resilience, and socio-ecological restoration for sustainability in the Himalaya region.

- A comparative monitoring of two representative springs Chipchey Dhara and Gaddi Khola between the baseline year (2020) and post-intervention year (2021-2023) showed substantial increase in spring discharge. Chipchey Dhara discharge increased from 12 liter per minute (lpm) in 2020 to 35 lpm by 2023, while Gaddi Khola discharge increased from 6 lpm to 23lpm over the same period. A multi-dimensional framework for evaluation of the effectiveness and cost-benefit of managed spring recharge interventions was developed in the project, covering provisioning, regulating, socio-cultural and supporting services. The Cost-Benefit Ratio value (CBR >1) indicated theeconomic viability of the interventions for more than 10 years horizon. The direct benefits included improved water availability, reduced time in water collection and drudgery of women, increased livelihood options and resilience, and reduced social vulnerabilities of the rural communities. Indirect benefits included increase in carbon sequestration, improved soil health, reduced soil erosion, etc. Comparative analysis between spring intervention and non-intervention sites revealed significantly higher SOC stocks in spring intervention sites, with values of 213.48 ± 27.01 Mg ha^{-1} at Alley and 254.54 ± 18.28 Mg ha^{-1} at Tendon-g (0–30 cm soil depth), compared to 132.91 ± 12.91 Mg ha^{-1} and 166.87 ± 34.59 Mg ha^{-1}, respectively, at non-spring intervention sites (Fig. 56).

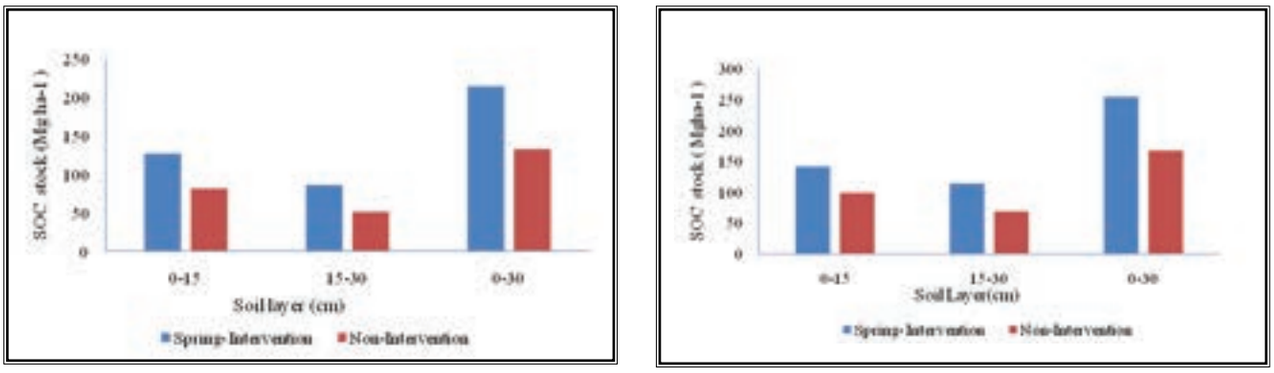

Fig. 56 Soil organic carbon (SOC) stock comparison between the spring intervention and non-intervention sites at Alley RF(A) and Tendong RF(B)

Springs ecosystem in Uttarakhand Himalaya: Boundary Protocol for Rejuvenation Policies (Mountain Division, 2021-2024)

Springs are crucial freshwater sources in the Indian Himalayan region, supporting household, agricultural, and ecological needs. Mountain people depend on the springs for household, livestock, and irrigation work. 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 pattern of rainfall and human interferences, and activities. The perennial springs have now turned seasonal, and many of them have dried up. This is not only a matter of concern for the recharge of the spring, but is also important in terms of the spring's ecosystem. Springs have been scientifically understudied and overlooked. There has been a great difference that has occurred between the demand and supply of water in the world in the past few decades. This scarcity of water is seen in all the freshwater sources of this planet. The average decline in the discharge of water in the Himalayan springs has not only affected the population of the water scarcity but has also resulted in declining ecosystem services that the springs ecosystem offers. To understand the services provided by an ecosystem, it is important to map the ecosystem of the springs so that the information about the areas that provide more or less services can be identified. The spring rejuvenation policy framework released by the Ministry of Jal Shakti called for mapping of the spring shed, identification of recharge areas, pinpointing sites for appropriate recharge structures, and construction of recharge structures for increasing spring discharge. Ecosystem services provided by springs are not included in policy documents, which is highly important given changing climate scenarios. Keeping in view, the study focused on the development of a protocol to map the spring ecosystem based on its services, functions, and other physical parameters of the middle Himalayan region of Uttarakhand, with the following objectives. i. Collection and compilation of spring ecosystem information and activities of different regions of the Uttarakhand Himalaya; ii. to develop a RS/GIS-based protocol to delineate the spring ecosystem boundaries based on the ecosystem functions and services, and iii. to recommend a Decision Support System (DSS) that helps in developing appropriate policies for enhancing the productivity of a spring ecosystem with regard to socio-cultural services.

Major Outcomes:

- Identification of ecosystem services emanating from the springs was documented. Each of these services can be identified through various indicators. The dataset was created for the calculation of the spring's provisional ecosystem service area around Kantali village by using the population around the area, water use patterns, discharge, rainfall, etc.

- Impact of spring on Normalized Difference

Vegetation Index (NDVI) as a proxy for soil moisture has been analysed and ground water recharge potential map prepared (Fig. 57) for Upper Kosi Watershed.

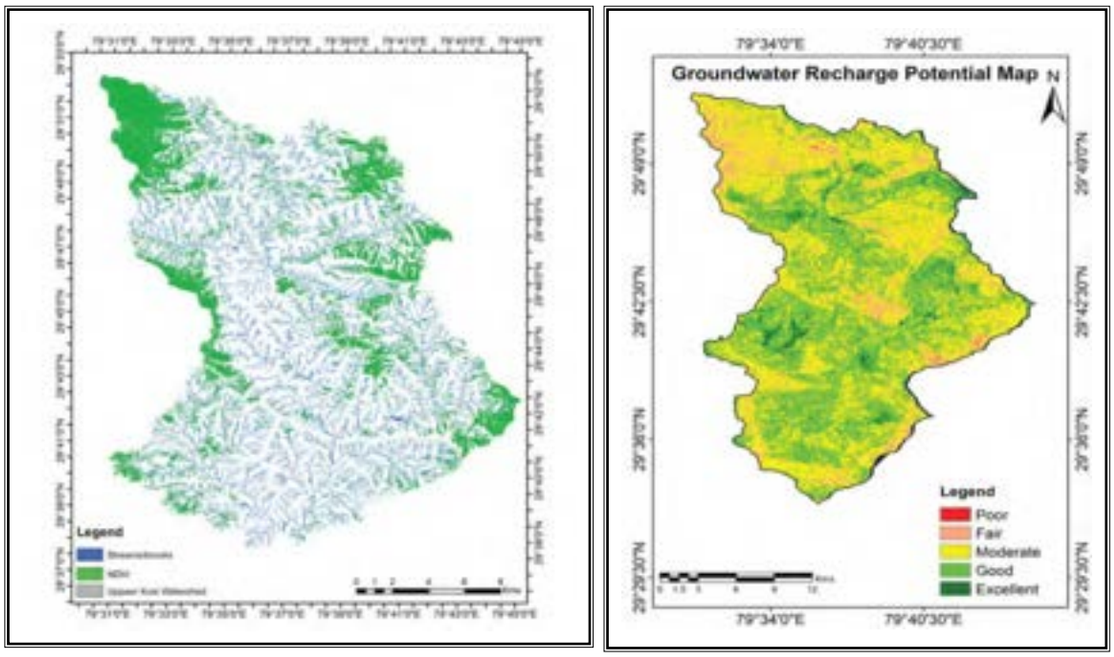

Fig. 57 Impact of spring on Normalized Difference Vegetation Index (NDVI) as a proxy for soil moisture and Recharge zone of springs *i.e.*, good and Excellent, considered as potential groundwater recharge areas

Application of R&D Outputs in Demonstration and Dissemination

EIACP Centre on Himalayan Ecology at the Institute HQs (MoEF&CC, 1992 onwards)

Environmental Information, Awareness, Capacity Building and Livelihood Programme (EIACP) Centre on Himalayan Ecology was set up in the Institute in the financial year 1992-93 as a part of EIACP network in India by the EIACP Secretariat, 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 54 EIACP Centres / Hubs / Resource Partners nationwide to provide national scenarios to the international set up, INFOTERRA Programme, of the UNEP.

Objectives

1. To conduct various Environment/outreach programmes and training under Mission LiFE.

2. Conduct Green Skill Development Programme (GSDP) approved by MoEF&CC.

3. Conduct capacity building programmes approved by MoEF&CC.

4. Organise mass awareness campaigns and activities on Mission LiFE as per directions of MoEF&CC.

5. Maintenance and regular updation of Programme Centre's website.

6. Preparation of at least one special publication on its assigned subject area bringing out policy implications on that subject.

7. Conduct outreach programmes on important environmental days.

Achievements

- The Centre received the Best EIACP Centre in North Zone award during the Coordinators' Meet organized by MoEF&CC at New Delhi.

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

- ENVIS Bulletin on Himalayan Ecology (Vol. 32, 2024) was also published on the following two theme namely (i) Himalayan Ecology and Environment (ii) Soil and Water Management in the Indian Himalayan Region. In addition, four thematic ENVIS Newsletters including (i) Land Restoration, Desertification, and Drought Resilience vol.21(1&2) (ii) Ecosystem-based Approaches (EbA) for Sustaining Himalayas, Vol. 21 (3&4), 2024 were also published.

- The EIACP centre alos participated in various mega events or exhibition and outreach programme such as (a) National workshop on "Lifestyle for Environment" at India Gate, New Delhi (b) Uttarakhand State Council for Science and Technology, on "Rural Science Congress", Doon University, Dehradun (C) Wetland Day at Gonda, Ayodhya, Uttarpradesh (d) 12th Regional 3R and Circular Economy Forum in Asia and the Pacific etc. The Centre showcased various sustainable lifestyle products from the northern region, which were appreciated by the Governments of Uttarakhand, Uttar Pradesh and Rajasthan.

Integrated Eco-development Research Programme (IERP) in the Indian Himalayan region (MoEF&CC, 1992 onwards)

The 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

1. To provide extramural funds to different Universities/Institutions/NGOs/Voluntary agencies for the support of location-specific R&D activities in the IHR.

2. To develop scientific capabilities in the IHR and strengthen infrastructure for environmental research.

3. To develop and execute coordinated programmes as per R&D needs of the IHR.

Achievements

- A total of 417 R&D projects have been supported by IERP so far, to various Universities, Institutions, NGOs and Government organizations across IHR, out of them 369 projects have been successfully completed.

- At present 48 R&D projects are under various stages of implementation, covering 8 States (namely; Assam, Arunachal Pradesh, Himachal Pradesh, Meghalaya, Nagaland, Sikkim, Uttarakhand and W.B.).

- 26th IERP-Project Evaluation Committee (PEC) meeting was convened on 18-19 November 2024 at Institute, Headquarters, Almora through hybrid mode. The total 86 nos. of project proposals were received during the F.Y. 2024-25, based on primary screening by subject matter experts and critical evaluation by experts members of PEC a total 13 projects were found suitable for funding support in the year. Regular monitoring and mid-term evaluation of project activities is being carried out.

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POLICY PAPERS

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FINANCIAL REPORT (2024-25)

S N R S & ASSOCIATES

CHARTERED ACCOUNTANTS

INDEPENDENT AUDITOR'S REPORT

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

Opinion

In our opinion and to the best of our information according to the explanation given to us, the financial statement of **G.B. PANT NATIONAL INSTITUTE OF HIMALAYAN ENVIRONMENT (An Institute of Govind Ballabh Pant Himalaya Paryavaran Evam Vikas)** for the year ended **March 31, 2025**, 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, the state of Affairs of the Institute as at **31st March 2025**.

(b) In the case of Income & Expenditure account, the Income/ Expenditure for the year ended on that date.

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

Basis of Opinion

We conducted our audit in accordance with Standard on Auditing (SAs). Our responsibilities under those standards are further described in the Auditor's Responsibilities for the audit of the Financial Statements section of our report. We are Independent of the Institute (Govind Ballabh Pant Himalaya Paryavaran Evam Vikas) in accordance with the code of Ethics Issued by the Institute of Chartered Accountant 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 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 do not provide a separate opinion on these matters.

In addition to the matters described in the basis of the 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

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Emphasis of Matters or Other Matter

The following facts are for the attention of the users of the financial statements:

1. We draw attention to the following matters relating to the maintenance of books of accounts and financial reporting:

   - *As disclosed in **Schedule-25 [X]** to the financial statements, the Institute implemented Tally accounting software during the financial year 2024-25 and is currently in the transition phase from a manual accounting system to a digital platform. While the majority of transactions have been recorded in the software, certain components—such as fixed assets and the opening balances of receivables and payables—continue to be maintained manually.*

   - *Bank reconciliation statements for the financial year include certain items that do not pertain to current year transactions. As the Institute is currently in the implementation phase of accounting system transition, the management has taken note of these items and will carry out the necessary reconciliations in due course.*

2. *The reconciliation between the sales reported in the Goods and Services Tax (GST) returns and those recorded in the books of account has not been carried out or made available for verification. As per the GST returns filed, the total sales for the year amount to **Rs.14.25 lakh,** whereas the books of account reflect sales of only **Rs. 2.80 lakh,** resulting in a difference of **Rs. 11.45 lakh.** Consequently, the income has been understated by **Rs. 11.45 lakh.***

   We further draw attention to the fact that the reconciliation of Input Tax Credit (ITC) as per the Goods and Services Tax (GST) records has not been undertaken. Further, the balances in the Credit Ledger and Cash Ledger available on the GST portal have not been reconciled with the books of account, as corresponding ledger balances are not maintained in the Institute's books. Additionally, it was observed that tax invoices have not been issued in accordance with the provisions of the GST law. These matters may have implications on the accuracy of tax reporting and compliance.

3. *The Institute falls under the category of persons liable to be registered under Section 51 of the Central Goods and Services Tax (CGST) Act, 2017, for the purpose of deducting tax at source (TDS under GST) with effect from 01.07.2017. Despite being eligible and liable for registration, the Institute has neither obtained registration under Section 51 nor deposited the GST TDS deducted from suppliers at the applicable rate of 2%. It is further noted that the Institute has been deducting 2% GST TDS from its suppliers without adhering to the statutory requirement of registration and subsequent remittance to the Government exchequer. This constitutes a non-compliance with the provisions of the CGST Act, 2017, and may expose the Institute to interest, penalty, and other regulatory consequences under the law.*

4. *As disclosed in **Schedule-25 [viii]** to the financial statements, During the F.Y. 2024-25, total GST demand notice issued by the GST department of **Rs. 32,18,111/-** is still pending. No correspondence document with departments provided to us.*

5. *The Institute has been depreciating Leasehold Land at Garhwal Reigonal Center Chauras, Srinagar (Garhwal), Uttrakhand at a rate of 40% on WDV basis, rather than amortizing the cost evenly over the lease period. The cost of leasehold land should be amortized evenly over the lease term. This has resulted in an overstatement of depreciation expense and understatement of the carrying amount of the asset and surplus for the year. The accounting treatment is not in line with applicable accounting standards. We further draw attention the title of Leasehold Land at Garhwal Reigonal Center Chauras, Srinagar (Garhwal), Uttrakhand not provided to us.*

413, Pratap Bhawan, 5, Bahadur Shah Zafar Marg, Delhi-110002
Tel.: 011-23730444, 23730888, gulbaharahmad@gmail.com

6. *The Credit Ledger and Cash Ledger at the GST portal are not reconciled since corresponding balances are not maintained in the Institute's Books of accounts. TDS under GST has not been deducted during the Financial Year 2023-24 and also Tax Invoices under GST for other incomes are not issued by the institute.*

7. *Some of Outstanding balances of receivables, payables and unsettled grants are pending for confirmation and reconciliations.*

8. *As disclosed in* ***Schedule-25 [viii]*** *to the financial statements, demands amounting to* ***Rs. 57,43,48,829/-*** *are outstanding under the Income-tax Act, 1961. Which is under dispute and appeal already submitted to the Income Tax Department on dated 04th April, 2025.*

9. *There is no reconciliation of TDS balances as per the books of accounts with the corresponding statutory records, including TDS returns and Form 26AS.*

    - *During the FY 2024-25, total TDS paid* ***Rs. 1,83,24,724/-*** *however reconciliation with books of accounts for the same is not made available to us.*

    - *As per 26AS, TDS Receivable is of* ***Rs. 4,81,569/-*** *and income receivable is of Rs.* ***72,33,800/-*** *(Interest income Rs. 72,25,020/- and other income Rs. 8780/-) however reconciliation for the same is not made available.*

10. *As disclosed in* ***Schedule-25 [viii]*** *to the financial statements, demands amounting to* ***Rs. 3,77,090/-*** *outstanding under the TDS.*

11. *GBP-NIHE registered under FCRA Act on dated 14/07/1987 Registration No 347860009 and last renewed on 05.08.2016 after that institute made application for renewal on 27/10/2021 and still is pending for renewal.*

12. *The total amount of* ***Rs.1,61,93,417/-*** *classified under Advances and Other Amounts Receivable since the financial year 2019-20, remains outstanding. The recoverability of this amount is uncertain, and the Institute is actively following up for its recovery.*

13. *Books of Accounts and financial statements of Institute maintained and prepared as per format and method prescribed by GFR-2017 and not as per Guidance note on non corporate entities issued by the Institue of Chartered Accountant of India.*

14. *Physical Verification Report of Property, Plant and Equipment and Stores not provided to us.*

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 judgments 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.

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In preparing the financial statements, management is responsible for assessing the Institute's ability to continue as a Going Concern, disclosing, as applicable, matters related to going concern and using the 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 objectives are to obtain reasonable assurance about whether the financial statements as a whole are free from material misstatements, whether due to Fraud or Error and to issue Auditor's report that includes our opinion. Reasonable assurance is a high level of assurance but is not a guarantee that an audit conducted in accordance with SAs will always detect a material misstatement when exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decision of users taken on the basis of these financial statements.

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.

For S N R S & Associates
Chartered accountants
FRN. 015975N

CA Gulbahar Ahmad
(Partner)
M.No. 529334

UDIN:

Date: 06.07.2025
Place: Almora

413, Pratap Bhawan, 5, Bahadur Shah Zafar Marg, Delhi-110002
Tel.: 011-23730444, 23730888, gulbaharahmad@gmail.com

G.B.Pant National Institute Of Himalayan Environment (NIHE)

(Also G. B. Pant National Institute of Himalayan Environment & Development)

(An Autonomous Institute under MOEF&CC, Govt. of India), Kosi- Katarmal, Almora, Uttarakhand-263643

[Registered as Govind Ballabh Pant Himalayan Paryavaran Evam Vikas Sansthan vide Reg. No. 17830 of 1987 dated 14th July 1987 under the Societies Reg. Act. 1860]

PAN: AAAGG0543D

Balance Sheet

As on 31st March 2025

Particulars	Schedule	Current Year (`)	Previous Year (`)
Liabilities			
Corpus / Capital Fund	1	5,91,33,821.94	5,03,43,661.23
Reserve And Surplus	2	43,94,05,681.46	39,76,44,009.91
Earmarked / Endowment Funds	3	-	-
Secured Loans & Borrowings	4	-	-
Unsecured Loans & Borrowings	5	-	-
Deferred Credit Liabilities	6	-	-
Current Liabilities And Provisions	7	28,64,76,250.70	28,09,94,686.75
Total		**78,50,15,754.10**	**72,89,82,357.89**
Assets			
Property, Plant & Equipments	8	46,53,25,062.92	47,94,20,944.47
Invest. From Earmarked/Endowment Fund	9	3,22,374.18	1,51,51,055.18
Invest. Others	10	-	-
Current Assets , Loans, Advances Etc.	11	31,93,68,317.00	23,44,10,358.24
Miscellaneous Expenditure			
Total		**78,50,15,754.10**	**72,89,82,357.89**

Significant Accounting Policies	24
Contingent Liabilities & Notes On Accounts	25

As per our report of even date attached.

(Kunal Sharma)
Accounts Officer

(Dr. Satish Chandra Arya)
D.D.O

(Dr. I. D. Bhatt)
Director (I/C)

Date : 06.07.2025
Place : Almora

For S N R S & Associate
Chartered Accountants
FRN: 015975N

CA Gulbahar Ahmad
(Partner)
M.No. 529334

UDIN:

G.B.Pant National Institute Of Himalayan Environment (NIHE)

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(An Autonomous Institute under MOEF&CC, Govt. of India), Kosi- Katarmal, Almora, Uttarakhand-263643

(Registered as Govind Ballabh Pant Himalayan Paryavaran Evam Vikas Sansthan vide Reg. No. 17850 of 1987 dated 14th July 1987 under the Societies Reg. Act. 1860)

PAN: AAAAG0013P)

Income & Expenditure A/c
For the Year as on 31st March 2025

Particulars	Schedule	Current Year (`)	Previous Year (`)
Income			
Income from Sales/Services	12	8,03,138.00	4,22,294.00
Grants/Subsidies(net off exp)	13	33,30,03,931.60	30,82,88,042.42
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	6,61,845.00	12,60,288.00
Other Income	18	73,25,177.26	98,50,892.41
Increase (decrease) in stock of Finished goods and work in progress)	19	-	-
Total (A)		**34,17,94,091.86**	**31,98,21,516.83**
Expenditure			
Establishment Expenses: a) Institute	20	16,53,49,830.00	16,27,43,119.00
b) Projects		2,08,47,240.00	1,96,76,637.00
c) F.C (Projects)		31,90,887.00	-
Administrative Expenses :a) Institute	21	9,19,47,998.46	6,91,00,368.62
b) Projects (As per Annexure II)		3,51,24,507.14	3,90,52,366.47
c) F.C (Projects)(As per Annexure I)		28,74,796.00	70,052.33
Expenditure on Grants, Subsidies etc.	22	1,36,68,673.00	1,76,45,499.00
Interest	23	-	-
Depreciation	08	3,28,01,600.53	3,49,80,824.02
Total (B)		**36,58,05,532.13**	**34,32,68,866.44**
Balance being excess of Expenditure over Income (A - B)		**(2,40,11,440.27)**	**(2,34,47,349.61)**
Transfer to special Reserve			
Transfer to/ from General Reserve			
Bal. Being Deficit Trf.To Corpus Fund (Other Income)		**(2,40,11,440.27)**	**(2,37,92,244.61)**
Bal. Being Surplus Trf.To Corpus Fund (Corpus Interest)		-	**3,44,895.00**
Add: Transferred from General Reserve Fixed Asset Fund		**3,28,01,600.53**	**3,49,80,824.02**
Interest income of other Saving Accounts.			
Significant Accounting Policies	24		
Contingent Liabilities & Notes On Accounts	25		

As per our report of even date attached.

(Kunal Sharma)
Accounts Officer

(Dr. Satish Chandra Arya)
D.D.O

(Dr. I. D. Bhatt)
Director (I/C)

Date : 06.07.2025
Place : Almora

For S N R S & Associate
Chartered Accountants
FRN: 015975N

CA Gulbahar Ahmad
(Partner)
M.No. 529334

UDIN:

G.B.Pant National Institute Of Himalayan Environment (NIHE)

(Alias G. B. Pant National Institute of Himalayan Environment & Development)

(An Autonomous Institute under MOEF&CC, Govt. of India), Kosi- Katarmal, , Almora, Uttarakhand-263643

(Regd. as Govind Ballabh Pant Himalayan Paryavaran Evam Vikas Sansthan Reg. No. 17856 of 1987 dated 14th July 1987 under Societies reg. Act. 1860, PAN: AAAAG3518P)

Receipts & Payments A/c
For the year as on 31st March 2023

Receipts	Current Year	Previous Year	Payments	Current Year	Previous Year
I. Opening Balances			**I. Expenses**		
a) Cash in hand	1,01,912.30	1,13,436.02	**a) Establishment Expenses**		
	-	-	**i) Institute**	14,27,72,361.00	14,87,03,351.77
b) Bank Balances		-	**b) Administrative expenses**	-	-
	-	-	i) Institute	4,31,77,665.67	5,50,35,622.62
i) In Current accounts	-	-	ii) R&DE Rev[expenses	2,43,44,949.65	1,31,79,794.00
			iii) Payments for Current Liabilities		
ii) In deposit accounts (Corpus Fund)	1,51,51,095.18	1,11,92,560.18	(Gratuity/Leave)	2,20,05,403.00	88,76,470.00
iii) Savings accounts	19,80,00,232.32	17,88,49,509.04	**C. Capital expenditure**	-	-
c) Advances & Others	2,86,07,251.13	9,83,41,804.89	i) Purchase of Fixed Assets	5,85,27,753.00	9,22,90,072.56
(As per Annexure attached)	-	-	ii)Expenditure on Capital Work in Progre	-	5,36,51,700.00
F.C. Account	-	-	iii) Acquirement of land (Lease money)		-
A) Cash in hand	-	0.33	**II Payments made against funds for**	-	-
b) Cash on bank	37,54,568.32	40,27,149.32	**Expenditure State govt. projects**	-	-
c) FC Advances	9,15,331.00	9,15,331.00	a) Capital	98,92,156.00	1,69,80,148.00
II. Grants Received	-	-	b) Revenue	-	-
a) From Government of India	39,50,00,000.00	32,00,00,000.00	Fellowship/ Manpower/Salary	1,92,71,360.00	1,96,76,637.00
i) IDEARSD Scheme MOEF & CC	-	77,71,91,576.00	Research expenses	3,67,00,387.14	3,90,52,366.47
Contribution corpus from CPF	11,59,692.00	10,63,126.00	**Expenditure FC projects**	-	-
b) From Other agencies	10,67,70,180.80	8,60,64,998.00	**a) Capital**	10,32,117.00	-
c) From other sources [from FC]	73,20,000.00	-	**b) Revenue:**	-	-
Intl. Cent. for Inte.Mountain Dev (ICIMOD	-	2,10,603.24	Fellowship/ Manpower/Salary	31,90,887.00	1,44,142.00
III. Income on Investments from	-	-	Research expenses	28,74,796.00	2,83,426.33
a) Corpus Fund(Interest from institute)	-	-	Payments made against funds for	2,10,603.24	2,10,603.24
	-	-	IDEARSD Scheme MOEF & CC (inst away	-	77,71,91,576.00
IV. Interest Received	-	-	**IEDP grant released**	1,36,68,673.00	1,76,45,499.00
a) On Bank deposits savings a/c	1,44,696.00	6,88,474.00	**III Investments and deposits made**	-	-
b) On term deposits a/c	-	-	Pension trust (out of corpus fund)	11,59,692.00	17,18,493.00
c) Loans, Advances etc.	-	-	**IV Refund of Surplus money/Losses**	-	-
			a) To the Government of India/		
d) Interest income Corpus Fund	1,71,319.00	3,44,895.00	Bharatkosh	6,55,24,183.57	2,40,97,284.13

INSTITUTE FACULTY (2024-25)

HEAD QUARTER – SCIENTISTS

S.N.	NAME	DESIGNATION	AREA OF SPECIALIZATION
1	Prof. Sunil Nautiyal	Director	Natural resource management and conservation
2.	Dr. I.D. Bhatt	Scientist-G	Plant Physiology, Phytochemestry, Tissue Cultre, Medicinal Plants Propogation
3.	Dr. Paromita Ghosh	Scientist-F	Plant Science; Soil Science
4.	Er. M.S. Lodhi	Scientist-F	Environmental Impact Assessment
5.	Dr. A.K. Sahani	Scientist-E	Anthropology; Social Science
6.	Dr. S.C. Arya	Scientist-E	High Altitude Ecology
7.	Dr. K.S. Kanwal	Scientist-E	Biodiversity Conservation, Plant ecology Environmental Impact Assessment
8.	Dr. Mithilesh Singh	Scientist-E	Plant and Microbial Biotechnology, Bio prospection
9.	Dr. Ashutosh Tiwari	Scientist-D	Remote Sensing of the Environment, Geoinformatics
10.	Dr. Sumit Rai	Scientist-D	Soil Science; Soil and water Conservation
11.	Dr. V.E. Gosavi	Scientist-D	Hydrology; Watershed Management
12.	Dr. Harshit Pant	Scientist-D	Forest Ecology
13.	Dr. Shailaja Punetha	Scientist- D	Agriculture; Horticulture
14.	Dr. Aseesh Pandey	Scientist –C	Biodiversity Conservation, Alpine ecology,
15.	Dr. Suresh Kumar Rana	Scientist-C	Biogeography ; Evolutonary Eiology; Biocuration
16.	Er. Himanshu Joshi	Scientist-C	Hydrology; Watershed Management
17.	Er. Manish Singh	Scientist-C	Air Pollution and Monitoring Techniques
18.	Dr. Subodh Airi	Sr. Tech. Officer (II)	Forest Ecology; Biotechnology
19.	Er. Om Prakash Arya	Sr. Tech. Officer (I)	Biochemical Engineering; Natural Product Chemistry
20.	Dr. Lalit Giri	Tech. Assistant (II)	Biodiversity Conservation

GARHWAL REGIONAL CENTRE

S.N.	NAME	DESIGNATION	AREA OF SPECIALIZATION
1	Dr. K. C. Sekar	Scientist-F	Plant Taxonomy (High Altitude), Conservation Biology
2	Dr. Arun Kumar Jugran	Scientist-E	Conservation genetics, Plant population genetics, Molecular Markers, Plant Biochemistry
3.	Dr. Kusum Pandey	Scientist –C	Soilless Culture, Protected Cultivation, Soft Computing, Natural Resource Management

HIMACHAL REGIONAL CENTRE

S.N.	NAME	DESIGNATION	AREA OF SPECIALIZATION
1.	Er. R. Kumar Singh	Scientist-F	Information Technology (Data Information Management and Decision Support System)
2.	Dr. Vasudha Agnihotri	Scientist-E	Environmental monitoring,; management and conservation
3.	Dr. Sarla Shashni	Scientist-E	Rural Entrepreneurship and Small Business
4.	Dr. Renu Lata	Scientist-D	Environmental Governance & Policy; Environment Impact Assessment & Management
5.	Dr. Kesar Chand	Scientist –D	Climate Change, Environmental Pollution and Disaster Management
6.	Dr. Manish Tripathi	Scientist-B	Lichen (Taxonomy, Ecology and Bioprospection)
7.	Dr. Kishore Kumar	Sr. Tech. Officer (I)	Insect Ecology; Pollination Biology; Biodiversity Conservation Education

LADAKH REGIONAL CENTRE

S.N.	NAME	DESIGNATION	AREA OF SPECIALIZATION
1.	Dr. Sandipan Mukherjee	Scientist-E	Meteorology; Climatology, Hydrometeorology; Climate Change
2.	Dr. P. Kumar Garg	Scientist –C	Glaciology; Remote sensing
3.	Dr. Ajay Kumar Gupta	Scientist-C	Climate Change Risk; Vulnerability and Adaptation Assessment
4.	Dr. Naveen Chandra	Scientist-C	Vegetation ecology; Plant taxonomy,; Biodiversity assessment
5.	Dr. Dalbeer Singh P.	Tech. Assistant (II)	Medicinal Plants cultivation; Natural Resource Management

NORTH EAST REGIONAL CENTRE

S.N.	NAME	DESIGNATION	AREA OF SPECIALIZATION
1.	Dr. Devendra Kumar	Scientist-E	Forest Ecology; Ecological Modeling
2.	Dr. Wishfully M.	Scientist-C	Forest Ecology and Biodiversity
3.	Smt. Tridipa Biswas	Scientist –C	Cartography;Photogrammetry; Digital Image Processing
4.	Dr. Sivaranjani S	Scientist-C	Carbon flux; Carbon Sequestration; Carbon credit
5.	Dr. Mriganka S. Sarkar	Scientist-C	Ecology; Genetics
6.	Mr. Ranjeet Singh	Tech. Assistant (II)	Forest Ecology

SIKKIM REGIONAL CENTRE

S.N.	NAME	DESIGNATION	AREA OF SPECIALIZATION
1.	Dr. Rajesh Joshi	Scientist-F	Mathematical modeling
2.	Dr. S. Tarafdar	Scientist-E	Weather & Climate Change; Groundwater, Hydrology
3.	Dr. Sandeep Rawat	Scientist –D	Plant Biotechnology; Natural product chemistry
4.	Dr. Mayank Joshi	Scientist –C	Tectonic Geomorphology
5.	Dr. K.S. Gaira	Technical Officer	Biodiversity and climate change modeling

INSTITUTE SUPPORTING STAFF

HEADQUARTER, ALMORA

S.N.	NAME	DESIGNATION
1.	Mr. Surya Kant	Finance Officer
2.	Mr. L.M.S. Negi	Accounts Officer
3.	Mr. S. Higgins	Sr. Technical Officer (I)
4.	Mr. Mahesh Chandra Sati	Technical Officer
5.	Mr. K.N. Pathak	Sr. Technician (I)
6.	Mr. Govind Singh	Technician (I)
7.	Mrs. Sarita Bagdwal	Stenographer
8.	Mr. Jagdish Kumar	Stenographer
9.	Mrs Mamta Higgins	Office Superintendent
10.	Mr Heera Singh	Office Superintendent
11.	Mr. K.K. Pant	Upper Divisional Clerk
12.	Mrs. Hema Pandey	Upper Divisional Clerk
13.	Mr. Mayank Verma	Upper Divisional Clerk
14.	Mr. Atul Bisht	Lower Divisional Clerk
15.	Mr. Vipin Chandra Sharma	Lower Divisional Clerk
16.	Ms. Vaishali Rani	Lower Divisional Clerk
17.	Mr. Sanjeev Kumar Arya	Driver
18.	Smt Ganga Joshi	Group 'C'
19.	Mr. Gopal Singh Bisht	Group 'C'
20.	Mr. Govind Singh Malwal	Group 'C'

LADAKH REGIONAL CENTRE

S.N.	NAME	DESIGNATION
21.	Mr. Stanzin Zangmo	Lower Divisional Clerk

HIMACHAL PRADESH REGIONAL CENTRE

S.N.	NAME	DESIGNATION
22.	Mr. Ajay Pawar	LDC
23.	Mr. Daulat Ram	Group 'C'
24.	Mr. Jagdish Kumar	Driver

GARHWAL REGIONAL CENTRE

S.N.	NAME	DESIGNATION
25.	Mr. D.P.Kumeri	Upper Divisional Clerk
26.	Mr. M.P Nautiyal	Lab/Field Assistant/ Housekeeping
27.	Mr. R.C. Nainwal	Lab/Field Assistant
28.	Mr. R.P. Sati	Lab/Field Assistant

SIKKIM REGIONAL CENTRE

S.N.	NAME	DESIGNATION
29.	Mr. Jagnnath Dhakal	Lab/Field Assistant
30.	Mr. P.K. Tamang	Lab/Field Assistant
31.	Mr. R.K. Das	Lower Divisional Clerk
32.	Mr. Hemant Singh	Group 'C'
33.	Mr. Musafir Rai	Group 'C'
34.	Mr. Shyambir	Group 'C'

NORTH-EAST REGIONAL CENTRE

S.N.	NAME	DESIGNATION
35.	Mr. Sandeep Kumar	Lower Divisional Clerk

SCIENTIFIC ADVISORY COMMITTEE

Chairperson
Prof. D.S. Rawat, FRSE, Cchem (London)
Vice Chancellor
Kumaun University, Nainital and
Professor of Chemistry
Delhi University, Delhi

Thematic Experts
Dr. S.P. Aggarwal
Director
North East Space Application Centre (NESAC)
Department of Space, Government of India
Umiam -793 103, Meghalaya

Prof. (Dr.) Anil K. Gupta
Head of Division
International & National Cooperation
National Institute of Disaster Management (NIDM), Ministry of Home Affairs, Govt. of India, Rohini, New Delhi

Prof. R. Uma Shankar
Head, Bioscience and Bioengineering
Indian Institute of Technology Jammu Jagti
Nagrota Bypass Road, Jammu & Kashmir

Peer Institutions
Director/or his representative
CSIR – Institute of Himalayan Bioresource Technology, Palampur, H.P.

National Centre for Sustainable Coastal Management (NCSCM), Anna University Campus
Chennai, Tamil Nadu

Botanical Survey of India
CGO Complex, 3rd MSO Building
Block F (5th & 6th Floor), DF Block, Sector-I
Salt Lake City, Kolkata

Zoological Survey of India
Prani Vigyan Bhawan, M Block, New Alipore
Kolkata, West Bengal

Chairman
State Biodiversity Board Uttarakhand
423, Indira Nagar Colony (Near Malik Chowk)
P.O. New Forest, Dehradun-248 006
Uttarakhand

Institute Faculty
Dr. I.D. Bhatt
Scientist G, Head Quarter,
G.B. Pant National Institute of Himalayan Environment, Kosi-Katarmal, Almora, Uttarakhand

Dr. Sandipan Mukherjee
Scientist E, Ladakh Regional Centre,
G.B. Pant National Institute of Himalayan Environment, Leh, Ladakh

Dr. Sivaranjani S
Scientist-C, North-East Regional Centre,
G.B. Pant National Institute of Himalayan
Itanagar, Arunachal Pradesh

Member Secretary
Director
G.B. Pant National Institute of Himalayan Environment
Kosi-Katarmal, Almora

Representatives of MoEF&CC

Joint Secretary (CSI)
Ministry of Environment, Forest & Climate Change
Indira Paryavaran Bhawan, Jorbagh Road, Aliganj, New Delhi

Scientist-in-Charge (CS-I, Mountain Division)
Ministry of Environment, Forest & Climate Change
Indira Paryavaran Bhawan, Jorbagh Road, Aliganj, New Delhi

PROJECT EVALUATION COMMITTEE

Chairman
Dr. R. K. Maikhuri
Professor and Head, Department of Environment Sciences, HNB Garhwal University (Central University),
Srinagar, Garhwal, Uttarakhand

Members
Dr. Shri Kant Tripathi
Professor, Department of Forestry,
Mizoram University, Aizawl, Mizoram

Dr. Sanjay Kumar Uniyal
Sr. Principal Scientist,
Institute of Himalayan Bioresource Technology,
Palampur, H.P.

Prof. Manzoor A. Shah
Department of Botany, University of Kashmir, Srinagar, J & K

Prof. Niranjan Roy Department of Economics,
Assam University, Silchar, Assam

MOEF &CC Representative
Dr. Susan George
Scientist E, Mountain Division
Ministry of Environment, Forest & Climate Change, Jorbagh Road, Aliganj, New Delhi

Member Secretary (Nominee of the Director, NIHE)
Dr. K. S. Kanwal
Designation: Scientist-E
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About the Institute:

G.B. Pant National Institute of Himalayan Environment (NIHE), 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.

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