ANNUAL REPORT 2023-24

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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Prof. Balaram Pani
Dean of Colleges
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A representative of the Indian Institute of Forest Management
Director
Indian Institute of Forest Management
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Director General
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Gulistan Residency, Dwarka,New Delhi

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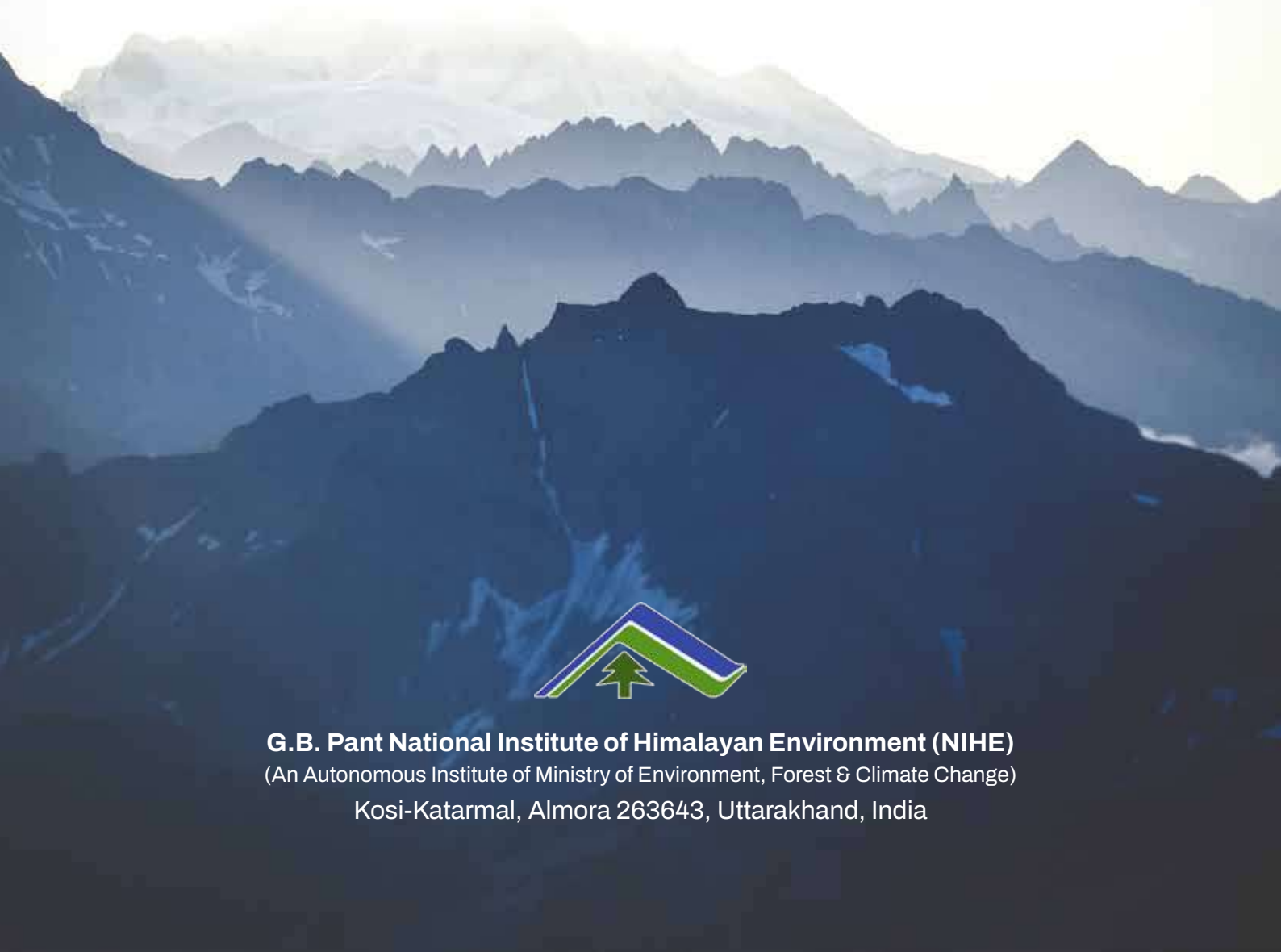
Bag Mugalia, Bhopal, M.P.

Member Secretary
Director
NIHE, Kosi-Katarmal, Almora, Uttarakhand

ANNUAL REPORT 2023-24



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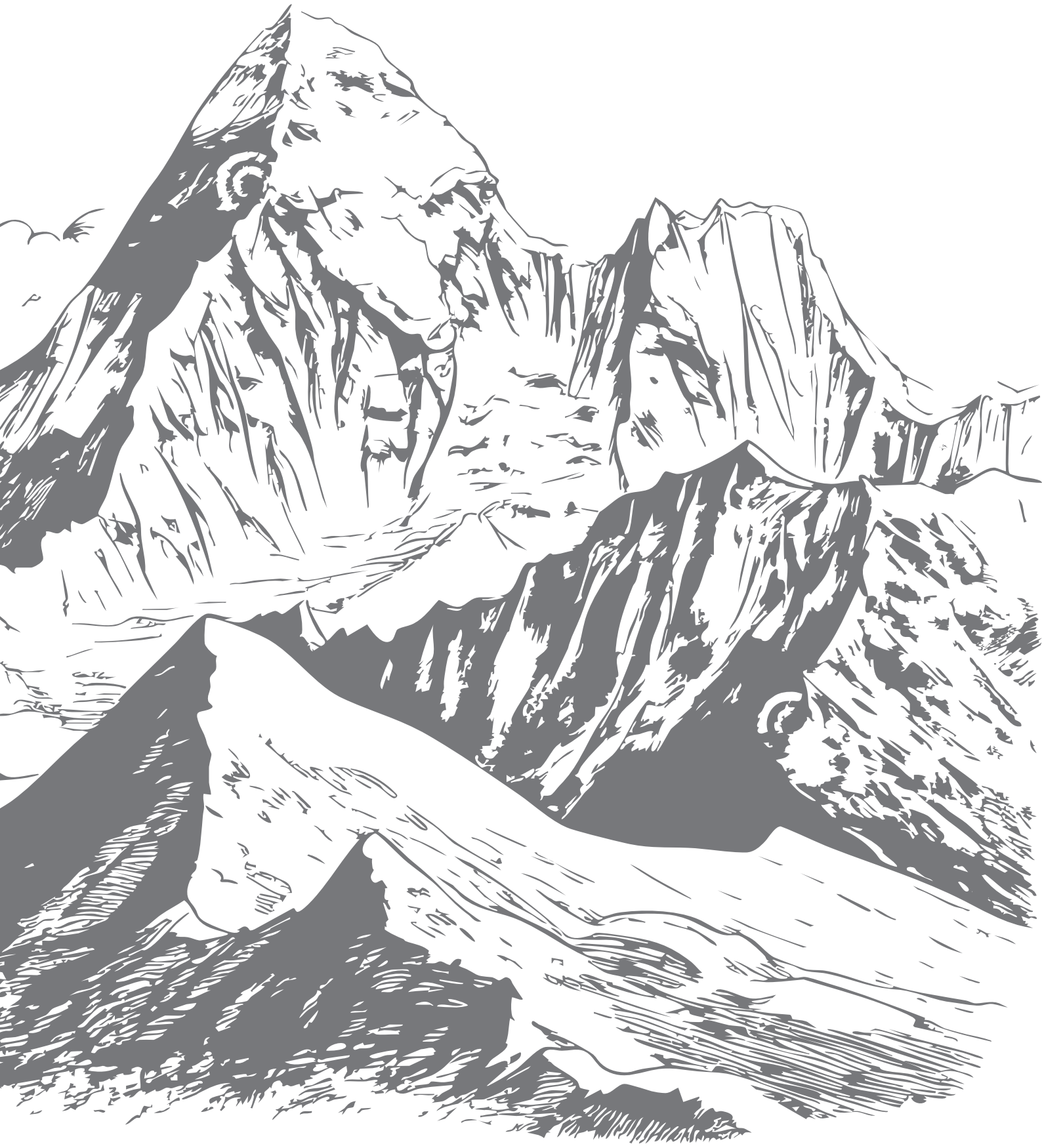
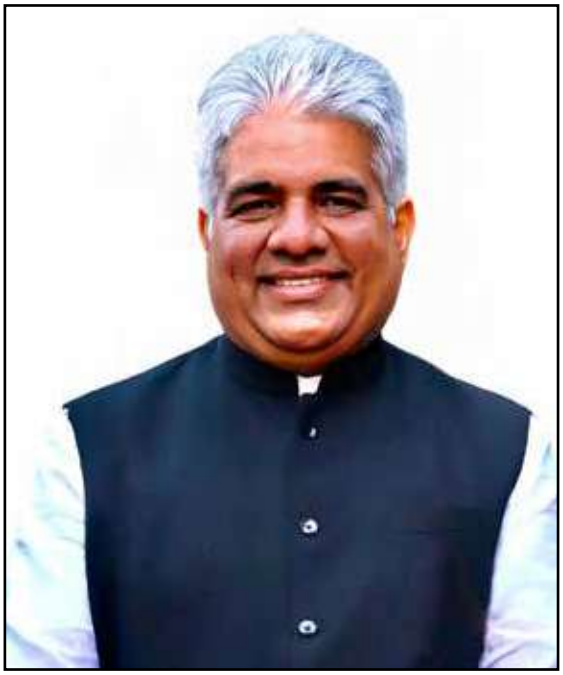
CONTENTS



NIHE, ANNUAL REPORT 2023-24



Sh. Bhupender Yadav
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

FOREWORD

G.B. Pant National Institute of Himalayan Environment, an autonomous institute under the Ministry of Environment Forest and Climate Change, is entrusted with enhancing scientific understanding, creating integrated management strategies, showcasing their effectiveness in conserving natural resources, and promoting sustainable development in the Indian Himalayan Region (IHR). The Institute utilizes a decentralized and multidisciplinary approach, operating through its six regional centers in the IHR, to better comprehend local R&D requirements and deliver science and nature-based solutions. The Institute's core competencies are divided into four primary disciplines: Land and Water Resource Management (LWRM), socioeconomic development (SED), Biodiversity Conservation and Management (BCM), and Environmental Assessment & Climate Change (EA&CC). The research and development initiatives conducted within these areas have received acclaim at the regional, national, and global levels for their contributions to sustainable development in the Himalayan region.

The Institute marked 2023 as a year of notable accomplishments and fruitful partnerships. The institute developed a demonstration model of a passive solar-heated building in Sosa village, Uttarakhand, employing Trombe walls and retrofitting methods to promote renewable energy and decrease carbon emissions. A comprehensive inventory of Himalayan glacier lakes in the Kargil District of Ladakh UT was compiled using the 2022 Sentinel-2 Multispectral Instrument imagery. Additionally, a record of extreme weather events (Cloudburst, Flash Flood) in the Beas Basin from 1994 to 2022 was created. To enhance the phytodiversity database of the Himalayan region, a geo-coordinated map featuring 1,076 endemic plant taxa (1,061 flowering plants, three gymnosperms, and 12 ferns and fern allies) was developed. One of India's highest altitude (5000m asl) hydrometeorological observatories was established on the Rulung Glacier forefield in Ladakh to study glacier resources. A typology for three landscapes–the Rudraprayag, Lahaul Spiti, and Karbi Anglong districts- was formulated to develop a framework for climate-resilient village. An economical solar-powered hydroponic system was implemented in polycarbonate greenhouses in Bombguard, Leh, Pangthang, Sikkim, Almora, and Uttarakhand. As per the National Green Tribunal's directive, the Institute completed various assignments, including (i) an analysis of the Joshimath disaster as a cautionary tale for Mussoorie, (ii) appeals concerning the Vishungad-Pipalkoti Hydro Electric Project, and (iii) an assessment of tourism's benefits and drawbacks in the IHR.

The Institute's research and development efforts garnered significant recognition, as evidenced by a diverse range of publications: 119 articles in peer-reviewed journals; 38 contributions to book chapters and proceedings; 31 books, booklets, bulletins, and monographs; 71 popular articles; and two policy papers. Additionally, the Institute conducted 49 events across the IHR, focusing on critical issues such as climate change, para-hydrology, alternative livelihood strategies, biodiversity conservation, and affordable rural technologies. These initiatives successfully enhanced the capabilities of over 3,000 stakeholders, with the aim of improving their quality of life. In the past year, the Institute secured more than ten externally funded projects and established formal partnerships with four organizations, bolstering its research, development, and collaborative endeavors. From groundbreaking studies to impactful community engagement, the institute continues to make substantial contributions across various environmental domains.

The Institute's achievements can be attributed to the guidance and support provided by its apex bodies: the Society, Governing Body, and Scientific Advisory Committee. The dedication of faculty members, research scholars, and staff has been instrumental in realizing these accomplishments. Looking ahead, the Institute remains committed to fostering partnerships with all stakeholders and collaborators, expressing confidence in the NIHE's ability to reach even greater heights in the future.

Prof. (Dr.) Sunil Nautiyal
Director

MAJOR ACHIEVEMENTS

- The spring inventory database across IHR is strengthened to a total of 6523 and available at HIMAL portal for wider stakeholder use. Further, to strengthen the water security, initial efforts of bio-engineering recharge interventions through the Jal Abhayaranya project showed promising impact on spring discharge enhancement in the initial stage at 5 sites in Uttarakhand, Sikkim, Tripura, West Bengal and Meghalaya state.

- Field demonstration model of Passive Solar Heated building, utilizing a Trombe wall and retrofitting techniques, has been developed at Sosa Village in Pithoragarh, Uttarakhand to promote renewable energy, reduce carbon footprints, and raise awareness in the high-altitude Himalayan villages.

- Inventory of glacial and high-altitude lakes within the Kargil District of Ladakh UT is prepared based on Sentinel-2 Multispectral Instrument (MSI) images for the year 2022 in order to strengthen the database on the Himalayan glacier lakes. The inventory also systematically assesses lake-topographic attributes and their relationship with the permafrost occurrence. A total of 355 (4.8 ± 1.2 km2) lakes were identified in the region.

- Glaciers in Kali basin of Uttarakhand [Chipa (elevation 3550 m), Neola (first ever expedition at an elevation of 3700 m)], and Indus basin region of Ladakh [Rulung (first ever expedition at an elevation of 5000 m)] were identified to establish the glacier-climate response functional relationships. Baseline data on snout measurement, stake installation for velocity measurement, water sampling, and stream discharge measurement was collected.

- Long-term data generated on aerosol climatology, radiative forcing, and temperature rise at Mohal-Kullu (Himachal Pradesh) and Kosi-Katarmal, Almora (Uttarakhand). Similarly, a database for extreme weather events (Cloudburst, Flash Flood) in the Beas basin from 1994 to 2022 has been prepared, indicating a drastic 409% increase in the frequency of extreme weather events.

- Towards developing a framework for Climate Resilient Village, typology was developed for three landscapes i.e., Rudraprayag, Lahaul Spiti and Karbi anglong districts. Village Climate Resilience Index (VCRI) for 60 villages was calculated using primary field-based data on services, infrastructure and policy governance support to the indigenous communities for climate resilience and adaptation. The results reveal high resilience of all the studied villages (25) in Lahaul and Spiti, 5 villages in Karbi Anglong and 1 in Uttarakhand. Medium resilience was reported for 14 villages in Uttarakhand and 58 in Karbi Anglong in Assam. Low resilience was observed only for 3 villages in the Karbi Anglong landscape. The high resilience of villages is attributed to better infrastructure, services and governance.

- Towards improving the livelihoods of the villagers, various promising rural technologies such as (i) Dragon fruit cultivation in NE Regional Centre, (ii) Improved Curing Kiln for Large Cardamom and (iii) protected cultivation using poly-tunnel technology (Sikkim Regional Centre), (iv) promotion of crop diversity and assessment of agriculture production deficit (Garhwal Regional Centre), (v) Promotion of “Shree Anna” (small millet), (vi) a high-return yielding strawberry, kiwi, and walnut plantation, in Jeyoli village cluster (Head Quarters) were introduced in the Eco-smart villages across the IHR.

- For strengthening the database of the plant diversity of the Himalayan region, a geo-coordinated map of 1,076 endemic plant taxa (1,061 flowering plants, 3 gymnosperms, and 12 ferns and fern allies) belonging to 432 genera and 100 families is developed. Also, a total

of 6638 flowering plants distributed in 1539 genera and 139 families have been documented, which includes 5535 dicotyledons (1307 genera and 127 families) and 1103 monocotyledons (232 genera and 12 families).

- To meet the fulfill the demand of planting materials, germplasm repositories of threatened and high-value plants have been established at Suryakunj, Almora; Pangthang, Sikkim; Trijuginarayan, Uttarakhand; Mohal, Kullu, Himachal Pradesh, Leh, Ladakh and Itanagar, Arunachal Pradesh. Threatened and high-value species like *P. verticillatum, P. cirrhifolium, Hedychium spicatum, Allium stracheyi, Malaxis acuminata,* Orchid species (18 No.), *Hedychium spicatum* accessions (>85 nos.), large cardamom accessions (>25 accessions), and Zingiberaceae (26 species) have been introduced. Herbal Gardens (6 No.) at different schools of Himachal Pradesh through the plantation of *Taxus contorta, Swertia chirayita, Withania sominfera, Gingko Biloba, Bergenia ciliata* have been established.

- A low-cost solar-powered hydroponic prototype was developed within the polycarbonate greenhouse, generously provided by LEDeG, Leh, near the Faecal Sludge Treatment Plant (FSTP) of the Municipal Committee Leh (MCL) at Bombguard. A hydroponic-based soilless plant production system for commercial crops in Sikkim with 03 types of model (i.e., A-type nutrient film technique, trench culture system, & bag culture system) and HQs Almora has been initiated.

- To protect traditional genetic resources, molecular tools were used to characterize Himalayan crops such as kidney beans. Internal Transcribed Spacer (ITS) sequences of 152 traditional Himalayan Kidney Bean (*Phaseolus vulgaris,* Rajmash) accessions were submitted to the National Centre for Biotechnological Information (NCBI) database. These sequences will be beneficial for the future identification and conservation of the unique Rajmash germplasm of the Himalaya.

- The Institute, as per the NGT assignment, has completed various tasks such as (i) Joshimath disaster – a warning for Mussoorie, (ii) appeals on Vishungad- Pipalkoti Hydro Electric Project, (iii) Tourism - Prosperity & Ill Effects in the IHR, and (iv) the Environment plan of the state Uttarakhand and 13 districts.

- To build the capacity of different stakeholders such as CBOs, Gram Panchayat leaders, local NGOs, SHGs, farmers, students, and teachers from various parts of Uttarakhand, Himachal, Sikkim, Arunachal Pradesh, and Ladakh, the Institute organized 49 events in different themes such as climate change, para-hydrology, alternative livelihood options, biodiversity conservation, low-cost rural technologies, etc. The capacity of –around 3000 stakeholders was built.

PUBLICATIONS

1. Peer Reviewed National & International Journals	119
2. Chapters in Books / Proceedings	38
3. Authored/ Edited / Books / Booklets / Bulletins / Monographs	31
4. Popular Articles	71
5. Policy Papers	2

EXECUTIVE SUMMARY

The G.B. Pant National Institute of Himalayan Environment (NIHE), mandated for environmental conservation and sustainable development of the Indian Himalayan Region (IHR), addresses front-running environmental issues of physical, biological, and socio-economic nature in an integrated manner to cater to the need of a range of stakeholders including academia, policymakers and planners, Govt. line agencies engaged in field implementation, NGOs and CBOs, etc. The R&D mandate of the Institute is broad and covers all the facets of mountain environment and development. In order to achieve this goal, in-depth knowledge generation through multidisciplinary R&D projects and integration of multiple subjects are the guiding principles. Further, the interlinking of natural and social sciences is emphasized in all the R&D projects. In this endeavor, special attention is placed on the intricate balance between the fragility of mountains, indigenous knowledge, and sustainable use of natural resources. Stakeholders' viewpoints and feedback are invited and taken into consideration when designing and implementing R&D activities. Adequate efforts are devoted to addressing priority environmental problems and developing and demonstrating best practices, technology packages, and delivery systems for improved livelihood and socio-economic development of the people. Also, conscious efforts are made to mobilize various stakeholders (students, researchers, academicians, farmers, citizens, NGOs, policymakers, National and International funding agencies, and others) to participate in Institute programmes through different initiatives and mechanisms. Training, education, and awareness of various stakeholders are the essential components of all the R&D programmes. The R&D activities of the Institute are conceptualized, governed, and executed through four thematic Centres and five regional Centres. Thematic Centres include (i) Centre for Land and Water Resource Management (CLWRM); (ii) Centre for Socio-Economic Development (CSED); (iii) Centre for Biodiversity Conservation and Management (CBCM); and (iv) Centre for Environmental Assessment and Climate Change (CEA&CC). The regional Centres of the Institute are (i) Ladakh Regional Centre (LRC); (ii) Himachal Regional Centre (HRC) (iii) Garhwal Regional Centre (GRC) (iv) Sikkim Regional Centre (SRC) (v) North-East Regional Centre (NERC) and (vi) Mountain Division Regional Centre (MDRC) housed in MoEF&CC, New Delhi. These regional centres cater to the specific R&D needs of the respective states/regions. During the reporting period, 51 R&D projects were implemented across the IHR, and 10 projects were completed. A brief summary of R&D activities and achievements of different Centres of the Institute during the reporting year 2023-24 is as follows:

1. Thematic Centres

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

In accordance with the well-defined objectives and following the holistic approach in conducting the scientific studies to offer R&D based sustainable solutions to freshwater-related problems in the Indian Himalayan Region, the Centre's research and development activities in 2023-24 were focused on understanding the land and water centric problems and formulating the holistic replicable strategies/plans and policy directives for efficient conservation and management of the land and water resources in IHR. Through in-house and externally funded projects, the centre covers all 11 states and 1 UT of IHR to address the key challenges pertaining to land and water resources ranging from the development of protocol for spring ecosystem assessment and management, spring rejuvenation for water security in IHR, assessment of Glacier-Climate functional relationships across IHR through long-term network observations. A demand-driven study is also being conducted by the centre in this reporting year, which focused on mainstreaming passive solar-heated buildings in the IHR with the integration of science with traditional practices to enhance climate resilience. The centre is addressing the burning issue of drying of springs in IHR through one in-house and two externally funded projects by development for spring ecosystem assessment and management of the protocol, understanding the spring-ecosystem functioning, their hydro-geological dynamics, and efforts for their conservation and management through Jal Abhayaranya concept through which recharge interventions are being placed across the study sites in collaboration with multiple institutes and regional centres of the Institute as well. The spring inventory data from primary and secondary sources across IHR strengthened to a total of 6523 covering 111 blocks in 25 districts of twelve States/UTs of IHR. Monitoring spring quality and discharge and delineating spring recharge potential zones are also continuing across the project sites. Also, the ground-based bio-engineering interventions for the rejuvenation of spring showed promising results in the initial phase, and the impact of the same will be monitored in the coming years as well. Further, the centre also conducted various awareness and capacity-building/training programmes to sensitize the wider stakeholders. The centre also reaches out to the line department through various meetings to replicate springshed management work by imparting technical know-how training or providing replication plans. The major stakeholder includes Forest dept., JJM, village Panchayat, NGOs, district authorities, and state and central government are also involved. This reporting year, centre also started an assessment of Glacier-Climate functional relationships across IHR through long-term network observations for developing glacier-climate response function preferably through network approaches and spatially distributed glacier mass balance and ice-flow models for three selected ungauged glaciers of Jammu and Kashmir, Uttarakhand, and Sikkim Himalaya. Four expeditions were also conducted in this direction in the glaciers selected in Jammu, Kashmir, and Uttarakhand. Through a unique project, efforts are being made to mainstream passive solar heated buildings in the IHR by studying best practices, evaluating PSHBs for thermal efficacy, their cost-benefit analysis, developing replicable designs and SOPs, and promoting skills development of wider stakeholders. During the reporting period, the central laboratory under the center facilitated the analysis of different parameters for 832 soil samples, 98 water samples, and 364 plant samples from internal and external agency's requests.

ii) Centre for Socio-Economic Development (CSED)

The Centre for Socio-Economic Development envisages planning its programs in line with the "Vikshit Bharat Schemes," which prioritizes inclusive development and social welfare to ensure everyone benefits from economic progress. Over the years, the Centre has delivered several landmark initiatives to support disadvantaged populations and marginalized communities and expand social security. Our sustainable development plan aims to protect and recover nature, augmenting a food supply system that is sustainable in the long run with a thrust on natural resource management through established targets and time-bound objectives. The center's activities revolve around the core competence that includes location-specific eco-development, rehabilitation of degraded land through multi-purpose tree species, sustainable use of natural resources, socio-economic development that includes value chain development, product development, ecotourism promotion, protected cultivation, and agroforestry systems. The center is also responsible for the documentation of Indigenous knowledge and natural resources management planning. Social outreach is provided through the Rural Technology Centre to central and state governments and line agencies through capacity building and technological backstopping. Quality planting material is also raised through appropriate nursery techniques. The group works towards a circular economy that begins and ends in nature through low-cost livelihood-enhancing technologies. The centre works in synchrony with the SDG 2030 goals and Sansad Adarsh Gram Yojna and aptly works towards the Prime Minister's clarion call towards Van Dhan, Jan Dhan and Govardhan, a major economic component of our country.

iii) Centre for Biodiversity Conservation and Management (CBCM)

The Centre is addressing the innumerable challenges facing the Himalayan biodiversity. Despite its richness and uniqueness, the Himalayan biodiversity is threatened by high dependency on natural resources, poor management, and a lack of comprehensive understanding. Recognizing the urgency of developing adaptive strategies for conservation and sustainable management, the centre's activities during 2023-24is focused on a series of research and development programs aimed at strengthening the database on plant biodiversity, restoration programs using medicinal plants on degraded lands, promoting the conservation of threatened and endemic plants, developed propagation methods for valuable medicinal plants, encouraged farmer cultivation of high-value medicinal plants and assessing the impacts of climate change on floristic diversity. The key initiatives included the identification and mapping of biodiversity-rich areas across the Indian Himalayan Region (IHR), updating People's Biodiversity Registers (PBRs) to strengthen the Access and Benefits

Sharing (ABS) mechanism, and prioritizing potential medicinal plant species for value chain development to optimize the sustainable use of these species. Under UCOST funded project a germplasm repository of *P. verticillatum* and *P. cirrhifolium* has been established in the Surya-Kunj-ex-situ conservation site of the institute and plantlets from different populations are conserved. In alignment with the UN Decade of Ecosystem Restoration, a participatory restoration program was implemented, plantation of 7,500 individuals of 3 medicinal tree and herb species (*Cinnamomum tamala, Amomum subulatum, Zanthoxylum armatum*) across 6 hectares of degraded land were conducted. 60.44% survival rates were recorded among three pilot sites after one year of plantation. The capacity of the villagers was also built through hands-on training in plantation and nursery techniques. Furthermore, the centre is facilitating the preparation of Chapter IV of India's Biennial Transparency Report (BTR-1) and Chapter III of the Fourth National Communication (4NC) of the country, focusing on the impacts, vulnerability, and adaptation strategies for the Himalayan plant diversity under NATCOM, Project. Under NABARD funded projects, CBCM promoted the cultivation of medicinal plants in Hawalbagh and Takula Blocks of Almora district to uplift the livelihoods of rural people. The program aimed to conserve medicinal plant diversity while providing economic benefits to local farmers. The centre conducted a plant functional trait-based evaluation of Himalayan temperate forests under the NMHS project. This study showed an important lead on the plant adaptation of the photosynthetic rates, leaf area, specific leaf area, chlorophyll content, and water use efficiency. These insights are crucial for understanding the impacts of anthropogenic pressures and climate change on forest ecosystems and developing sustainable management strategies. During the reporting period, CBCM has celebrated the international day of biological diversity, wildlife week, World Environment Day, and International Mountain Day. The centre also conducted various seminars, workshops, training, and meetings on diverse themes of Himalayan biodiversity to build the capacity of a wider range of stakeholders. CBCM's multifaceted approach, integrating conservation, restoration, and sustainable utilization of biodiversity, is vital for ensuring the long-term health of the Himalayan ecosystem and the livelihoods of its inhabitants.

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

In the year 2023-24, Centre for Environmental Assessment and Climate Change (CEA&CC) implemented multiple projects, including an in-house project seven externally funded projects, and completed two projects. The In-house project on 'Fostering Climate Smart Communities in the Indian Himalayan Region' aims to assess the vulnerability of the Himalayan communities, develop a decision support system, and foster climate smart communities and climate change leaders in the IHR. The second-third projects mainly pertain to aerosols and gaseous pollutants and their impacts on radiative forcing and temperature rise. Aerosols, including black carbon and gaseous pollutants, have been driving climate change from local to regional levels under the "Aerosols Radiative Forcing over India (ARFI)" and "Atmospheric Chemistry, Transport, and Modelling" programs of ISRO-GBP since 2007 onwards. The fourth is the DST-funded project, which pertains to one of the eight National missions titled "Forest Resources and Plant Biodiversity, TF-3 Phase II (NMSHE; DST, 2021-2026)" under NMSHE TF3, Second Phase. The fifth project funded by DST aims to assess the "Geospatial variability of soil microbial

indices of climate-sensitive alpine treeline ecotone of the Indian Western Himalaya and its linkages to soil organic carbon fractions. Similarly, the sixth project is DST funded project that pertains to "Influence of climate change on Debris-covered Milam Glacier (Goriganga River Basin, Central Himalaya, India): Monitoring and Modelling of Physical Processes Governing Snow and Glacier-fed Watershed Dynamics". The seventh project is 'Microbial Assisted Bio/Phytoremediation of Municipal Waste Dump Sites in the Central Himalaya' funded by NMHS. The centre has finalized the District/State environmental management plans for important environmental issues raised by the Hon'ble National Green Tribunal (NGT), studying gaps and suggesting action plans as policy guidelines. Also, the centre has investigated potential medicinal plants of the Sikkim Himalayan region against breast cancer angiogenesis and subsequent identification and isolation of biologically active molecules and lead structures that can be used to develop effective anti-angiogenic or anti-breast cancer drug leads.

2. Regional Centres

i) Ladakh Regional Centre (LRC)

The Trans Himalayan region of Ladakh is characterized by cold desert climatology with limited precipitation and water resources, inculcating limited opportunity for agricultural practices. Moreover, the current warming scenarios have recently enhanced the threat of disasters such as glacial lake outburst floods, etc. Hence, the primary goal of research and developmental activities of the Ladakh Regional Centre during 2023-24 was to assess present scenarios of the water resources within the region with the formulation of innovative technologies for water management supporting agricultural practices, primarily during harsh winters. Consequently, an inventory of high-altitude glacial lakes of the Kargil districts of Ladakh UT was prepared, detailing 355 glacial and high-altitude lakes encompassing a total area of approx. 4.8 km^2. The study found that the glaciated areas in Kargil are occupied by 85 proglacial and 103 supraglacial lakes, which are sensitive in nature and likely to expand as glaciers retreat. To further explore the status of glaciers within the region, an expedition to the Rulung Glacier, having an elevation of approx. 6000 m asl. was carried out to monitor glacial hydrodynamics. In this endeavor of sustainable water management for agricultural practices, a novel low-cost hydroponic prototype within a polycarbonated greenhouse was devised wherein wastewater from the Faecal Sludge Treatment Plant managed by the Leh Municipal Committee was used for agricultural production. The systematic evaluation of winter leafy and vegetable crops from this facility showed no chemical contamination and was safe for human consumption. Recognizing the importance of Trans Himalayan biodiversity, the first Peoples' Biodiversity Register for the Leh town having 13 wards, supported by Municipal Committee Leh, was prepared. A total of 06 shrubs, 30 herbs, 09 grasses, 01 climbers, 11 medicinal plants and 4 timber plants, along with 87 birds, 10 mammals, 45 insects, 3 fishes, and 01 reptiles were identified. To promote ex-situ conservation for threatened and high-value medicinal plants of the region, the centre had standardized cultivation techniques for *Inula racemosa* under Hydroponic, Polyhouse, and Open-Soil. Documentation of vegetation diversity within the region through NMSHE Task Force – 3 activities resulted in identification of a total of 37 families, 79 genera, and 58 plant species across the Drass and Suru valleys. During 2023-24, one of the unique activities of the Centre was to mainstream passive solar heated buildings (PSHBs) in the Ladakh region, wherein 59 such PSHBs from this region were surveyed to document their various aspects viz. typology, age, design, orientation, construction material, thermal efficiency. etc. In addition, real time in-situ thermal performances of selected 04 PSHBs were also carried out. The physical, real and effective carrying capacities were estimated under the Mountain Division supported project on tourism carrying capacity estimation for Leh Town Complex. This assessment is anticipated to provide valuable insights into managing tourism in Leh while preserving its cultural and historical significance. The centre had also organized 10 hands-on training on integrated mushroom cultivation and basket weaving using local natural resources, and a total of 127 villagers participated in these events.

ii) Himachal Regional Centre (HRC)

During the reporting year, a spring inventory of 80 springs from the Kullu district of Himachal Pradesh was prepared. The Water Quality Index was also calculated for the collected water samples. Isotopic studies for stable isotopes of δ18O and Hydrogen δD were conducted for the identification of recharge to springs. The Unnat Bharat Abhiyan (UBA) Questionnaire Survey for 2028 households in the identified villages of 10 districts of Himachal Pradesh has been completed. As per the survey, it has been observed that climate related hazards, including landslides, flash floods, avalanches, and cloudburst have increased and crop productions are also decreasing due to increased incidents of insect pest diseases in both Kinnaur & Sirmour district which directly impacting local communities' economy adversely. Established 6 herbal gardens at various Schools in Kullu district and high value medicinal plants cultivation is being promoted in the farmer's field by providing quality plant and seed material to interested cultivators/farmers. Seeds of medicinal plants i.e., *Aconitum heterophyllum, Inula racemosa, Saussurea costus, Angelica gluaca* (3 kg. each) were distributed to the farmers. Prepared inventory of flood hazard incidences of the last 10 years in Beas Basin, Kullu. Geotagging of flood vulnerable sites in Beas basin of Kullu valley region has been completed and NDVI (Normalize Difference Vegetation Index) of Beas Basin in Kullu Valley has been done. A processing unit has been established at Lahaul and Spiti, equipped with essential equipment such as Solar dryers, Microwave dryer, Fruit pulpers, weighing machines, sealing machine, etc., with project activity expansion to entire Lahaul Valley and establishment of Women Enterprise on Sebuckthorn in Lahaul Valley has been done. LULC study from 2010 to 2020 was done for Lahaul & Spiti district of Himachal Pradesh and temperature data of 12 years from 2010 to 2022 were analyzed. Water Quality Index (WQI) study of 30 springs of Lahaul & Spiti district was done, revealing an overall excellent water quality of 22 springs and with good quality of the remaining 8 springs. Listing of 159 allocated PBRs has been done. For monitoring Gaseous air pollution in the background sites of sprawling urban environments in Himachal Pradesh, the ARIMA model used for projections using specific parameters (1,0,0), and O3 was found within its permissible limit till December 2025. Seasonal variability of surface ozone was also monitored using satellite data. Under the study, aerosol climatology over the north-western Indian Himalayan region, AOD values at shorter wavelengths are higher indicating an increase in anthropogenic activities. Mean AOD500nm at Mohal (1154 m AMSL) in 2023 stood to be 0.42±0.0 followed by 0.39 in 2022 as maximum and minimum 0.22 in 2007. Black carbon shows a bimodal peak, average concentration of black carbon peaked 1348.4±84.4 ngm^{-3} in 2023 and 2345.2±154.4 ng m^{-3} from 2009 to 2023. Documentation and questionnaire of traditional and Passive Solar Houses in Spiti & Kinnaur district of Himachal Pradesh has been done with 1053 respondents across 23 villages in Spiti and 60 respondents in 5 Kinnaur villages. Analyzed environmental data (solar irradiance, rainfall patterns, land cover) to evaluate Spiti's average insolation of 5.79232 (kWh / m^2 / day) indicating high solar energy potential. To understand the study area, various maps were created: Rainfall erosivity map, Soil texture map, Soil erodibility map, Interpolation map of soil available potassium, Land use land cover map, NDVI map, and Sediment transport index maps. Database of contribution of permafrost active layer (up to 30 cm) in terms of dissolved organic and inorganic carbon and nitrogen (DOC, DOM, DON and DIN) for the year 2020, 2021, 2023 (July-August and September- October) in thawed soil and in nearby water bodies is generated. A total of 38 training cum capacity-building programmes have been organized during the reporting year for the various groups of stakeholders.

iii) Garhwal Regional Centre (GRC)

The main research focus areas for this reporting year (2023-24) were the assessment and management of spring ecosystems, the creation of community-driven ecosmart model villages to support climate smart communities, the development of biodiversity databases, assessment of genetic diversity, establishment of propagation protocols and conservation of MAPs. A baseline spring inventory of the villages lying in the Pabo block, Pauri district was conducted. The household and demographic assessments (socioeconomic profiles, forest resources, livestock, and land use) in Barsu village cluster, district Rudraprayag, Uttarakhand, have been completed as a part of the in-house projects. Apart from this, the DNA sequence information of 152 accessions of Rajmash from Uttarakhand has been analyzed and submitted to the NCBI database. Genetic resources developed through this study could be utilized by the breeders for germplasm identification and conservation of common bean accessions from Uttarakhand. Further, towards the strengthening of the plant

diversity dataset of Indian Himalayan Region, total of 6638 flowering plants distributed in 1539 genera and 139 families have been documented, which includes 5535 dicotyledons (1307 genera and 127 families) and 1103 monocotyledons (232 genera and 12 families). The life cycle of the medicinal plant *Malaxis acuminata* was evaluated for the first time to investigate the principal growth stages of the species. GRC has conducted eight outreach events, including workshops, training, demonstrations, and other activities, to raise awareness among the mountain communities about rural technologies, water and biodiversity conservation, and sustainable utilization of mountain resources.

iv) Sikkim Regional Centre (SRC)

Sikkim Regional Centre has been taking up R&D activities on environmental, ecological and social aspects in Sikkim Himalaya. During the current year (2023-24), major focus of the activities of the Centre was towards climate-tree growth projection of selected tree species in IHR, reconstruction of pollution history and heavy metal concentration using tree rings of selected tree species from eastern Himalaya, spring rejuvenation and sustainability, improving livelihood and ecological security, fostering climate smart communities, biodiversity conservation, ecological dynamic and ecosystem health of selected high altitude wetlands, development of soilless plant production system as hydroponic system for commercial crops, genomic resource creation for medicinal plant species, genetic and chemical diversity analysis for management of conservation and cultivation and strengthening of Nature Learning Centre through the implementation of 4 In-house projects, 6 externally funded projects and one fellowship programme. Under the In-house projects, classification of agro-climatic zones of Sikkim based on elevation and geographical characteristics, elevation-wise classification of districts with respect to their elevation range, baseline data (geo-tagging and physical parameters) of springs, 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 DBT-funded project, chemical profiling of different solvent extracts of *Hedychium spicatum* was conducted using LC-ESI-MS/MS analysis for the identification of potential chemical constituents and elite germplasm was identified based on essential oil yield and its GC-MS analysis. Under the NABARD-funded project, different types of hydroponic models were developed for commercial crops, and based on the performance of different crops, best model type, nutrient solvents and supporting materials were identified. Under the Mountain Division Fellowship program, good soil and water conservation practices adopted by local communities were validated and patterns of water consumption and demand & availability were assessed, and framework for economic valuation and cost-benefits analysis of managed aquifer recharge in eastern Himalaya was prepared. Under NMSHE Task Force-3 (Phase-II) project, the reconstruction of pollution history was carried out for the past 123 years (1900-2022) using *Tsuga dumosa* tree ring samples and for 60 years (1960-2022) using tree ring samples

of Pinus roxburghii. The concentration of major heavy metals in both species was studied. Further, using the dendrochronological technique, quantified and predicted the future growth trend of Himalayan cedar (*Cedrus deodara*) and explored its spatial growth variability under two different climatic regimes (monsoon dominated rainfall and westerly disturbances dominated site) from 17 deodar sites in the Hindukush Himalayan Region under RCP 4.5 and RCP 8.5. Under the NHHS-Glacier project, damage occurred due to the Sikkim Glacier Lake Outburst Flood Event of South Lhonak Lake in October 2023 was assessed. Under the NHHS-Solar passive heating project, traditional houses are made up of vernacular, which includes wooden planks/bamboo walls and floors, mud floor, tin sheet roofs, supported by wooden pillars were studied. The centre also organized various workshops (e.g., a workshop on the Assessment and monitoring of high altitude wetlands, scoping workshop on synergies efforts for co-creation and networking of knowledge, a brainstorming workshop on feasibility assessment of the solar passive heating system, a regional workshop on Sustaining the Himalayan landscapes for identifying challenges and priorities for North East Himalaya, etc.), awareness, training and capacity building programme (e.g. state level interface meeting with different government departments of Sikkim, focus group-cum-expert meeting organized in Tripura in collaboration with Tripura University, training workshop on integrated beekeeping for fostering climate resilient communities and ecosystem-based adaptation in Sikkim Himalaya, etc.) and exposure events for farmers, government officials of state departments, school and university level students for dissemination of the knowledge and extension of activities. This year the Sikkim Regional Centre contributed towards scientific excellence of the Institute through 23 publications, including 15 peer-reviewed research papers, 6 book chapters, and 2 edited books.

v) Northeast Regional Centre (NERC)

The northeastern region is a critical ecological and socio-economic zone facing multifaceted challenges. This executive summary encapsulates the endeavors and accomplishments of various projects to address these challenges and foster sustainable development in the region. During the reporting year, the NERC has undertaken various R&D programs in alignment with the Institute's mandates covering forest resources and biodiversity, the impact of forest fires on vegetation and soil health, water security, and socio-economic empowerment of local communities, including climate change as the cross-cutting theme. Under the NMSHE Task Force-3 project, three Long-Term Ecological Monitoring (LTEM) sites were established in Tawang district, Arunachal Pradesh. LULC classification and change detection have been done for NE India for the years 1991, 2001, 2011, and 2021, and forest fire susceptibility zones were identified in northeast India. Short-term projects to study the impact of forest fires on vegetation dynamics, proliferation of invasive species and soil health were acquired with funding from the Dept. of Environment & Forests, Govt. of Arunachal Pradesh. Preliminary works have been done, including a literature review and documentation of past forest fire areas in Arunachal Pradesh. Under the four major in-house projects, significant impact has been made in the field through mapping and geotagging of springs in the Lower Subansiri district, comprehensive landslide inventory for seven states of northeast India, creation of a comprehensive fern species database for Arunachal Pradesh, including species distribution models for current and future scenarios, and socio-economic survey of different villages. Several training and capacity building programmes were also conducted under these projects to create a cadre of para-hydrologists, para-taxonomists, and change leaders in green livelihood interventions and biodiversity conservation. During the reporting period (2023-24), the NERC collaborated with different institutes and universities and organized nearly 41 events, such as conferences, workshops, training and awareness programs, and celebrations of national and international days. Two major events include (i) a special session on "Himalayan Biodiversity & Climate Change: Strengthening Monitoring and Regional Cooperation in North East Himalaya" at the International Conference held at Assam Agricultural University (AAU), Jorhat and (ii) Workshop on "Navigating Species Distribution Models: From Theory to Practical Training for Plant and Animal Species Distributions" at the Indian Regional Association of Landscape Ecology (IRALE) Conference 2024 in West Bengal. Within the state of Arunachal Pradesh, the NERC has jointly organized different events or involved resource persons from different Research Institutes and Universities, viz., Rajiv Gandhi University, Himalayan University, SIRD&PR, Dept. of Urban Development & Housing, Govt. of AP, Dept. of Environment & Forests, Govt. of AP, Arunachal Pradesh State Biodiversity Board, Botanical Survey of India, Zoological Survey of India and several local schools and colleges. Dissemination of works has also been done through publication of journal articles, books and booklets, training manuals, and articles in magazines and newspapers.

vi) Mountain Division Regional Centre (MDRC)

The Himalayan region is a unique treasure of environmental goods and services and a rich repository of biodiversity, including cultural and ethnic diversity. Realizing its sensitivity to climatic and anthropogenic perturbations, a dedicated centre as "Mountain Division" was established 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 the conservation of mountain ecosystem and sustainable development of the mountain regions. The envisaged broad objectives of the Mountain Division are i) To contribute to the sustainable development of mountain ecosystems in an integrated manner within divisions of the ministry and across the key ministries; ii) To sharpen focus on mountain issues by bringing in "Mountain Perspective" across policies, programmes, missions, and schemes; iii) To foster linkages between upstream and downstream regions by influencing policy & planning based on mutual dependence; iv) Develop a suitable framework of incentives for providers of ecosystem services. To achieve the objectives of the division, various project-based studies are launched through Himalayan Research Fellows and Associates.

1. INTRODUCTION

During the year 2023-24, various R&D activities were executed by the Institute, focusing on environmental conservation and sustainable development across the IHR through its HQs at Kosi-Katarmal (Almora) and Regional Centres, viz., Himachal Regional Centre (Kullu), Garhwal Regional Centre (Srinagar-Garhwal), Sikkim Regional Centre (Pangthang), NE Regional Centre (Itanagar), Ladakh Regional Centre (Leh) and Mountain Division Regional Centre (MoEF&CC, New Delhi). In all the R&D activities, a major thrust has been to deal with issues of environmental conservation and sustainable development in the IHR, develop region-specific approaches, demonstrate their efficacy in the field, and disseminate information to various stakeholders. The diverse problems thus addressed through in-depth research on bio-physical and socio-economic aspects of the mountain environment, devising R&D-based strategies for natural resource conservation and management, documenting traditional practices, promoting livelihood opportunities, developing approaches for biodiversity conservation, devising mitigation measures to the impact of climate change, biotechnological applications for conservation of important plant taxa, etc. The Institute implements its activities through core funds provided by the MoEF&CC, Govt. of India, and projects sponsored by external funding agencies (National and International). The Institute also funds the R&D activities of partner Institutions in different Himalayan states through the Integrated Eco-development Research Programme (IERP) and National Mission on Himalayan Studies (NMHS). The Scientific Advisory Committee (SAC) of the Institute reviews the progress of existing projects annually and guides the development of new R&D programmes. All these R&D projects are implemented through the four Centres of eminence: (i) Centre of Land and Water Resource Management (CLWRM), (ii) Centre for Socio-Economic Development (CSED), (iii) Centre for Biodiversity Conservation and Management (CBCM), and (iv) Centre for Environmental Assessment and Climate Change (CEA&CC), and the region-specific issues of the IHR are addressed by Regional Centres such as (i) Ladakh Regional Centre (LRC), (ii) Himachal Regional Centre (HRC), (iii) Garhwal Regional Centre (GRC), (iv) Sikkim Regional Centre (SRC), and (v) North-East Regional Centre (NERC), and (vi) Mountain Division Regional Centre (MDRC) housed at MoEF&CC, New Delhi lookafter the policies and programmes related of the Indian Himalayan region. During the reporting period, R&D work was pursued on various projects across the IHR. The summary of these projects' major outputs/outcomes is given in this report, along with the summary of completed projects. In time, relevant detailed documents will be published and available to the various stakeholders. Particular thrust will be placed on bringing out policy imperatives to handle the region's front-running environmental issues. This report presents a brief account of academic and other activities, along with the statement of accounts for 2023-24 carried out under various in-house and externally funded projects. The Institute would be happy to receive critical comments and suggestions for improving the quality of outputs of various R&D activities.

2. MAJOR EVENTS

India's G20 Presidency and Sustainable Development in the Himalaya.

The Institute in collaboration with the HNB Garhwal University (A Central University), Srinagar-Garhwal, Uttarakhand organized a national conference cum brainstorming on the India's G20 presidency on April 17, 2023 at Srinagar Garhwal. The conference presents a significant opportunity for the country to strengthen its global role and contribute to sustainable development. A conscious effort is made to mobilize a variety of stakeholders (students, researchers, academicians, policy makers and others) together with the developmental process. The key policy recommendations of the "One Himalaya One Policy" include, (i) Implement "Carbon footprinting" approach to establish the Ecosystem Integrity Index (EII) in the IHR, (ii) Identify Ecologically Sensitive Zones (ESZ) and establish a Himalayan Biobank, and provide tangible and transferable credits to mitigate biodiversity loss, (iii) Enable biodiversity-motivated subsidies and payments for ecosystem services to promote green cover and reduce GHG emissions in the IHR, (iv) Ban multilayer plastic and establish Waste Management Boards/Commissions at the state level to promote eco-friendly, biodegradable packaging materials in the IHR and to streamline waste management policies, (v) Promote ECC (Ecological Carrying Capacity)-based tourism and 'Climate Smart Index' methodology and investment planning framework to identify and secure funding for climate-resilient and sustainable projects, (vi) Strengthen research institutions in the IHR to address policy issues, bridge technological gaps, and contribute to sustainable development and effective governance, and (vii) Empowering indigenous community institutions for the management of CPR to adapt climate change mitigation initiatives through indigenous knowledge systems by them. Over 60 participants from the diverse organizations attended the conference cum brainstorming.

Scientific Advisory Committee Meeting

The XXXI Scientific Advisory Committee (SAC) meeting was organized at HQS Almora (May 3-4, 2023). The first day of SAC (3rd May 2023) was organized as Knowledge Sharing Day. On this day, Dr. Kalachand Sain, Director, Wadia Institute of Himalayan Geology (WIHG) delivered a keynote lecture on Geohazards. It was followed by group discussions. During the Knowledge Sharing day, all the scholars of the institute along with scientific faculty participated. On the second day (4th May 2023) the Institute organized its XXXI SAC at the headquarters, Almora to review the ongoing scientific progress of the Institute. The meeting was organized under the chairmanship of Dr. Eklabya Sharma, Vice Chancellor, TERI University. Among the SAC members, Prof. Arun Kumar Saraf, Prof. R. M. Pant, Prof. Sandeep Tambe, Dr. Kalachand Sain, Dr Dhriti Banerjee, Prof. Sunil Nautiyal, Director, NIHE and Institute members Dr. Rajesh Joshi, and Dr. Arun Jugran participated in the SAC meeting

International Day for Biological Diversity

The headquarters of the institute and all regional centres have celebrated the International Day for Biological Diversity (IBD) on the theme "From Agreement to Action: Build Back Biodiversity". In HQs, the day was celebrated with a brainstorming session at Surya Kunj with a wide range of stakeholders. Over 91 participants including members from Vyapar Mandal, research scholars, and scientists from the GBPNIHE, teachers and students from different schools of district Almora participated. The discussion revolved round on the restoration of degraded land so that biodiversity can be brought back. At the Ladakh Regional Centre (LRC) of the Institute, the day was celebrated in collaboration with the Municipal Committee Leh (MCL). Dr. Ishey Namgyal, President of MCL, chaired the program, while Dr. RK Goyal, Head of CAZRI-Leh, and Mr. Sajjad Hussain Mufti, IFS, Chief Wildlife Warden, Ladakh UT, were the Guest of Honour. During the event, the 1st Biodiversity Management Committee (BMC) meeting was also conducted with the presence of BMC members, including Dr. Ishey Namgyal, President, MCL (BMC-Chairman), Shri StanzinRabgais, Executive Officer, MCL (BMC-Secretary). Dr. Lalit Giri presented the progress on the Peoples' Biodiversity Register, highlighting the rich biodiversity of the 13 wards of the Leh Municipal area. The PBR project has documented 217 forest biodiversity and 157 domestic biodiversity species, including 86 birds, 50 insects, 10 mammals, 11 medicinal plants, 9 types of grasses, 32 herb species, 107 horticulture plants, and 9 domestic animals, etc. Similarly, the Sikkim Regional Centre celebrated IBD at Government Junior High School Pangthang. During the program, a total of 40 students, as well as teaching and non-teaching staff, participated. After the brief introduction to the program, an interactive activity called 'Know your Biodiversity' was conducted for students to give them exposure to nature and understand the important resources around them.

World Environment Day

The World Environment Day (June 5 2023) was celebrated by the Institute on its HQs Kosi-Katarmal, Almora, and all the regional centres i.e., NERC, Itanagar; SRC Pangthang; LRC Leh; HPRC Kullu; and GRC Srinagar under the campaign "Beat Plastic Pollution". At NERC The event was held at Gellam Memorial High School, Itanagar. It aimed to raise awareness among students and the public about the crucial need to protect our environment for future generations. The event drew over 100 participants, including faculties and researchers from NIHE-NERC. The event was divided into two sessions to engage the students actively. The first session featured a Competition for Slogan with Poster Making, while the second session consisted of a Drawing Competition, both centred on the theme of "Beat Plastic Pollution". Similarly, at SRC, over 200 people were sensitized to the 3 R'S (refuse, reuse, and reduce) of plastic uses and waste segregation. In an interactive activity on 'Ecological Print', students were given exposure to nature and an understanding of the importance of World Environment Day. 25 saplings of medicinal plants and wild edible plants were planted on the school campus. The LRC of the institute celebrated the day at Government High School Stok, Leh, Ladakh UT. The school children were made aware of the environment and its concurrent issues with a special discussion on the WED-2023 theme 'solutions to plastic pollution'. A drawing competition on 'Environment Issues' was also organized for junior (Class III-VI) and senior (Class VII-X) classes in the school. Besides, students were encouraged to adopt an environmentally friendly lifestyle under various themes of Mission LiFE, viz. Save Energy and Water, Adopt Healthy Lifestyles, Reduce Waste, and Adopt Sustainable Food Systems. A total of 55 participants attended the event, including school children, school teachers, institute faculty, researchers, and other staff. All the participants also took the LiFE pledge to protect the environment. At HQs, the day was celebrated with researchers and school students and was focused on the theme 'Beat plastic pollution'.

National Conference on "India's G20 Presidency & Green-growth Strategies for Sustaining Himalayan Societies under Changing Climate: Policy, Pathway & Tools"

The Institute, in collaboration with the National Centre for Sustainable Coastal Management (NCSCM), Chennai, Tamil Nadu organized a National Conference," India's G20 Presidency & Green-growth Strategies for Sustaining Himalayan Societies under Changing Climate: Policy, Pathway &Tools" on June 27-28, 2023 at NIHE, HQs, Kosi-Katarmal, Almora. A total around 45 institutions/organizations participated in the above conference. A total 61 research papers were presented in these two days conference. The main aim of above conference was to address the challenges faced by Himalayan societies in the context of climate change and explore green growth strategies for the sustainable development of the Himalayan region. The conference provided a platform for researchers, policymakers, experts, and stakeholders to share knowledge, experiences, and research findings related to India's G20 Presidency and the sustainable development of Himalayan societies. It also helped foster dialogue and collaboration among participants from diverse backgrounds, including academia, government agencies, non-governmental organizations, and local communities, to develop a holistic understanding of the issues and challenges faced by the Himalayan region. During the conference, discussion and deliberation were mainly focused on green-growth strategies that integrate environmental sustainability, social inclusivity, and economic development to ensure the well-being and resilience of Himalayan societies. The conference also generated recommendations and actionable insights for policymakers and stakeholders to design and implement effective policies, projects, and initiatives to address the unique challenges of the Himalayan region under changing climatic conditions.

Workshop on "Assessment of Traditional Knowledge on Passive Solar Heated Buildings (PSHB)

LRC Organized a workshop on "Assessment of traditional knowledge on Passive Solar Heated Buildings (PSHB) across IHR" in collaboration with the Himalayan Institute of Alternatives, Ladakh (HIAL) on 10th September 2023 to understand various challenges and opportunities pertaining to their scientific evaluation and upscaling. The workshop was organized under the aegis of the National-coordinated project titled 'Mainstreaming Passive Solar Heated Buildings in the Indian Himalayan Region: Integrating modern science with traditional practices to enhance climate resilience'. In this workshop, a keynote lecture was delivered by Shri Sonam Wangchuk, Founder & Director HIAL, wherein he presented a comprehensive overview of the origin and evolution of PSHBs in the Trans-Himalaya. He highlighted that PSHBs can recover their entire cost in 10 years of fuel budgets of a conventional building. Dr. Mohammad Deen Retd. IAS, Founder LEHO, Leh, highlighted a need for policy formulation for upscaling PSHBs across Ladakh along with awareness generation among the masses. A total of 35 participants have participated in the workshop.

Governing Board Meeting

The Institute organized the 45th meeting of the Governing Body of G.B. Pant National Institute of Himalayan Environment (NIHE) on July 5, 2023, 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), Prof. S.K. Mishra, Professor & Former Head, Indian Institute of Technology, Roorkee, Shri Hem Pande, Dwarka, New Delhi (Member), Shri B.M.S. Rathore, Bhopal, M.P. (Member), Shri. C. Achalender Reddy, Chairperson, National Biodiversity Authority (Special Invitee), Shri. Raghu Kumar Kodali, Scientist-G/Director, MoEF&CC (Special Invitee), Shri R. Prabhakar, Representative DG Forest, MoEF&CC and Prof. Sunil Nautiyal, Director, NIHE (Member Secretary) were present. The Chief Secretary, Govt. of Uttarakhand, Secretary, Department of Biotechnology, Govt. of India, and Dr. V.P. Dimri, Former Director & CSIR Distinguished Scientist, Hyderabad could not attend the meeting. During the meeting various issues on R&D of the Institute were presented and discussed.

Consultation Workshop on Promotion of Cultivation Techniques for High Altitude Medicinal Plants of Arunachal Pradesh

A one-day Stakeholders' Consultation Workshop on 'Promotion of Cultivation Techniques for High Altitude Medicinal Plants of Arunachal Pradesh' was held on August 25, 2023, at D.C. Conference Hall, Tawang, Arunachal Pradesh. The Workshop was jointly organized by GB Pant National Institute of Himalayan Environment and State Medicinal Plants Board, Department of Environment, Forests and Climate Change, Govt. of Arunachal Pradesh. The DC in-charge, Tawang, Shri Rinchin Leta, was the Chief Guest, while the Divisional Forest Officer (DFO), Tawang Shri Piyush Gaikwad, IFS was the Guest of Honour in the Workshop. About 62 participants attended the Workshop, including representatives from the Departments of Agriculture, Horticulture, DRDA, BDO Tawang, local NGOs, Gram Panchayat Chairpersons, Medicinal plant cultivators, officials and staff of DFO Tawang, and scientists and research scholars of NERC of GBPNIHE.

Annual Day Celebration

The 35th Annual Day of the Institute was celebrated at its HQs Kosi-Katarmal, Almora, and all the regional centres, i.e., LRC Leh, HRC Kullu, GRC Srinagar, NERC Itanagar, and SRC Sikkim on September 10, 2023. Also, the 29th G.B Pant Memorial Lecture was delivered by renowned ecologist Prof. Mohammed Latif Khan, Senior Professor, Dr. Harisingh Gour Vishwavidyalaya (A Central University) on 'Bridging Voices and Visions: Empowering Communities for Climate Resilience in the Forests'. Shri Ajaya Tamta, Hon'ble Member of Parliament, Lok Sabha presided over the event. Around 300 participants, including dignitaries of different organizations, including Prof. S.P. Singh, Former VC, HNBGU, Prof. RK. Maikhuri, Department of Environmental Sciences HNBGU, Mr. Shekhar Ghimire, Director Administration, Finance and Operations, ICIMOD, Nepal, Dr. Sanjeev Bhuchar, Intervention Manager – Spring, ICIMOD, Nepal, Prof. Lalit Tiwari, Department of Botany, Kumaun University, Nainital, Shri Arvind Nautiyal, Joint Secretary, MoEF&CC, GoI, Dr. BS Kalakoti, Director, Monard Industries Pvt. Ltd. Haldwani, etc., participated. On this occasion Smt. Ila Pant, Member of Parliament, 12th Lok Sabha, daughter-in-law of Pt. Govind Ballabh Pant Ji & President, G.B. Pant Memorial Society, New Delhi, visited the Institute headquarter, Almora. During the visit she first offered the garlands to the newly established statue of Pt. Govind Ballabh Pant Ji followed by a meeting with the Institute faculty. Smt. Pant appreciated the work carried out by the institute across the I.H.R. and said that Pt. Pant was nature lover and affectionate towards the mountains. Director of the institute welcomed her and briefed her about the institutional activities and initiatives. At LRC Popular Lecture Ladakh Series: 4 was delivered by Shri JigmetTakpa, IFS & Principal Chief Conservator of Forests, Ladakh UT (Retd.) on the title "Exploring the Marvels of Himalaya and Shaping the Future Environmental Research". The event was chaired by Hon'ble Shri Stanzin Chosphel, Executive Councillor – Agriculture, Leh, Ladakh UT. The event was attended by Dr. S. K. Mehta, Vice Chancellor, Ladakh University, Leh; Dr. O. P. Chaurasia, Director, Defence Institute of High-altitude Research, Leh, and Shri Eshay Namgail, Chairman, Municipal Committee, Leh. Moreover, scientists and researchers from ICAR-Centre for Arid Zone Research Institute (CAZRI), Leh and National Institute

of Sowa Rigpa (NISR), Leh, and LRC-NIHE also participated in the event. At HPRC, the day was celebrated, and the 10th Himalayan Popular Lecture was delivered by Prof. (Dr.) T. C. Bhalla, Former UGC-BSR Faculty Fellow and Dean, Department of Biotechnology, Himachal Pradesh University, Shimla on "Microbial Diversity and Resources of Himachal Pradesh". The NERC celebrated the day and the 10th Pt. Govind Ballabh Pant Himalayan Popular Lecture was delivered by Prof. Abhaya Prasad Das, Professor (Retd.), North Bengal University & Adjunct Professor (UGC), Rajiv Gandhi University, Arunachal Pradesh on the topic "Effects of Climatic Amelioration on Environment, Biodiversity, and Future of the Biosphere". Shri Jitendra Kumar, IFS, Principal Chief Conservator of Forest (PCCF), Arunachal Pradesh, attended as Chief Guest, and Prof. Sumpam Tangjang, Dean Faculty of Life Sciences, Rajiv Gandhi University, Arunachal Pradesh graced the event as Guest of Honour. Prof. K.K. Sharma, Vice-Chancellor, Himalayan University and Shri. Gautam Saha, Deputy Director General, Geological Survey of India, Arunachal Pradesh, attended the function as Special Guests. A total of 61 participants, including scientists and faculties from different organizations, including BSI-APRC, ZSI-APRC, SRSAC, APSC S&T, D.N. Govt. College, Rajiv Gandhi University, and Himalayan University, along with NERC staff, attended the programme. At GRC, Prof. M.C. Nautiyal, Director - High Altitude Plant Physiology Research Centre, H.N.B. Garhwal University, Srinagar Garhwal delivered the 10th Popular lecture entitled 'Prospects of conservation and cultivation of some important Himalayan medicinal and aromatic plants'. The SRC celebrated the Annual Day function of the Institute at its campus at Pangthang, it was presided over by Prof. Avinash Khare, Hon'ble Vice Chancellor, Sikkim University, Sikkim. On this occasion, 10th Himalayan Popular Lecture was delivered by Dr. Eklabya Sharma, Chairman of the Scientific Advisory Committee, NIHE, Strategic Advisor and Distinguished Senior Fellow, ATREE, and Former Deputy Director General, ICIMOD on "Hindu Kush Himalaya vis-à-vis Indian Himalayan Region: Transformation for Resilience and Sustainability". During the event, publications of the Sikkim regional centre, including a book entitled "Cultures and Indigenous conservation practices of Lepcha community in KL, India," were released. On this occasion, over 90 participants were present.

Workshop on Rethinking Ecosystem-based Approach (EbA)

A three-day workshop on Science-policy Dialogue And multi-stakeholder interaction on 'Rethinking Ecosystem-based Approach (EbA) for water, livelihoods, and disaster risk reduction in the Indian Himalaya' co-organized by the Institute in collaboration with ICIMOD, Nepal, during 11th Sep 2023-13th Sep 2023. A total of 78 participants, including domain experts, representatives of line agencies and departments, Scientists and Scholars, actively participated. The major recommendations of the event were (i) Springshed management needs to be introduced in all the policies at the state and central government levels. At present, the Ministry of Jal Shakti (Govt. of India) already has a national-level committee for springshed management, so similar other policy level interventions are required, (ii) There is a need to establish a nodal agency (e.g., NITI Ayog, MoEF&CC etc.) State-level agency required which can act as a data hub, (iii) There is a need to prepare clear guidelines at the state level. At present, there are few policies/ guidelines (e.g., Watershed guidelines 2.0) but the role of state government agencies is not clearly defined, so this needs to be done as priority, (iv) The importance of the Role of the judiciary in the formulation of policy guidelines is to be defined, (v) Recognition of Indigenous knowledge and its inclusion at the policy level in springshed development programs, (vi) It is essentially required to do the hydrological mapping of springs/ springsheds across IHR which is a transboundary issue, so such types of policies need to be designed, and (vii) Fiscal Policies on springshed management and incentive-based implementation.

Hindi Pakwada

The Institute headquarters and regional centres celebrated "Hindi Pakwada" from 14 to 28 September 2023. The event aimed to promote the Hindi language in government work and to use the Hindi language officially. During the pakwada, several activities including easy writing, English-to-Hindi translation, Hindi dictation, poetry recitation, painting, noting and drafting, etc., were organized for the scientific staff, technicians, researchers, and contractual staff. The prizes were distributed to the winners of various competitions. A total of 64 participants have participated in the event.

International Conference on Himalayan Environment in Changing Climate Scenario

The Institute organized the International Conference on Himalayan Environment in Changing Climate Scenario on September 19-23, 2023, in collaboration with the University of Ladakh with a "Special Session on Mountain Biodiversity Status, Impacts and Livelihood Potential in Indian Himalayan Region". The Inaugural Session of the event was chaired by Shri Ghulam Mehdi, the Hon'ble Executive Councilor (Forest/Minority), LAHDC, Leh. Other respected chairs of the session were Prof. Zafar Reshi, Registrar, Kashmir University, Shri Ishey Namgyal, President, Municipal Committee, Leh, and Prof. Padma Gurmet, Director, National Institute of Sowa Rigpa (NISR), Leh. Dr. Zafar Reshi, in his opening remarks, highlighted the importance of such workshops for sharing ideas and identifying issues related to climate change and biodiversity in the Trans Himalayas. Dr. Gurmet highlighted the importance of local medicinal plants for Aamchi System of Ladakh. Dr. Ishey Namgial, welcomed the preparation of People Biodiversity Register for Leh town by NIHE and MCL, and asked for further R&D collaboration. Hon'ble Shri Ghulam Mehdi, Executive Councilor (Forest), LAHDC, Leh, in his Inaugural remarks, highlighted the importance of the biodiversity of Ladakh and highlighted that the Ladakh region boasts a significant number of migratory and local birds except for cold desert climatology. During Session – 1, two lectures were delivered by Prof. Zafar Reshi, Kashmir University, and Dr. Padma Gurmet, Director, NISR, Leh, on assessing biodiversity and ecosystem health status across IHR. During the session – 2, the keynote lecture was delivered by Prof. S.A. Romshoo, Vice Chancellor, Islamic University of Science and Technology (IUST), J&K. He highlighted the importance of glaciers and their monitoring in the changing climate. The second keynote lecture of the session was delivered by Dr. Subrat Sharma, Former Scientist, NIHE highlighted the tree line shift in the Himalayan region as an impact of changing climate. A brief panel discussion was held after the lectures. The third session started with the Keynote Lecture by Dr. Pankaj Tewari, Executive Director, Aarohi, Uttarakhand. His talk was focused on the sustainable utilization of bio-resources and converting them into market products. The second keynote lecture of the session was delivered by Dr. Mahesh Gaur, principal scientist at CAZRI, Leh. He provided an overview of the physical land use pattern of Ladakh region and how it has changed over the years. Dr. Bhaskar Padigala, Head, Climate-Hub, WWF, India, also delivered the Keynote lecture at the event. He touched on some of the most important parts for implementing all these challenges in changing climate. A total of 120 attendees participated in the conference.

Demonstration of sustainable livelihood-centric technologies

The G.B. Pant National Institute of Himalayan Environment presented technologies centric to sustainable livelihood at the Field Technology showcase in Champawat District from 18-19th October 2023. Innovative technologies include pine needle-based products bio-briquette, paper-based products making; medicinal plant cultivation, value addition, and product making; Jaldahara Mobile App for in situ spring data acquisition, etc. The event was jointly organized by UCOST, Uttarakhand, and AGNIi, Govt. of India, at different places in the district Champawat under the Aadarsh Champawat initiative of Govt. of Uttarakhand, India. Dr. Aseesh Pandey and Er. Ashutosh Tiwari has demonstrated these technologies to the school children villagers and Ms. Dhami, wife of Hon,ble CM of Uttarakhand, was the chief guest and head of various line departments such as the Department of Forest, Department of Horticulture, etc., was also present in the event. All the line departments appreciated NIHE initiatives and showed their willingness to adopt these technologies in Champawat. District Magistrate Champawat and Dr. Durgesh Pant, DG UCOST Dehradun, also attended the event.

International Mountain Day

The Institute celebrated International Mountain Day (IMD) at its HQs Kosi-Katarmal Almora and regional centres across IHR on 11 December 2024 under the theme "Restoring Mountain Ecosystem". Centre for Biodiversity Conservation and Management of the institute organized a brainstorming session. During the event, Prof. Sunil Nautiyal (Director, NIHE) highlighted the importance of International Mountain Day and discussed various mountain systems of India, including Himalaya. He said Himalaya is the youngest and most sensitive mountain system and thus requires urgent conservation action to save its rich and unique biodiversity. Prof. Nautiyal also praised the centre's efforts in eco-restoration of Oak species in a Pine dominated area in Surya Kunj. Dr. I. D. Bhatt (Head, CBCM) discussed the theme "Restoring Mountain Ecosystem". The programme further continued with the discussion of researchers and subject experts. Similarly, at LRC of the Institute organized a seminar on this occasion wherein Dr. Tsewang Namgail, Director Snow Leopard Conservancy India Trust, delivered a lecture titled "Mountain: the fountain of life". The lecture was followed by an open discussion on the natural resource conservation of Ladakh, which was participated by Shri Rohit Rattan, Head: World Wildlife Fund (WWF), Ladakh; Shri Tsewang Dorjey, NABARD, Leh.

State level interface meeting with different Government departments of Sikkim

The Sikkim Regional Centre of G.B. Pant National Institute of Himalayan Environment organized a 'State level interface meeting with different Governments of Sikkim' at Forest secretariat, Gangtok on 19 January 2024 during the visit of the Director of the Institute, NIHE. The meeting was chaired by Shri Pradeep Kumar IFS, Secretary, Department of Forest and Environment, the government of Sikkim and attended by senior officers from different departments of state government, including Forest and Environment, Science & Technology, Agriculture, Horticulture, Animal husbandry, State Pollution Control Board and scientists of Sikkim Regional Centre. During the meeting, deliberations was held on the importance of region-specific priorities of the research and extension activities in Sikkim, and priority issues were worked out.

Scoping Workshop to Synergies efforts for Co-creation and Networking of Knowledge

A scoping workshop on synergies efforts for co-creation and networking of knowledge was organized by Sikkim Regional Centre with various central government institutions, universities, and other organizations located in Sikkim on 19 January 2024. The meeting was aimed to identify the possible gap areas and priorities of the region in R&D sector that can be addressed through synergy and convergence for collaboration between NIHE and different organizations. The meeting was chaired by the Director of the Institute and Prof. Asish Sharma, Vice Chancellor Sikkim State University was Chief Guest of the event. More than 45 Scientists, academicians, and researchers from different Universities, Centre government organizations and NGOs of Sikkim and West Bengal attended the meeting.

Regional Workshop on Sustaining the Himalayan Landscapes: Challenges and priorities for North East Himalaya

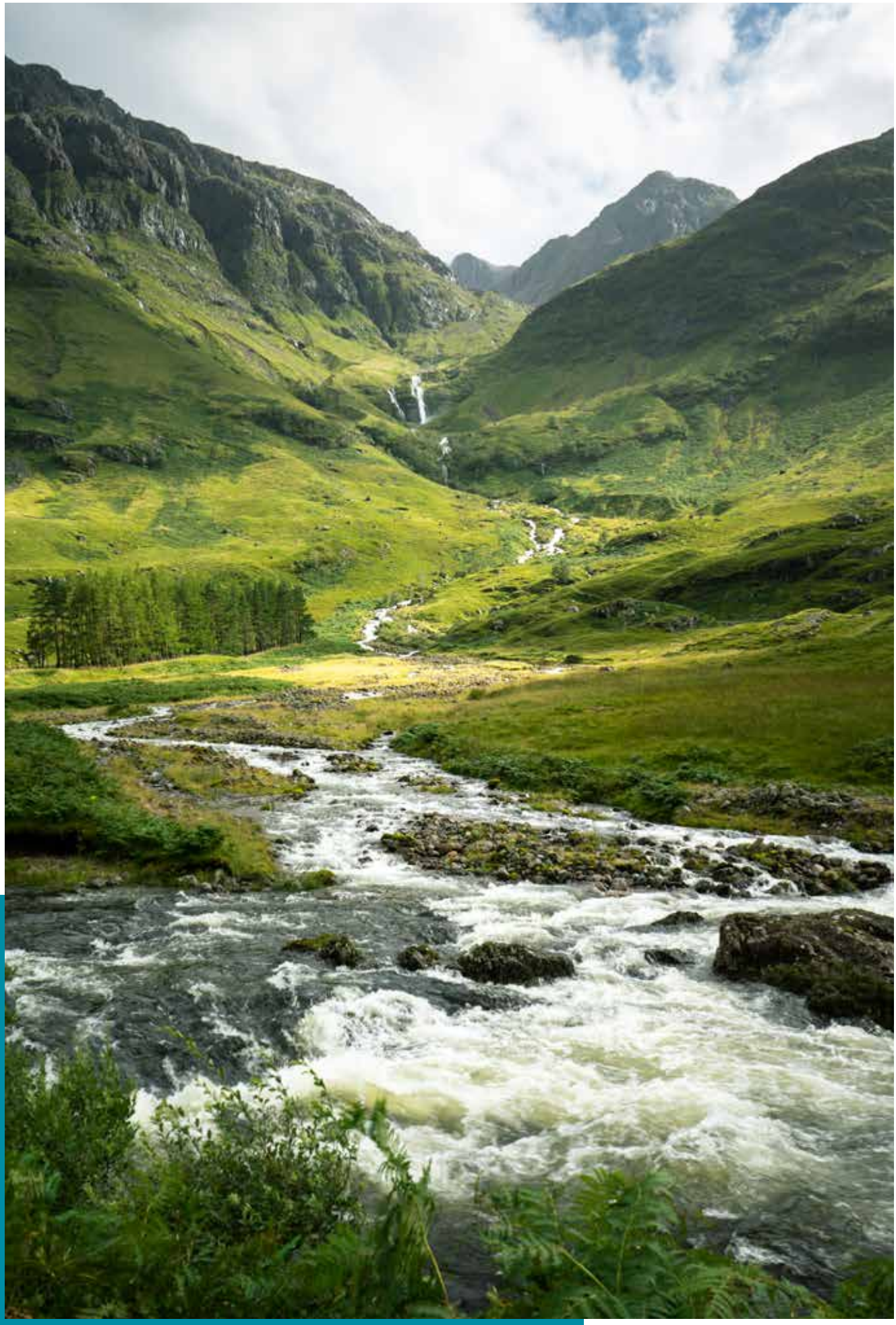
Sikkim Regional Centre of NIHE in Collaboration with Indian Regional Association for Landscape Ecology (IRALE) organized a regional workshop on "Sustaining the Himalayan Landscapes: Challenges and priorities for North East Himalaya" during 22-23 February 2024 at Murti, Siliguri, West Bengal. The aim of the workshop was to (i) Identifying priorities for sustaining landscapes in North East Himalayan region, (ii) Initiate dialogue and create a consortium to collate evidence-based knowledge to influence policies and practices, (iii) Foster collaborative networks engaging science– policy–practice constituencies for sustainable development. More than 30 experts from different premier organizations participated in the work.

Seminar on 'Women and Health in the Northeastern Himalayan Region'

In a bid to address pressing health issues faced by women in the Northeastern Himalayan Region, the NERC of GBPNIHE organized a Seminar on 'Women and Health in the Northeastern Himalayan Region' on 18th December, 2023, at Itanagar, Arunachal Pradesh, which was sponsored by National Commission for Women (NCW), New Delhi. The Seminar garnered participation from diverse stakeholders from Research and Academic institutions, state government departments, local NGOs students, and research scholars. Chief Guest, Prof. Saket Kushwaha, VC, Rajiv Gandhi University, Arunachal Pradesh, stressed the need to develop a policy for 'integrated medicine and food management' to address health issues. Resource persons include Dr.(Mrs.) Subu Tasso Kampu, Dy. Director of Health Services, Govt. of Arunachal Pradesh, Dr. Prasanta Kumar Deka, Professor TRIHMS, Arunachal Pradesh, Dr. Pallabi Kalita Hui, Asst. Professor, NIT Arunachal Pradesh, Dr. Imlikumba, Medical Officer, NEIAFMR, Pasighat; and Dr. Gurucharan Bhuyan, Asst. Director (AYUSH) & In-Charge Regional Ayurveda Research Institute (RARI), Itanagar, who discussed diverse topics such as maternal and child health, the role of Ayurveda, plants used in folk medicinal practices, drug development from plant species, and available government health schemes for people.

International conference - Mountain ecosystem processes and sustainable livelihood

The Himachal Regional Centre (HRC) of the Institute organized a 3 days International Conference on Mountain Ecosystem Processes and Sustainable Livelihood (ICMEPSL) from 5-7th March 2024. On 5th March 2024, NIHE witnessed the presence of Hon'ble Governor of Himachal Pradesh, Shri Shiv Pratap Shukla Ji. The inaugural session marked a significant occasion as the Hon'ble Governor inaugurated the "Seminar Hall and Guest House '' building of the Institute and conference itself, symbolizing a strong commitment to advancing research and innovation in mountain ecosystem studies. Prof. (Dr.) Sunil Nautiyal, Director-NIHE welcomed the guests and highlighted NIHE's research and development initiatives across the Himalayas, particularly in Himachal Pradesh. Hon'ble MLA, Shri Sundar Singh Thakur, emphasized the importance of studying mountain ecosystems in the face of environmental change, while keynote speaker Prof. (Dr.) Arti Kashyap discussed forest fire issues and sustainable forest utilization. The Hon'ble Governor Shri Shiv Pratap Shukla underscored the significance of the event in advancing scientific research and fostering innovation in mountain ecosystem studies. He urged for concrete actions on the ground, emphasizing science-based decision-making and inclusive governance for the preservation of mountain ecosystems and sustainable livelihoods. Over 120 participants from India and abroad participated in the conference. Various Technical Sessions on water resources, waste water, waste management; Biological diversity resources and management; mountain specific socio economic development issues; hydrometrical, atmospheric, cryospheric and climate impact studies, etc., have been organized.



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

S. No.	Date	Title of events	Venue	Total participants
1	03 April 2023	Poshan Pakhwada Campaign to Promote Millets and Backyard Kitchen Gardens	Jyoli village, NIHE, Almora	69
2	6-10 April 2023	One Week training programme on beekeeping under project titled 'Conservation and management of traditional beekeeping (Apis cerena) practices through development of honeybee based sustainable livelihood chain in Kullu Valley'	Karadsu village, and NIHE-HRC	19
3	28 April 2023	Reducing single use plastics in the Himalaya: challenges and opportunities	NIHE, Almora	40
4	04 May 2023	1st NIHE Special Lecture on Climate-induced Geo hazards in the Himalaya and Plausible Mitigation by Dr. Kalachand Sain, Director, Wadia Institute of Himalayan Geology, Dehradun	NIHE, Almora	195
5	11 May 2023	Promoting medicinal plant cultivation for conservation and livelihood upliftment of rural people	Takula, NIHE, Almora	38
6	20 May 2023	Conservation education programme and development of herbal garden under	GIC, Syalidhar, Almora	68
7	31 May to 4 June 2023	Lifestyle for Environment Program	Nearby villages of NIHE, Almora	188
8	06 June 2024	2nd NIHE Special Lecture on Re-greening the Himalaya via the trails of cultural ecosystem by Prof. D. R. Purohit, Former Professor, HNB Garhwal University, Srinagar	NIHE, Almora	160
9	12 July 2023	3rd NIHE Special Lecture on Solid Waste Management and Sanitation in Leh, Ladakh by Dr. Ishey Namgyal, President, Municipal Committee Leh, Ladakh UT	NIHE-LRC	186
10	17 July 2023	Celebrating Harela Parv and plantation drive	Surya Kunj, NIHE, Almora	60

11	08 August, 2023	4th NIHE Special Lecture on Nursery Techniques of Himalayan Conifers and High Valued Temperate Medicinal Plants by Dr. Sandeep Sharma, Director In-Charge, ICFRE HFRI, Shimla, Himachal Pradesh	NIHE-HRC	210
12	11-12 September, 2023	Assessment and Monitoring of High-Altitude Wetlands (HAWs) in Sikkim and other states of IHR	NIHE-SRC	30
13	21-22 September 2023	Conservation and Cultivation of Medicinal Plants	Keemu and Malkha Dungariya Bageshwar	63
14	25 September 2023	Promoting Conservation education: Management of invasive species in agricultural and forest ecosystems	Betalghat, Nainital	80
15	25 September 2023	Training Programme for officials of the Department of Urban Development & Housing, Govt. of Arunachal Pradesh	NIHE-NERC	40
16	02-7 October 2023	World Wildlife Week Celebration	G.I.C. Pangu, Pithoragarh, G.I.C. Majkhali, Almora	163
17	09-13 October 2023	One-week compulsory training course for the Indian Forest Service (IFS) Officers on 'Forestry issues related to Himalayan Ecology and Ecotourism	NIHE, Almora	13
18	09-13 October 2023	Training programme on Cultivation	NIHE-HRC	36
19	28th October 2023	Promoting medicinal plant cultivation for conservation and livelihood upliftment of rural people	Katarmal village, Almora	30
20	30 October, 2023	5th NIHE Special Lecture on Multifaceted Perspective of Himalayan Biodiversity from Space by Dr. Hitendra Padalia, Head, Forestry & Ecology Department, IIRS, Dehradun	NIHE-GRC	220
21	08-10 November, 2023	Three days training workshop for the Indian Forest Service (IFS) Officers on "Plant functional trait-based evaluation of ecosystem functioning and service of Himalayan Forests"	NIHE, Almora	09
22	08 November 2023	Promoting medicinal plant cultivation for conservation and livelihood upliftment of rural people	Basoli, Takula, Almora	10

23	21 November 2023	6th NIHE lecture on Vulnerability, Disaster Risk and Sustainability	NIHE-SRC	172
24	19 December 2023	Promoting medicinal plant cultivation for conservation and livelihood upliftment of rural people	Pantgav, Chitai, Almora	10
25	20 December 2023	7th NIHE lecture on Lichens as a tool to monitor environmental pollution and climate change by Dr. D. K. Upreti, Scientist-G, CSIR-National Botanical Research Institute, Lucknow	NIHE-NERC	160
26	14-16 February, 2024	Three Days Training Program "Natural Resource Management and Sustainable Development" Sub theme: Water resources, Socio Economic Development, Biodiversity Conservation and Disaster Management	NIHE-HRC	40
27	14 March 2024	Awareness meeting on Impacts of climate change and forest fire	Matila, Sitlakhet, Almora	52
28	18 March, 2024	Focus group-cum-expert meeting organized in Tripura in collaboration with Tripura University	NIHE-SRC	25
29	21-23 March 2024	Workshop-cum-Training: Integrated Beekeeping and Food Security: A Climate Change Adaptation Strategy in the Eastern Himalaya	NIHE-SRC	31

CENTRE FOR LAND AND WATER RESOURCE MANAGEMENT (CLWRM)

The Institute has been engaged in scientific research and development concerning land and water resources management in the Indian Himalayan Region (IHR) since its inception. Over the years, it has implemented various programs focusing on mountain hydrology, water resource augmentation, glacier dynamics, hydrometeorology, geo-tectonics, landslide restoration, catchment area treatment, water security, and soil and water conservation technologies across the IHR. In light of challenges posed by globalization and climate change, including the melting of glaciers, increasing incidents of droughts and floods, and water scarcity, as well as a growing recognition of the Himalayas' significance as a water tower, climate regulator, and provider of ecosystem services to the North Indian plains, there is an evident need for heightened R&D aimed at conserving and managing land and water resources in the Himalayas. Recognizing this need for more concentrated efforts, the Institute restructured related themes/groups to establish the Centre for Land and Water Management (CLWRM) in 2017, tasked with conducting more specialized research and development activities throughout the Indian Himalayan Region (IHR). The Centre's endeavors encompass a range of thematic areas such as spring ecosystems assessment, spring rejuvenation, water security, socio-economics of water resources, glacier dynamics, the interaction of water-climate-biodiversity, rainfall-induced disasters, wastewater treatment etc. Keeping in view the wider implications of the subject, the centre sets a holistic approach to conduct the research and developmental work on land and water resources with the primary objectives as (i) conducting studies on land and water and related eco-sociological processes at various levels including upstream-downstream linkages; (ii) developing tools and techniques for sustainable land management considering various developmental interventions; and (iii) providing inputs to government and policymakers 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)

Emerging in many forms, springs are part of groundwater ecosystems and are the main freshwater sources that serve nearly 40 million people across the Himalayas. Springs vary greatly in flow, water chemistry, geomorphology, and ecology and have socio-cultural and economic importance. However, the problem of the drying of springs is being increasingly felt, resulting in the substantial alteration of spring ecosystem structure and functions. Being the most structurally complicated, ecologically and biologically diverse ecosystems, it has been observed that the interaction of dependent ecosystem services of springs is hardly documented or being studied over Himalaya, and no standardized spring-ecosystem management practices are available. Hence, the study has been undertaken with two-fold objectives such as (i) to provide a better understanding of the functioning of the spring ecosystems through the development of spring-ecosystem assessment and management protocols and (ii) to enhance water security through the revival of spring through Jal Abhayaranya concept. The project is under implementation in 4 IHR states through four regional centres of the Institute.

Objectives

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

Achievements

1. The spring inventory data from primary and secondary sources across IHR strengthened to total of 6523(new spring inventory updated: 58 in Himachal Pradesh, 167 in Arunachal Pradesh, 129 Uttarakhand, 45 in Ladakh) springs. RS and GIS based methodology (Fig. 1) and its findings for deriving springs' recharge potential zone (using 8 different

thematic layers and AHP method) was validated using ground based geological investigations and isotopic analysis for springs of Manadunga village cluster. The isotopic analysis of springs and rain water samples was conducted in Uttarakhand and Himachal site indicates that the majority of springs are rain-fed, highlighting the need of rainwater harvesting structures to rejuvenate the springs. The bio-engineering interventions were carried out at Uttarakhand (9 springs at Manadunga village cluster) and Sikkim (2 springs at South Sikkim) site showing promising impact on spring discharge and will be continuously monitored in future as well. The model will be further applied to other study area, where basic RS-GIS based methodology is completed for identified sites at Jyoli,Kantli, Kullu, Lower Subansiri and Jakholi block.

2. Quantification of new spring ecosystem health indicators, i.e. Spring Variability Index (Vi), have been analyzed for 8 springs of Manadunga and 3 springs of Kantli village using statistical and hydrological analysis and will be adopted at Jyoli,Kantli, Kullu, Lower subansiri and Jakholi block, where data collection and hydrograph analysis of spring discharge is continuing. Further, quantification of another spring ecosystem health indicator, i.e. spring Water Quality Index (WQI) is continued using seasonal spring water quality analysis at Uttarakhand, Himachal Pradesh, Arunachal Pradesh and found to be in good to excellent quality condition as per BIS standard (Table 1).

3. Total 21 dissemination and outreach programmes including capacity building cum training programs, workshop, LiFE events, and days of national/ international importance were organized in four states (Fig 2); wherein 1039 stakeholders got exposure on water scarcity issues, water conservation and springshed management. Among them,87 participants were trained as 'Para-hydrogeologists' through lectures and field demonstrations.

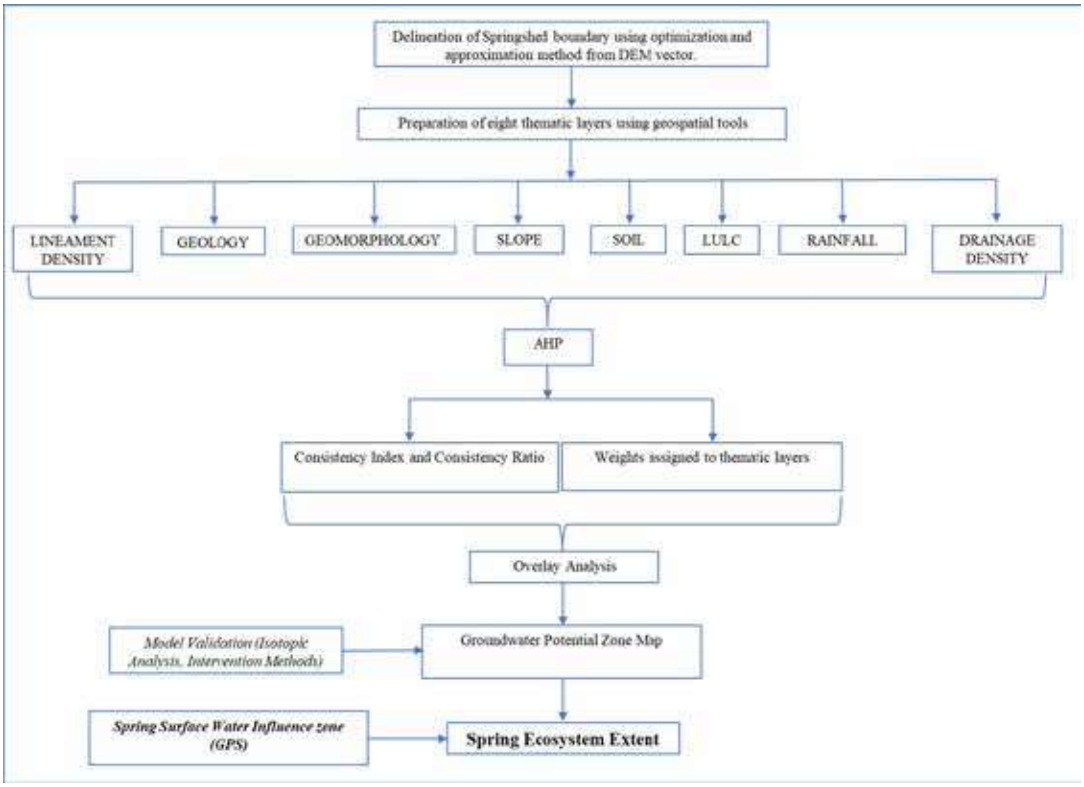


Fig. 1. Flow diagram for delineation of spring ecosystem extent

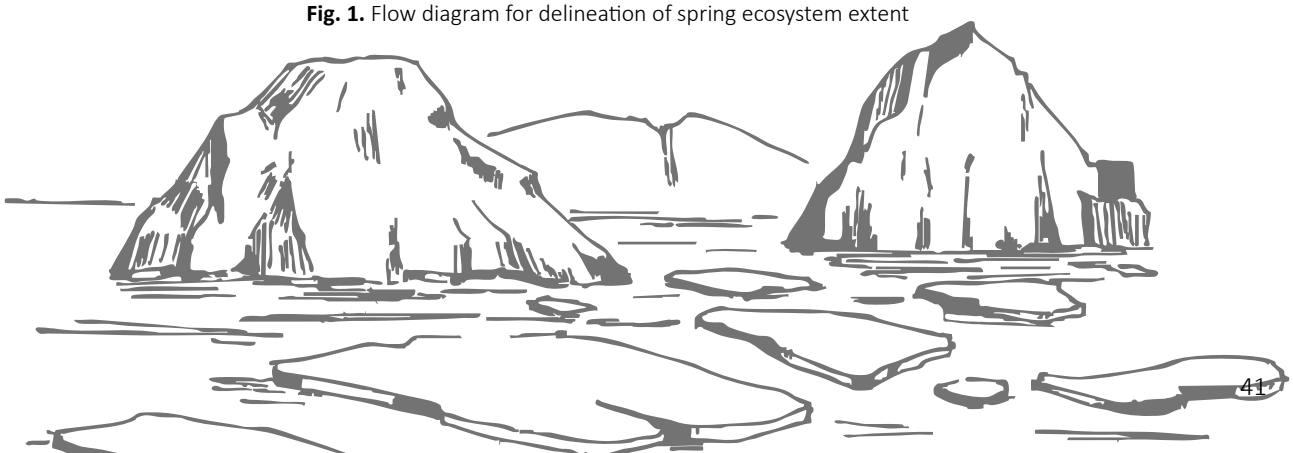


Fig. 2 Glimpses of various dissemination and capacity building activities (Top Row: by GRC, Middle Row: by NERC and Bottom Row: HQ, GBPNIHE)

Table 1 Water Quality Index (WQI) of springs of Jyoli village cluster, Almora for the duration 2023-2024 (pre-monsoon, monsoon and post-mansoon)

Spring	WQI	Quality	Grade
Jyoli	19	Excellent	A
Bisra	10	Excellent	A
Kharkuna	29	Excellent	A
Kujyadi	10	Excellent	A
Dilkot	13	Excellent	A

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 winters in the Higher Himalaya and Trans-Himalayan Regions, where temperatures drop to -30°C. Despite ample sunlight in the region, traditional biomass energy sources are used for heating, leading to localized carbon emissions. This project aims to mainstream PSHB concepts in the Indian Himalayan Region by studying best practices and developing solutions. Objectives include documenting traditional knowledge, evaluating PSHBs for thermal efficacy and cost-benefit analysis, developing replicable designs and SOPs, and promoting skills development. Existing PSHBs were studied in vernacular settings, with methodologies including documentation, material studies, technical evaluations, and energy simulation. The study provided a knowledge repository, simulation models, field demonstration models, and SOPs, along with workshops and training courses. The project aims to engage policymakers, local administrations, researchers, and communities to promote PSHB adoption through region-specific policies, low-carbon materials, research advancements, awareness efforts, and long-term sustainability.

Objectives

- To document the traditional knowledge on thermal efficiency of solar passive heated building across the high-altitude areas of IHR to build a knowledge base for further required interventions.
- To Evaluate Qualitative and Quantitative assessment of PSHBs and structural design evaluation of some existing PSHBs of trans and high-altitude Himalayan region for thermal efficacy and impact on resource requirements.
- To assess Cost-Benefit analysis of selected solar passive heated buildings of trans and high-altitude Himalayan region.
- To Develop region specific 'Standard Operating Protocol' and Replicable Designs on identified methods and policy advocacy to upscale the technology through field demonstrations and training of youth for entrepreneurship development.
- Promote skills development in the PSHB market by developing design thumb rules and courses for training institutions.

Achievements

1. A comprehensive review of region-specific policies, guidelines, laws, and building codes pertaining to passive solar heating measures in the Indian Himalayan Region (IHR) states has been done to identify gaps, challenges, and issues. Surveyed 173 passive solar representative buildings across Ladakh, Himachal Pradesh, Uttarakhand, Sikkim, and Arunachal Pradesh regions for documentation of a knowledge repository on PSHB and thermal comfort. A performance assessment of passive solar buildings for thermal comfort in the Ladakh region, including thermal comfort and energy simulation modelling of selected PSHBs houses in Stok Village, Leh, has been conducted.

2. Stakeholder engagement was done by organizing three workshops/trainings about PSHBs, its concept, traditional knowledge assessment, feasibility assessment, and advancements in design and performance assessment etc.

3. A field demonstration model of a Trombe wall through retrofitting at the Panchayat Bhavan of Sosa Village is developed to disseminate knowledge and raise awareness in the Chaundas Valley, Uttarakhand. Further, a technical manual entitled "Practical Guide for Passive Solar Heated Buildings (PSHBs) - Design and Practice" and "Standard Operating Protocol (SOP) for Passive Solar Heated Buildings in the Ladakh Region" was developed.

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

This project is proposed for 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 would be chosen in a manner that not only represents the different geographic zones but also different climatic zones where the different behaviors of glacier response have been reported in the last few decades. This will contribute to the Ministry of Environment, Forest and Climate Change to have representative/benchmark glaciers across IHR for having the networks established for long-term monitoring, data generation, and the glacier-climate response model for a better 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. The study identified glaciers across all three selected basins, and baseline data, such as a topographical map including elevation profile, slope, aspect, hill shade, etc., has been generated.

2. Three expeditions were conducted for glaciers identified in the Kali basin of Uttarakhand (Chipa and Neola), and one expedition was conducted for a glacier identified in the Indus basin region of Ladakh (Rulung).

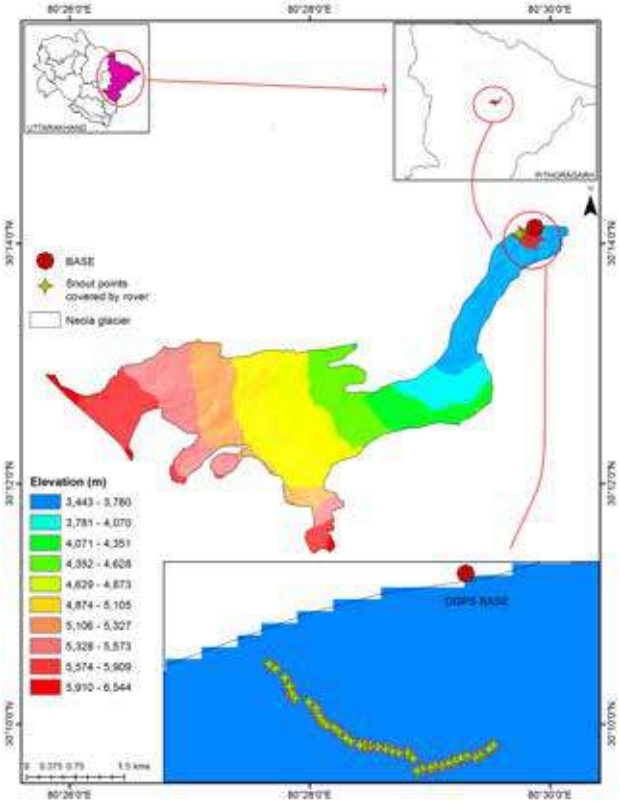


Fig. 3 Snout survey carried out using DGPS

3. A DGPS survey was carried out for snout measurement, stake installation for velocity measurement, water sampling, and stream discharge measurement for these glaciers (Fig. 3).

Spring Rejuvenation for Water Security in Himalaya (NMHS, 2020 – 2024)

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

Objectives

- To develop at least one Jal Abhyaranya demonstration model in each Aspirational District of all 12 Himalayan States

- To promote replication of field model for rejuvenation of drying springs in the Himalayan States through Technology and Community based approaches for providing water security to local communities in collaboration with state agencies

Achievements

1. Under the Jal Abhayarnya concept, a total of 1035 water augmentation structures (trenches, percolation pit/ponds, toe trenches, check dam, small water storage/conveyance structures, etc.) have been implemented so far across the study sites (i.e., 11 states and 1 UT of IHR) for rejuvenation of 32 spring sources. Initial efforts showing promising impact on spring discharge enhancement at the initial stage in 5 sites in Uttarakhand (Fig. 4), Sikkim, Tripura, West Bengal, and Meghalaya state and corresponding impacts on women's lives is also drafted as a success story.

2. In order to identify the altitudinal variation in recharge area,stable isotopic analysis of spring water and rainfall sample was carried out for two seasons (monsoon and post-monsoon of 2023) for the 9 springs of Mandunga village cluster on an experimental basis. The initial results data revealed that δ18O values ranged from -6.5 to -8.5 ‰, with an average of -7.5‰, and δ2H values ranging from -68.1 to -58.8 ‰, with an average of -64.51‰. The values are very close to the isotopic signature of rainfall values, indicating major springs are rain-fed and recharged through a common aquifer system. The initial findings will help guide and construct the intervention measures for spring rejuvenation in appropriate areas.

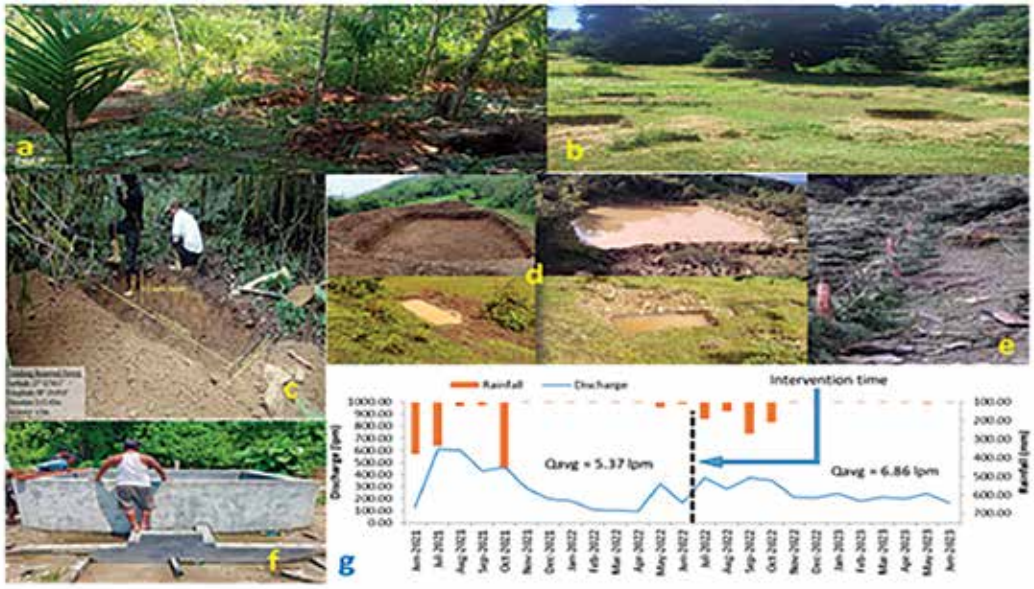


Fig. 4 Bio-engineering interventions at sites – (a) ManimohanRowaja para, Dhalai, Tripura; (b) Kupwara, J & K; (c) South Sikkim; (d) Manadunga, Uttarakhand; and (e) Chamba, Himachal Pradesh; (f) Namsai, Arunachal Pradesh; and (g) representative spring hydrograph for pre and post-intervention at Manadunga spring at Uttarakhand

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

Objectives

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

Achievements

1. Towards the efforts of rejuvenation springs, a groundwater recharge potential zone mapping was done using geo-spatial methodology in the Keylong area covering 12 identified springs (Fig. 5). Intervention sites for spring rejuvenation have been identified at the top of the Yangrang village, which provides water for six numbers of springs in the area. The spring revival plan was developed, which will be carried out in collaboration with Keylong Forest Division.

2. Regular monitoring of spring water quantity and quality is continuing. With reference to Springshed Health Card, variation in spring water quality parameters of 30 springs was analyzed in three different seasons i.e., winter, spring and summer in LahaulValley in Himachal Pradesh. The water Quality (WQI) was calculated based on 12 physiochemical parameters and compared with BIS specification for drinking water. WQI trend shows the Index value varied from 14 to 31 during all winter, spring, and summer seasons which indicates that all of the springs are of good and excellent quality.

3. Total 3 capacity building activities were carried out to engage different stakeholders for spring rejuvenation efforts, wherein 71 participants from the village got exposure on springshed management (Fig. 5).

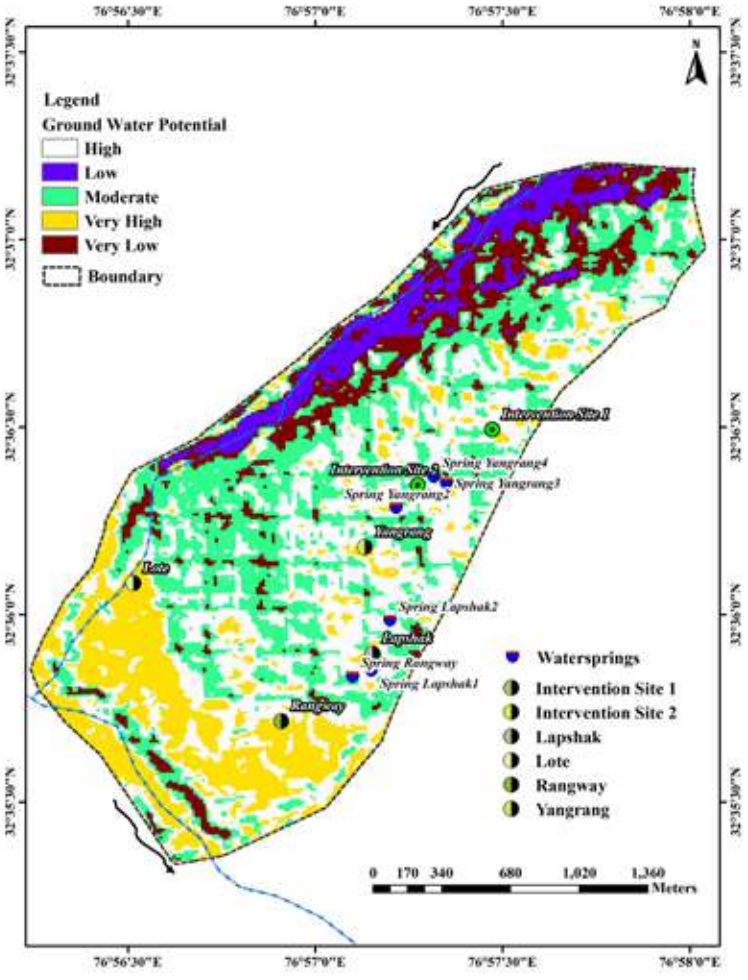
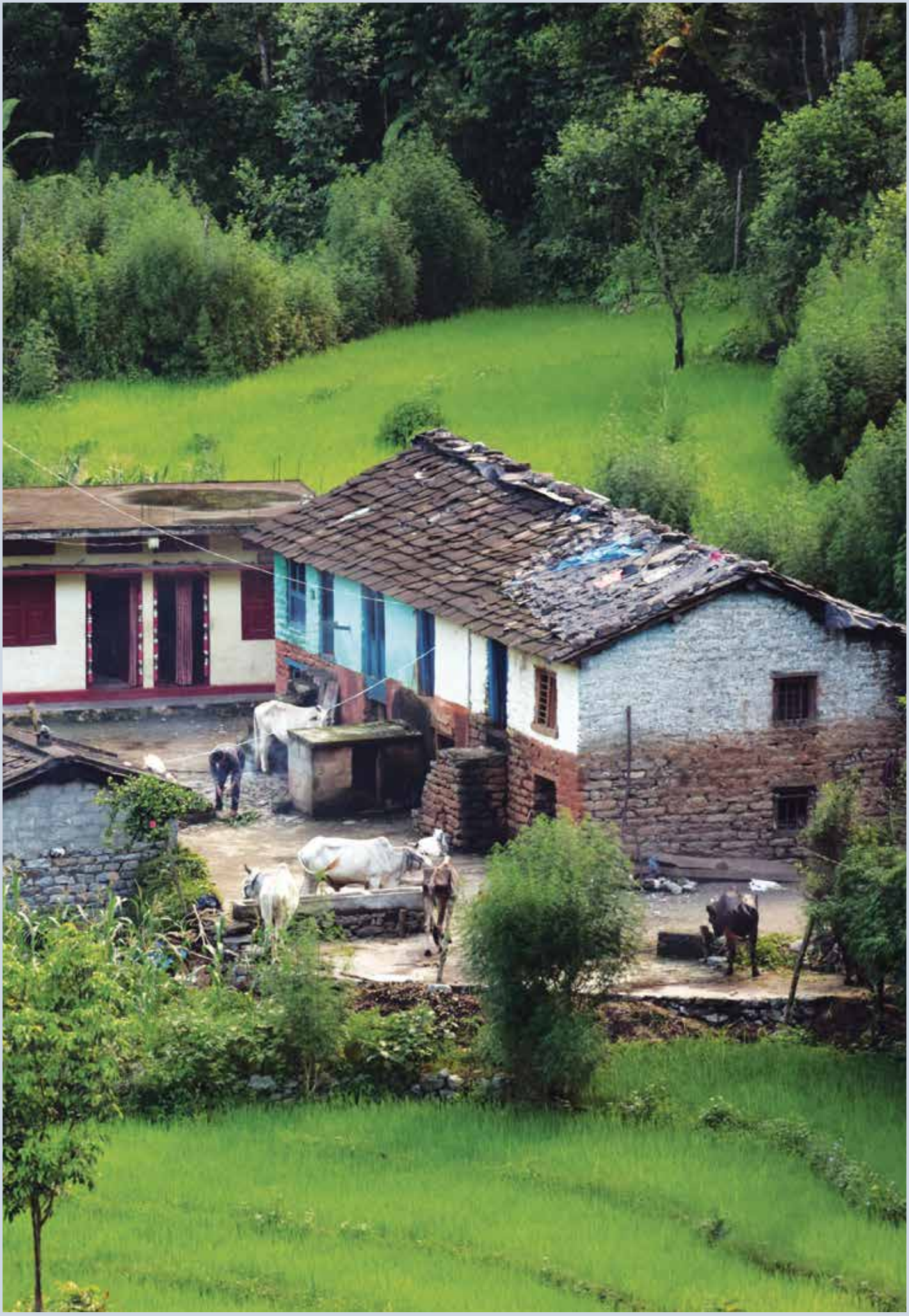


Fig. 5 Groundwater recharge potential zone mapping



CENTRE FOR SOCIO-ECONOMIC DEVELOPMENT (CSED)

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

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

Different approaches to village development have been envisaged as "Smart Village," with a vision to transform villages into examples of sustainable development based on environmentally responsible individual and collective action for reducing human ecological footprints through the judicious use of natural resources. This project aims at developing 'Eco-smart Model Villages' across four representative localities in the IHR through an innovative community-driven process while safeguarding the ecological balance of targeted villages /village cluster employing carrying capacity concept and consequently lead to the creation of an Eco- smart model village.

Objectives

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

Achievements

Head Quarters

1. The effects of different mulches on the soil and strawberry growth under protected conditions were evaluated to enhance production. Four treatments—no mulch, silver on black polyethylene, black polyethylene, and straw mulch—were compared (Fig. 6). Results showed that black polyethylene mulch significantly improved soil temperature, moisture, and organic content and enhanced the number of flowers, fruits, and fruit weight and antioxidant activities, while straw mulch maximized phenol and protein levels in strawberries. Black polyethylene mulching promoted optimal strawberry growth.

2. Monitoring and data collection across Jyoli village cluster was conducted. Poultry farming activity helped the stakeholders to earn a sum of Rs. 94710, out of which Rs. 64600 was earned from the sale of chick birds and Rs.30110 from the sale of eggs. Two trainings on livelihood for rural development through pine needle based biobriquetting and home-stay benefits have been conducted in Chitayivillage (Almora) covering 120 stakeholders (F=72, M=48).

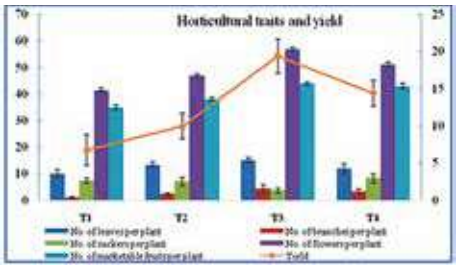


Fig 6. Effect of four different mulching on yield of strawberry in Jyoli village cluster.

Himachal Regional Centre

1. A three-day training program on Natural Resource Management and Sustainable Development was conducted at the Himachal Regional Centre, from February 14- 16, 2024. Thirty-seven participants were engaged in learning about water resources, socio-economic development, disaster management, and biodiversity conservation. Data collection was done for all 254 households across four cluster villages in the Mandi district: Kashna, KotKamradha, Nau-Tepar, and Piun villages. Analysis of the data is in progress.

2. A total of 375 stakeholders from various panchayats have actively participated in capacity-building and training initiatives within this project. Data entry has been accomplished for all 254 households across four cluster villages in Mandi district: Kashna, Kot Kamradha, Nau-Tepar, and Piun villages. This includes documenting the social structure of the cluster villages in Mandi district. As part of the Unnat Bharat Abhiyan (UBA), questionnaire surveys were conducted across various districts. Data from Lahaul and Spiti (108 households), Kangra (206 households), Kinnaur (77 households), and Chamba districts have been entered into Excel spreadsheets, and analysis is currently underway. Additionally, surveys for UBA have been successfully completed in Solan (185 households), Bilaspur (250 households), Hamirpur (175 households), and Sirmaur (217 households) districts.

Garhwal Regional Centre

1. The household survey was conducted in eight different villages, namely, Ghandiyalika, Kyarki, Khedi, Biro, Gwaad, Kothiyu, Pokharsari, and Punaad villages of the Barshu cluster, Rudraprayag, Uttarakhand, to collect baseline data on the socioeconomic status of the people. A total of 113 households were surveyed, and data was assessed to determine the household income, livelihood options, livestock, milk production, land holdings, and agriculture production.

2. The maximum population was recorded in Kyarki village (104), while the lowest population was found in Gwaad (49). The total land holdings were found to be highest in Gwaad (244.5 Nali) and lowest in Punaad (18 Nali) village. Biro village showed the highest total annual agriculture production (2942 kg/year), while it was the lowest (104 kg/year) for Kothiyu village. Similarly, annual pulse production was found to be at its maximum in Kyarki (55 kg) village. Total milk production was at its maximum in Ghandiyalika (55 liters/day) and at its minimum in Punaad village (1 liter/ day). The study exhibited a great diversity of the crops being cultivated in the studied sites (Table 2).

Table 2. Major crop diversity among different studied villages of 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), *Amaranthus* spp. (Chaulai), *Triticumaestivium* (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)

3. A survey was conducted on human-wildlife conflicts in representative villages of the Uttarakhand region. Results showed that the majority of female respondents (46.67%) did not support wild animal conservation, indicating that they have negative attitudes. In comparison, the majority of male respondents (43.75%) supported the conservation of these wild animals. Additionally, people with higher educational levels were more interested in the conservation of wild animals than people with lower education levels. The Chi-Square test showed that there was a significant difference between gender and educational status regarding their interest in wild animal conservation ($df = 2$, $p < 0.018$, and $df = 10$, $p < 0.00$).

Sikkim Regional Centre

1. Trained 45 stakeholders on baseline data collection and resource use map preparation through five training programs organized at Kholagari, Lower Mamlay, and Upper Kamrang villages of South Sikkim and Tumin and Samdong villages of East Sikkim. Through the training programs, village resource maps of 08 villages (Kholagari, Lower Mamlay, and Upper Kamrang villages of South Sikkim and Upper Tumin, Middle Tumin, Khesey, Namrang and Samdong of East Sikkim) were developed based on participatory mode.

2. A total of 15 Villages covering 308 households were surveyed for baseline data collection in the Format of 'Unnat Bharat Abhiyan' from East and South Sikkim (Barang, Sheley, Middle Tumin, Namrang, Khese, Lower Kamal, Upper Kamal, Raley, Upper Kamal, Upper Samdong) and South Sikkim (Pabong, Pakzer, Lower Tingrithang, Upper Tingrithang, KholaGhari).

3. The agricultural activities of several villages have been studied, providing valuable insights into the trends and patterns of farming activities across different months. During the post-monsoon season, agriculture activities are higher in all the Gram Panchayat Units (GPU), while during winters, it is very low in all GPUs. Based on the data trends, interventions can be made for the winter season to improve income generation; thus, protected cultivation under polyhouse and polytunnels might be a useful agricultural practices.

Fig. 7. Capacity Building Training Programmes on vermicomposting, protected cultivation and curing kiln for large cardamom.

4. 67 participants from Upper Jaubari and Lower Jaubari villages were trained, and their skills were upgraded through two training programmes on 'vermicompost processing', 'Improved Curing Kiln for Large Cardamom' and 'protected cultivation using poly-tunnel technology' (Fig. 7). 15 beneficiaries adopted these technologies in their fields. In the protected cultivation models under polytunnel, vegetable crops such as cauliflower, green coriander, cabbage, lettuce, carrot, beetroot, and green leafy vegetables show good responses with an annual production of more than 300 kg/ polyhouse (15 x 30 m) as compared with the traditional cultivation techniques with less the 250 kg in the same area.

North East Regional Centre

1. A hands-on training program on "Dragon Fruit Cultivation" was organized at Dikopita Village, Siiro on 12th March 2024 with an aim to train and develop the skill of the local women farmers on techniques involved in Dragon Fruit cultivation and to adopt it as an alternative livelihood option. A total of 11 participants from different SHGs attended the training program (Fig. 8).

2. Monitoring and consultation program was undertaken for all the interventions at the cluster village from 22nd September 2023 to 06th October 2023 where all the beneficiaries were called to interact and share feedback on the interventions installed at their respective sites. Byapin SHG expressed their plan to enhance their vermicompost product by enlarging their production facility in the upcoming season. They also requested assistance in procuring the primary raw material, primarily cow dung, which is both costly and not readily available in the market. It was stated that the cultivation using monoculture methods was adversely impacting soil health, fertility, and traditional farming practices and therefore members of the DikoAjing SHG expressed interest in an intervention promoting Integrated Farming.

Fig. 8. Glimpses of the hands on Training Program on Dragon Fruit Cultivation

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-third of the village, people are mostly dependent upon firewood, which constitutes about 75% of the total energy consumption. In the tough mountain terrain, the consumption pattern depends on the availability of the forests in nearby areas as well as socio-economic conditions of the people. On average, per capita firewood consumption varies from 5-10 q/year in Uttarakhand, posing immense pressure on surrounding vegetation and leading to loss of biodiversity and C sink value of the forest ecosystems. In recent decades, increasing incidences of forest fire in the Chir Pine (*Pinus roxburghii*) dominated middle-mountain belt has further aggravated this problem.

Therefore, our forests are facing the twin challenges of forest fire as well as pressure for firewood collection by rural people. The present project focuses on large-scale demonstration of making bio-briquettes through the carbonization of dry biomass and then in the presence of binder, can be manufactured into briquette using an iron mould and thus can be easily manufactured at the household/village level using Chir-Pine needle litter along with weeds and invasive plants as raw materials.

Objectives

- 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.
- 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.
- To introduce and popularize cost effective energy solution using the obnoxious Pine needles thus saving forests from biotic pressure and creating income generating opportunities for women through sale of bio-briquettes.

Achievements

1. To fulfill project objectives, 11 workshops (both online and on-field) have been conducted, with 304 stakeholders participating (male 158, female 146, SC-223). The workshops cover 10 villages and 4 NGOs in three developmental blocks (Hawalbagh, Takula, and Dhauladevi) of Almora district (Fig 9).

2. Monitoring of the two established interventions in Village Manaun (Hawalbagh), Almora, and Manan (Hawalbagh), Almora, is in process.

3. Sensitization and showcasing the importance of bio-briquettes in combating forest firesacross the villages is continuing.

Fig. 9. Bio-briquette preparation under the training programs across the villages

Biochemical and molecular characterization of selected legume crops for identification of suitable germplasm to bridge the nutritional and yield gaps in Uttarakhand (UCB, 2022-25)

Uttarakhand is renowned for its abundant agricultural biodiversity, especially in the realm of legumes, which are cultivated in both monoculture and mixed cropping systems. These legumes offer significant nutritive and therapeutic benefits. However, despite their importance, there has been a lack of research focused on enhancing their qualities and understanding their genetic diversity and nutraceutical values. Consequently, this study aims to assess the genetic diversity, nutritional quality, and yield potential of these legumes. The goal is to promote their widespread cultivation in Uttarakhand and potentially obtain them Geographical Indication (GI) tags.

Objectives:

- To evaluate morphological traits of the germplasm of target species viz., soyabean (*Glycine max*) and horse gram (*Macrotyloma uniflorum*), French bean (*Phaseolus vulgaris*) from a range of localities across Uttarakhand encompassing various agro-climatic conditions.
- To measure the nutritional and nutraceutical properties of the target species.
- To evaluate the molecular diversity among the genotypes of target species collected from various

locations and

- To build capacity of rural people for promoting and adopting superior varieties for large scale cultivation

Achievements

1. A total of seventy-three French bean/ kidney bean landraces, fifteen horse gram landraces, and twenty-six soybean landraces were collected from various altitudinal ranges across Uttarakhand and evaluated for for morphological characteristics, yield potential, and quality attributes. Based on the phytochemical and antioxidant analysis of French beans, the landrace R42 from Harsil, Uttarkashi exhibited the highest total phenol content (TPC) at 14.048 ± 0.558 mg GAE/g dw. Additionally, the landrace R15 from Tejam, Dharchula, demonstrated the highest total flavonoid content (TFC) at 9.26 ± 0.67 mg QE/g dw. Moreover, the landrace R48 from Sobala, Dharchula, displayed the highest total monomeric anthocyanin content at 7.96 ± 0.60 mg/g dw. Finally, the landrace R53 from Joshimath, Chamoli exhibited the highest antioxidant activity, recording at 3.490 ± 0.115 mg AAE/g dw.
2. Among soybean landraces, BS15(28.24 ± 0.686 mg GAE/g dw) (Ramgarh, Mukteshwar) followed by BS3 (27.42 ± 0.836 mg GAE/g dw) (Tejam, Dharchula) showed the highest TPC, the flavonoid content was observed highest in landrace BS15 (4.252 ±0.610 mg QE/g dw), the highest anthocyanin content in soybean was recorded in landrace BS15 (9.15 ± 0.33 mg/g dw), the highest antioxidant activity was recorded in BS3 (14.15 ± 0.62 mg AAE/g dw).
3. Across the horse gram landraces, the highest total phenol content was observed in H12 from Thal, Pithoragarh, recording at 8.40 ± 0.522 mg GAE/g dw. Meanwhile, the highest flavonoid content was recorded in H7 from Lamgada, Almora, reaching 10.90 ± 1.466 mg QE/g dw. Additionally, the landrace H1 from Patiya, Almora exhibited the highest tannin content at 1.07 ± 0.232 mg TAE/g dwand the highest antioxidant activity was recorded in H9 (3.602 ± 0.116 mg AAE/g dw) collected from Nachani, Pithoragarh (Fig. 10).

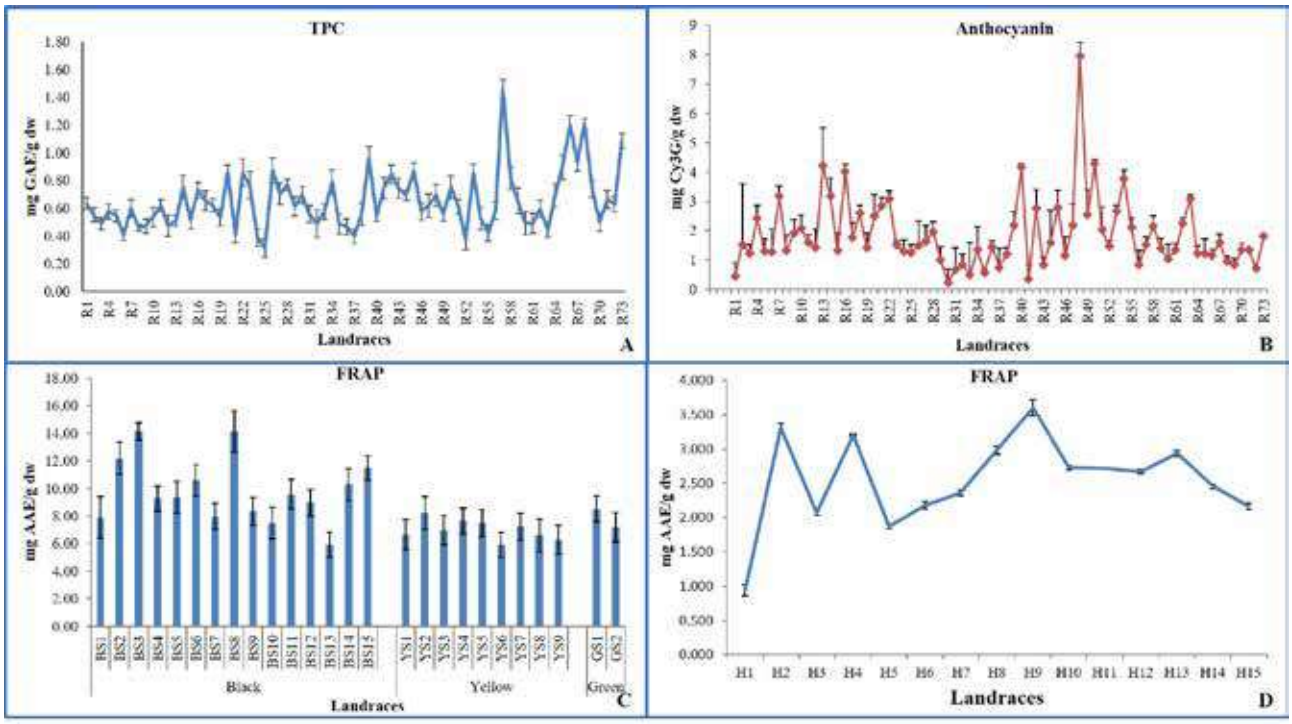


Fig.10. (A) Phenol content in kidney beans (B) Anthocyanin content in kidney beans (C) FRAP activity in soybeans (D) FRAP activity in horse gram

Summary of the Completed Projects / Activity

Millets for Sustainable Livelihoods and Doubling Farmers Income: An assessment of Millets Productivity, Value Chain and Entrepreneurship Development in Hill Districts of Uttarakhand (ICSSR, 2023-24), Short term empirical collaborative research project

The Himalayan region presents a distinct agricultural ecosystem characterized by ancient practices that have been less impacted by rapid changes compared to plains. Uttarakhand, with its varied landforms ranging from hills to plains, holds a unique agricultural landscape. Historically, the Himalayan region of Uttarakhand has served as a significant niche for millet crops, deeply embedded in ethnic culture and livelihood practices. The hilly terrain, typified by gravelly and light-textured soils with poor water retention, is conducive to millet cultivation. Traditional kharif season crops include barnyard millet, finger millet (ragi), and foxtail millet, among others. In some areas of Uttarakhand hills, mixed cropping during the kharif season, known as banaraja, is a common practice involving a blend of millets, legumes, amaranths, buckwheat, sesame, and more. Approximately 55% of the total cultivated area in Uttarakhand is under rainfed cultivation, and millets play a crucial role in filling specific ecological niches, thriving under stressful conditions where other crops struggle to yield viable harvests. Minor millets such as finger millet (Manduwa), barnyard millet (Jhangora), foxtail millet, proso millets, and pulses exhibit remarkable resilience, making them well-suited to withstand various stressors. Consequently, these crops have been cultivated in the hills of Uttarakhand since ancient times. Millets are renowned for their ability to adapt to diverse ecological conditions. There is a growing demand for millets from the Uttarakhand region in export markets, particularly varieties like Barnyard Millet, Foxtail Millet, Proso Millet, Sorghum, and Amaranth. The study attempted (i) to assess the present status of the area under millets, production, demand and supply, crop diversity, and value chain of traditional millets in the study area,(ii) to document the popular recipe of millets, nutritional profile, organic practices, value addition for popularization and livelihood support and income generation of the local community, (iii) to delineate millets micro region or millets clusters and to assess the possibilities of millet-based entrepreneurship development, micro enterprises, Start-ups and supply chain management and (iv)to identify the institutional and technological challenges as well as barriers and bottlenecks in millet mainstreaming and proposed a suitable policy framework for revival of millets for sustainable livelihood and doubling farmers income.

i) Millets show a worrying decline in cultivation area and production, projected through exponential forecasting tools. By 2031, food grain area may halve to 2.06 lakh hectares, leading to a significant drop in total production to around 4.84 lakh metric tonnes, much lower than 2021 levels. Problems observed by millet cultivators represented (Fig. 11). ii) In the best-case scenario, with a slightly larger area under cultivation, food grain production may reach around 6.46 lakh metric tonnes, only slightly higher than current levels. iii) Millet productivity trends show fluctuations without policy intervention. By 2031, Finger millet productivity remains stable, while Barnyard millet and Amaranth are projected to increase to 23.7 and 22.11 quintals per hectare respectively. However, their smaller cultivation areas limit the impact on total production compared to Finger millet.

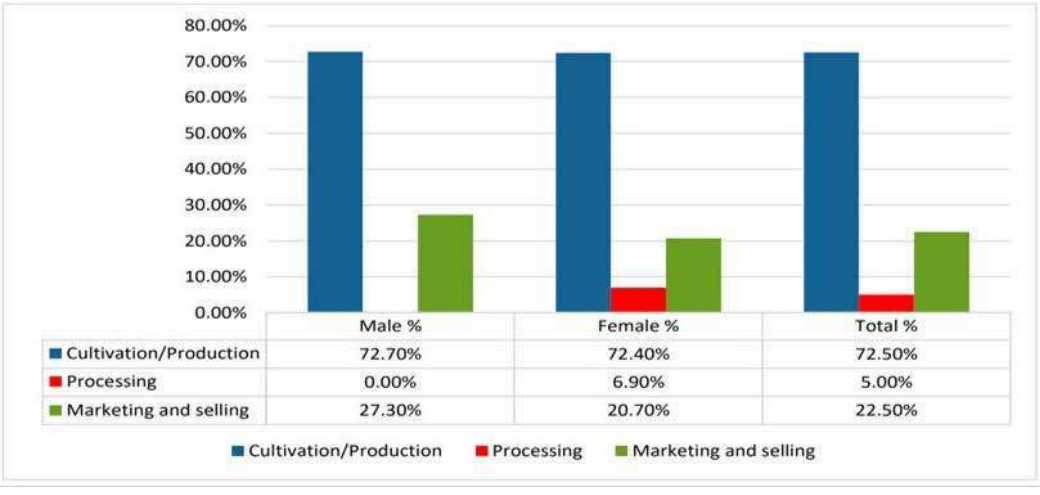


Fig. 11. Problem observed by the millet-based entrepreneurs at different stages in Uttarakhand hills

CENTRE FOR BIODIVERSITY CONSERVATION AND MANAGEMENT (CBCM)

The Centre for Biodiversity Conservation and Management (CBCM) is proactively working on Institute's longstanding commitment of 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 gives 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 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 wellbeing. CBCM's multifaceted approach goes beyond traditional research. It employs both in-situ and ex-situ conservation practices and fosters collaboration with a wide range of stakeholders, fulfilling international and national biodiversity conservation commitments that emphasize participatory conservation models. This includes engaging rural communities in initiatives like medicinal plant cultivation and wasteland restoration, empowering them economically and socially while achieving conservation goals. CBCM also promotes the replication of successful models to ensure 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 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 on 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 to the unique ecological and socio-economic system of the Himalayan region.

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

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

Objectives

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

Achievements

HQs (Kosi-Katarmal)

1. Towards strengthening the database of the Himalayan plants, endemic vascular plants were updated. A total of 1076 taxa (1061 angiosperm, 03 gymnosperm, and 12 pteridophytes) belong to 432 genera and 100 families documented. Grid-based mapping identified

six grids (Jowai hills, Mawsynram, Mawsmai, Khasi-Jaintia Hills, Jarain-Pynursula-Cherapunjee, Kalamuni-Betulidhar-Munsyari) as rich diversity of endemic taxa.

2. The field validation of biodiversity-rich areas, namely Kalamuni-Munsiyari of district Pithoragarh, Uttarakhand, was completed. Further, five endemic species, namely *Berberis osmastonii, Kashmiria himalaica, Rhododendron rawatii, Rubus nepalensis,* and *Trachycarpus takil* were validated in the field.

3. Propagation protocols for 2 high-value medicinal plants (*Pittosporum eriocarpum* and *Bunium persicum*) were standardized. Through different means 45,500 seedlings of selected species (*Cinnamomum tamala*- 15000, *Hedychium spicatum* - 20000, *Paeonia emodi* - 2000, *Pittosporum eriocarpum* - 2000, *Polygonatum verticillatum* - 500, *Saussurea costus* - 1000, and *Valeriana jatamansi* - 5000) were produced.

4. To promote cultivation in the farmers' field, 64 farmers of Jeoli and Bamnigdh cluster (District Almora) initiated cultivation of medicinal plants (Fig. 12). All the farmers were registered at the Herbal Research Development Institute (HRDI), Gopeshwar. At the initial stage, 9 farmers from Bamanigarh village harvested 2250 kg of *Hedychium spicatum* (Van Haldi) and earned Rs. 1,35,000/-.

5. Value chain assessment of seven potential species, namely, *Aconitum heterophyllum, Cinnamomum tamala, Hedychium spicatum, Nardostachys jatamansi, Picrorhiza kurroa, Swertia chirayita,* and *Tinospora sinensis* indicated that the highest traded species from the Kumaun Himalaya is *C. tamala* (859.76 MT/ Year) followed by H. spicatum (4.45 MT/ Year), *P. kurroa* (1.42 MT/ Year), and *T. cordifolia* (0.41 MT/ year). The *A. heterophyllum* and *S. chirayita* were not recorded in trade in the Kumaun region of Uttarakhand.

6. A total of 21 awareness and conservation education and Green Skill Development programmes were organized in the Almora, Bageshwer, Pithoragarh, and Champawat districts of Uttarakhand. A total of 3369 participants actively participated.

Fig. 12. Van Haldi cultivation in village Bamanigad, Almora Uttarakhand (A) Sowing van haldi in famers field (B) Monitoring crop in famers field (C-F) Harvesting and purchasing of cultivated plant species in farmer's field

Himachal Pradesh Regional Centre

1. Technical support provided to Regional-Cum-Facilitation Centre (RCFC), National Medicinal Plants Board (NMPB), Jogindernagar, Himachal Pradesh, for the preparation of 05 People's Biodiversity Registers (PBRs) of 5 blocks of Chamba district.

2. A total of 55 farmers (Teerthan valley-30, Parvati valley-25) are promoted to cultivate different high-value medicinal plants in 50 bigha land.

3. Two biodiversity-rich areas i.e., Kamrunag (Mandi District) and Dharo ki Dhar (Solan District) were studied for field validation, and recorded 134 plant species from Kamrunag and 95 species from Dharoke Dhar area. Verified locations of Critically Endangered, Vulnerable, and Threatened medicinal plants *Aconitum heterophyllum, Angelica glauca, Inula racemosa,* and *Saussurea costus* at different locations such as Jispa, Kardang, Keylong, Koksar, andTrilokinath of Lahaul-Spiti District of Himachal Pradesh.

4. Established 11 herbal gardens at Govt. Senior Secondary Schools and Industrial Training Institute, Shamsi, Kullu, and planted various high-value medicinal and threatened species (i.e., *Bergenia ciliata, Ginkgo biloba, Swertia chirayita, Taxus contorta, Withania somnifera*).

5. Organized training programme on "Post harvesting techniques of medicinal plants" with representatives from the Marketing and Procurement Division of Dabur India Limited in Himachal Pradesh.

Garhwal Regional Centre

1. The morphological, phytochemical, and genetic diversity of 14 different populations of *Allium stracheyi* collected from Western Himalaya was analyzed. Considerable differences ($p < 0.05$) were recorded in morphological traits such as plant height, fresh weight, dry weight, leaf diameter, and stem diameter. The phytochemical assessment demonstratedhighest total phenol (3.93 mg GAE/g) and flavonoids (6.17 mg QE/g) content in the Kailashpur population, and higher total tannin content (1.84 mg TAE/g) in the Malari population. The highest (He = 0.338; Pp = 90.57%) genetic diversity was observed in the Kailashpur population and the lowest (He = 0.185; Pp = 47.17%) in the Niti population. Population structure analysis unanimously grouped all studied *A. stracheyi* populations into two sub-populations (ΔK= 2) (Fig 13).

2. Identified 8 principal growth stages (PGS) [i.e., bud development (PGS-0), leaf development (PGS-1), shoot

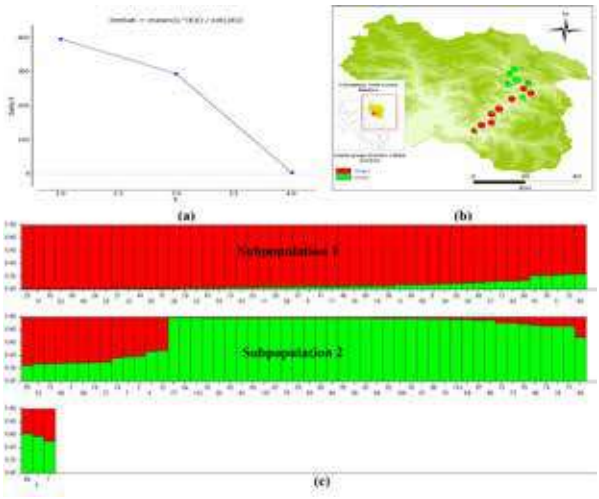


Fig. 13. Population Structure analysis for 103 *Allium stracheyi* genotypes based on Bayesian simulation. (a) The most likely K value using the Delta K (K=2) method. (b) Geographic distribution of genetic structure of A. stracheyi populations in the western Himalayas, showing prevalence of gene pools denoted by red and green colors (c) Estimated population structure divided into 2 sub-groups

development (PGS-3), inflorescence emergence (PGS-5), flowering (PGS-6), fruit development (PGS-7), fruit maturation (PGS-8), and senescence (PGS-9)] and 26 secondary growth stages in Malaxis acuminata species using the extended Biologische Bundesanstalt, Bundessortenamt und Chemische Industrie (BBCH) scale. (Fig 14)

3. A baseline agro-diversity survey based on the semi-structured questionnaire was carried out in 8 villages (Barsu, Gawphar, Ghandiyalka, Kayarki, Khadi, Kothiyar, Pokharsari and Punaad) of Barsu cluster of Rudraprayag district, Uttarakhand (intervention site) and recorded 72 species presently growing in the area.

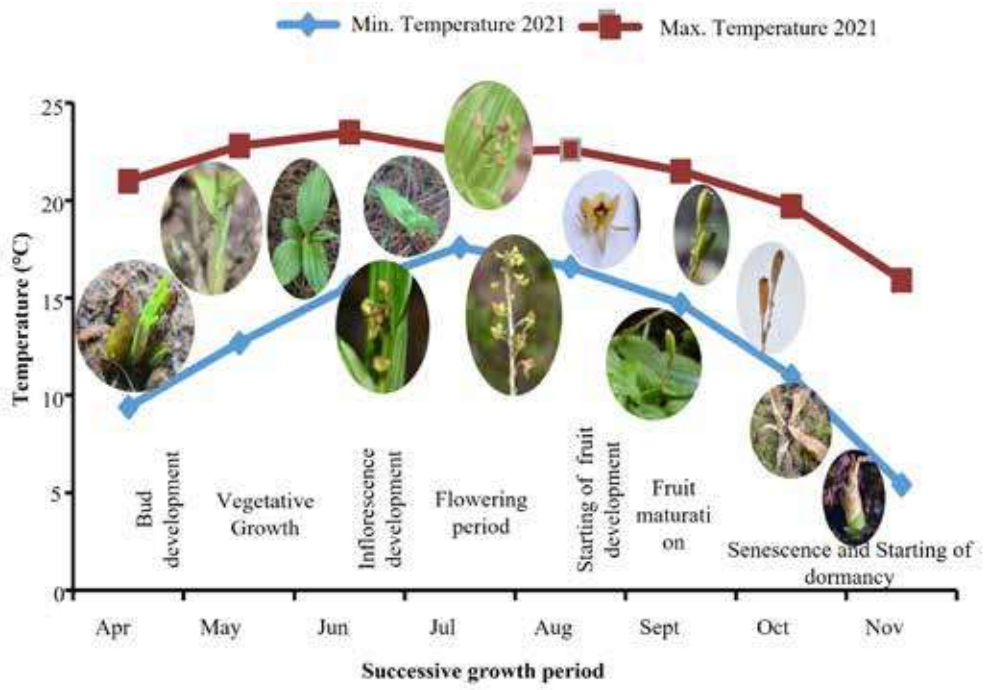


Fig. 14. Life cycle and progression of the growth stages of *Malaxis acuminata* in the growth period using the BBCH scale

Sikkim Regional Centre

1. Propagation protocols of two high-value medicinal plants, namely, *Rhododendron dalhousieae,* and *R. maddenii* were standardized, and a total of 550 seedlings of selected species (i.e., *Rhododendron arboreum* - 25 ind, *R. dalhousieae* - 25 ind, *Swertia chirayita* - 500 ind) were propagated through appropriate technologies (i.e., seed germination, vegetative propagation, in-vitro techniques).

2. Introduced 18 new orchid species in the orchidarium of the institute and developed one Zingiberaceae Sanctuary to strengthen the in-situ conservation and demonstration site. The sanctuary currently represents more than 95 genotypes of *Hedychium spicatum,* 25 genotypes of *Elettaria cardamomum* and 26 Zingiberaceae species covering *Hedychium* (10 species), *Globba* (04 species), *Curcuma* (03 species), *Amomum* (02 species), and *Zingiber* (02 species).

3. Recorded distribution points (210 nos.) of 04 threatened and medicinal plants species namely, *Crepidium acuminatum, Habenaria edgeworthii, H. intermedia* and *Hedychium spicatum*) from secondary literature and field visits.

Nort-East Regional Centre

1. Technical inputs on the revision of 20 PBRs of Ziro Valley, Lower Subansiri District were provided and submitted to the Arunachal Pradesh Biodiversity Board.

2. Identified Conservation priority areas for mammals in Northeast India using a Novel Conservation priority index (Fig. 15)

3. The Fern database of Arunachal Pradesh has been prepared using herbarium data and GBIF, and species distribution modelling of ferns in Arunachal Pradesh has been done in current and future scenarios.

4. Organized three awareness programs on different aspects of biodiversity and its conservation, in which 175 people were sensitized.

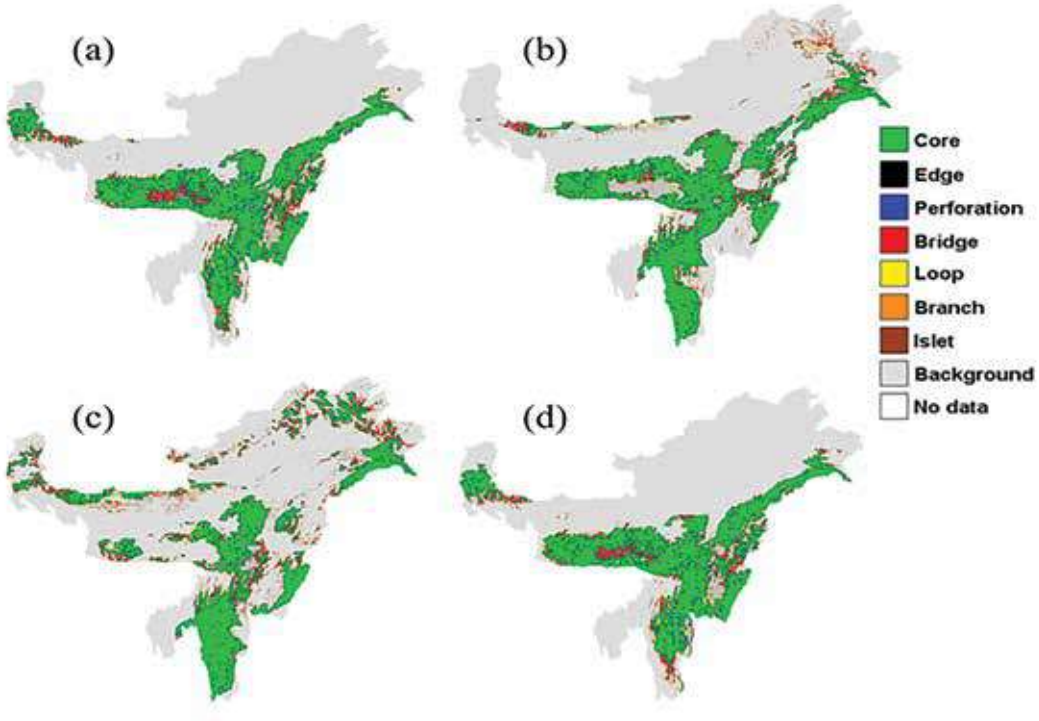


Fig. 15. Core areas from the Conservation Priority Indexes of mammals in North East India (a) Total Mammal (b) Threatened Mammals (c)Large Bodied Mammal (d) Small Bodied Mammal.

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

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

Objectives

- To develop propagation methods for mass multiplication of target species
- To develop agro-technologies and initiate PPP model

for the targeted species
- To optimize the extraction procedure of bioactive compounds
- To raise awareness and impart training on the conservation and sustainable utilization of the target species

Achievements

1. A germplasm repository of *P. verticillatum* and *P. cirrhifolium* has been established in the Surya-Kunj ex-situ conservation site of the institute and plantlets from different populations are conserved.
2. In vitro propagation of target species is under process and *in vitro* culture establishment using different explants viz. rhizome, leaf node etc. has been achieved. Various experiments on direct and indirect organogenesis are going on in both the species using different concentrations and combinations of Plant growth regulators (PGRs). Among the tested PGRs thidiazuron (TDZ) alone or in combination with α-Naphthaleneacetic acid (NAA) and/or gibberellic acid (GA_3) fortified Murashige and Skoog (MS) media showed significantly better shoot multiplication responses then the control(without PGRS) Fig. 16.

Fig. 16. In vitro propagation of *Polygonatum species*; a. *Polygonatum verticillatum* in the natural population; b. shoot multiplication response of *P. cirrhifolium;* c. shoot multiplication response in *P. verticillatum*; d. response under control treatment; e. *in vitro* established cultures of *Polygonatum spp*. All the responses depicted here are after 60 days of culture.

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

The Himalaya, one of the largest and highest mountain systems on the earth, is facing the impact of global warming at a rate which is higher than the global average. Limited scientific evidence is available on climates induced changes in the ecosystem structure and functioning in the Himalaya whereas such changes are severely impacting the dynamics of the Himalayan ecology in an unprecedented manner. Human societies in the Himalaya are facing severe impacts in terms of alteration in their agricultural and natural ecosystems, needing immediate attention for adaptation and developing resilience towards such changes. The project aims at developing village typologies to assess the vulnerability and climate resilience capacity of the selected villages from different clusters of villages in three agro-climatic zones i.e., Lahaul and Spitiin Himachal Pradesh, Rudraprayag and Almora in Uttarakhand and Karbi Anglong in Assam. Using the data on socio-economic,environmental and ecological parameters the project aims at understanding the severity of climate change impact on different rural village typologies to develop a climate resilient village framework using the traditional ecological knowledge and modern adaptation strategies available in the Himalaya and elsewhere.

Objectives

- To develop typologies for rural areas with respect to selected high-level geoclimatic and socioeconomic indicators.
- To conduct indicator-based socio economic/socio ecological assessment.
- To study the resource availability, use and spatio-temporal change of a village/cluster/landscape.
- To perform need and demand assessment for basic services and infrastructure.
- To map and plan for risk, resilience, and challenges regarding development of a village/cluster/landscape and identification of technological interventions required.
- To study traditional ecological knowledge and identify its role in increasing the smartness of existing villages.
- 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.
- To implement CRV interventions in two selected villages based on their needs and suitability and execute sustainability-driven exit plan.

Achievements

1. Village typology was developed for three landscapes using key indicators. Data from Census of India 2011 was analysed for 410 villages in Rudraprayag, 257 villages in Lahaul Spiti and 2611 villages in Karbi anglong districts to develop village typology for identification of villages to collect field data. A total of 19 parameters were used in analysis for development of village typology.

2. Hierarchical clustering on principal components (HCPC) technique was used to develop village typology and identify village clusters with similar typology for selection of villages to collect field data for development of climate smart village framework. A total of five unique clusters in Assam, four in Himachal Pradesh and three in Uttarakhand were identified for selection of villages. Data was collected on various parameters related to services, infrastructure and policy and governance.

3. Village Climate Resilience Index (VCRI) for 60 villages was calculated using primary field-based data on services, infrastructure and policy governance support to the indigenous communities for climate resilience and adaptation (Fig. 17).The results reveal high resilience of all the studied villages (25) in Lahaul and Spiti, 5 villages in Karbi Anglong and 1 in Uttarakhand. Medium resilience was reported for 14 villages in Uttarakhand and 58 in Karbi Anglong in Assam. Low resilience was observed only for 3 villages in the Karbi Anglong landscape. The high resilience of villages is attributed to better infrastructure, services and governance.

4. To understand the bio-physical impact of climate change in the Himalaya, spatio-temporal analysis of extreme weather events of 135 districts in the Indian Himalayan region was carried out. A total of 4640 extreme weather events were recorded by IMD during the period of 1980-2018, with a total of 2211 events caused by heavy rains and floods accompanying landslides and cloud bursts followed by 1486 events of heavy snowfall and 303 events of cold wave. The results shows that the western Himalayan region is more prone to extreme weather events as compared to the eastern Himalaya. Temporal distribution of the extreme weather events reveals an overall decline in heavy snowfall events after the 1990s whereas heavy rain and floods remain frequent.

5. A review of 768 publications from Himalaya reveals a significant increase in studies during past decades focusing on climate change adaptation and resilience in the Himalayan region (Fig. 17). Key research areas included climate change adaptation, vulnerability, resilience, food security, agriculture, adaptive capacity, adaptation strategies, traditional knowledge, sustainable development etc.

6. A total of five capacity building training programme and focused group discussion were organised at different villages cluster under the project. Around 450 participants from different villages, Self-help groups (SHGs), officers from line departments and NGOs representatives participated in these programmes.

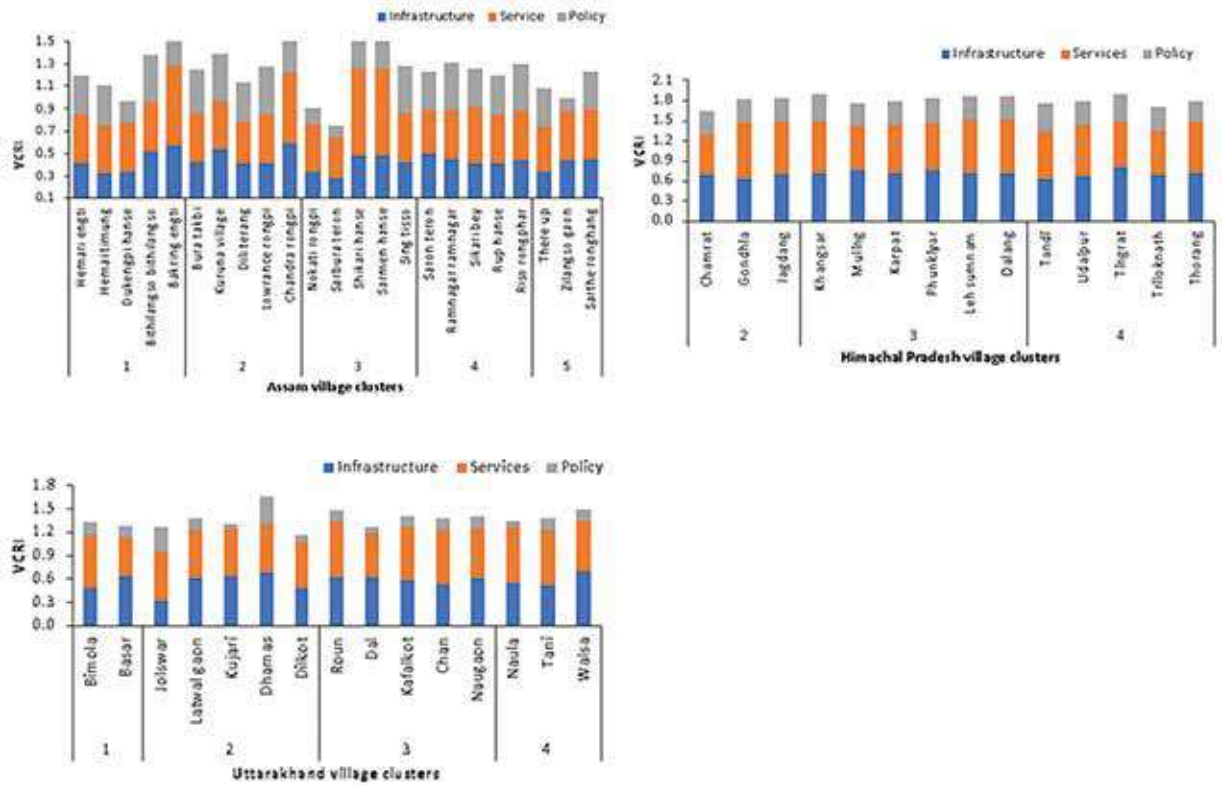


Fig. 17. Village climate resilience index (VCRI) of villages in three landscapes in the IHR.

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, GoI, 2024-26)

The National Action Plan on Climate Change (NAPCC), among others, recognizes the Himalayan ecosystem as vital for preserving the ecological security of the country. Also, it underlines the intense vulnerability of this ecosystem towards both anthropogenic and environmental perturbations. The sensitivity of the region is likely to be exacerbated by the impact of CC. Realizing the need, Govt of India (GoI), through the Department of Science and Technology and the Ministry of Environment Forests and Climate Change, initiated various programmes to study the impact of climate change, vulnerability and adaptation in different Himalayan ecosystems. For instance, NAPCC sets out 'Sustaining the Himalayan Ecosystem' (NMSHE) as one and the only area-specific mission among the eight National Missions. This mission envisages measures for sustaining and safeguarding the glaciers and mountain ecosystems. In addition, MoEFCC has initiated the National Mission on Himalayan Studies to understand the Himalayan region more holistically. The Himalayan region is highly sensitive towards natural (e.g., climate change) and human-induced perturbations. The magnitude and consequences of the impacts of climate change and loss of biodiversity are still poorly understood. Arguably, the future of biodiversity in the region would define the future of local communities and downstream-dependent people. Therefore, understanding climate change impact, vulnerability, and adaptation in Himalayan biodiversity is urgently required to develop sound strategies for its conservation and sustainable utilization.

Objectives

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

Achievements

1. Framework has prepared for preparation of Chapter IV of India's Biennial Transparency Report (BTR-1)

2. Comprehensive literature review carried out on impact, vulnerability, and adaptation for Himalayan Ecosystem particularly focusing on plant biodiversity

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, 2023-2026)

The Himalayan range is one of the 36 global biodiversity hotspots known for rich, unique and useful biodiversity and providing goods and services to a large population of India. In addition, the increasing pressure of development infrastructure, concurrent habitat loss, and unscientific exploitation coupled with increasing indifferences of the people has reduced the bio-diversity of the Himalayas. In recent years there is an increase in demand for the raw material of medicinal and aromatic plants by the pharmaceutical companies. Keeping in view the increasing demand of raw material of medicinal and aromatic plants by the pharmaceutical companies and 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

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

Achievements

1. Interactive meetings were conducted in the selected villages of the project and identified suitable land of 120 farmers for cultivation of medicinal plants.

2. Preliminary survey was conducted in the selected villages for household data collection, available cultivated land identification and willingness for cultivation of medicinal plants.

3. Five medicinal plants have been selected i.e. *Rosmarinus officinalis* (Rosemary), *Valeriana jatamansi* (Samyo), *Zanthoxylum armatum* (Timur), *Cinnamomum tamala* (Tejpat), *Hedychium spicatum* (Van haldi) for cultivation in farmer's field.

4. Nurseries have been developed to establish herbal garden/ demonstration sites of medicinal plants at Institute arboretum.

5. Plantation work of medicinal plants was initiated in Katarmal and Jyoli villages and work in other villages is in progress.

Promoting restoration programmes on degraded lands through medicinally important species- A participatory approach (NMPB, 2019-2024)

The Forests which are the sentinels of mountainous biodiversity face several threats in the form of over exploitation, unmanaged utilization, illegal trade, increased demand for fuel, fodder, timber, fiber, wild edibles, medicinal and aromatic plants, land use changes, forest fire, climate change etc. The above mentioned factors have resulted in degradation and depletion of forests and biodiversity resources. Restoration is likely to reverse the loss of biodiversity, improve ecosystem resilience, enhance the provision of ecosystem services, and mitigate the effects of climate change. Therefore, it would be pertinent to undertake land restoration, which will be helpful for reducing the pressure on natural resources, play an important role in conservation of biodiversity and uplift the economic condition of people and provide ecosystem goods and services for well-being of people. The GBP-NIHE, under NMPB funded project initiated land restoration activities on the degraded land through medicinally important species.

Objectives

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

Achievements

1. A total of 6 meetings/ workshops were organized in all three pilot sites, in which a total of 247 villagers (150 Male, 97 Female) from 5 villages participated in these meetings. A total of 6-hectare area from 5

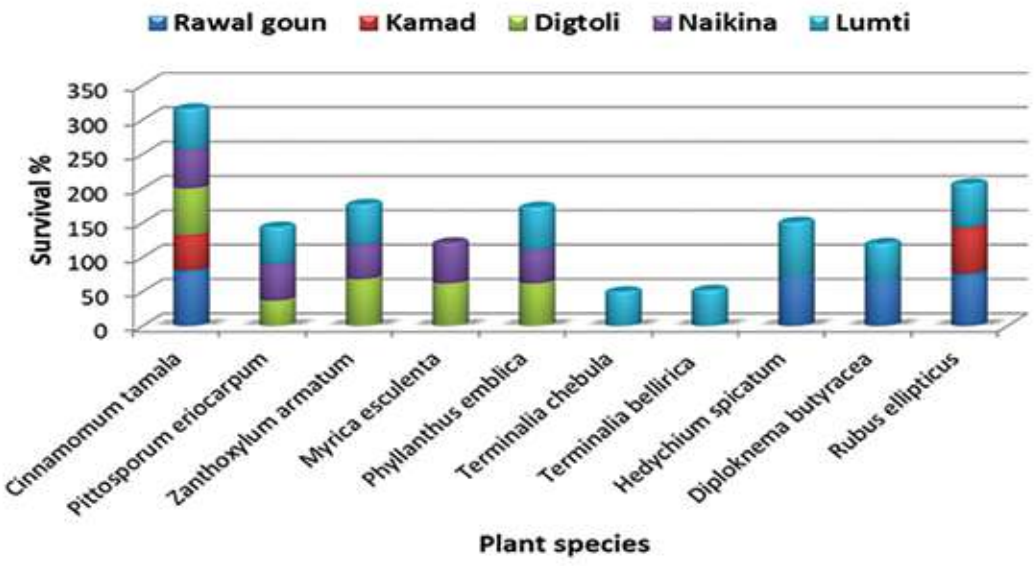


Fig. 18. Survival percentage of planted species after 3 years of establishment

villages at two different pilot sites was added in this year, 2023 for development of restoration model.

2. A total of 7,500 individual of 3 medicinal tree and herb species (*Cinnamomum tamala, Amomum subulatum, Zanthoxylum armatum*) were planted which are surviving at the rate of 60.44% among three pilot sites after one year of plantation (Fig. 18).

3. The capacity building of 140 villagers (85 Male and 55 Female) from 5 villages were enhanced through 4 hands-on training programmes on plantation and nursery technique, moisture and water conservation work, CRA technique and plant growth monitoring.

Ecosystem functioning and services of Himalayan Temperate Forest under Anthropogenic Change: A Plant functional trait-based evaluation (NMHS, 2020-2024)

Forest ecosystems deliver numerous services to mankind for their survival and are at the centre stage of climate change dynamics as they act both as a source (degrading or deforested) as well as sink (under afforestation and reforestation) of carbon dioxide. In the recent past, these ecosystems have witnessed degradation to varying extents due to prevailing environmental changes and anthropogenic pressures and thus functioning of these prized forests is being compromised leading to reduced flow of services. The reduced flow of services would result in an accelerated rate of forest extraction to fulfill the matching demand with increasing population, resulting in more degradation of forests. The continuous extraction led forest degradation undermines the sustainability of both the forests as well as the dependent communities. Therefore, management of forests is critical for continuous and sustainable delivery of invaluable ecosystem goods and services for the dependent communities.

Objectives

- To characterize the ecosystem based on plant function traits.
- To characterize the interrelationship between different functional traits with major ecosystem services in the IHR.
- To understand the biomass accumulation in the Temperate Forest ecosystem of the IHR .
- To predict and develop model for assessment of delivery of ecosystem services based on functional traits in the IHR .
- Total Economic Value for the Forest Types for control and other sites.
- Valuation of intangible ecosystem services for carbon capturing and climatic functions.

Achievements

1. A plant functional trait-based study was conducted across five temperate forest types in the Kumaun Himalaya region to investigate the growth performance of seven major tree species: *Quercus semecarpifolia, Q. lanuginosa, Q. leucotricophora,*

Q. floribunda, Rhododendron arboreum, Lyonia ovalifolia, and *Cedrus deodara* (Fig.19)

2. Photosynthetic rate ($\mu molCO_2\ m^{-2}\ s^{-1}$) directly or indirectly affected by the seasonal variations and recorded significantly higher in the Rainy season for *Q. semecarpifolia* (17.82) followed by *Q. lanuginosa* (13.11).

3. Leaf area was recorded higher during winter for *Q. lanuginosa* (69.4 cm^2) whereas lower during rainy season for same species (68.92 cm^2) while lower leaf area is recorded for *C. deodara* (4.60 cm^2) followed by *Q. floribunda* (19.65 cm^2) in rainy season.

4. Specific leaf area (SLA), Chlorophyll content, Leaf nutrients (carbon and phosphorus), Leaf photosynthetic rate and stomatal conductance reported maximum for *Q. semecarpifoliain* Kharsu oak forest, Nainital.

5. Water use efficiency recorded maximum for *L. ovalifolia* (101.8 μmol^{-1}) followed by *R. arboreum* (87.98 $\mu\ mol^{-1}$) due to resource conservation plant strategy.

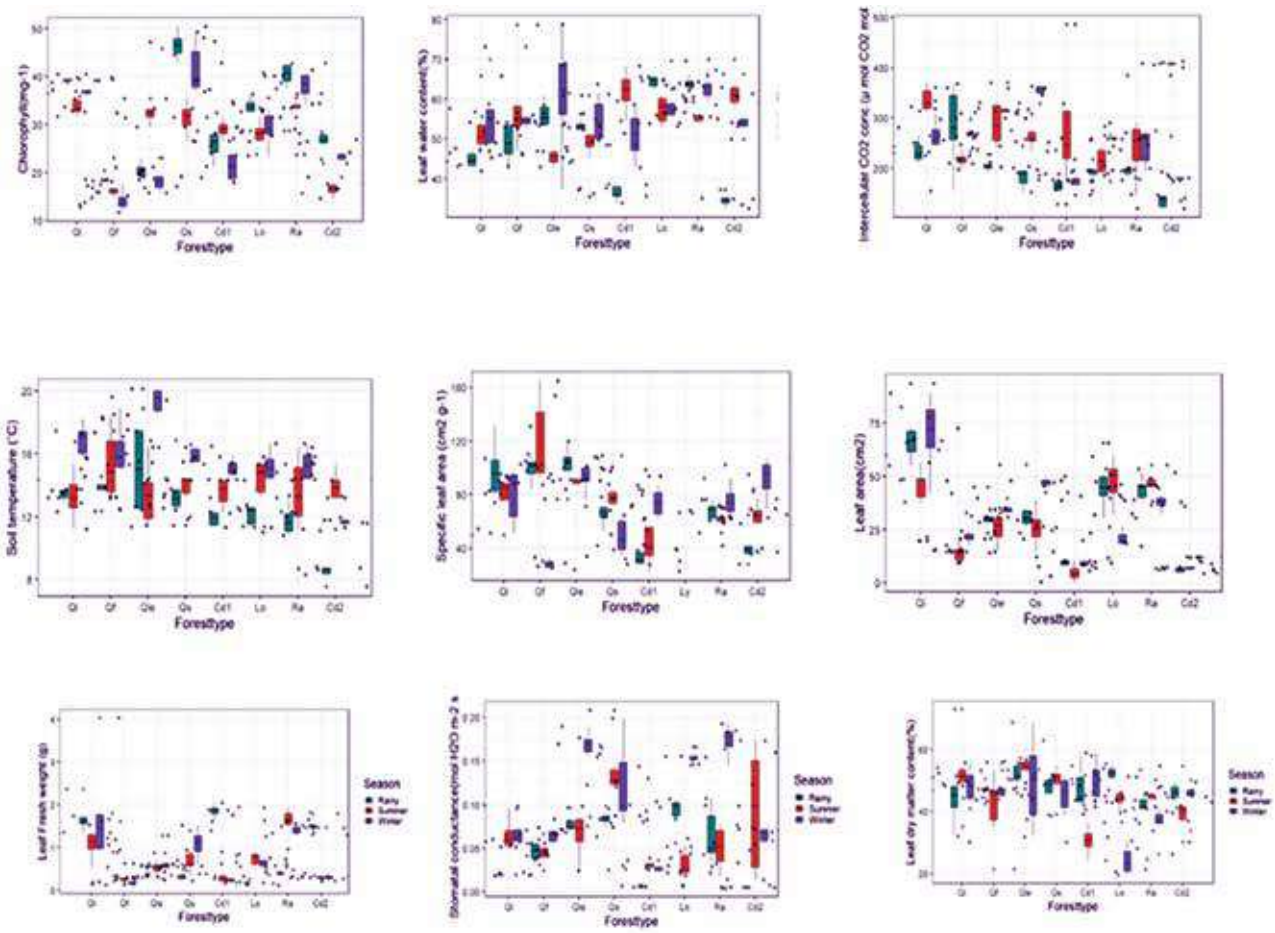


Fig.19. Seasonal variation of selected temperate forest

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

Climate change and other global change forces are causing dramatic changes in the Himalayan ecosystems. In addition to temperature changes, these changes are caused by variations in precipitation patterns, atmospheric carbon dioxide/gaseous pollutants 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. These changes threaten natural resources worldwide, including mountain regions, and subsequently, the natural resources of the Himalaya. Climate change (CC) is recognized as a major global environmental challenge that is going to affect ecosystems in a variety of ways and will pose a threat to social and economic development in the IHR, where societies' dependence on natural resources is very high. The CEA&CC caters to the Himalayan needs on these issues in tune with MoEF&CC and SDGs (Goal no. 13), which requires urgent action to combat CC and its impacts. The broad approach for achieving these goals includes: (i) identification and prioritization of climate-sensitive sectors in the Himalaya for research and 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 environmental parameters for the sustainable development in the IHR, and design measures for CC mitigation and adaptation by communities and developing ecosystem resilience to cope with CC risks. Thus, our vision is that by 2025, the Centre will attempt to become self-sustaining and play a leading role in Environmental Assessment and Climate Change research and advisory in the IHR. Our mission is bridging between research and practice on impacts of CC in identified key sectors of the Himalaya.

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

Climate change is widely recognized as the most significant worldwide concern. However, its effects are particularly noticeable in the Himalayan region. This breathtaking landscape harbours invaluable ecosystems that furnish essential resources and services crucial for human sustenance. However, in recent decades, the Indian Himalayan region have witnessed an alarming trend of accelerated warming and erratic precipitation patterns, leading to 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 restricted livelihood possibilities and social infrastructure. In such conditions, these communities are prone to being more susceptible to the impacts of climate change. Thus, it is crucial to evaluate the vulnerability of communities in order to devise adaptation strategies in the Indian Himalayan Region. The current research endeavours 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

1. A comprehensive analysis has been conducted, encompassing 239 climate extreme indices with a resolution of 0.5°, spanning the period from 1950 to 2023, specifically tailored for the Indian Himalayan Region using ERA reanalysis gridded climate data to discern trends and patterns in climate extremes, providing crucial insights into the region's climatic dynamics.

2. Environmental vulnerability index (EVI) has been prepared for the four states of the Indian Himalayan Region (Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh) based on 11 causative factors (soil texture, geology, elevation, slope, Forest type, road density, population density, drainage density, LULC). This index serves as a comprehensive tool for assessing and prioritizing areas prone to environmental stressors.

3. A series of 13 training and awareness programs have been organized aiming to empower and educate communities within the Indian Himalayan Region. These programs collectively cater to 1129 beneficiaries, equipping them with the awareness and skills necessary to confront the myriad challenges posed by environmental degradation and climate change during the year of 2023-2024. Through these initiatives, we endeavor to foster resilience and catalyze sustainable development within the region.

4. An Environmental vulnerability index (EVI) map has been developed for the four states of the Indian Himalayan Region: Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh. Among them, Himachal Pradesh stands out with the highest percentage of land falling into the High (19.26 %) to Severe (10.72 %) vulnerability class together accounted for nearly 30% area, followed by Arunachal Pradesh with 29.5% area then Uttarakhand with 25.47% area under high to severe environmental vulnerability class (Fig.19).

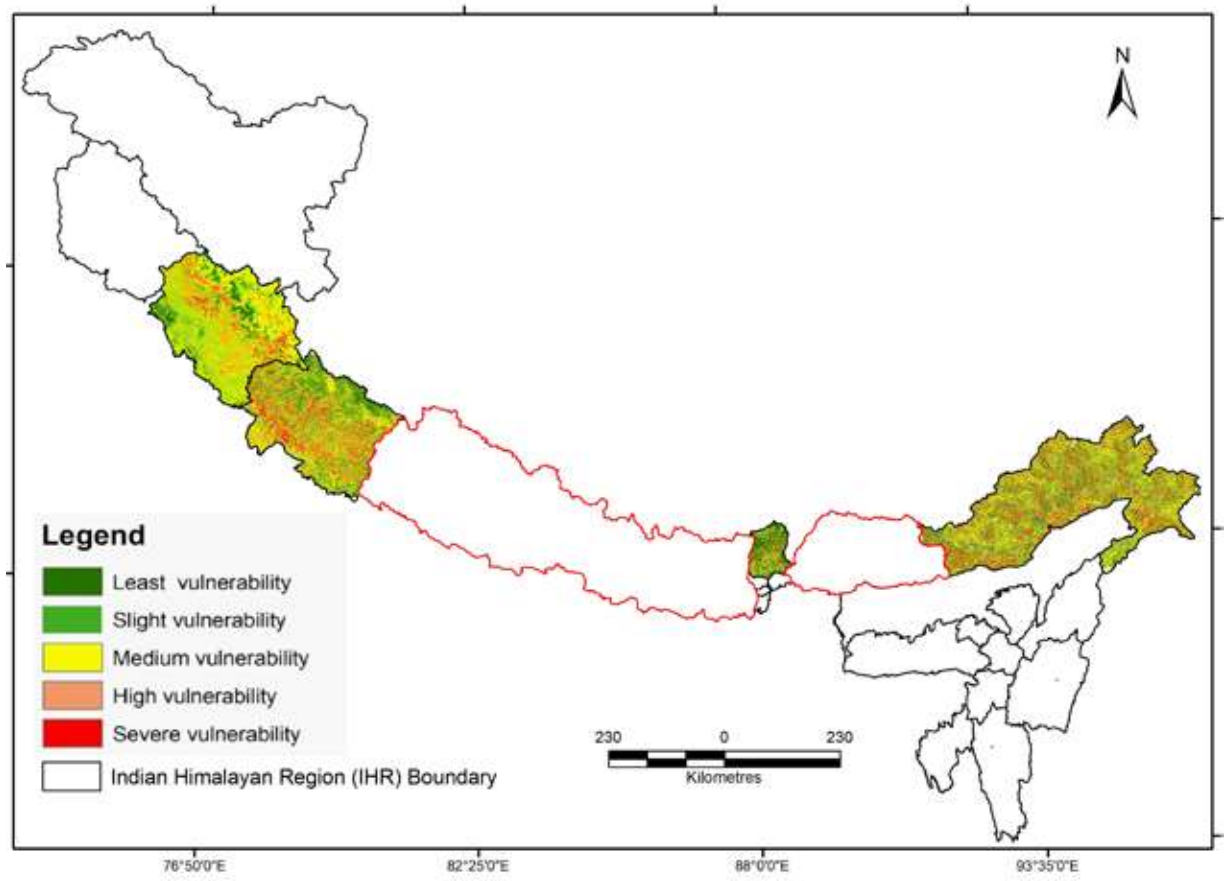


Fig.19 Environmental Vulnerability Map of the four states (Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh) of the IHR

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

The changing climate poses direct challenges to Earth, amplifying issues like 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 human-made aerosols burden, impacting the local climate and glaciers in places like the Kullu Valley, Himachal Pradesh. This leads to direct aerosol radiative forcing, alters Earth's radiative

balance, contributing to regional climate disparities. Regular monitoring of aerosol properties regionally and daily is crucial for understanding their impact on 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 (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 Weather Stations (AWSs) installed at Mohal (Himachal Pradesh) and Katarmal (Uttarakhand).
- To estimate radiative forcing using different models.

Achievements

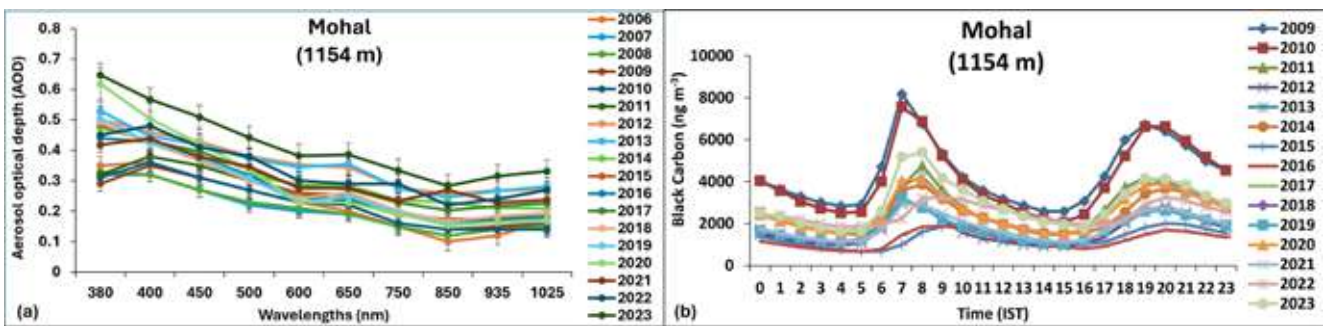
Mohal-Kullu, Himachal Pradesh (1154 m amsl)

1. AOD values at shorter wavelengths are higher, indicating an increase in anthropogenic activities (Fig. 20). The mean AOD at 500 nm at Mohal in 2023 stood at 0.42 followed by 0.39 in 2022 and a minimum 0.22 in 2007 (Fig. 21a). The percentage increase was ~57.4% from 2006 to 2023.

2. Black carbon (BC) shows a bimodal peak, with an average concentration of 1348.4±84.4 ng m^{-3} in 2023. Over the period from 2009 to 2023, the average concentration was 2345.2±154.4 ng m-3 (Fig. 21b).

3. The Respirable Dust Sampler recorded an average PM10 (8-hourly) concentration of 54.74 µg m^{-3}, while the Fine Particulate Sampler measured an average PM2.5 (24-hourly) concentration of 33.3 µg m^{-3}

Fig. 20 Multi-wavelength radiometer (MWR) and sunphotometer set up for aerosol measurements at Mohal, HP



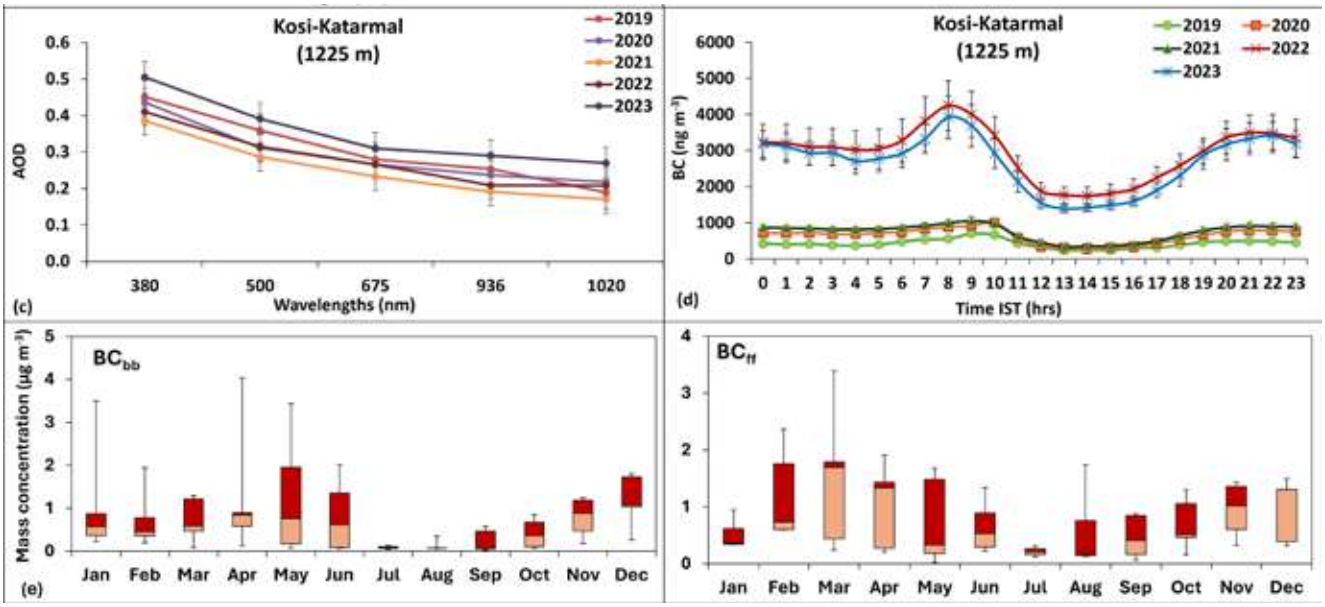


Fig. 21 (a) AOD variation from 2006 to 2023; (b) diurnal variation of BC from 2009 to 2023 at Mohal, while at Kosi-Katarmal from 2019 to 2023; (c) AOD variation; (d) diurnal variation of BC; and (e) Monthly mean variation of BCff and BCbb mass concentration observed respectively

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

Surface ozone, a secondary pollutant, forms when primary pollutants such as nitrogen oxides (NO and NO_2) from natural as well as anthropogenic sources react in the atmosphere. Understanding the relationship between O_3 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. Analysing 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 industrial. Other trace gases such as SO_2 also react in the atmosphere and lead to production of secondary pollutants such as PM10 and PM2.5 which adversely affect the environment.

Objectives

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

Achievements

Mohal-Kullu, Himachal Pradesh

1. Surface O_3 exhibited its peak concentration in Aug 2023 (41.39±4.61 ppb) and reached its lowest level in Jan 2024 (18.26±10.73 ppb) (Fig. 22a). NOx recorded its highest concentration in Jan 2023 (9.49±0.91 ppb), followed by Feb 2023 (8.63±1.14 ppb) (Fig. 22b). SO2 levels peaked in Dec 2023 (3.13 ±0.15 ppb), while its lowest concentration was in Aug 2023 (0.56±0.19 ppb).

2. Projections using the ARIMA model forecasted within its permissible limit until 2025 by using specific parameters (1,0,0).

3. Seasonal O_3 variability analysis via satellite data indicated cleaner air parcels originated from the marine areas during the monsoon season, while polluted ones came from the northwestern land region (back trajectories) traced using the Hysplit model.

Kosi-Katarmal, Almora, Uttarakhand

- In Jan, the highest concentrations were observed for SO_2 (8.94 µg/m³), NO_2 (12.26 µg/m³), and NH_3 (16.78 µg/m³), respectively. Conversely, the lowest concentrations were recorded in Dec for SO_2 (3.41 µg/m³), in Sep for SO_2 (7.30 µg/m³), and in Nov for NH_3 (6.95 µg/m³) (Fig. 22c).
- During forest fire days, NO_2, SO_2, and NH_3 showed an increase of ~122%, 107%, and 10% compared to non-forest fire days (Fig.22d).

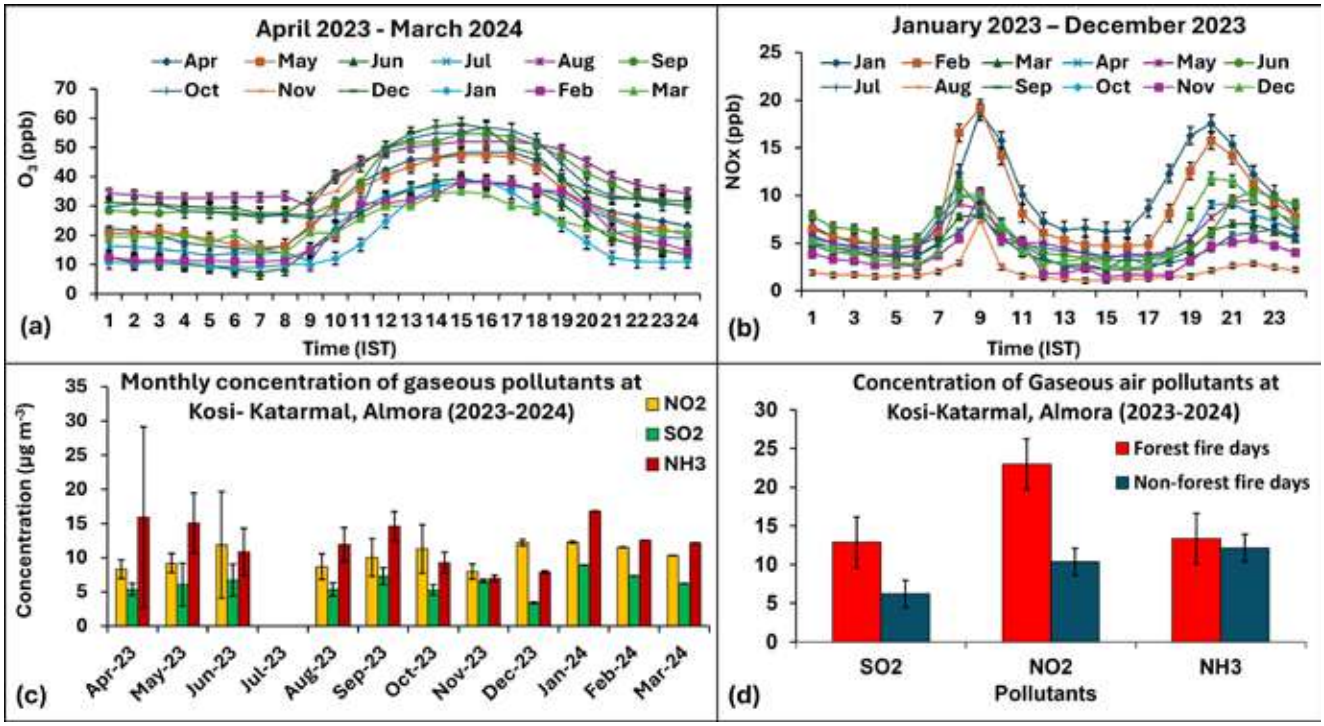


Fig. 22 (a- b) Monthly average concentration of O_3, NOx at Mohal Kullu respectively and Gaseous air pollutants; (c) Monthly concentration of gasesous air pollutants during April 2023 – March 2024; and (d) concentration of gasesous air pollutants during forest fire and non-forest fire days at Kosi-Katarmal, Almora in 2023-2024

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

The National Action Plan on Climate Change (NAPCC), acknowledges the critical role of the Himalayan ecosystem in India's ecological security and its vulnerability to anthropogenic and environmental pressures. The Task Force 3, coordinated by G. B. Pant National Institute of Himalayan Environment (NIHE), 'Forest Resources and Plant Biodiversity'. The project would develop a database of plants in the IHR under different life forms i.e., tree and shrub species of western Himalaya, invasive species of Indian Himalayan Region (IHR), threatened plants and wild edibles in the IHR etc. The database aims to facilitate participatory conservation and sustainable use of forest resources by stakeholders, promoting awareness and informed decision-making.

Objectives

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

Achievements

1. In total 6638 flowering plant species, distributed in

1539 genera and 139 families, have been inventoried in the IHR. These include 5535 dicotyledons (1307 genera and 127 families) and 1103 monocotyledons (232 genera and 12 families). Out of the total documented angiosperms, the maximum number of taxa were recorded from Uttarakhand-2954 (44.5%) followed by Sikkim-2945 (44.3%), Arunachal Pradesh-2771 (41.7%), and Jammu & Kashmir-2271 (34.2%).

2. Initial findings from the newly established LTEM plots in Kameng and Tawang districts of Arunachal Pradesh highlight that in the Tawang plot (2750 masl) a total of 51 species, i.e., 28 herbs, 10 shrubs, and 13 trees were reported into 12 genera and in 10 families.

3. A rapid floristic survey along the altitudinal gradient (1000 masl to 4400 m) in West, Arunachal Pradesh highlights 268 plant species distributed in 171 genera and 79 families

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

- To Study the Rhizosphere effect of treeline ecotone of the Inian Western Himalaya on soil enzyme, soil C & N, and other physicochemical properties of soil
- 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
- To study the Geospatial variability of the soil microbial indices of Alpine treeline ecotone in the Western Himalayan region using a geostatistical approach

Achievements

1. Representative Treeline ecotones in the Parvati valley Himachal Pradesh were selected at different elevation ranges. Pre and post monsoon sampling was performed at different elevation ranges of Darma valley Uttarakhand and Parvati Valley.

2. Soil physicochemical properties were analysed in Alpine meadow and agricultural soil samples of various villages of Darma valley Pithoragarh. Results revealed a negative correlation between pH, organic carbon,

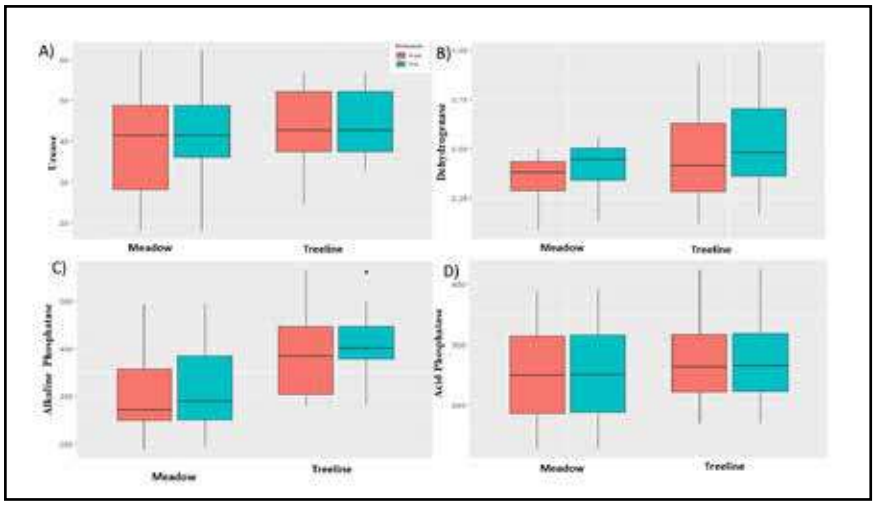


Fig.23 Seasonal and Land use type wise variations in soil (A) Urease, (B) Dehydrogenase, (C) Alkaline Phosphatase (D) Acid Phosphatase of Darma valley, Uttarakhand

total nitrogen, phosphorus and potassium with elevation indicating decreases with the increasing elevation (Fig. 23). Dehydrogenase activity was higher in treeline ecotone regions, while urease activity was higher in agricultural land. In Parvati Valley, alkaline phosphatase activity varied, with the highest in Kher to Bhunbuni sample. Acid phosphatase activity was highest in the Tundabhuj elevational sample and lowest in the Kheer to Bhunbuni elevational sample. Protein content varied across locations, with maximum in Philam meadow and minimum in Dantutreeline during the second year of Darma valley study.

3. Cultivable microbes have been isolated and colony forming units (CFUs) were analyzed along with morphological and microscopic characterization isolates.

Influence of climate change on Debris-covered Milam Glacier (Goriganga River Basin, Central Himalaya, India): Monitoring and Modelling of Physical Processes Governing Snow and Glacier-fed Watershed Dynamics (DST, 2023-2026)

Himalayan Cryosphere regime plays a critical role in controlling the regional climate and maintaining the water supply to the South Asian Rivers. Understanding its mechanism and behavior is crucial for Himalayan Cryosphere system and associated watershed, and is necessary to quantify the influence of climate change and future water availability. This proposed study focuses on the debris-covered Milam Glacier in the Gori ganga River Basin, Uttarakhand. It involves monitoring and modelling various physical processes and climate factors affecting snow and glacier-fed watersheds. A coupled approach combining ground-based observations, satellite monitoring, and modelling will be used to study glacier-climate interactions and predict future responses to climate change. A semi-distributed hydrological model will be developed to simulate meltwater discharge and surface runoff, considering snow and glacier melt, rainfall runoff, and evaporation. Simulation results will be validated using statistical techniques against available in-situ data.

Objectives

- Studying the physical processes of Milam Glacier by means of monitoring glaciological parameters (hydro-meteorology, hydrology, surface accumulation and ablation processes, terminus fluctuation, and snow cover changes) and climate forcers (absorbing aerosols, temperature and precipitation).
- Development of a physically based coupled glacio-hydrological model to assess the processes governing dynamics of snow and glacier-fed Himalayan watershed.
- To quantify the recent influence of climate change and future response of the glacier catchment.

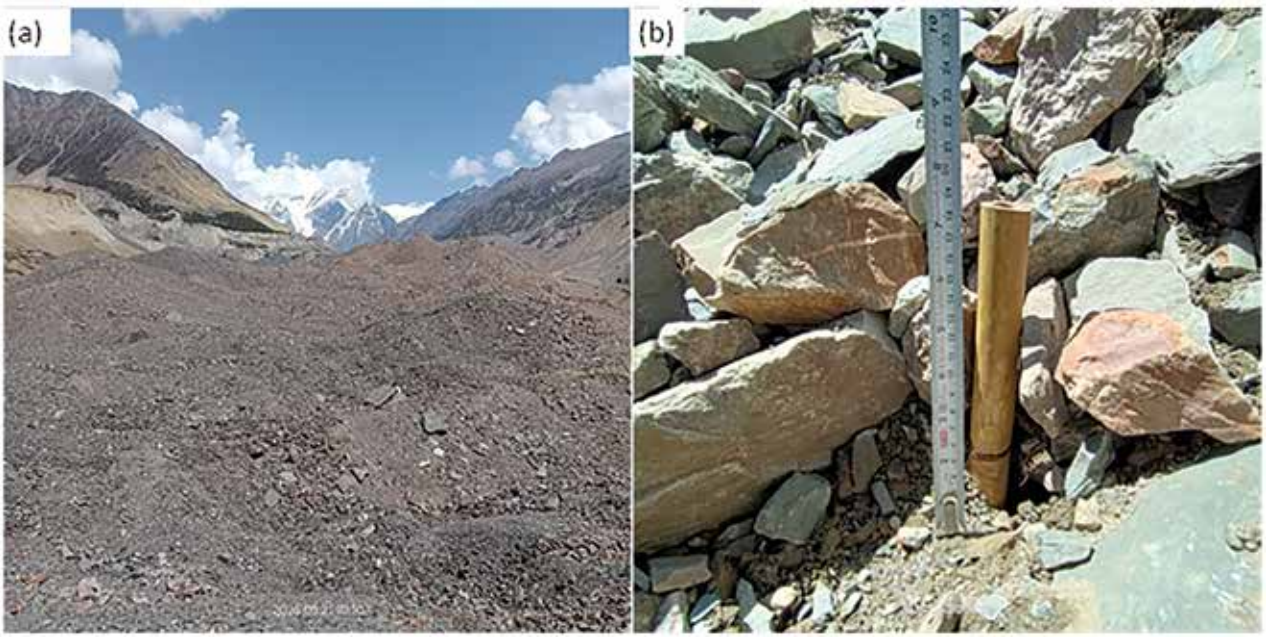


Fig. 24 (a&b) Hydro-Meteorological Observatory at Base Camp of Milam Glacier

Achievements

1. Five hydro-meteorological observation sites were established near the Milam Glacier at varying altitudes from October 2023 to November 2023: Milam Glacier Base Camp (3557 masl), Milam Hydro-meteorological Discharge site (3515 masl), Zero-point Milam Base Camp (3510 masl), ITBP camp Milam Village (3425 masl), and ITBP camp Bougdiyar Village (2550 masl) (Fig.24 a&b).

2. Meteorological data sets including near-surface air temperature (average (Tavg), minimum (Tmin), maximum (Tmax)), precipitation, and evaporation were extracted from CORDEX at 0.5 degrees. This data set is further downscaled to study area elevation point.

3. Snow and vegetation indices (NDVI, NDSI) have been computed for Milam Glacier catchment for Ablation and Accumulation season for the available dataset period (1993 – 2023).

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 and 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

- To identify, isolate and characterize the microbes for bioremediation potential waste dumping sites and development of microbial consortia for bioremediation of waste dumping sites in the colder region.
- To assess the suitable plant species and isolated microbes for the bio/phytoremediation capacity of the municipal waste dump sites.
- To build the capacity of stakeholders w.r.t microbial assisted bio/phytoremediation eco-restoration model setup for municipal waste management.

Achievements

1. A detailed literature review has been conducted on the microbial assisted waste management of municipal solid waste in the Indian Himalayan region.

2. The waste dumping sites for sample collection have been finalized.

Summary of the Completed Projects /Activity

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

Hon'ble National Green Tribunal (NGT) vide order, dated 26/09/2019 in O.A. No. 360/2018 filed by Shree Nath Sharma Vs. Union of India and Others directed that Central Pollution Control Board (CPCB) shall facilitate the District Magistrates (DM) in preparation of District Environment Plan and an integrated State Environment Plan. In view of this, NIHE in collaboration with Uttarakhand State Pollution Control Board (UKPCB) prepared the environment plan for all the 13 districts of Uttarakhand along with a consolidated State Environment Plan (Fig. 25). These environment plans covered 15 thematic areas related to waste management, air and water pollution, illegal sand mining, etc. Data analysis for the district environment plans were performed on urban local body (ULB) level while the data analysis for state environment plan was done based on topographical and geographical conditions of Uttarakhand. The thirteen districts of the state were divided into four topographical divisions: Tarai-Bhabar plain, mixed topographical region, mid-hill, and high-hill areas. Based on these divisions, the data collected on fifteen thematic areas for the formulation of the environment plan were examined. These data allowed for the identification of gaps in view of different environmental indicators pertaining to each thematic area. An action plan was then prepared for each of the thematic areas in accordance with the gap analysis and future requirements.

Overall, it was observed that the districts in plain regions, viz., Haridwar, Udham Singh (US) Nagar, and Dehradun are facing environmental issues pertaining to management of municipal solid waste, deteriorating air and water quality, etc. The hilly regions are also not immune from various environmental challenges which get amplified during the pilgrimage season. In view of this, micro-level action plans are formulated which could be undertaken for environment-centric development. These environment plans are dynamic documents which require upgradation periodically. All the environment obligations, which are deemed necessary for sustainable development, were covered under this plan.

Fig. 25. Some overview of consultative meetings and field visits undertaken for the preparation of District/State Environment Plans of Uttarakhand

Bioprospecting of medicinal plants of Sikkim Himalaya against breast cancer angiogenesis (DBT, New Delhi, 2019-2023)

The study was aimed to investigate potential medicinal plants of Sikkim Himalayan region against breast cancer angiogenesis and subsequent identification of biologically active molecules which can be used to develop effective anti-breast cancer drug leads. In this project, five endemic plants of Sikkim Himalaya viz. *Rhododendron dalhousiae, R. ciliatum, R. maddenii, Primula sikkimensis* and *Panax sokpayensis* were investigated for antioxidant, antimicrobial and anti-angiogenic activities. Subsequently, extracts showing good biological activities were investigated for bioactive compounds. Among the studied species, the highest total phenolic content, total flavonoid content and total tannin content were found in *R. maddenii, R. ciliatum* and *R.dalhousiae,* respectively. The 2, 2-diphenyl-1- picrylhydrazyl (DPPH) and 2, 2-azinobis-3-ethylbenzothiazoline-6 sulfonic acid (ABTS) free radical scavenging potential were found maximum in the *R. dalhousiae* with IC50 values of 13.58±1.81 µg/ml and 11.21±1.88 µg/ml, respectively (Fig.9). Ferric reducing antioxidant potential of *R. dalhousiae* was also comparatively better than other extracts. High performance liquid chromatography (HPLC) analysis showed the presence of various phenolic acids namely gallic acid, ferulic acid, vanillic, caffeic acid, catechin, p-coumaric and m-coumaric acid in the plant Rhododendron extracts. The *Rhododendron* spp. leaf extracts also exhibited antimicrobial potential against both gram-positive and gram-negative bacteria. The results of the present investigation revealed that all the selected plant extracts: *R. dalhousiae* (IC50=20±0.11µg/ml), *R. ciliatum*(IC50=64±0.19µg/ml), *R. maddenii* (IC50=90±0.22µg/ml), *P. sikkimensis*(IC50=23.2±0.36µg/ml) and *P. sokpayensis* (IC50=35.8±0.25µg/ml) demonstrated an effective cytotoxic effect against MDAMB-231breast cancer cells. In the CAM model, the plant extracts exhibited significant anti-angiogenic activity by inhibiting the

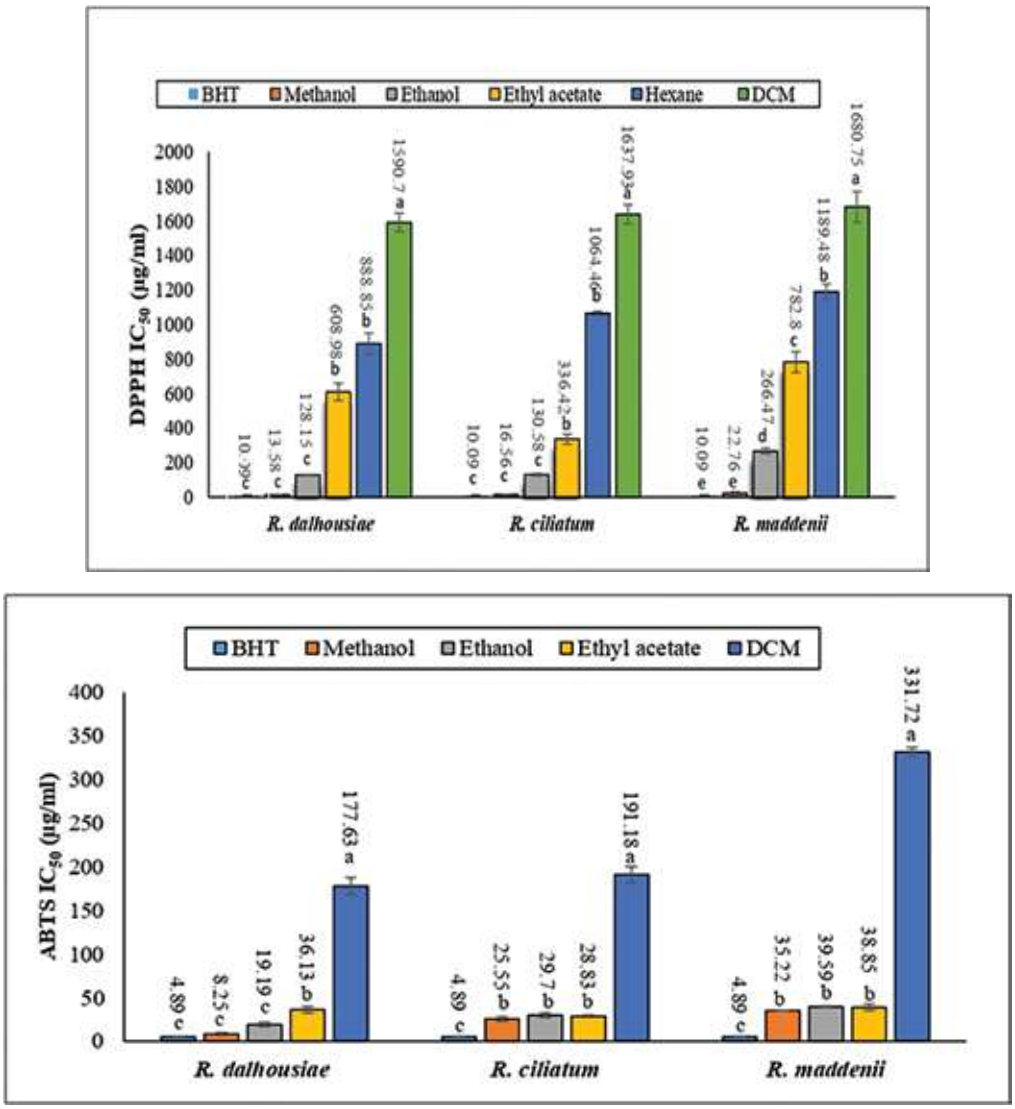


Fig.26. Antioxidant activity of *R. dalhousiae, R. ciliatum* and *R. maddenii* leaf extracts; (a) DPPH Free radical scavenging activity; (b) ABTS free radical scavenging activity, and Mean value ± SE was calculated from three.

blood vessels density. Amongst the tested samples, the most efficient anti-angiogenic effect was demonstrated by *R. dalhousiae* (79.71±0.57%) and *P. sikkimensis*(67.76±0.27%), respectively. Metabolites of studied plants were characterized using GC-MS which results revealed the identification of 32 compounds in *R.dalhousiae*, 40 compounds in *R.ciliatumand* 37 compounds in *R. maddenii*. Most of these identified compounds are known to possess several pharmacological bioactivities.The main bioactive compounds identified in leaf methanolic extract of R. dalhousiae are baccharis oxide (21.68%), alpha. –amyrin (21.61%), beta.-D-Glucopyranoside, methyl(10.09%), beta.–amyrin(6.74%),1,3,4,5Tetrahydroxycyclohexanecarboxylicacid (quinicacid) (3.41%). In *R. ciliatum* identified major compounds are 4,5-Epoxypentenal (21.95%),1,3,4,5-tetrahydroxycyclohexanecarboxylic (20.23%),beta.-D-Glucopyranose-1,6-anhydro-(levoglucosan)(3.63%),4H-pyran-4-one,2,3-dihydro-3,5-dihydroxy-6-methyl- (2.73%), phytol (2.19%). Major identified compounds of *R. maddenii* are alpha–amyrin (37.21%), beta –amyrin (11.48%) and friedelin (16.49%). Compounds such as 1,3,4,5-tetrahydroxy-cyclohexanecarboxy (3.41%), n-hexadecanoicacid (4.97%), neophytadiene (0.83%), phytol (1.54%), squalene (0.67%), respectively were present in small amounts. In *P. sikkimensis* extract, flavone (39.34%), neophytadiene (5.95%), 9,12,15-octadecatriene-1-ol (5.25%) and phytyal palmitate (5.14%) were found to be major compounds.

Major Outcomes

1. For the first time, five endemic plants of the Sikkim Himalayan region viz. *R. dalhousiae, R. maddenii, R. ciliatum, P. sokpayensis* and *P. sikkimensis* were investigated for antioxidant, cancer angiogenesis and phytochemicals. Antioxidant assays of investigated endemic species showed that methanolic leaf extract of *R. dalhousiae* has exceptional activity in DPPH and ABTS assays (Fig. 26).

2. Amongst the investigated plants, *R. dalhousiae* and *P. sikkimensis* exhibited potent anti-angiogenic activities in human endothelial and cancer cells in vitro and mice model of angiogenesis *in vivo*. GC-MS analysis confirmed that these plants are rich in bioactive compounds.

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 centre – (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.

Rural Technology Centre-Leh (In-house, 2023-2024)

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, Rural Technology Centre (RTC) emerged as a knowledge centre 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.

Objectives

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

Achievements

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

2. Hydroponic cultivation for the leafy vegetable Mongol (*Beta vulgaris* L. var. cicla) and Spinach (*Spinacia oleracea*) under the polycarbonate was carried out and compared with its soil-grown plant under the same polycarbonate in the peak winter months of Ladakh (Jan-Feb 2024). The study found that the hydroponically raised plants in both species were significantly higher in terms of plant height, leaf number, leaf size, biomass, and root length compared to soil-grown ones (Table 3; Fig. 27). The proximate analysis of both species is underway.

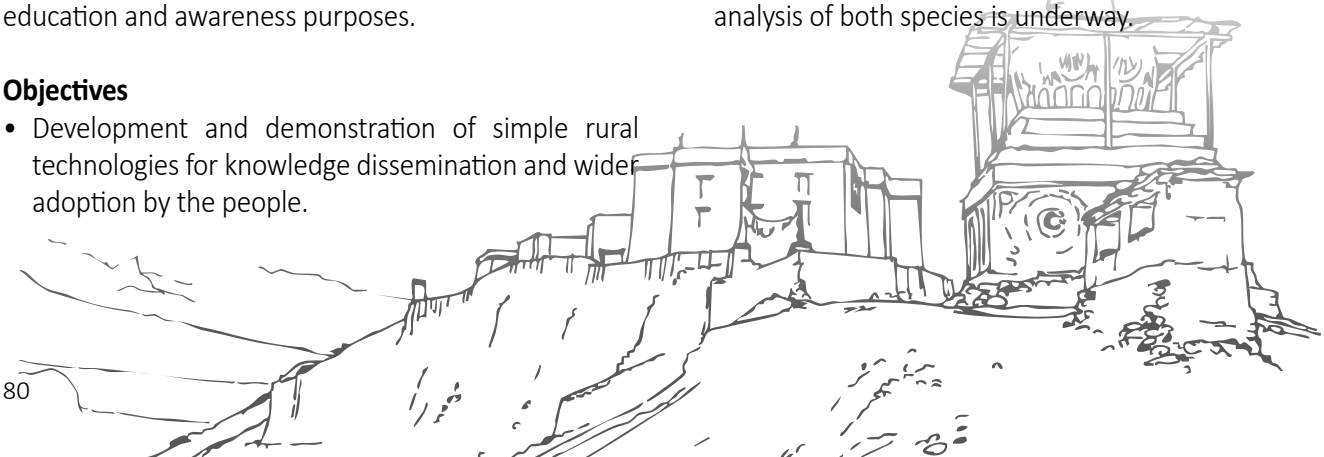


Table 3: Plant morphometric characterists grown under different conditions in the RTC of LRC-NIHE, Leh.

Leafy Vegetable	Condition	Plant height (cm)	Leaf No	Leaf Length (cm)	Leaf Width (cm)	AGFW (g)	Root Length (cm)
Spinach	Hydroponic	37.24±1.15	77.00±8.18	19.64±0.75	11.74±0.91	99.20±9.22	31.56±4.34
	Soil	23.98±2.02	10.60±1.45	10.10±0.91	7.44±0.69	7.24±1.71	10.16±0.38
Mongol	Hydroponic	34.08±1.42	8.40±0.97	24.80±1.51	4.96±0.41	51.68±6.56	31.10±2.88
	Soil	25.24±1.01	7.20±0.81	16.54±0.74	3.32±0.73	19.96±1.00	13.74±1.48

AGFW=Above

Fig. 27. The Nutrient Film Technique (NFT) hydroponic method was utilized to grow two leafy vegetables and compared with soil-grown: (a) to (c) Mongol raised hydroponically, (b) Mongol raised in soil, (d) to (e) Spinach raised hydroponically, and (f) Spinach raised in soil.

Natural Resources-Based Livelihood Options and Off-Farm Employment in Rural Landscape of Ladakh (In-house, 2023-2024)

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

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

Achievements

1. Among 15 villages within the Leh districts of Ladakh UT, a total of 6 villages (Sumoor, Changa, Khatpoo, Martselang, Himya and Tarchit) were identified for targeted training and capacity-building programmes.

2. Total eight (08) hands-on Integrated Mushroom Cultivation training programs were conducted with a total participation of 97 villagers (7 male and 90 female). The objective of these training sessions was to address nutritional deficiencies and to bolster livelihood opportunities within the region.

3. Two (02) hands-on basket-weaving training sessions were held over a span of 10 days in Changa and Martselang, 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 (Fig. 28). 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)*.

Fig. 28. Glimpses of training programmes organized at different villages in the Leh district.

Exploring the use of treated wastewater for vegetable cultivation through hydroponic in Ladakh UT (NMHS, 2023-24)

Water scarcity represents a critical global challenge exacerbated by the significant depletion of water resources attributed to irrigated agriculture, which accounts for over 69% globally. The rapid expansion of urban areas further 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, such as accelerated growth rates, heightened productivity, and efficient water utilization. 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 centreed on utilizing treated wastewater from the Faecal Sludge Treatment Plant managed by the Leh Municipal

Fig. 29. Wastewater based Hydroponic prototype for cultivation of leafy and fruity vegetables (a) Optimized and treated wastewater (Lacking of heavy metals) for drip based hydroponic, (b) to (e) Tomato, (f) Capsicum, (g) Lettuce

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

- To develop a solar powered hydroponic prototype to utilize the treated water for the production of vegetables.
- To standardize the protocol for cultivation of selected target species in Hydroponic technology utilizing the treated water.
- To popularize the hydroponic technique by conducting various training program to local beneficiaries.

Achievements

1. Conducted nutrient and heavy metal (Pb, Cr, and Cd) analysis on treated wastewater to optimize its use as hydroponic nutrients. The report indicates that the wastewater possesses a sufficient nutrient concentration but lacks heavy metals.

2. A low-cost solar-powered hydroponic prototype was developed within the polycarbonate greenhouse, generously provided by LEDeG, Leh, situated near the Faecal Sludge Treatment Plant (FSTP) of the Municipal Committee Leh (MCL) at Bombguard (Fig. 29).

3. Over the reporting period, experiments were conducted to cultivate five fruits/leafy vegetables: Tomato, Capsicum, Lettuce, Mango, and Spinach—using the wastewater-based hydroponic prototype. More than 50,000 L of treated wastewater were utilized for cultivating the aforementioned vegetables.

4. Proximate and heavy metals analysis was conducted on tomatoes cultivated in treated wastewater and compared with those grown in a nutrient based drip hydroponic and soil medium. The carbohydrate content in tomato fruit exhibited a significant difference ($P<0.05$) among the various growth conditions, with plants grown under nutrient conditions displaying the highest content (80.42 mg/g), followed by those grown under wastewater conditions (55.91 mg/g) and soil conditions (39.48 mg/g). Similarly, the fat content in tomato fruit mirrored this trend, with significantly higher levels observed in plants grown under nutrient conditions (31.04 mg/g), followed by wastewater (24.38 mg/g) and soil (15.32 mg/g) conditions. Regarding total energy, a significant increase was noted in plants grown under nutrient conditions (69.88 kcal/100g) compared to those grown under wastewater (54.06 kcal/100g) and soil (36.98 kcal/100g) conditions. The heavy metals like Pb, Cd and Cr were absent in treated wastewater grown tomatoes.

Developing new and improved agriculture techniques (mushroom cultivation) in the GoI-UNDP-GEF SECURE Himalaya Project Landscape in the Union Territory of Ladakh (UNDP, 2023-24)

In the Trans Himalayan region of Ladakh, characterized by its high-altitude terrain and where traditional agriculture grapples with the harsh challenges of severe weather and limited food supplies, mushroom cultivation emerges as a promising solution. Beyond providing a sustainable source of income, it holds the promise of fortifying food security and promoting environmental sustainability. The proposed project is poised to advance this vision by fostering innovation, knowledge-sharing, and community empowerment. In collaboration with the Government of India, the United Nations Development Programme (UNDP), the Global Environment Facility (GEF), and the Ladakh Regional Centre of NIHE, the project endeavors to introduce novel mushroom cultivation methodologies and refine existing practices tailored to Ladakh's distinctive ecological and socio-economic milieu. Focused on three target villages: Khatpu, Hemya, and Tarchit nestled within the captivating Rong Valley of Leh district of Ladakh. Through a multifaceted approach encompassing capacity-building initiatives, technological innovations, and inclusive community engagement, the project aspires to cultivate a vibrant ecosystem of sustainable agriculture, economic prosperity, and ecological resilience across the Ladakh region.

Objectives

- Pioneering novel and enhanced agricultural methodologies, specifically focusing on mushroom

cultivation, to drive income generation.

- Setting up 25 mushroom cultivation facilities to anchor local economic development.
- Conducting comprehensive capacity-building initiatives and practical training programs on integrated mushroom cultivation techniques.

Achievements

1. Conducted 06 comprehensive Mushroom Training Programs across the three target villages, engaging a total of 87 enthusiastic farmers.

2. Organized 02 training sessions focused on constructing low-cost polyhouses, with a participation of 21 farmers.

3. Established 25 mushroom cultivation units across three picturesque villages: Khatpu, Hemya, and Tarchit, nestled within the captivating Rong Valley of Leh district (Fig. 30).

4. Distributed a total of 10 mushroom bags (approximately 4 kg each) in each polyhouse.

5. Obtained remarkable success in oyster mushroom yield, with an initial harvest averaging between 0.23 to 0.45 kilograms per bag, showcasing consistent high performance among all beneficiaries.

Fig. 30. The glimpses of mushroom unit establishment activities at target sites

Preparation of People's Biodiversity Registers for Municipal Areas of Ladakh: Leh (Urban Local Bodies – Ladakh, 2023-24)

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

Objectives

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

Achievements

1. Official PBR document of Leh Urban area was submitted to Municipal Committee Leh, Ladakh UT on 30 March 2024. This is the first PBR document of Ladakh UT.

2. According to the PBR, a total of 193 floral taxa were recorded, encompassing a variety of categories. These include 27 types of cereals and vegetables, 9 horticultural species, 10 fodder plants, 12 weed species, 13 cultivated medicinal plants, 46 ornamental plants, 6 cultivated timber plants, and 61 wild herbs and shrubs. Additionally, the report documented 29 wild medicinal plants.

3. Furthermore, the PBR recorded 154 faunal species, which comprised a diverse range of animals. This included 10 domestic animals, 5 wild animals, 55 bird species, 2 reptiles, 2 fish species, and 37 insect species, among others.

4. Notably, 97 of these floral and faunal taxa (12 flora and 85 fauna) are categorized under various IUCN threatened Categories, underscoring the importance of conservation measures.

Summary of the Completed Project/ Activity

Urban Beautification - Proposal to develop Educational Mini Urban Arboretum using permanent flower-pot containers located in main market of Leh Town (Municipal Committee Leh-2023-24)

Urban gardening is in no way a new concept in the global scenario but has not been established in India as a tool to educate people, rather confined for the beautification of landscape. As an additional benefit people find solace in these plants, as well as increasing their general emotional and social well-being while reducing stress levels. A number of tourists visit Leh town and walk through the corridors of the main market where many well-structured cemented pots have been placed permanently. Up-keep of these pots, a common property resource, is in question due to various reasons including appropriateness of plants chosen, behavior of people (inside spitting and littering is common) and shelter of street dogs. The main objective of this proposal is to utilize the urban landscape of the main market of Leh Town for beautification and educational purposes to bring awareness about plant wealth of Ladakh and sensitize local inhabitants and the tourists visiting Leh town. These flower-pots will also serve as mini urban arboretum in Ladakh. Therefore, it is proposed that upkeep and maintenance of all the permanent flower-pots located in the main market of Leh Town may be done by the NIHE, Ladakh Regional Centre with financial support from UT Administration of Ladakh. The objectives of the project were (i) to utilize the urban landscape of main market of Leh town for beautification and educational purpose and to bring awareness about plant wealth of Ladakh and sensitize local inhabitants and the tourists visiting in the Leh town; and (ii) to maintain all the permanent flower pots located in the main market of Leh town. The beatification activities were initiated during the G20 summit at Leh market area using 03 targeted tree species: 01 sacred *(Juniperus polycarpos)* and 02 ornamental *(Cupressus sempervirens and Thuja orientalis)*; 01 medicinal shrub *(Rosa macrophylla)* ; and 05 high value medicinal herbs i.e., *Allium stracheyi*, Ladakhi Sanjeevani *(Rhodiola imbricata)*, *Inula racemosa, Salvia scalria, Plantego* spp. To assure longer survival of the tree species, plant protection units (around 18) were established. Farm yard manure was used to increase the soil productivity and plantations were carried out after the harsh winter seasons of Ladakh. To assure minimum disturbances on the planted trees wards and watches were carried out. One of the important activities carried out under this project was wider dissemination of the ethnobotanical values of planted trees through proper name tagging using Hindi, English and Bodhi languages. The project concluded in November, 2023.

Himachal Pradesh Regional Centre (HRC)

The Himachal Pradesh Regional Centre (HRC) caters to the needs of the entire Himachal Pradesh state. The focus of the centre is the 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 follows:

- 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 mechanisms 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 scenarios.
- Assessment, monitoring and management of agricultural crops/farming systems for sustainability along an altitudinal gradient in North Western Himalaya.
- Assessment and sustainable management of eco-tourism through entrepreneurship development.

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

The Lahaul&Spiti district of 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 also offering a promising avenue for economic empowerment. Project activity involves harnessing this resource, particularly involving women members of self-help groups, farmers, and youth. The project also aims to develop collection tools, establish local processing units, and diversify product offerings, including herbal teas, jams, dried berries, and seed oils. By enhancing the value of seabuckthorn through timely processing and value addition, the project not only uplifts livelihoods but also promotes entrepreneurship rooted in scientific and technological innovations.

Objectives

- Formation/involvement of Women/Farmer Self Help Groups for entrepreneurial activity of SBT
- Development/Customization of berries harvesting tool
- Establishment of processing unit in the region
- Product development and testing

- Enterprise and Value chain creation of SBT
- Awareness/Capacity building of stakeholders on various aspects of SBT.
- Marketing linkages

Achievements

1. A processing unit has been established at Jahalma Village, Lahaul and Spiti, equipped with essential equipment such as Solar dryers, Microwave dryer, Fruit pulper, weighing machine, sealing machine, etc., with project activity expansion to the entire Lahaul Valley.

2. In the first year of project implementation, 128 Women members from various Self Help Groups and Mahila Mandals are actively engaged and trained on entrepreneurial activities such as collection, processing, drying and packaging. Plantation of around 850 seabuckthorn seedlings was also done in the entire valley (Fig. 31).

3. Establishment of Women Enterprise on Sebuckthorn in Lahaul Valley has been done and operational with the revenue generation of around Rs. 3 lakhs during Kullu Dusshera 2023, International Shivratri fair Mandi, 2024 and through various local and regional agencies.

Fig. 31. Seabuckthorn seedling distribution; Pulp Processing at Unit and Product Marketing

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

In the Indian Himalayan Region, water springs serve as crucial sources of drinking water and irrigation for the local populace. However, in recent years, these springs have faced the threat of depletion, primarily due to declining rainfall, escalating temperatures, changes in land use and cover, attributed to infrastructural development and hydropower projects, have further exacerbated the situation. In the Lahaul valley, through

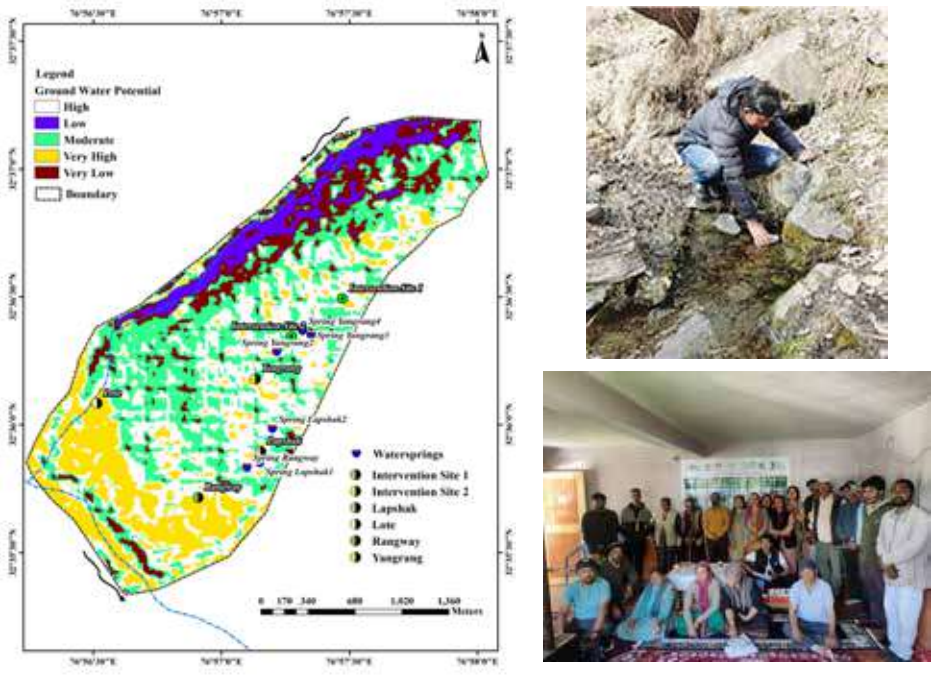


Fig. 32. Groundwater potential of the intervention site; Spring water sampling; Awareness Programme

comprehensive studies and fieldwork, our team has identified and assessed the condition of various water springs in the region. This involved analysing factors such as water flow rates, groundwater levels, and surrounding land use patterns. Collaborating closely with local communities, governmental agencies, and environmental experts, we have initiated various interventions aimed at conserving and restoring these vital water sources.

Objectives

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

Achievements

1. Review of springs' related planning and management practices was done and identified policy gaps.

2. LULC study from 2010 to 2020 has been done and Temperature data of 12 years from 2010 to 2022 were analyzed.

3. Water Quality Index (WQI) study of 30 springs was done, revealing an overall excellent water quality of 22 springs and with good quality of remaining 8 springs. .

4. Identified intervention sites for spring rejuvenation, focusing on the top of Yangrang village and assessed groundwater recharge potential at selected intervention sites and also organised various awareness programmes (Fig.32).

5. Continuously monitored water discharge from Rangbayspring to evaluate changes pre- and post-intervention.

6. Recorded highest water discharge of 28 liters per minute during monsoon season, and lowest during post-monsoon season.

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

Hydroelectric projects involving constructions of big dams, tunnels and powerhouses are causing several environmental problems. The approach for formulation of an Environmental Management Plan (EMP) is to maximize the positive environmental impacts and minimize the negative ones. The steps suggested include modifications of plans, engineering designs, construction schedules and techniques, as well as operational and management practices. After selection of suitable environmental mitigation measures, cost required for implementation of various management measures will also be worked out. An Environmental Monitoring Programme for implementation during project construction and operation phases has been estimated to oversee the environmental safeguards, to ascertain the agreement between prediction and reality and to suggest remedial measures not foreseen during the planning stage but arising during operation and to 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 main purpose of the EMP is to determine the environmental impacts of the project and to give an idea about how to mitigate the adverse impacts, their effects and their monitoring periodically after the project becomes operational.

Objectives

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

Achievements

1. To understand the study area various maps like Rainfall erosivity map, Soil texture map, Soil erodibility map, Interpolation map of soil available potassium, Land

use land cover map, NDVI map, Sediment transport index maps were created.

2. For the soil quality assessment, a total of 22 samples were collected from different sites from 7km surrounding areas of SHEP.Soil moisture, pH and EC were checked in the laboratory The Values of soil moisture percentage ranged between 1.7 – 15.7% where as in case of pH and EC range are 5.6 - 6.19 and 0.05- 0.84 respectively. The available potassium (K) content in soil for 22 different forested sites was measured in kilograms per hectare (Kg/ha). Soil samples were classified into three groups: Low (< 110 Kg/ha), medium (110-280 Kg/ha), and high (> 280 Kg/ha). Out of 22 soil samples none are in low category, 3 are in medium and 19 soil samples were in High class.

3. Revised Universe soil loss equation model has been created by using Rainfall- Runoff Erosivity Factor, Soil-Erodibility Factor, Slope Length Factor, Slope Gradient Factor, Cropping Management Factor, and Support Practice Factor. The Resultant map was classified into Six classes and the average rate of soil loss for the entire study area is "8.94 tons/ ha/ yr". Soil erosion using the RUSLE model reveals that the annual predicted soil loss ranges between "0 to 258.07 tons/ ha/ yr".

4. For land use/land cover assessment, NDVI-based monitoring for the year 2016 to 2022 were identified using Landsat 8 images of 30m resolution in ArcGIS Pro environment. During this period, grassland and unhealthy vegetation decreased by 6.56% and 9.01% respectively, while there was an 11.38% increase in healthy vegetation.

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Permafrost Mapping and Characterization of Western Himalayan Region (NMHS, 2020-2024)

Permafrost is the layer, which is separated from the atmosphere by a boundary layer consisting of the active layer which is covered with vegetation in summer and with snow cover in winter. The active layer transmits heat to and from permafrost. It reduces the amplitude of thermal variations at the top of permafrost compared with the ground surface. It is the medium through which moisture and gases are exchanged between permafrost and the atmosphere and provide water and nutrients for biological processes. Permafrost (perennially frozen) soils store vast amounts of organic carbon (C) and nitrogen (N) that are vulnerable to mobilization as dissolved organic carbon (DOC) and dissolved organic and inorganic nitrogen (DON, DIN) upon thaw. Such releases will affect the biogeochemistry of permafrost regions, yet little is known about the chemical composition and source variability of active-layer (seasonally frozen) and permafrost soil DOC, DON and DIN. Dissolved organic carbon (DOC) and total dissolved nitrogen (TDN); as dissolved organic and inorganic N; DON, DIN) broadly influence terrestrial and aquatic ecosystem function and greenhouse gas emissions as they are biogeochemically cycles within soils, transported laterally to aquatic systems, and processed and/or exported to coastal environments.

Objectives

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

Achievements

1. Database of contribution of permafrost active layer (up to 30 cm) in terms of dissolved organic and inorganic carbon and nitrogen (DOC, DOM, DON and DIN) for the year 2020, 2021, 2023 (July-August and September- October) in thawed soil and in nearby water bodies is generated, which would be helpful to understand the release of these components along with other nutrient due to temperature changes.

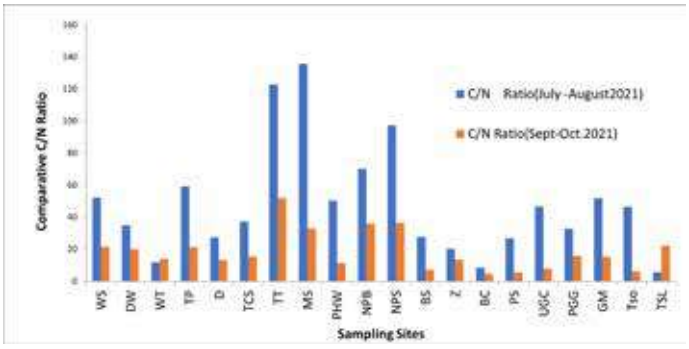


Fig. 33. Comparative results of Dissolved organic carbon and Nitrogen Ratio (C/N Ratio) of Permafrost soil collected from permafrost areas of Leh.

Summary of the Completed Project/ Activity

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

As envisaged under the project, 150 master beekeepers were trained on the various aspects of beekeeping. After training distribution of one active beehive with 70% subsidy amount under the project were done including miner beekeeping equipment such as bee veil, gloves, cutter, queen cage, smoker, etc. Major equipment like honey harvesting machines were also distributed among the group of beekeepers. Training was imparted to the beekeepers for basic beekeeping management with indigenous bee species including introduction to bee colony, its management, shifting of bees from traditional to modern hives, swarm identification and catch from wild and nearby areas, division of colony, disease and pest management, honey and wax harvesting, its processing, packaging, labeling, etc. Identification and plantation of native bee flora in the study site was also done. Testing of the products and its marketing channel was also established during the project period. Value added products such as honey and beeswax lip balm were developed as an entrepreneurial activity which were marketed through various platforms such as Kisan Mela, Dusheera and through other local and regional level agencies. During the project period more than 300 kgs of honey and 1000 pcs of lip balm has been sold generating an income of Rs. 2.80 Lakhs. The activity has been emerging as one of the major livelihood activities of the locals in the region. At the same time conservation of the indigenous bee species Apiscerana has also been done in its natural habitat for its sustainability. Currently, the honey with the brand name of Tirthan Honey is being marketed throughout local, regional and national level in collaboration with private agencies.

Rejuvenation of the Kosi River of Kumaun Himalaya through field intervention and people participation (NMHS, 2019-2023)

The Kosi River, essential for sustaining Almora City and nearby villages, is experiencing a decline in water volume attributed to diminished flow from mountain aquifers. To address this, various initiatives have been undertaken to revive the river, including the implementation of water conservation methods such as trenching, check dams, and plantation. The study focused on two recharge zones, namely Deolikhan and Simtola, with Deolikhan showing promise due to its favorable groundwater prospects. Additionally, the study evaluated the impact of rainfall, water quality, soil conditions, and suggested optimal locations for water conservation structures. Rejuvenation efforts encompass both mechanical (check dams, trenches) and biological (tree planting, grass plantation) measures, aimed at enhancing infiltration and retaining runoff. The locations were identified for preparation of recharge structure, based on the fact that Amrit Sarovar was also developed near Kyala village. The dataset on discharge rate and water quality of first to third order streams generated for further interpretations.

Pine needle-based wastewater treatment system for recycling of domestic waste effluents (NMHS, 2019-2023)

Greywater is the wastewater usually generated from the kitchen sink, shower, laundry or washing machine, etc., which is sent to the environment as a waste. This can be reused subsequently by a simple and cost-effective treatment technique. The consumption of domestic water varies from country to country and can be reduced up to 30-45% by using treated greywater. It has been observed that many countries are reusing grey water for several purposes like irrigation, firefighting, toilet flushing, etc. There is a great dependency on the quantum of greywater in near future as the consumption of freshwater is not at par with the production of freshwater. Grey water Treatment methods such as physical methods include coarse sand, soil, and membrane filtration. Chemical treatments include coagulation, photocatalytic oxidation, ion exchange and granular activated carbon. Biological treatment includes chlorination and disinfection. Activated carbon is considered to be attractive for the treatment. Studies have been reported on the use of various organic wastes, like sugarcane bagasse, sawdust, rice hulls, and pine bark as filter media for grey waste water treatment. However, sand filtration, coagulation and pine needle-based filter combination has not been used for the treatment of grey waste water. The project utilized the pine needles for the treatment of grey water in combination with other known wastewater treatment processes. A waste water (greywater) treatment plant developed which has the capacity to treat the wastewater up to the level of non-potable purposes. Phytoremediation set up is established at pilot site and Brassica junceaand Mentha spicata plants have shown the capacity to remove the xenobiotic compounds like caffeibe and Bisphenol A from the contaminated soil. These plants also have shown positive results in the presence of grey water.

Garhwal Regional Centre (GRC)

The Garhwal Regional Centre (GRC), Srinagar, has been actively working in the fields of biodiversity, biotechnology, water resource sustainability, model village development, tourism, and climate change impacts along with imparting training and demonstration through several skill development programs. Basically, it deals with the need for a more diverse range of livelihood options in rural ecosystems by showcasing environmental friendly rural technologies, sustainable land use, water resource management, and eco-friendly tourism practices at field demonstration sites spread across various districts of the Garhwal Region. The research and development efforts of the centre are concentrated on 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 Centre is also continuously contributing in the various national level programs/committees, including National Green Tribunal (NGT). The Centre also helps to raise awareness on Mission LiFE and Swachh Bharat Mission among regional stakeholders.

Cumulative Impact Assessment for Cascading Interventions in Himalayan Rivers (Ci2HR) (NMHS, 2020-2024)

The thermal regime of streams and rivers is critical for freshwater ecosystems. The temperature regimes could be regulated by many factors and the most important could be the land surface air temperature as well as the groundwater contribution to the river-groundwater hydrological continuum. Further, the likely impacts of climate change on surface and groundwater warming could result in loss of habitat threatening many endangered species as reported elsewhere from other parts of the world.

Objectives

- To manufacture low-cost robotic technology with sensors and communication system for measuring micro-environment underwater and nearby land surface ecology for inaccessible river reaches
- To conduct physical hydraulic experiments for underwater micro-environment characterization by measuring parameters (velocity, turbulence, temperature and dissolved oxygen (DO)).
- To conduct three-dimensional mathematical hydrodynamic sediment and water quality modeling for obtaining flow depth, velocity, temperature, DO for development of Hydrology – Ecology relationships.
- To improve Building Block approach of CIA by using long term hydrologic dataset and ecological relationships for Himalayan Rivers.
- To develop a Network Approach of CIA by considering landscape connectivity and impact rating in Himalayan Catchments.

Achievements

1. The paired Air-Water sensor observation data indicates a very good correlation (0.9) between the air and river water temperature in the Nayar river system. While in the Ganga River at Byashghat the air and water temperature were not correlated well (0.1) due to higher thermal inertia of large rivers and different source regions.

2. The paired Air-Water sensor observation at different elevations using linear and logistic regression models highlights that the western Nayar River basin is dominated by the shallow groundwater system at basin scale (Fig. 34).

3. The preliminary results highlight that the warmest stretch of the river body starting from the confluence of West and East Nayar to its confluence till it meets River Ganga could be the most ecologically sensitive area and thus might require utmost protection.

4. A joint two days collaborative Training Programme on “Climate and human-induced hydro ecosystem alterations on the freshwater ecosystems in Himalaya, Uttarakhand” by Garhwal Regional Centre and the Department of Zoology, HNB Garhwal University was organized on 18th and 19th July2023. A total of 35 participants from the Department of Zoology, HNB Garhwal University participated in the event.

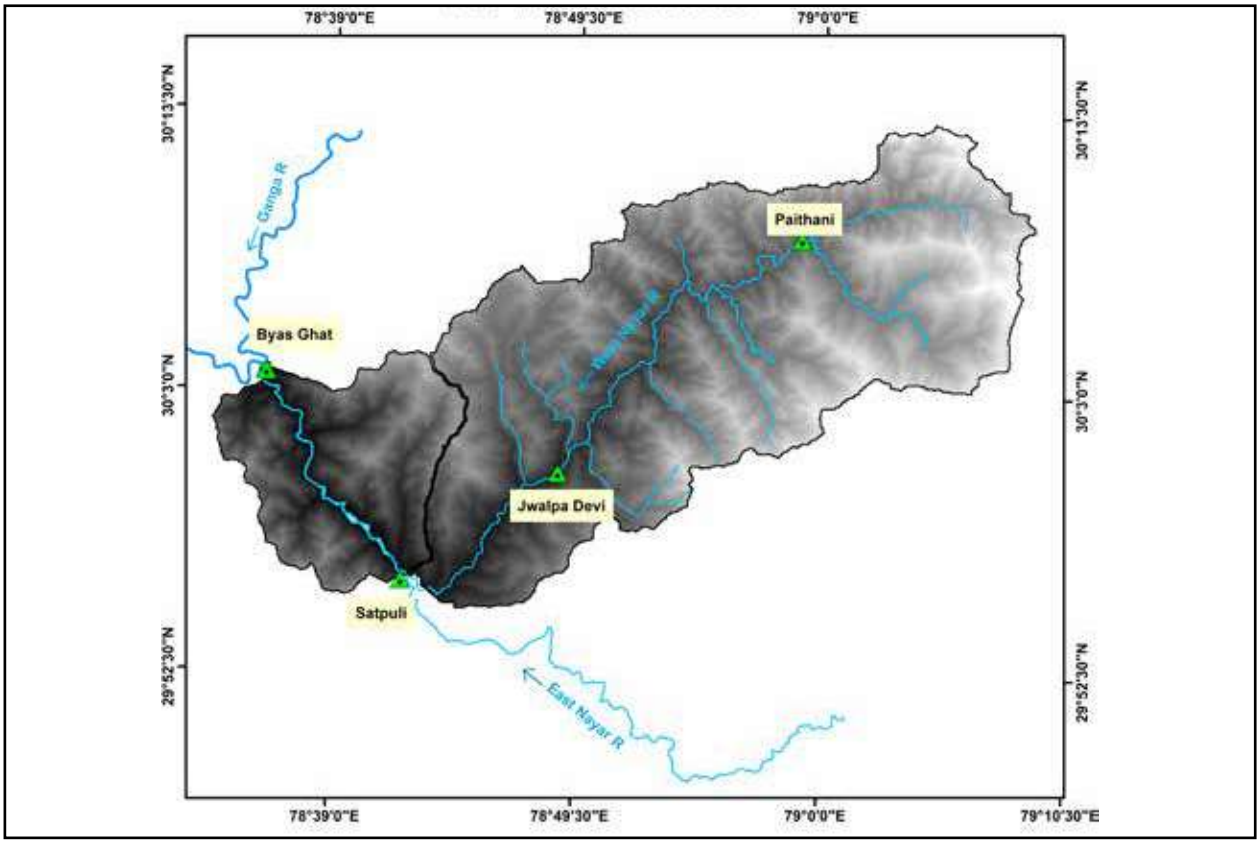


Fig. 34. West Nayar and Nayar sub-basin in the middle Himalaya with locations of spot river water monitoring stations as well as air temperature locations used for TLR estimation. Index map shows the coverage of west and east Nayar in Pauri district.

Summary of the Completed Project/ Activity

Protocol for rejuvenation of springs in Uttarakhand with due preparedness for climate change (NMHS, 2020-2023)

Managing water in the 21st century in the complex sloping landscape of the middle Himalaya will need a more holistic understanding of soil, hydrogeology, land use, forest, hydrometeorology and the recent changes including climate change. More so, the interaction between soil–water and landscape–soil-hydrology relationships should be studied in greater detail. The present study highlights that the near-surface, topsoil and the sub-soil are showing very low hydraulic conductivity which indicates a high runoff potential of the soil formation in permanent fallow land which dominates the landscape. The rainfall intensity measurements in close proximity from the adjoining watersheds show rainfall intensity of less than 2.5 mm/hour (light intensity) dominates the monsoon rainfall event and is likely to cause overland flow in most of the rainfall event under saturated soil. Agricultural land abandonment with livestock trampling have caused the compaction of soil in recent times and hence necessitate appropriate land management. Documentation of the successful interventions, lessons learned, and best practices from the project is important. This information should be disseminated widely through reports, case studies, workshops, and conferences. Sharing knowledge and experiences will facilitate replication of successful approaches in other areas. Foster collaboration and partnerships with relevant stakeholders, including government agencies, non-governmental organizations, research institutions, and local communities. Collaborative efforts can enhance the project's impact, leverage expertise, and share resources and knowledge for a more comprehensive approach to spring rejuvenation. Advocate for the integration of spring rejuvenation principles and approaches into relevant policies, regulations, and development plans at the regional and national levels. Engage with policymakers and advocate for supportive frameworks that promote sustainable water management and natural resource conservation.

Major outcomes

1. Soil samples from the abandoned agricultural field from Kafalna village, Pauri indicate a dominantly coarse grain soil with soil type falling into sandy and loamy sand class. An overall infiltration per day for soil surface under abandoned agriculture land (permanent fallow) ranges from 0.44 m/day to 0.93 m/day.

2. The saturated hydraulic conductivity (Kfs) up to 15cm depth, ranges between 0.001 to 0.0364 m/day with a median value of 0.0096 m/day (n=6). The Kfs value for 30cm depth ranges between 0.0005 to 0.0228 m/day with a median value of 0.0109 m/day (n= 4). The variability is more in the 15cm saturated hydraulic conductivity as compared to the 30cm depth values in the abandoned fallow land, however no significant differences in hydraulic properties at two depths in topsoil was recorded.

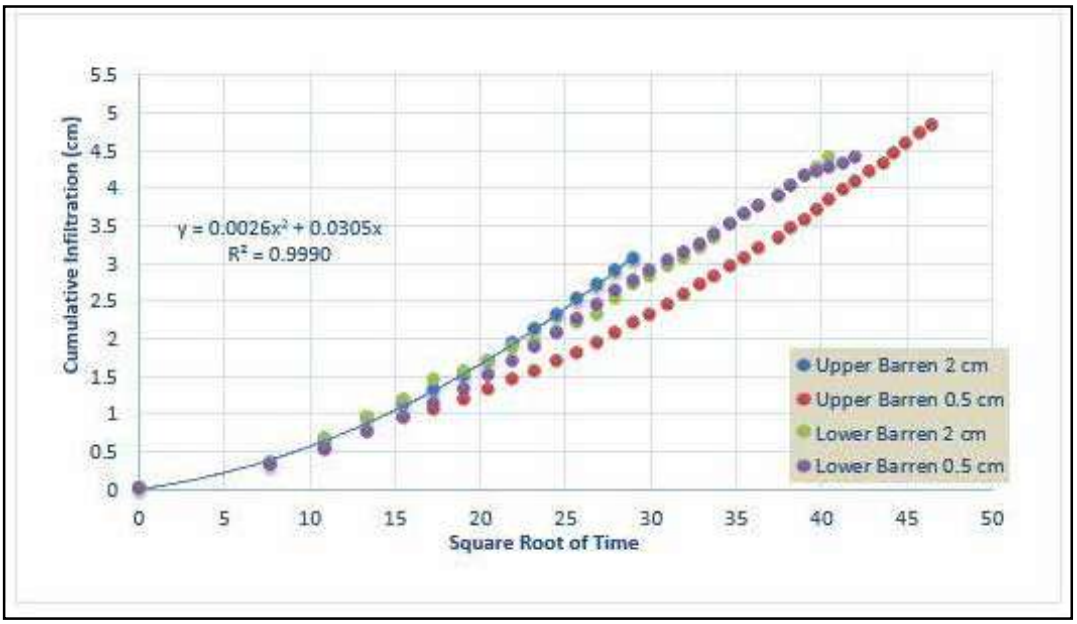


Fig. 35. The graph showing minor variability in the cumulative infiltration rate at different initial heads measured using mini disk infiltrometer (MDI).

3. The results indicate that the soil is having moderate to very high runoff potential when thoroughly wet. The mini disk infiltrometer results also indicate that the near-surface hydraulic conductivity is low and moderately high runoff potential of soil primarily caused by the compaction of soil (Fig. 35).

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

The IHR covers approximately an area of 4,19,873 Km^2 and is considered one of the global biodiversity hotspots which comprises an altitudinal range that reflects a huge bioclimatic gradient across the globe. The unique and diverse Himalayan forests create a significant atmosphere towards developing biodiversity elements richness at diverse stages that places this region among 36 recognized Global Biodiversity Hotspots. The region contains various natural resources, including medicinal plants (MPs) which play a vital role in the healthcare system and act as a vital source of livelihood, local consumption, and culinary practices for local inhabitants of the region. Among these medicinal plants of the Himalayan region, two are *Malaxis muscifera* and *Malaxis acuminata* belonging to Genus *Malaxis* of the orchidaceae family. Both plants have positive effects on fertility, bleeding cessation, immunity, and treating tuberculosis and being used in Ayurvedic tonics like Chyavanprash, Astaverga Rasayan, etc to prevent degenerative diseases and maintain youthfulness. Keeping the all above in view, the present study attempted to investigate morphological analysis of *M. muscifera* and *M. acuminata* for germplasm characterization along with the phytochemical evaluation for elite (chemotype) identification followed by germplasm accessioning, standardization of the propagation protocols, mass multiplication, hardening and domestication practices for cultivation of these species. Among the enlisted sites, 41 for *M. acuminata* and 12 for *M. muscifera*, across 11 districts of Uttarakhand state have been surveyed and explored for research work under this project. For the first time, nine new sites (Sirakot, Gangolihat, Mayawati Ashram, Jarmola, Radi top, Dol Ashram, Lweshal, Devidhura and Jakholi) for *M. acuminata* were reported. Populations status assessment demonstrated that the best suitable microhabitats for *M. acuminata* are shady forest floors of Oak-Deodar and other mixed forests like Banj Oak-Myrica mixed forest, Banj Oak-Rhododendron mixed forest, Mixed oak forest, Banj Oak-Deodar Forest etc. Based on phytochemical assessment, Gangolihat (Below ground part) and Jakholi (Above ground part) populations of *M. acuminata* were found to possess highest values for phenols, flavonoids and tannins. At the same time, phytochemical assessment of Madmaheshwar population of *M. muscifera* possessed highest phenolic (Above ground) and tannin content (below ground) while Phurkiya (Above ground) population showed highest flavonoid content. *In vitro* propagation methods for callus induction of *M. acuminata* showed that combination of 1:1 ratio [(6 µM and 12 µM Naphthalene acetic acid (NAA) and 6-Benzylaminopurine (BAP)] ratio of hormone showed good response and facilitated growth. Life cycle study of *M. acuminata* displayed the presence of 8 principal growth stages and 26 secondary growth stages in its natural habitat. The species was observed to complete its life cycle from April to November mid, a period of about 6-7 months with several phenophases succeeding one followed by the other. The correctly identified phenophases of *M. acuminata* are vital for characterization and management because of importance in cultivation and maintenance of any medicinal plant species. Therefore, this approach can be recommended as an efficient tool for elite identification for the growers and researchers for pharmaceutical and drug discovery along with gene expression studies. The findings of the study are also useful to promote cultivation of these plants in Uttarakhand.

Major outcomes

1. The survey and exploration of the target species in Uttarakhand, identified nine new sites for *M. acuminata*, where the species was found for the first time. The ecological studies identified suitable microhabitats for *M. acuminata* in shady forest floors of Oak-Deodar and mixed forests. The study generated systematic information and a passport dataset on the morphological, biochemical and nutritional parameters of the two target species.

2. In vitro propagation methods for callus induction and plantlet development were developed using NAA, 2, 4-D, BAP, and TDZ for shoot induction of *M. acuminata.*

3. The life cycle study of *M. acuminata* identified 8 principal growth stages and 26 secondary growth stages for bud development, leaf development, shoot development, inflorescence emergence, flowering, fruit development, fruit maturation, and senescence following the BBCH scale of crop phenology. The target species completes its Life cycle from April to November mid, 6-7 months with several phenophases. Data on the climatic requirements (temperature and precipitation) of *M. acuminata* in its natural habitat is also presented (Fig. 36). The study divides the plant's life cycle into the vegetative phase, reproductive phase, and senescence phase.

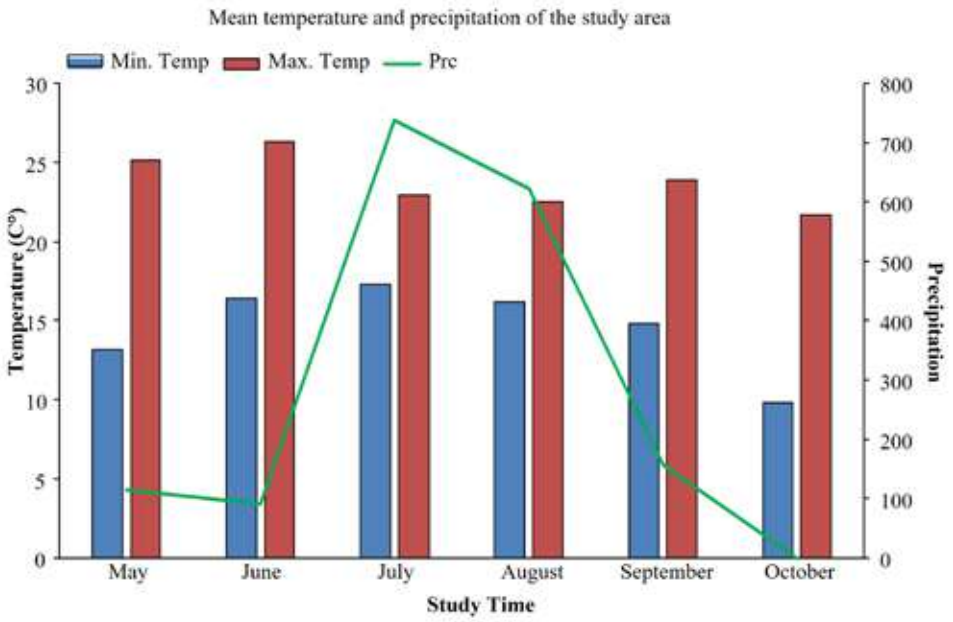


Fig. 36. Climatic requirements (temperature and precipitation) of *M. acuminata* in its natural habitat

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

The Himalayan alpine zone is characterized by unique features like Krummholz, cushion plants, and tussock forming graminoids, spans across various biogeographic provinces, covering a significant portion of the region's geographical area. Efforts to assess biodiversity in the Himalayan alpine zones have been hampered by limited data and the challenging terrain. Traditional assessment methods have been constrained to spot surveys due to the rugged landscape and harsh conditions. This lack of baseline information inhibits effective policy formulation and management strategies for conservation efforts in the Western Himalaya's alpine zone. To address this gap, this study conducted a rapid assessment using advanced techniques like multi-scale field observations, remote sensing, and geospatial modeling. The study area assigned to the institute was the alpine regions of Bageshwar and Pithoragarh districts of Uttarakhand. The project's objectives encompass conducting an ecological gap analysis to inform management decisions, pinpointing areas conducive to bioprospecting, and refining ecological zone classifications. By establishing a comprehensive database, the study endeavors to serve as a baseline reference for governmental institutions and agencies engaged in biodiversity conservation. For the inventorying of plant composition and diversity in the alpine region of Kumaun Himalaya, a systematic and multistage sampling framework was adopted with geo-coded / location specific data. Soil samples from various communities in the alpine region across the study area were collected and analyzed for key soil nutrients. A total of 312 species belonging to 58 families and 187 genera were recorded in the targeted region. Among the genera, *Potentilla* (6), *Bistorta* (5), *Corydalis* (4), *Anaphalis* (4), and *Saussurea* (3) exhibited the highest number of species. Asteraceae accounted for the largest proportion of plants (15%), followed by Poaceae (11%), Rosaceae (9%), Polygonaceae (8%), Ranunculaceae, and Gentianaceae (5% each), among others. Regarding density, *Trachydiumroylei, Potentilla atrosanguinea, Viola biflora, Oxygraphis polypetela, Danthonia cachemyriana,* and *Bistorta affinis* emerged as the most dominant species in the study area, while *Angelica glauca, Cremanthodium arnicoides, Meconopsis aculeata, Arnebia benthami,* and *Bupleurum rupestre* were among the least dominant plant species. The distribution of species and communities is determined by the concentration of different elements and soil physiochemical properties. The pH ranges from 3.5 to 8.2, with its peak at 3900m and its lowest point at 3100m. Organic carbon content (%) varies between 0.47% and 15.11%, reaching its maximum at 3127m and its minimum at 4300m. Nitrogen (%) ranges from 0.1% to 0.9%, with its highest concentration at 3127m and its lowest at 3404m. Phosphorus (%) varies between 0.0003492% and 0.0023135%, peaking at 3183m and dropping to its lowest at 3432m. Sodium (%) fluctuates between 0.0162% and 0.0952%, with its highest and lowest values recorded at 3981m and 4042m respectively. Calcium (%) ranges from 0.0028% to 0.139%, with its maximum and minimum values observed at 3293m and 3381m respectively. Similarly, Potassium (%) varies between 0.0012452% and 0.0358603%, reaching its

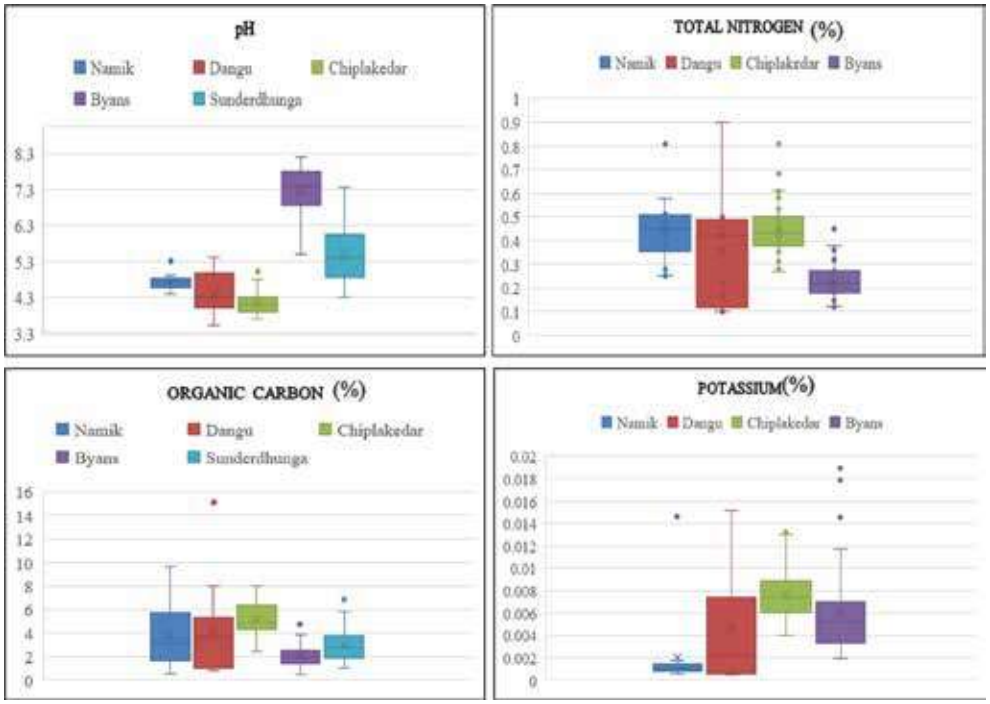
peak at 3637m and its lowest at 3105m. Water Holding Capacity (%) varies from 20% to 98%, with its maximum recorded at 3100m and its minimum at 3300m.

Major outcomes

A total of 1594 geo-coded quadrats (1×1 m2) were analysed for assessing the alpine plant diversity in Bageshwar (Dangu- 64, Sundardunga-320, Pindari-110) and Pithoragarh (Chiplakedar-600, Namik-100, Byans- 200, Munsyari-200) districts. The dominant and least dominant plant species documented in the different targeted landscape.

A total of 83 soil samples from Chiplakedar (39), Namik (7), Byans (21), Sunderdhunga (10) and Dangu (6) from different communities of the alpine region were collected at depths, i.e., 0-10 cm & 10-20 cm and further analysed for physico-chemical properties viz., pH, Total Nitrogen (%), Organic carbon (%), Available Potassium (%), Available Sodium (%), Available Calcium (%), Water Holding capacity (%), Available Phosphorus (%) (Fig. 37&38).

Fig. 37. Different species present at studied sites of alpine region, A. *Saussurea taraxacifolia*, B. *Senecio laetus*, C. *Cassiope fastigiata*, D. Vegetation sampling, E. Soil sample collection, F. *Salix lindleyana*



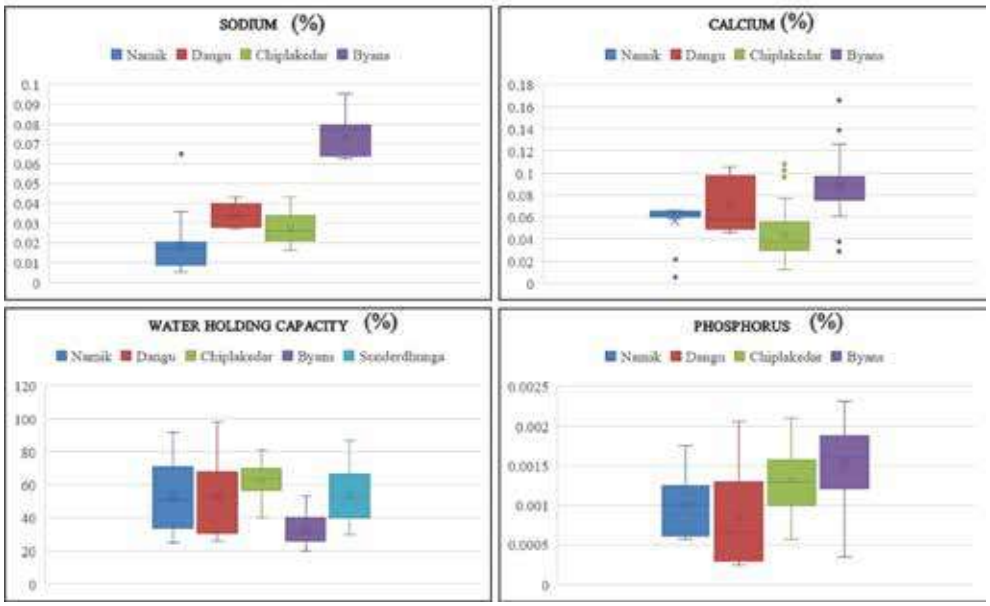


Fig. 38. Soil physico-chemical properties of the studied sites

Pine and Oak system of Himalaya: water, climate and plant Biodiversity (NMHS, 2019-2023)

The Objective of the study was to determine the species composition, distribution, population structure, utilization and regeneration patterns of plants in Kosi watershed area which is dominated by Pine and Oak forests, and analyze the possible conservation action to rejuvenate the Kosi River for securing the livelihood of the region. River Kosi originates from Koshimol near Kausani and flows on the central part of Almora and the western part of Nainital district. Extensive field surveys were conducted during the year 2020-2023 for study in the Kosi watershed area in Uttarakhand, India. In order to quantify distribution of vascular plant diversity (Angiosperms and Gymnosperms), the grid-based approach was used where the entire watershed area was divided into a total of 33 grids (10x10km). Out of 33 grids, Almora region covers 21 grids with a total area of 1094.32km^2 and Nainital covers 12 grids with a total area of 773.68 km^2. Further each 10x10 km grid was further divided into 2x2 km for refining the documentation on plant diversity and soil characteristics. We recorded a total of 33 tree species (24 genera and 17 family) from 323 sampled sites. Rosaceae was found to be the most dominant family (7 species), followed by Fabaceae (6) and Moraceae (3). The study recorded a total of 20 dominant plants. About 752 km^2 of area dominated by *Pinus roxburghii* (58%), *Quercus leucotrichophora* by 240 km^2 (18.66%), other species, i.e., *Celtis australis, Ficus auriculata, F. palmata, Grewia optiva, Juglans regia, Lyonia ovalifolia, Mangifera indica, Malus domestica, Melia azedarach, Myrica esculenta, Phoenix dactylifera, Prunus cerasoides, P. persica, Pyrus communis, P. pashia, Quercus glauca, Rhododendron arboreum, Toona ciliata dominated* in 144 km^2 (11%) area. Around 152 km^2 (11.8%) area has not recorded the arboreal forms. Among the studied sites the tree density ranged between 25-1375 ind/ha, having maximum at *Quercus leucotrichophora* dominated stands (200- 1375 ind/ha). However, the tree density in Pure Pine stands ranged from 25- 450 ind/ha and for mixed Pine dominated stands the density ranged between 150- 1175 ind/ha indicating a higher density of trees in Mixed-pine dominated stands.

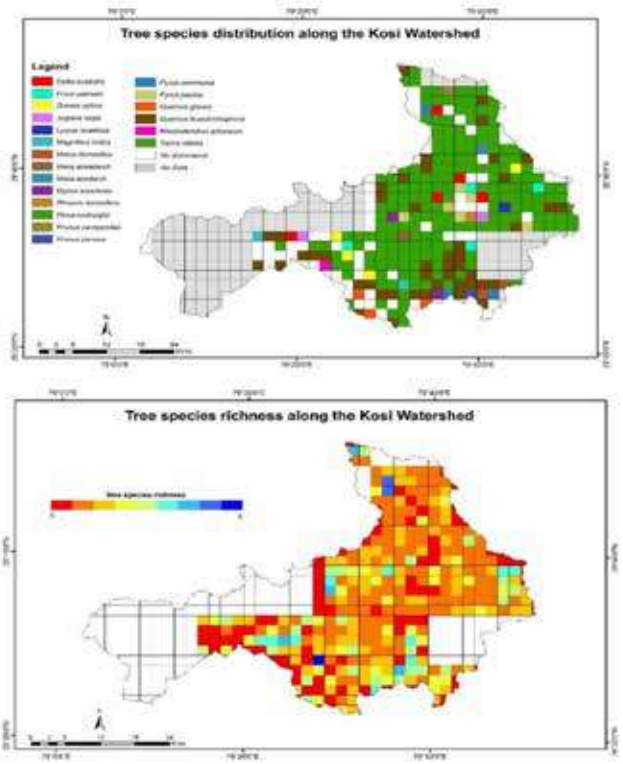


Fig. 39. Maps showing tree species distribution along the Kosi Watershed region

Results indicated that Oak forests were found to have high species richness as compared to Pine Forest, Pine forests exhibit either a single species or communalism with some other species.

Major Outcomes

1. Around 58% of total studied area of Kosi watershed is dominated by *Pinus roxburghii* and 18% area is dominated by *Quercus leucotrichophora* vegetation which signifies the Pine dominance over the area (Fig. 39).

2. The tree density of the Kosi watershed ranged between 25-1375 ind/ha, having maximum at *Quercus leucotrichophora* dominated stands (200- 1375 ind/ha) and minimum in *Pinus roxburghii* dominated stand (25-450 ind/ha).

3. Twenty-two grids represented maximum dominance of *Pinus roxburghii* and co-dominance of *Quercus leucotrichophora*. Similarly, twelve sub-grids recorded dominance of *Pinus roxburghii* at tree stage but *Quercus leucotrichophora* was found dominant at sapling and seedling stages, which can further replace the *Pinus roxburghii,* if the forest can be protected from forest fire.

Sikkim Regional Centre (SRC)

Sikkim state supports rich floral and faunal diversity varying in different eco-climatic ranges (300m to 8685m). 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 above mentioned priorities of the Sikkim state, Sikkim Regional Centre of the Institute has been working on environmental and socioeconomic issues of the Sikkim Himalaya which includes the entire Sikkim state and West Bengal Hills. Main thrust areas of Sikkim Regional Centre are (i) Biodiversity safeguarding at ecosystem, species and genetic level, including ecosystem services, (ii) Natural resource use, management, and sustainability, (iii) Geo-environmental assessment of land hazards and mitigation strategies, (iv) Assessment of climate change impacts and vulnerability on critical ecosystems, (v) Enhance implementation of strategies through participatory planning and policy analysis.

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

The Himalayan region offers a high variety of habitats as well as great climatic variability that support a unique biodiversity repository in the region. Many medicinal and aromatic plant species found in this region are commercially used pharmaceuticals, cosmetic and nutraceutical industries. Lack of quality material for cultivation remains always a problem for growers thus, collecting from wild habitats is practiced. Therefore, conservation and cultivation initiatives for these medicinal plants are required. Modern high throughput sequence has significantly enhanced our ability to assess genomic variation for breeding efforts. These techniques can be used to analyze entire genomes of non-reference species, and understand complex biological processes, characters and traits associated with parameters of 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 among the global distribution range of species can create information on their speciation, evaluation, cultivation and conservation.

Objectives

- Survey and collection of natural populations of Hedychium spicatum across the geographical range in India for chemical fingerprinting and habitat prediction
- Development of transcriptional genomic resources for elucidation of key biosynthesis pathways and genome-wide SSR markers.
- Genetic diversity and population genetic structure assessment for identification of core populations/

elite cultivars for implantation of conservation and captive cultivation strategies.

Achievements

1. Surveyed 30 populations of target species in Uttarakhand (18 nos.) and Sikkim (12 nos.) and all the populations were geo-tagged.

2. Plant material was collected from 09 natural populations (15-25/ genotypes/ populations and total 160 genotypes) from Uttarakhand and Sikkim. Germplasm were planted and maintained in the herbal garden of the SRC, GBPNIHE. Besides, 26 species of Zingiberaceae (including 09 *Hedychium* species) were collected and maintained in Zingiberaceae Sanctuary of the SRC, GBPNIHE.

3. The water extract, methanol and ethanol extract compounds were investigated for chemical fingerprinting by LC-ESI-MS/MS analysis. A total of 58 compounds were putatively identified in *Hedychium spicatum,* including 11 compounds belongs to phenolics including, p-coumaric acid, ferulaldehyde, ginkgolic acid (C13:0), 2,7-dihydroxycadalene, carnosol, 1,7-bis(4-hydroxyphenyl)-3,5-heptanediol. etc were present in most of the extracts.

4. Also, essential oil was isolated from rhizomes of 30 genotypes of Sikkim and Uttarakhand. Essential oil yield varied from 0.05 to 0.94% among genotypes. Gas chromatography- mass specrophotometry (GC-MS) analysis of 16 samples revealed the presence of eucalyptol as major compound (Fig. 40).

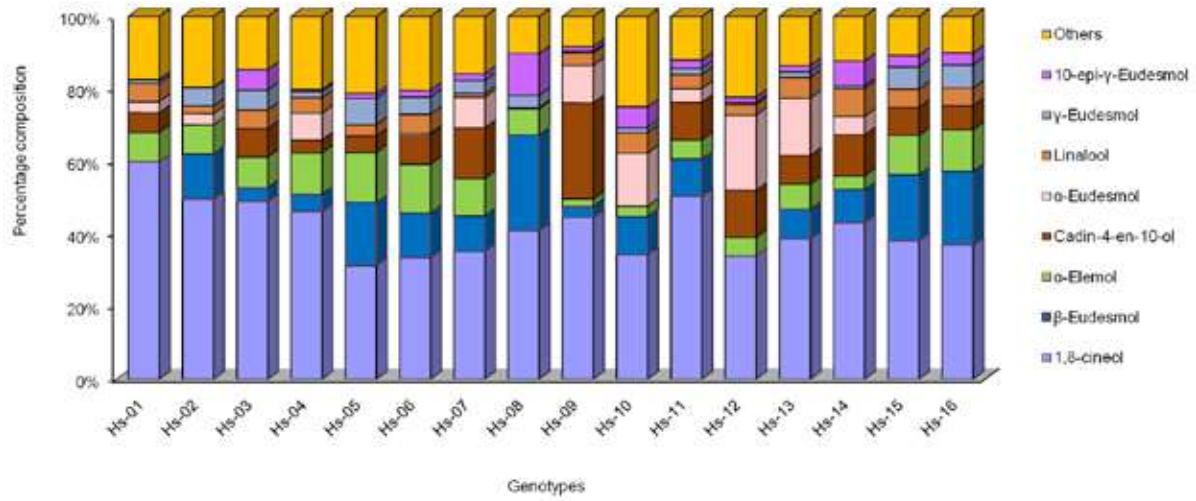


Fig 40. Essential oil composition of *Hedychium spicatum* genotypes (16 nos.) collected from different geographic regions of Indian Himalayan Region. Among these Sp01 to Hs10 represent Uttarakhand and Hs11 – 16 represent Sikkim.

Development of hydroponic based soilless plant production system for commercial crops in Sikkim (NABARD, 2023-2024)

To feed the world's growing population, current methods for sufficient food production are inadequate. In this regard, 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 vegetables, fruits and medicinal plants.

Objectives

- 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.

- Demonstration and training of farmers for technology adaptation and cost-benefit analysis for determination of profitability of the innovation.

Achievements

1. Developed 03 types of hydroponics models at SRC (including i. A-type nutrient film technique, ii. trench culture system, & iii. bag culture system) for method optimization, training and demonstration. A-type Nutrient film technique performed best among all the models in terms of yield and productivity of leafy green vegetables, tomato spinach and Swiss-chard (Fig. 41).

2. Developed 03 types of nutrients solutions (i.e., i. commercial hydroponic nutrient, ii. Hoagland nutrient, & iii. Vermi-wash Nutrient solutions), for reducing in-put-cost and increasing productivity. Commercial hydroponic nutrient performed well among these all and can be recommended in combination of vermi-wash nutrient solution for selected commercial crops.

3. Optimizing 03 types of Substrate types 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, the 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 41. Different types of hydroponic models i.e., i. A-type nutrient film technique, ii. trench culture system, & iii. bag culture system developed in SRC and crops like, *Brassica* species (Rayi), Strawberry, Swiss Chard, Italian tomato, Cauliflower and Carrot are growing in hydroponic

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). The entire NE region is known for its rich diversity of flora and fauna, as well as its socio-cultural, linguistic and ethnic communities. The local communities possess rich indigenous knowledge in utilization of the natural resources around them for their sustenance. Unfortunately, the rich biodiversity of the region is currently facing various threats, including degradation, deforestation, settlement expansion, indiscreet hunting, therefore, warrants the development of viable, replicable, and effective community-based resource management initiatives for its conservation. To conserve the biodiversity and ensure sustainable utilization of the resources, the NERC has been working on the following focal research areas: (i) People-centered land use models for shifting cultivation, (ii) Indigenous knowledge systems and natural resource management options for tribal communities, (iii) Biodiversity and Wildlife conservation through community based natural resource management, (iv) 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 fulfil 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 and capacity building of local people of North-East India through training, demonstration and knowledge products.

Impact of Forest Fires with reference to extent of Invasive Plant Species, Soil Health status, and Vegetation Dynamics (Dept. of Env. & Forests, GoAP, 2024)

The increasing presence of invasive plant species in Arunachal Pradesh poses a significant ecological challenge, impaired by the rising incidence of forest fires. These fires, whether natural or human-induced, profoundly disrupt vegetation regeneration processes. Despite their ecological importance, the interaction between invasive species and the impact of forest fires remains largely unexplored in this region. Addressing this gap, our study aims to elucidate this intricate relationship, which is particularly vital for the Eastern Himalayan region's ecological integrity. Furthermore, forest fires pose a grave threat to soil health, potentially leading to degradation and endangering wildlife habitats. The severity and frequency of fires, alongside post-fire climatic conditions, dictate the extent of soil property alterations. Understanding these dynamics is paramount for devising effective conservation strategies. Moreover, forest fires exert both immediate and long-term impacts on vegetation dynamics, altering species composition and ecosystem structures. Through comprehensive assessment across various forest types, our study endeavors to delineate these effects, providing essential insights for sustainable forest management and biodiversity conservation efforts in Arunachal Pradesh.

Objective

- To examine the relationship between forest fires and the distribution of invasive species in Arunachal Pradesh.

Fig. 42. Vegetation and soil sampling in different forest areas.

- To investigate the impact of forest fire on soil health status in selected forest types of Arunachal Pradesh, and
- To assess the current status of plant diversity in areas affected by fires within selected forest types in Arunachal Pradesh.
- To examine the relationship between forest fires and the distribution of invasive species in Arunachal Pradesh.

Achievements

1. Documented 60 nos. invasive plant species from Arunachal Pradesh. The distribution data of invasive plant species in Arunachal Pradesh were compiled using secondary literature and online web resources.

2. The satellite imageries, climatic and other variables were downloaded and processed for mapping the distribution of invasive plant species and their extent in different forest types of Arunachal Pradesh.

3. Conducted vegetation assessment in two forest fire areas of Arunachal Pradesh for field verification.

4. Conducted vegetation assessment and soil sampling in controlled and forest fire areas of Arunachal Pradesh (Fig. 42.)

Him-Nature Learning Centre (Him-NLC), Arunachal Pradesh (NMHS, MoEF&CC; 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 poor management and therefore it is imperative to educate and create awareness among diverse stakeholders towards nature conservation. There have been few initiatives taken by various departments towards creating awareness and sensitizing people about nature conservation. These are often isolated efforts and thus need concentrated and focused efforts through a dedicated Nature Learning Centre (NLC). Keeping this in view, a NLC is being proposed to be established in Itanagar Wildlife Sanctuary adjacent to Biological Park 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

- To develop a learning and interpretation centre for the conservation of biodiversity through various interactive models.
- To create and demonstrate the best practices for sustainable models, such as solid-waste management, water harvesting, composting, early warning disaster monitoring systems, hydroponics, and forest management practices.
- To develop the curricula for nature based learning for school students.
- To encourage active conservation participation and efficient utilization and conservation management of bio-resources.
- To promote eco-tourism for conservation of natural

Fig. 43. Training and awareness programme on nature conservation

resources and sustainable livelihood generation, and

- To build capacity of various stakeholders to conserve the natural resource and develop the knowledge products for dissemination and raising awareness.

Achievements

1. Conducted field survey for documentation of plant diversity in Itanagar Wildlife Sanctuary (IWS). Till date 146 species of plant species were documented in IWS. Strengthened germplasm of 62 orchid species, which include 31 genera, in RTC of NERC for knowledge dissemination and showcasing to relevant stakeholders. Additionally, more than seventy herbarium specimens of plant species have been prepared.
2. One long term study plot inside the IWS was established with the aim to inventorize and regular monitoring of plant diversity, to monitor long-term phenolgical changes in plant species, assessment of carbon sequestration, soil health and microbial biomass.
3. Conducted 2 days workshop on Lichen Systematic and Nature Conservation at NERC of NIHE, in which 25 participants from different organizations participated (Fig.43).

Mountain Division Regional Centre (MDRC)

The Himalayan region is a unique treasure of environmental goods and services and a rich repository of biodiversity, including cultural and ethnic diversity. Realizing its sensitivity to climatic and anthropogenic perturbations, a dedicated unit as "Mountain Division" as 5th Unit of GBPNIHESD was established 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.

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)

Himachal Pradesh is in the western part of the Indian Himalaya which is environmentally fragile and susceptible to natural disasters. Flash flood disaster is a major problem in the state due to its diverse topography combined with meteorological and morphological conditions. In the present study, detailed terrain information was used to identify the causes of natural disaster. Remote Sensing data such as Landsat 8 satellite data and ASTER (DEM) coupled with geological and geomorphological data is utilized in a Geographical Information System (GIS) environment for the estimation of flash flood risk in upper Beas valley. The vulnerability to annual floods and associated loss of life and properties calls for immediate scientific study for mitigation and reducing the impact on its socio- economic fabric. This study revolves around an in-depth analysis of the previous works, temporal and spatial study of floods, changing patterns of river course using topographic sheets, satellite imageries and field studies.

Objectives

- To assess the flood hazard and their impacts in upper Beas basin
- To Map the Flood Hazard Zonation in upper Beas Basin
- To assess the Vulnerability of Floods in upper Beas basin
- To investigate the community based approached for flood hazard management in high altitude area
- To identify and develop the suitable flood mitigation measure options for the study area

Achievements

1. Conducted questionnaire surveys in various flood affected villages of the Parvati valley. The River Beas which is the main drainage basin is prone to recurrent floods which inundate the valley floor at various places. Flooding has been a recurrent phenomenon in the valley which causes great loss to life and property as well. The chief causes of flood hazard in the area are the heavy rainfall and heavy melting of snow, ice and glaciers in the upper catchment area.

2. Inventory of previous flood hazards of the past 10 years were documented. Geotagging of 4 flood vulnerable sites in Beas basin of Kullu valley region was completed

Assessing the sustainable tourism potential in Garhwal Himalaya Uttarakhand (Mountain Division, 2023-2025)

Tourism is a big industry worldwide, growing at a rate of 10-15% yearly and spending about 4 trillion US dollars each year. India has seen a lot of growth in tourism too, with 4.45 million international tourists visiting. Uttarakhand, especially, benefits from tourism with its beautiful Himalayan landscapes, scenic hill stations, and important pilgrimage sites like Badrinath and Kedarnath. Adventure activities like trekking and skiing also bring in money. But Uttarakhand faces challenges from natural disasters like earthquakes and landslides. The floods in 2013 caused over 6000 deaths, mostly tourists in Kedarnath, and damaged a lot of infrastructure. Despite this, the state government expects tourism to double by 2026, reaching 67 million visitors. A report from 2019 says tourism directly adds 2.96% to Uttarakhand's economy, and when you include other impacts, it's 6.59% and generates employment, showing how important it is for the state's economy.

Objectives

- To study the status of tourism and its contribution to the economy in Garhwal Himalaya,
- To assess the impacts of tourism on ecology/ environment, carrying capacity and natural resources of the area
- To create awareness on tourism potential for sustainable management.

Achievements

1. Population status of Mussoorie Town Panchayat was collected (Total: 30,118; Male: 16,623; Female: 13,495). Population of children aged 0-6 is 2673 (8.88%). Female sex ratio is 812 against the State average of 963. Literacy rate is 89.69% and higher than the State average (78.82%).

2. The arrival of tourists in Mussoorie is an increasing trend. A total of 850746 (Indian: 84719: Foreigner: 3,555) arrived in 2000 and increased to 3023839 (Indian: 3022774; Foreigner: 1065). Further, due to COVID, the trend will decrease. to 1173789 (Indian: 1171787; Foreigner: 2002) in 2022 (Fig. 44)

3. Meeting with district tourism officers of Chamoli, Rudraprayag, Uttarkashi and Pithoragarh & discussed the available dataset and establishing the possibilities of homestay arrangements in these districts, Uttarakhand.

4. Two-day training programme for veterans and virangana, organized by Garhwal Regional Centre, NGO's and Army Welfare Board at Rudraprayag and Chamoli Districts (Uttarakhand) on 12 & 13 March 2024. About 57 on the first day and 35 on the second day belonging to army background participated in the workshop and the people who are interested in building a homestay shared their contact details.

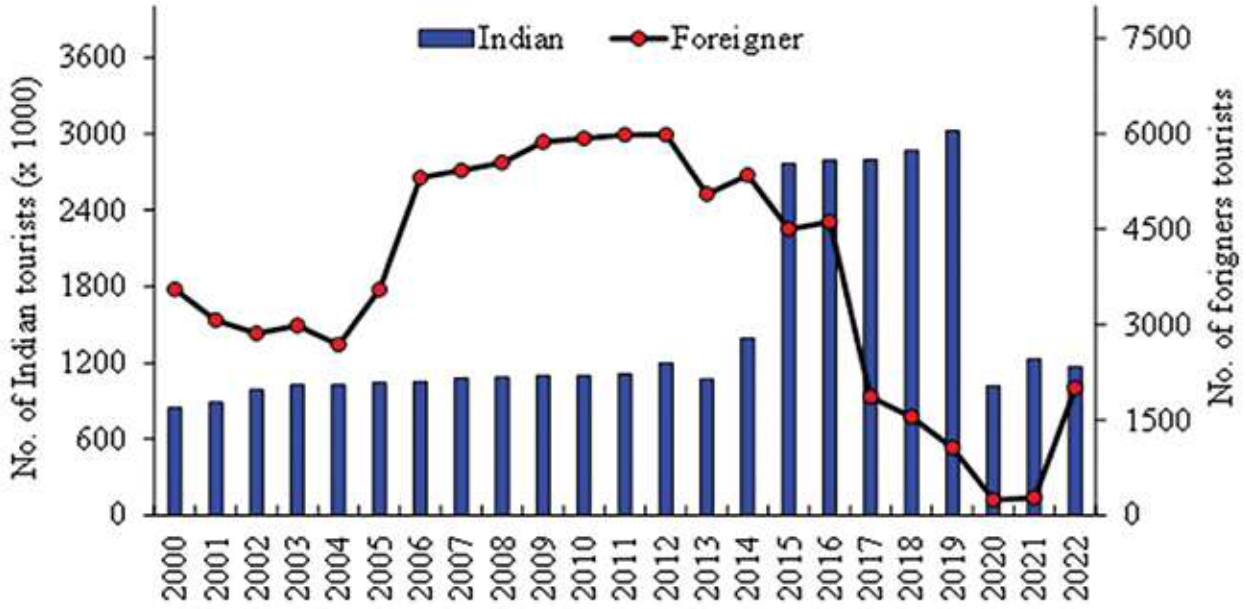


Fig. 44. Total numbers of tourists arrived in Mussoorie during last two decades

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

Spring is one of the most important sources of freshwater. The Indian Himalayan region is home to millions of springs which is also a source to many big and small rivers in this region. People here heavily depend on the springs for household, livestock and irrigation water needs. In various studies conducted in the last few decades it has been 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. With the changing and declining pattern of water discharge, the ecosystem dependent on spring is also degrading. Springs have been scientifically understudied and overlooked. The past few decades, much has been done for the rejuvenation of springs in different areas, but literature and reports related to the ecological importance of springs still remain absent. The Ministry of Jal Shakti has released a framework document to set a policy pathway for spring rejuvenation, however, the aspect of spring ecosystem is not considered. Some springs have the potential to support an entire ecosystem but till date the springs have been studied keeping in view the anthropocentric approach. A healthy spring possesses great potential for a thriving healthy ecosystem. This study focuses on the restoration of spring dependent ecosystems and its dynamics.

Objectives

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

Achievements

1. Extracted Normalized Difference Vegetation Index (NDVI), Land Use Land Cover (LULC), Land Surface Temperature (LST), Flow Direction, Flow Accumulation, Drainage Features, Contour Lines and other essential inputs which will help to delineate Springshed and this will lead to extract Spring Ecosystem Boundaries.

2. The runoff analysis was performed over Kosi watershed using SCS method. The runoff value of 340.69 mm and represents the amount of water that flowed over the land surface and was collected in rivers or other water bodies which is approximately 22% percent of rainfall

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

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

Objectives

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

Achievements

1. Evaluation and validation of good practices of soil and water conservation has been completed based on three criteria; namely effectiveness, replicability and ranking using Likert scale and weighted average value.The analysis suggests that terraces, stone barriers, and waterways as highly effective measures for conserving soil and water, with weighted average values of 4.88, 4.75, and 4.71, respectively.

2. Similarly, vegetative barriers (4.83) involving contour planting of fodder and fruit trees, along with agroforestry (4.49), stand out as highly effective measures for soil and water conservation (Table 4). Further, crop rotation (4.20) and mulching (4.07), which involves utilizing leaves, crop residues, and ferns, are considered effective techniques.

3. Analysis of patterns of water consumption and demand & availability showed that per household domestic water consumption in Alley village, Bul village and Punzitar village was 419 l/d, 444 l/d and 355 l/d, respectively. The per capita water consumption was found as 81 lpcd, 88 lpcd and 74 lpcd in Alley, Bul and Punzitar village, respectively with highest water usages during monsoon and post-monsoon months (Fig. 45).

4. A framework for cost-benefits analysis has been drafted, under which four broad benefit categories i.e. Environmental, Social, Economic and Ecological have been included for analysis. For validation of the framework, a detailed survey was conducted in three study villages for collecting information on pre and post intervention scenarios in the villages. Also, a water governance and management system is assessed for the project study sites.

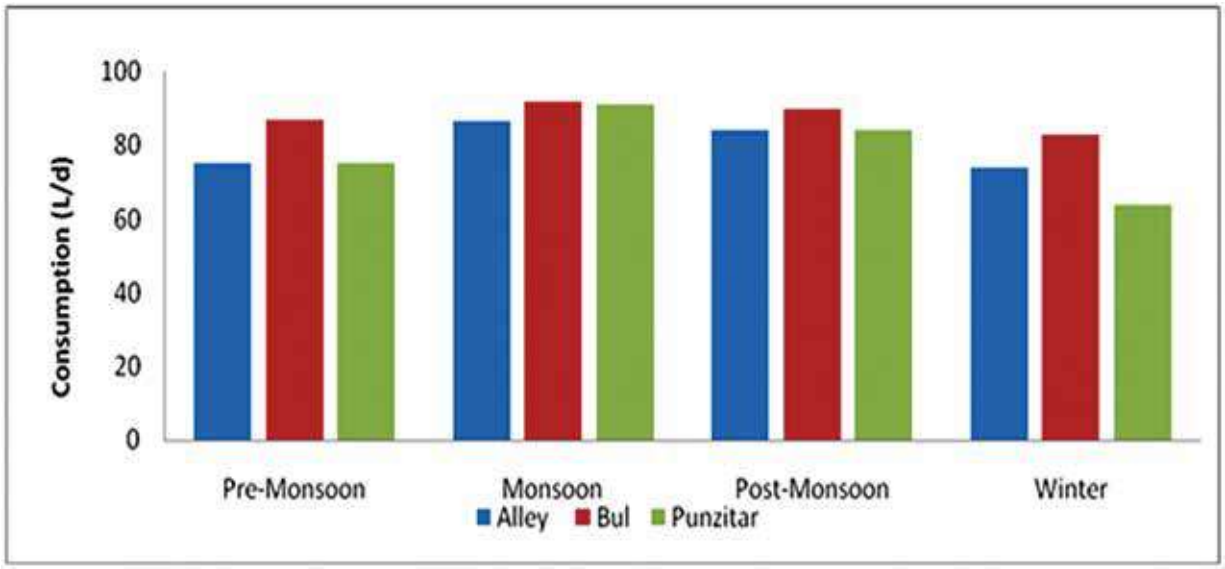


Fig. 45. Seasonal water consumption pattern of the study villages.

Table 4. Effectiveness of biological measures of soil and water conservation practices in South Sikkim.

Biological Measures						
	Alley	Bul	Punzitar	Weighted average	Std. Dev	Judgement
Alley Cropping	2.52	2.58	2.61	2.57	0.05	Less Effective
Mulching	4.24	4.42	3.56	4.07	0.46	Effective
Minimum Tillage	2.92	4.39	2.00	3.10	1.21	Moderately Effective
Vegetative Barrier	4.80	4.79	4.89	4.83	0.06	Highly Effective
Agroforestry	4.12	4.52	4.83	4.49	0.36	Highly Effective
Crop Rotation	4.4	4.24	3.94	4.20	0.23	Effective
Mixed Farming	2.36	3.21	3.28	2.95	0.51	Moderately Effective

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

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

Objectives

- To understand the role of tourism, perception mapping of diverse stakeholders in Leh town, and

Fig. 46. Tourist destination of Leh

identification of critical factors for the sustainability of the town and its environment.

- To develop a geospatial database, using crowd-sourcing, for spatial planning and management in vital sectors of Leh town.
- To analyze the carrying capacity of tourism on the basis of critical factors identified, and with respect to sustainability of the natural environment of Leh town.
- To provide a framework for action plans and guidelines for sustainable tourism in Leh and Ladakh region.

Achievements

1. The Leh town holds a diverse cultural and religious heritage, featuring various Buddhist monasteries, stupas, palaces, forts, etc. To assess its tourism capacity, twelve primary tourist sites have been identified based on visitor influx i.e., Shanti Stupa, Namgyal Tsemo, Leh Palace, Hall of Fame, Central Asian Museum, LehChokhang, Zorawar Fort, Jama Masjid 1, Jama Masjid 2, Gurudwara, Radha Krishan Temple and Leh market (Fig. 46).

2. Employing standardized methodologies, the Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), and Effective Carrying Capacity (ECC) of Leh town's identified tourist destinations were evaluated. The results obtained a total of 39307 PCC per day, 6080 RCC per day and 5132 ECC per day. These assessments provide valuable insights for managing tourism in Leh town while preserving its cultural and historical significance.

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

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

Objectives

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

Achievements

1. In the Indian Himalayan Region, biodiversity is preserved in 108 wildlife sanctuaries (32870.41 km^2), 5 Biosphere reserves (22181.66 km^2), 31 National parks (17141.32 km^2), 06 Tiger reserves (7385.75 km^2), 7 Elephant reserves (16250.07 km^2), 47 Conservation reserves (1200.04 km^2), 15 Ramsar wetland sites (935.44 km^2) and 208 Community reserves (1237.67 km^2) covering 99202.59 km^2 (18%) of the IHR area (Fig. 47).

2. A total of 14 international conventions/treaties/commissions/protocols/frameworks related to biodiversity conservation have been compiled, of which India is a signatory. Similarly, 19 National level policies/acts were compiled that contribute to biodiversity conservation.

3. Eight success stories were identified, two each from the IHR States/UT of Himachal Pradesh, Uttarakhand, Sikkim, and Jammu & Kashmir.

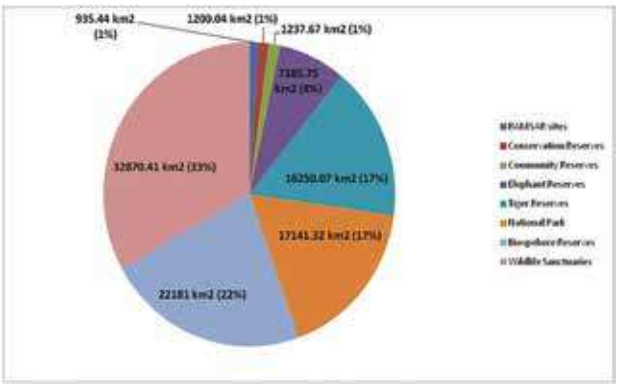


Fig. 47. Relative contribution of protected area network (PAN) types in IHR

Summary of the Completed Project/ Activity

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

At rural Technology Complex (RTC) at HQs of G.B. Pant National Institute of Himalayan Environment, Kosi-Katarmal, Almora and at the Regional Centres of the institute across IHR, various R&D based low-cost, eco-friendly and mountain-specific rural technologies were demonstrated for training and capacity building of rural people/farmers and other stakeholders for their large-scale replication across the IHR. In the process of training and adoption of technologies, feedback and suggestions were taken from the stakeholders since establishment of RTC in 2001-02 to improve the technology and processes. These feedbacks were analyzed to know people's perception towards technology adoption. Besides, fresh feedback from those beneficiaries, who got trained at RTC and implement the technology were taken, to draw inferences about success and failure of a given set of technologies and to make need-based modifications in the technologies to improve it and bring out policy imperatives.

The aim of the project was to identify issues influencing the interests of stakeholders towards the adoptability of different environment-friendly, low-cost, livelihood enhancing technologies promoted by the RTC over the last three decades and progression and performance after the implementation of these technologies for the policy imperatives through the assessment of feedbacks, ground truthing and validation of activities.

Analysis of the feedback received in the past, clearly indicated that farmers were keen to adopt various technologies, based on availability of resources and suitability of technology to their location. Highest number of farmers showed their preference for protected vegetable cultivation (>90%), followed by bio-briquetting (>80%), bio composting (>60%) and IFF (>60%). Relatively lower percentage of farmers preferred to take up mushroom cultivation, vermicomposting, beekeeping and poultry farming as a livelihood option. Preference to adopt protected cultivation is on account of continual threat to crops by wild animals like monkeys, wild boar etc. Analysis of the post implementation feedback received during the study, revealed that almost all the respondents (98.9%) have been cultivating vegetables in open areas by using farmyard manure (FYM) to sustain soil fertility. Majority of farmers (80%) have adopted protected vegetable cultivation, followed by cash crop cultivation, poultry farming, IFF and beekeeping, respectively. Vegetable cultivation under polyhouse is becoming popular in Himalayan region. Most of the farmers have built polyhouses for raising nursery and growing vegetables round the year. In polyhouse, substantially higher yields of bell pepper (94.0%), tomato (73.5%), summer squash (60.50%) and French bean (41.2%) was recorded as compared to yield of these crops on open fields. Besides yield advantages, the crop becomes ready to be harvested 15-25 days earlier in a polyhouse than crops grown on open fields. Early harvest of the vegetable crops fetch higher prices in the market. From vegetable cultivation in polyhouse, on an average farmers earned Rs 48,500 annually from medium size (100 m2) and Rs 1,35,000 from large polyhouse (200 m^2). The mean annual employment (man days) before the adoption of protected cultivation was 345 man days and after the adoption of protected cultivation technology (PCT) were calculated to be 715 man days. The percentage of change was 107.2 per cent marking the greater impact of PCT on employment generation. The adoption of the PCT ensures the year round production, which in turn enhances the employment days in the year. The study clearly indicated that Integrated Fish Farming comprising fish, poultry, vegetables, etc. is highly profitable for small and marginal farmers in hills. In IFF, composite carp culture in 100 m2 pond, a small poultry unit comprising 30 birds of dual purpose hybrid Kuroiler, round the year vegetable cultivation on 600 m2 around fish pond yielded fish 5.5-6.0 t/ha/yr, 55.0-65.0 kg chicken, and 2500-3000 eggs. Besides, year round cultivation of vegetables (French beans, capsicum, pea, tomato, and radish) yielded 1242-1398 kg of vegetables providing additional income of Rs 18,400. Over the period, the beneficiary family has been earning income of Rs 30,000-35,000 annually. IFF has the potential to improve farm profitability (240-250%) and employment (105-110%) compared to cereal-millet traditional farming. Several IFF models which were created 20 years before are still running successfully. After post implementation feedback analysis it was observed that only 18.9% farmers adopted the bio-briquette technology and farmers showed interest to make bio-briquettes for domestic use.

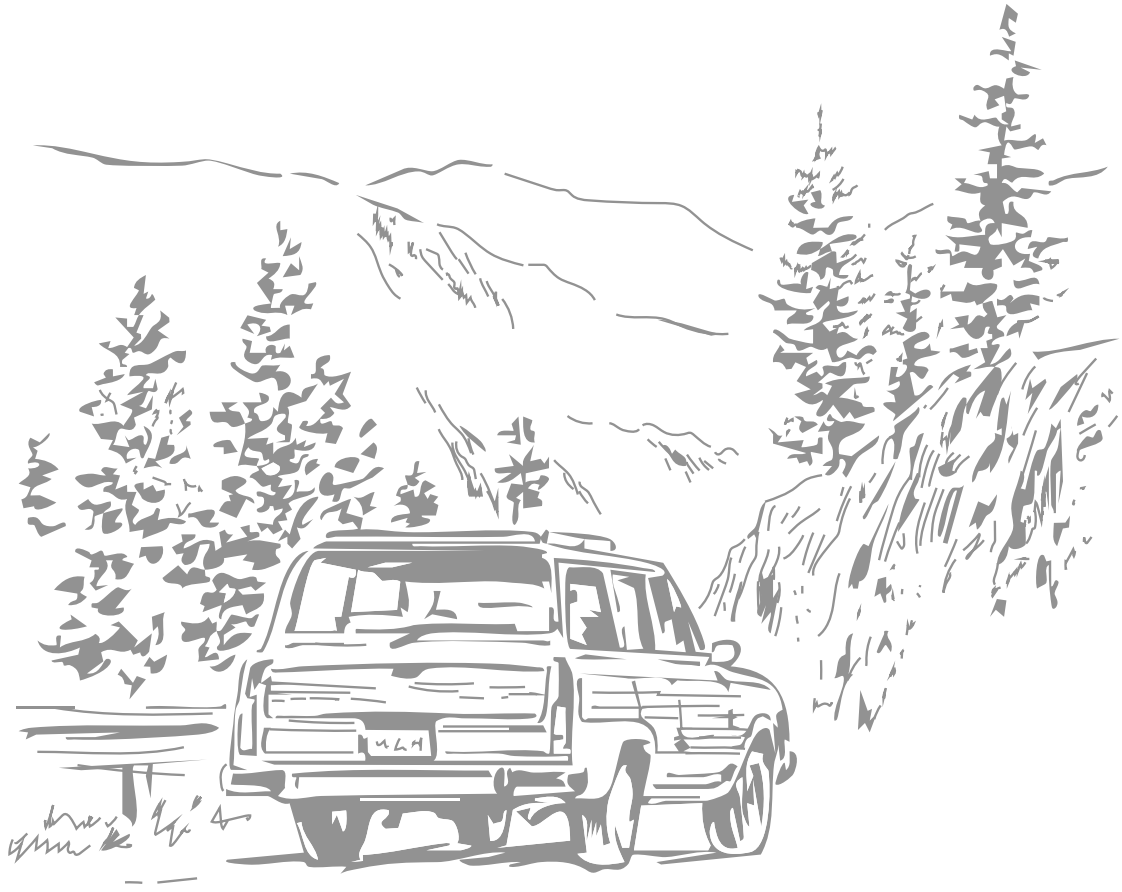
A comprehensive syntheses document focusing on scientific basis and efficacy of most adopted rural technologies popularized and up-scaled by RTC, have been developed. This document also contains socio-economic and environmental implications and scaling up potential of the selected technologies through rural development schemes/

programmes of State/ Central Govt. The document will be useful for the Line Departments of state government, R&D organizations and other agencies working for rural development in the IHR, particularly Uttarakhand.

Major outcomes

1. Through assessment of feedback forms available at RTC (GBPNIHE), post implementation feedback forms received from selected beneficiaries of RTC and their scientific validation, it is evident that protected cultivation, organic farming, integrated fish farming and bio-briquetting are the most suitable technologies for environmental conservation and socio-economic development of beneficiaries of hilly region of Uttarakhand (Fig. 48).

Fig. 48. Different activities at Rural Technology Centre and participation in different events



Application of R & D Activities

ENVIS Centre on Himalayan Ecology at the Institute HQs (1992 - Long Term Scheme, MoEF&CC, Govt. of India)

Environmental Information System (ENVIS) Centre on Himalayan Ecology was set up in the Institute in the financial year 1992-93 as a part of ENVIS network in India by the ENVIS 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 62 ENVIS Centres / Hubs / Resource Partners nationwide to provide national scenarios to the international set up, INFOTERRA Programme, of the UNEP.

Objectives

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

Achievements

1. 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.

2. EIACP Centre also published ENVIS Bulletin on Himalayan Ecology (Vol. 31, 2023) on the following two themes namely (i) Himalayan Ecology and Environment (ii) Bioprospecting Mountain Ecosystem. In addition, four thematic ENVIS Newsletters including (i) International Year of Millets, (ii) Climate Smart Practices in IHR, (iii) Food, Water and Energy security in IHR, (iv) Ecological urban planning and sustainable development, Vol. 20 (1-4), 2023 were also published.

3. The EIACP centre GBPNIHE Almora participated in various 19 mega events or exhibition and outreach programme such as (a) National workshop on "Lifestyle for Environment" at Indra Pariyavaran Bhawan, MoEF&CC, Jorbagh, New Delhi (b) 17th Uttarakhand State Council for Science and Technology, on "Rural Science Congress", Vigyan Dham, Dehradun (C) Role of science in human well-being, H.N.B Garhwal Central University, Srinagar, Uttarakhand etc..

4. On the occasion of the national workshop on Lifestyle for Environment of EIACP centers, the centre exhibited/ showcased various items/products from the northern region on a sustainable lifestyle.

Integrated Eco-development Research Programme (IERP) in the Indian Himalayan region (Funding Agency: MoEF&CC, Govt. of India; Month of Start: April 1992- Long Term Scheme)

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

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

- To develop scientific capabilities in the IHR and strengthen infrastructure for environmental research.
- To develop and execute coordinated programmes as per R&D needs of the IHR.

Achievements

1. A total of 404 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.

2. At present 35 R&D projects are under various stages of implementation, covering 6 States (namely; Assam, Himachal Pradesh, Ladakh (UT), Nagaland, Sikkim, and Uttarakhand).

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

Strengthening and Maintenance of the Central Library at HQs

The Central Library of the Institute at its headquarters, at the end of financial year 2023-2024, had 18225 books. The library collections include many of the valuable reference & text books, doctoral thesis, dissertations and reports. For management of Library and Information Centre, a network version of the KOHA library management software is being used. As a result, the library is providing a number of services such as Newspaper Clipping Service, Article Alert, Current Awareness, Selective Dissemination of Information, Reprography, Reference, Indexing, Bibliography, Web Services (Online Journals) etc., for the development of the human resources. The Library of the Institute is accessible through web OPAC through the internet (https://librarygbpnihesd.weebly.com). During the reporting year, 64 new book titles were added to the library. The library is subscribing to a total of 15 foreign journals. The records of NIHE publications were maintained. The library subscribed to the Institutional membership of the Developing Library Network (DELNET), New Delhi and their services were used for resource sharing and exchange of information.

Central Laboratory Services

The Institute has centralized facilities for physicochemical, biological, and heavy metal analysis with available instruments like atomic absorption spectrophotometer (Varian AA280Z), Gas chromatograph (Chemito, Ceres 800 plus), UV-Vis Spectrophotometer (Shimadzu), flame photometer (Systronics), digestion systems (Pelican) etc. The central laboratory of the Institute caters to the needs of the research scholar, local institutions, government organization, and non-profit organizations for analysis of water, soil, and plant samples. A total of 27 water samples from 8 different organizations/ departments/ which includes 4 Government organizations and 3 non-profitable organizations (NGO) and one individual local viz. including DRDO ATR Almora, Military Engineering Services (MES) Ranikhet, Jal Sansthan Almora, Jal Nigam Almora, SOS organics, Sanjeevani Ayurvedshala, Himmotthan Society etc. The samples were analyzed for 11 physicochemical and 2 biological parameters in the central laboratory during the reporting period. A total of Rs. 54,162.0 (Rupees fifty-four thousand one hundred and sixty-two only) were generated from the analysis of these samples (Fig. 49). In addition, the central laboratory also facilitated the internal researchers/ Ph.D. students/dissertation students for their research work. During the reporting period, the central laboratory facilitated a total of 21 requisitions for analysis of 832 soil samples, 71 water samples, and 364 plant samples for different parameters.

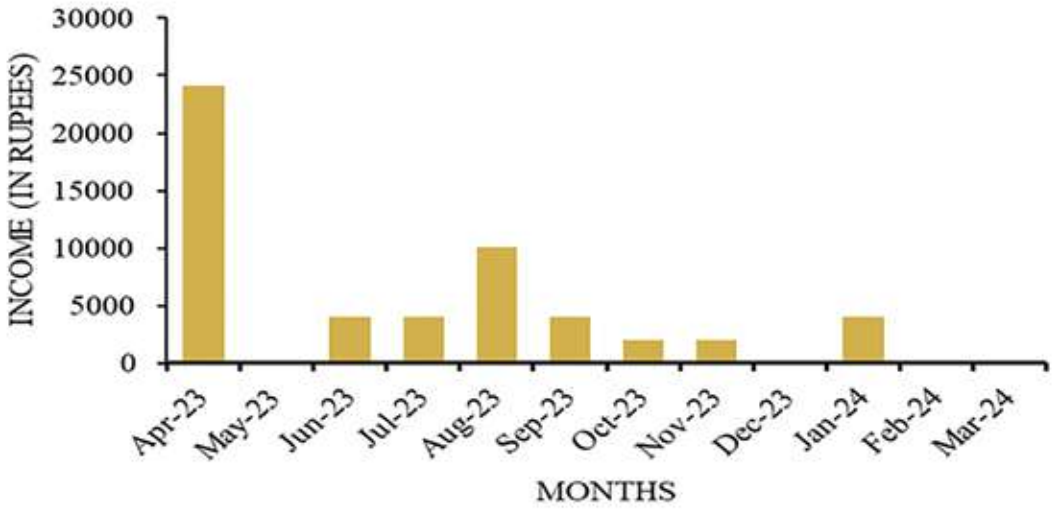


Fig. 49. Monthly details of income generated by the central laboratory from external samples

MISCELLANEOUS ITEMS

SCIENTIFIC PUBLICATIONS

i) SCIENTIFIC JOURNALS

International

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v) POLICY PAPERS

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Financial Report

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, 2024**, are prepared, in all material respects, in accordance with the law of India. The said account gives the information required and gives a true and fair view in conformity with the accounting principles generally accepted in India.

(a) In the case of Balance Sheet, of the state of Affairs of the Institute as at **31st March 2024**.
(b) In the case of Income & Expenditure account the Income/ expenditure for the year ended on that date.
(c) In the case Receipt and Payment Account the Receipt and Payment on cash and /or Bank account during the year ended on that date.

Bases of Opinion

We conducted our reaudit 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 qualified opinion.

Key Audit Matters

Key audit matters are those matters that, in our professional judgement were of most significance in our audit of the financial statements of the current period. These matters were addressed in the context of our reaudit 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 Qualified Opinion section, we have determined the matters described below to be the key audit matters to be communicated in our report.

Key Audit Matters	Auditor's response
None	None

Emphasis of Matters or Other Matter

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

1. 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.

2. 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.

SNRS & ASSOCIATES Chartered Accountants

413, Pratap Bhawan, 5, Bahadur Shah Zafar Marg, Delhi-110002
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3. Most of the balance related to receivable and advances given to parties are confirmed and reconciled. However, some Outstanding balances of receivables, payables and unsettled grants are pending for confirmation and reconciliations.

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.

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;

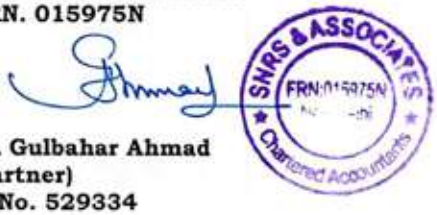
SNRS & ASSOCIATES * Chartered Accountants *

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

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: 24529334BKALUN5426

Date: 20.08.2024
Place: Almora

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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. 17856 of 1987 dated 14th July 1987 under the Societies Reg. Act. 1860;
PAN: AAAAG0515F)

Balance Sheet

As on 31st March 2024

Particulars	Schedule	Current Year (₹)	Previous Year (₹)
Liabilities			
Corpus / Capital Fund	1	5,03,43,661.23	3,88,65,555.82
Reserve And Surplus	2	39,76,44,009.91	37,73,99,228.50
Earmarked / Endowment Funds	3	-	-
Secured Loans & Borrowings	4	-	-
Unsecured Loans & Borrowings	5	-	-
Deferred Credit Liabilities	6	-	-
Current Liabilities And Provisions	7	28,09,94,686.75	25,45,64,071.63
Total		**72,89,82,357.89**	**67,08,28,855.95**
Assets			
Property, Plant & Equipments	8	47,94,20,944.47	37,73,99,228.50
Invest. From Earmarked/Endowment Fund	9	1,51,51,055.18	1,11,92,560.18
Invest. Others	10	-	-
Current Assets , Loans, Advances Etc.	11	23,44,10,358.24	28,22,37,067.27
Miscellaneous Expenditure			
Total		**72,89,82,357.89**	**67,08,28,855.95**

Significant Accounting Policies	24
Contingent Liabilities & Notes On Accounts	25

(Surya Kant)
Finance Officer

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

(Prof. Sunil Nautiyal)
Director

Date : 20.08.2024
Place : Almora

As per our report of even date attached.

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

SNRS & ASSOCIATES FRN:015975N New Delhi Chartered Accountants

CA Gulbahar Ahmad
(Partner)
M.No. 529334

UDIN: 24529334BKALWN5426

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. 17856 of 1987 dated 14th July 1987 under the Societies Reg. Act. 1860;

PAN: AAAAG3515F)

Income & Expenditure A/c

For the Year as on 31st March 2024

Particulars	Schedule	Current Year (₹)	Previous Year (₹)
Income			
Income from Sales/Services	12	4,22,294.00	4,53,459.00
Grants/Subsidies(net off exp)	13	30,82,88,042.42	29,24,49,568.93
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	12,60,288.00	2,35,030.00
Other Income	18	98,50,892.41	89,43,603.36
Increase (decrease) in stock of Finished goods and work in progress)	19	-	-
Total (A)		**31,98,21,516.83**	**30,20,81,661.29**
Expenditure			
Establishment Expenses: a) Institute	20	16,27,43,119.00	15,16,34,888.00
b) Projects		1,96,76,637.00	2,82,33,879.00
c) F.C (Projects)		-	19,07,078.00
Administrative Expenses :a) Institute	21	6,91,00,368.62	6,70,39,760.73
b) Projects (As per Annexure)		3,90,52,366.47	3,25,76,037.20
c) F.C (Projects)(As per Annexure)		70,052.33	22,45,411.00
Expenditure on Grants, Subsidies etc.	22	1,76,45,499.00	88,12,515.00
Interest	23	-	-
Depreciation	08	3,49,80,824.02	3,78,09,941.74
Total (B)		**34,32,68,866.44**	**33,02,59,510.67**
Balance being excess of Expenditure over Income (A - B)		**(2,34,47,349.61)**	**(2,81,77,849.38)**
Transfer to special Reserve			
Transfer to/ from General Reserve			
Bal. Being Deficit Trf.To Corpus Fund (Other Income)		**(2,37,92,244.61)**	**(2,84,12,879.38)**
Bal. Being Surplus Trf.To Corpus Fund (Corpus Interest)		**3,44,895.00**	**2,35,030.00**
Add: Transferred from General Reserve Fixed Asset Fund		**3,49,80,824.02**	**3,78,09,941.74**
Interest income of other Saving Accounts.			
Significant Accounting Policies	24		
Contingent Liabilities & Notes On Accounts	25		

As per our report of even date attached.

(Surya Kant)
Finance Officer

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

(Prof. Sunil Nautiyal)
Director

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

SNRS & ASSOCIATES FRN:015975N New Delhi Chartered Accountants

CA Gulbahar Ahmad
(Partner)
M.No. 529334

UDIN: 24529334BKALUN5426

Date : 20.08.2024
Place : Almora

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

(Regd. as Orchid Bulletin Pant Himalayan Paryavaran Evam Vikas Sansthan Reg. No. 17856 of 1987 dated 14th July 1987 under Societies reg. Act. 1860, PAN: AAAAG0515B)

Receipts & Payments A/c

For the year as on 31st March 2024

Receipts	Current Year	Previous Year	Payments	Current Year	Previous Year
I. Opening Balances			**I. Expenses**		
a) Cash in hand	1,13,436.02	1,59,812.56	**a) Establishment Expenses**		
	-	-	**I) Institute**	14,87,03,351.77	12,08,12,491.50
b) Bank Balances		-	**b) Administrative expenses**	-	-
	-	-	i) Institute	5,50,35,622.62	3,83,32,789.00
ii In Current accounts	-	-	ii) R&D(Rev) expenses	1,31,79,794.00	2,87,06,971.73
			iii) Payments for Current Liabilities		
ii) In deposit accounts (Corpus Fund)	1,11,92,560.18	68,76,296.82	(Gratuity/Leave)	88,76,476.00	2,72,71,572.00
iii) Savings accounts	17,88,49,509.04	18,79,96,538.02	**C. Capital expenditure**	-	-
c) Advances & Others	9,83,41,804.89	7,27,39,956.31	i) Purchase of Fixed Assets	9,22,90,072.56	1,00,26,179.00
(As per Annexure attached)	-	-	ii)Expenditure on Capital Work in Progress	5,36,51,700.00	1,50,00,000.00
F.C. Account	-	-	iii) Acquirement of land (Lease money)		-
A) Cash in hand	0.33	0.33	**II Payments made against funds for various proj.**	-	-
b) Cash on bank	40,27,149.32	44,87,658.62	**Expenditure State govt. projects**	-	-
c) FC Advances	9,15,331.00	9,15,331.00	a) Capital	1,69,80,148.00	2,02,67,728.00
II. Grants Received	-	-	b) Revenue	-	-
a) From Government of India	32,00,00,000.00	24,00,00,000.00	Fellowship/ Manpower/Salary	1,96,76,637.00	2,82,33,879.00
i) EEARSD Scheme MOEF & CC	77,71,91,576.00	-	Research expenses	3,90,52,366.47	3,25,76,037.20
Contribution corpus from CPF	16,63,126.00	26,58,050.00	**Expenditure FC projects**	-	-
b) From Other agencies	8,60,64,998.00	10,52,46,512.00	**a) Capital**	-	-
c) From other sources (from FC)	-	38,27,566.70	**b) Revenue:**	-	-
Intl. Cent. for Inte.Mountain Div.(ICIMOD)	2,10,603.24	-	Fellowship/ Manpower/Salary	1,44,142.00	19,07,078.00
III. Income on Investments from	-	-	Research expenses	2,85,426.33	23,76,083.00
a) Corpus Fund(Received from Institute)	-	-	Payments made against funds for various projects	2,10,603.24	-
			EEARSD Scheme MOEF & CC limit assigned	77,71,91,576.00	-
IV. Interest Received	-	-	**IERP grant released**	1,76,45,499.00	88,12,515.00
a) On Bank deposits savings a/c	6,88,474.00	-	**III Investments and deposits made**	-	-
b) On term deposits a/c	-	-	Pension trust (out of corpus fund)	17,18,495.00	26,58,050.00
c) Loans, Advances etc.	-	-	**IV Refund of Surplus money/Loans**	-	-
d) Interest income Corpus Fund	3,44,895.00	2,35,030.00	a) To the Government of India	2,40,97,284.15	-
V. Other Income	-	-	**V Other payments**	-	-
Received in Corpus Fund	37,37,500.00	40,81,233.36	Refund of EMD	2,25,000.00	-
(As per Annexure attached)	-	-	Fund transfar to Corpus fund (Centra)	37,37,500.00	40,81,233.36
VI. Amount Borrowed	-	-	**VI Closing balances**	-	-
VII. Any other receipts.	65,38,886.41	53,15,829.00	**a) Cash in hand**	1,01,912.30	1,13,436.02
unpresented Cheques Reversed	45,068.00	-	**b) Bank Balance**	-	-
VII. Adjustment received from CCU	2,93,16,611.00	-	i) In Current account	-	-
			ii) In deposit accounts (Corpus Fund)	1,51,51,055.18	1,11,92,560.18
			iii) In savings accounts	19,80,00,232.32	17,88,49,509.04
			c) Advances and others	2,86,07,251.13	9,83,41,804.89
			FC Project	-	-
			a) Cash in hand	-	-
			b) Bank Balance	37,54,568.32	40,27,149.32
			c) Advances and others	9,15,331.00	9,15,331.00
			Adjustment of Previous Year closing Advances	9,484.04	37,417.48
Total	**1,51,92,41,528.43**	**63,45,39,814.72**	**Total**	**1,51,92,41,528.43**	**63,45,39,814.72**

Auditor's Report

As per our separate report of even date annexed.

(Surya Kant)
Finance Officer

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

(Prof. Sunil Nautiyal)
Director

Dated : 20.08.2024
Place : Almora

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

CA Gulbahar Ahmad
(Partner)
M.No. 529334

SNRS & ASSOCIATES FRN:015975N New Delhi Chartered Accountants

UDIN: 24529334BKALUN5426

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. 17826 of 1987 dated 14th July 1987 under Societies Reg. Act. 1860, PAN: AAAGI3511F)

Schedules Forming Part of Balance Sheet

As on 31st March 2024

Particulars		Current Year (₹)		Previous Year (₹)
Schedule 1-Corpus / Capital Fund :				
As Per Last Balance Sheet		3,88,65,555.82		2,39,17,363.46
Add : Interest & Other income Trf. From Income & Exp. a/c (Corpus Fund)		3,44,895.00		2,35,030.00
Add : Contribution towards Corpus / Capital Fund		16,63,126.00		26,58,050.00
Add: Transferred from General Reserve Fixed Asset Fund		3,49,80,824.02		3,78,09,941.74
Less: Transferred to Pension Trust		17,18,495.00		26,58,050.00
Add/(Deduct) Transfer From Income & Expenditure A/c		(2,37,92,244.61)		(2,84,12,879.38)
Balance on the end of the Year		**5,03,43,661.23**		**3,88,65,555.82**
Schedule 2-Reserve & Surplus :				
1. Capital Reserve :				
- As Per Last Balance Sheet	-		-	
- **Add** : Addition During The Year	-		-	
- **Less**: Deduction During The Year	-		-	
		-		-
2. Revaluation Reserve :				
- As Per Last Balance Sheet	-		-	
- **Add** : Addition During The Year	-		-	
- **Less**: Deduction During The Year	-		-	
		-		-
3. Special Reserve : (Construction Fund)				
- As Per Last Balance Sheet	12,38,17,203.00		11,38,17,203.00	
- **Add** : Addition During The Year	5,36,51,700.00		1,00,00,000.00	
- **Less**: Deduction During The Year	2,93,16,611.00		-	
- **Less**: Adjustment/Deduction for previous Year	-			
		14,81,52,292.00		12,38,17,203.00
	-	**14,81,52,292.00**		**12,38,17,203.00**
4. General Reserve : (Fixed Assets Fund)				
- As Per Last Balance Sheet	25,35,82,025.50		26,10,98,060.25	
- **Add** : Addition During The Year	3,08,90,516.44		3,02,93,907.00	
- **Add** : Adjustment During The Year	(0.01)		(0.01)	
- **Add**: Adjustment Of Previous Year	-		-	
- **Add**: (Trf. From Const Fund A/c)				
- **Less**: Adjustment During The Year	-			
(Wdv Of Asset Sold During The Year)	-		-	
Add: Transferred To Corpus Fund	3,49,80,824.02		3,78,09,941.74	
(Depreciation For 2023-24)				
		24,94,91,717.91		**25,35,82,025.50**
Total (1 + 2 + 3 + 4)		**39,76,44,009.91**		**37,73,99,228.50**

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(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: AAAAG3513F)

Schedules Forming Part of Balance Sheet

As on 31st March 2024

Schedule 3-Earmarked / Endowment Fund :

Particulars	Current Year (₹)	Previous Year (₹)
(a) Opening balance of the fund		
(b) Additions to the funds	0.00	0.00
i. Dononiions/grants	0.00	0.00
ii.Income from invest made on account of funds	0.00	0.00
iii. Other additions	0.00	0.00
Total (a + b)	**0.00**	**0.00**
(c) Utilization/Expenditure towards objectives of funds		
i. Capital Expenditure		
Fixed Assets	0.00	0.00
Others	0.00	0.00
Total	**0.00**	**0.00**
ii. Revenue Expenditure		
Salaries, Wages and allowances etc.	0.00	0.00
Rent	0.00	0.00
Other Administrative expenses	0.00	0.00
Total	**0.00**	**0.00**
Funds merged with corpus Fund as per Governing Institute Decision:	**0.00**	**0.00**
Total (c)	**0.00**	**0.00**
Net Balance As on The Year-End (A+B-C)	**0.00**	**0.00**

Schedule 4- Secured Loans And Borrowings:

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

Schedule 5 - Unsecured Loans And Borrowings :

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

SNRS & ASSOCIATES * Chartered Accountants * FRN:015975N New Delhi

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. 17656 of 1987 dated 14th July 1987 under Societies Reg. Act. 1860; PAN: AAAAG0515F)

Schedules Forming Part of Balance Sheet

As on 31st March 2024

Particulars		Current Year (₹)		Previous Year (₹)
Schedule 6 - Deferred Credit Liabilities:				
a) Accep. secured by hypothecation of Cap. Equip. and other Assets		0.00		0.00
b) Others		0.00		0.00
Total		**0.00**		**0.00**
Schedule 7 - Current Liabilities And Provisions:				
A. Current Liabilities				
1. Acceptances				0.00
2. Sundry Creditors:				
a) For Goods			0.00	
b) Others [capital goods]			0.00	0.00
3. Advances Received:			-	
Project grant (As per **Annexure "A"**)	17,67,10,485.33		19,06,56,385.85	
Govt grant (R & D etc) (**Annexure "A1"**)	(1,91,18,324.72)		(4,97,99,589.10)	
Govt grant (cost fund)	-	15,75,92,160.61		14,08,56,796.75
4. Interest accrued but not due on:		-		-
a) Secured Loans/ borrowings			-	
b) Unsecured Loans/borrowings			-	-
5. Statutory Liabilities:				
a) Overdue			-	
b) Others			-	-
6. Other Current Liabilities (As per Annexure "B")		3,64,88,905.14		3,05,09,457.88
Total (A)		**19,40,81,065.75**		**17,13,66,254.63**
B. Provisions				
1. For Taxation		-	-	-
2. Gratuity		4,49,63,149.00	-	4,50,98,625.00
3. Superannuation / pension		-	-	-
4. Accumulated Leave Encashment		4,19,50,472.00	-	3,80,99,192.00
5. Trade Warranties/ Claims		-	-	-
6. Others		-		-
Total (B)		**8,69,13,621.00**		**8,31,97,817.00**
Total (A + B)		**₹ 28,09,94,686.75**		**₹ 25,45,64,071.63**

SNRS & ASSOCIATES * Chartered Accountants * FRN:015975N New Delhi

Institute Faculty (2023-24)

HEAD QUARTERS			
S.N.	**NAME**	**DESIGNATION**	**AREA OF SPECIALIZATION**
1.	Prof. Sunil Nautiyal	Director	Natural Resource Management and Conservation
2.	Er. Kireet Kumar	Scientist-G	Environmental Engineering; Hydrology
3.	Dr. J.C. Kuniyal	Scientist-G	Development Geography: Waste Management
4.	Dr. I.D. Bhatt	Scientist-G	Plant Physiology; Phytochemistry; Plant propagation
5.	Dr. Paromita Ghosh	Scientist-F	Plant Science; Soil Science
6.	Er. M.S. Lodhi	Scientist-E	Environmental Assessment
7.	Dr. A.K. Sahani	Scientist-E	Social Science; Anthropology
8.	Dr. S.C. Arya	Scientist-E	High Altitude Ecology
9.	Dr. K.S. Kanwal	Scientist-E	Strategic Environmental Assessment
10.	Dr. Mithilesh Singh	Scientist-D	Plant tissue culture; Bioprospecting
11.	Er. Ashutosh Tiwari	Scientist-D	Remote Sensing & GIS
12.	Dr. Sumit Rai	Scientist-D	Soil Science; Soil & Water Conservation
13.	Er. V.E. Gosavi	Scientist-D	Hydrology; Watershed Management
14.	Dr. Harshit Pant	Scientist-D	Forest Ecology
15.	Dr. Shailaja Punetha	Scientist-C	Agriculture; Horticulture
16.	Dr. Kapil Kesharwani	Scientist-C	Cryosphere; Atmospheric and Environmental Science
17.	Dr. Aseesh Pandey	Scientist-C	Biodiversity Conservation; Alpine ecology
18.	Dr. Suresh Kumar Rana	Scientist-C	Biogeography; Evolutionary Ecology; Bio curation
19.	Dr. Subodh Airi	Sr. Technical Officer (II)	Forest Ecology; Biotechnology
20.	Mr. Om Prakash Arya	Technical Officer	Biotechnological Application
GARHWAL REGIONAL CENTRE			
1.	Dr. K. Chandra Sekar	Scientist-F	Plant Taxonomy; Animal Taxonomy
2.	Er. Soukhin Tarafdar	Scientist-E	Weather & Climate Change; glaciology; Hydrology
3.	Dr. Arun Kumar Jugran	Scientist-D	Plant Biotechnology, Biodiversity Conservation; Conservation Genetics
4.	Dr. Kusum Pandey	Scientist-C	Protected cultivation; Natural Resource Management
5.	Dr. Lakhpat Singh Rawat	Technical Assistant (II)	Socio Economic Development

SIKKIM REGIONAL CENTRE			
1.	Dr. Rajesh Joshi	Scientist-F	Mathematical Modelling
2.	Dr. Sandeep Rawat	Scientist-D	Biodiversity Conservation; Conservation Genetics; Biochemical and Nutritional Analysis
3.	Dr. Mayank Joshi	Scientist-C	Tectonic Geomorphology
4.	Dr. K.S. Gaira	Technical Assistant (II)	Biodiversity Conservation
HIMACHAL REGIONAL CENTRE			
1.	Er. Rakesh Kumar Singh	Scientist-F	Information Technology
2.	Dr. Vasudha Agnihotri	Scientist-E	Soil Science; Plant Analysis; Instrumentation
3.	Dr. Sarla Shashni	Scientist-E	Rural Entrepreneurship and Small Business
4.	Dr. Renu Lata	Scientist-D	Environmental Assessment and Climate Change
5.	Dr. Kesar Chand	Scientist-D	Climate Change; Environmental Pollution and Disaster Management
6.	Dr. Manish Tripathi	Scientist-B	Lichen (Taxonomy and Ecology)
7.	Dr. Kishore Kumar	Technical Officer (II)	Pollination Biology; Conservation Education
NORTH EAST REGIONAL CENTRE			
1.	Dr. Devendra Kumar	Scientist-D	Biodiversity Conservation, Forest Ecology
2.	Dr. Wishfully Mylliemngap	Scientist-C	Forest Ecology, Ecosystem Services
3.	Er. Tridipa Biswas	Scientist-C	Climate Change and Environment Pollution
4.	Dr. Shivaranjani S.	Scientist-C	Carbon Flux
5.	Dr. Mriganka Shekhar Sarkar	Scientist-C	Ecology, Genetics
6.	Mr. Ranjeet Singh	Technical Assistant (II)	Forest Ecology
LADAKH REGIONAL CENTRE			
1.	Dr. Sandipan Mukherjee	Scientist-E	Climate Change; Ecosystem Services
2.	Dr. Puroshottam Garg	Scientist-C	Geology
3.	Dr. Ajay Kumar Gupta	Scientist-C	Climate Change
4.	Dr. Lalit Giri	Technical Assistant (II)	Biotechnology

Institute Supporting Staff

HEADQUARTER, ALMORA		
S.No.	**Name**	**Designation**
1	Mr. Sajeesh K. P. V.	Administrative Officer
2	Mr. Surya Kant	Finance Officer
3	Mr. L.M.S. Negi	Accounts Officer
4	Mr. S. Higgins	Sr. Technical Officer (I)
5	Mr. Mahesh Chandra Sati	Sr. Technical Officer (I)
6	Mr. K.N. Pathak	Sr. Technician (I)
7	Mr. Govind Singh	Technician (I)
8	Mrs. Sarita Bagdwal	Stenographer
9	Mr. Jagdish Kumar	Stenographer
10	Mrs Mamta Higgins	Office Superintendent
11	Mr Heera Singh	Office Superintendent
12	Mr. K.K. Pant	Upper Divisional Clerk
13	Mrs. Hema Pandey	Upper Divisional Clerk
14	Mr. Mayank Verma	Upper Divisional Clerk
15	Mr. Atul Bisht	Upper Divisional Clerk
16	Mr. Vipin Chandra Sharma	Lower Divisional Clerk
17	Ms. Vaishali Rani	Lower Divisional Clerk
18	Mr. Sanjeev Kumar Arya	Driver
19	Smt Ganga Joshi	Group 'C'
20	Mr. Gopal Singh Bisht	Group 'C'
21	Mr. Govind Singh Malwal	Group 'C'
LADAKH REGIONAL CENTRE		
22	Mr. Stanzin Zangmo	Lower Divisional Clerk
HIMACHAL REGIONAL CENTRE		
23	Mr. Ajay Pawar	Lower Divisional Clerk
24	Mr. Daulat Ram	Group 'C'
25	Mr. Jagdish Kumar	Driver
GARHWAL REGIONAL CENTRE		
26	Mr. D.P.Kumeri	Upper Divisional Clerk
27	Mr. M.P Nautiyal	Lab/Field Assistant/ Housekeeping
28	Mr. R.C. Nainwal	Lab/Field Assistant
29	Mr. R.P. Sati	Lab/Field Assistant
SIKKIM REGIONAL CENTRE		
30	Mr. Jagnnath Dhakal	Lab/Field Assistant
31	Mr. P.K. Tamang	Lab/Field Assistant (II)
32	Mr. R.K. Das	Lower Divisional Clerk
33	Mr. Musafir Rai	Group 'C'
34	Mr. Shyambir	Group 'C'
NORTH-EAST REGIONAL CENTRE		
35	Mr. Sandeep Kumar	Lower Divisional Clerk

Participation in Different Events by Institute Faculty

Events	HQ	Regional Centres						Total
National		NERC	SRC	GRC	HPRC	LRC	MDRC	
Symposia/Conference/ Work-shop/Webinar	61	23	20	8	22	5	23	162
Training Courses	68	11	7	5	18	5	11	114
Meetings	56	5	13	8	22	-	23	127
Participation as a Resources Person	47	9	12	7	29	-	1	105
Any Other	4	10	2	1	14	2	-	33
International	**4**	**7**	**6**	**-**	**-**	**-**	**-**	**17**
Total	**240**	**65**	**60**	**29**	**105**	**12**	**58**	**558**

SCIENTIFIC ADVISORY COMMITTEE

Chairman
Dr. Eklabya Sharma
Vice Chancellor
TERI School of Advanced Studies
(Deemed University), New Delhi

Thematic Experts
Dr Arun Kumar Saraf
Professor (High Academic Grade) Department
of Earth Sciences Indian Institute of Technology,
Roorkee

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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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