ANNUAL REPORT 2021-22

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

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

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NIHE, Kosi-Katarmal, Almora, Uttarakhand

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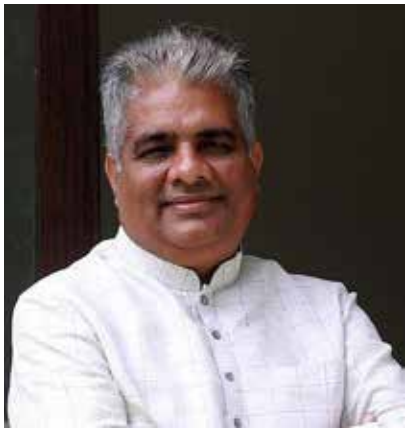
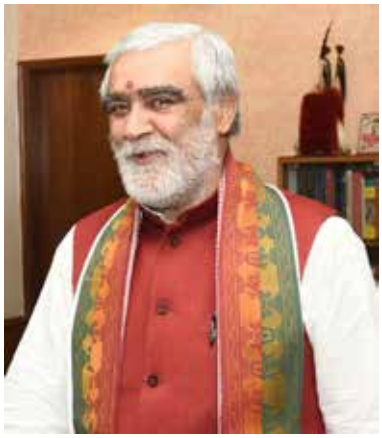


Sh. Bhupender Yadav
Hon'ble Union Minister
Ministry of Environment, Forest & Climate Change
Government of India



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

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Foreword

The Institute is mandated to carry out in-depth research and development on the environmental and socio-ecological issues of the Himalayas. In this endeavour, special efforts are made in year 2021-22 to upscale the micro-scale innovations and research successes to Pan-Himalaya through synergies between the Institute and Govt. Line agencies, R&D organizations and respective stakeholders. The R&D activities are implemented through the Institutional thematic centres, i.e. Land & Water Resource Management, Socio-Economic Development, Biodiversity Conservation & Management, and Environmental Assessment & Climate Change. The regional centres of the Institute in Ladakh, Himachal Pradesh, Srinagar-Uttarakhand, Sikkim and Arunachal Pradesh have also catered for the regional R&D needs. Addressing water scarcity through the augmentation of natural freshwater springs of lesser Himalayas remained one of the priority research areas of the Institute, and this year a total of 652 springs were digitally inventorized. In this regard, the successful watershed management activities of the Kosi-river together with the district administration, Almora, Uttarakhand, for rejuvenating river flows chartered a special mention. The initiative for the development of model villages across the Himalayas has resulted in around 68% increment in the per capita income of 117 households of six villages of Jyoli cluster, Almora, Uttarakhand through the adoption of natural resource-based livelihood enhancing technologies. Low-cost vermicompost and mushroom cultivation units, developed by the Institute, have benefitted a total of 11 villages in Arunachal Pradesh and Uttarakhand. Institute, since its inception, has been actively working towards the restoration of degraded lands using medicinal and aromatic plants across the Himalayas. Simultaneously, the creation of a spectral library of 42 plant species representing 25 families and 36 genera is a commendable accomplishment. Similarly, in collaboration with the Indian Space Research Organisation (ISRO), monitoring of aerosols and gaseous pollutants is being carried out in Himachal Pradesh and Uttarakhand mountains. The establishment of the Rural Technology Centre at Leh, Ladakh, UT, to promote Trans Himalayan winter agriculture through innovative approaches, in collaboration with the Ladakh Autonomous Hill Development Council, is a significant achievement. Similarly, an Orchidarium and Orchid Trail are being established at the Nature Learning Centre of the Sikkim Regional Centre. The institute is committed to quality research outcome, and this year faculties and researchers of the Institute has published more than 130 peer-reviewed articles in national and international journal of reputes along with 28 edited books and monographs, and two pertinent policy documents on sustainable tourism in Ladakh and sustainable Yak production in Sikkim. Faculties and researchers of the Institute were also actively engaged in research dissemination, and more than 50 events along with 45 webinars and web meetings were organized.

The Institute is thankful for continuous and timely guidance and encouragement from its decision-making bodies (i.e., the Society, the Governing Body, and the Scientific Advisory Committee). I place my sincere gratitude to every member of the apex bodies. The scientists and researchers of the Institute are committed to a better understanding of the socio-ecological issues of the Himalaya and providing pertinent solutions. I am confident that the Institute will reach at International level in future with a young and motivated group of researchers and faculties.

Er. Kireet Kumar,
Director-in-Charge

MAJOR ACHIEVEMENTS (2021-22)

- A baseline inventory of 652 springs across four Himalayan states (Uttarakhand, Himachal Pradesh, Sikkim and Arunachal Pradesh) has been completed and uploaded on the Himal data portal.

- A “Rural Technology Centre” was established at the Council Secretariat Complex, Leh, for demonstration, education and awareness of low-cost, pro-environment rural technologies.

- Database for extreme weather events, including cloudburst and flash floods in the Beas basin (H.P.), was prepared from 1994 to 2021. Developed eco-restoration plans for sub-alpine and alpine landscapes of Uttarakhand Himalaya to control habitat degradation.

- People’s Biodiversity Registers (PBRs) of Kullu district and its 5 Blocks were prepared and submitted to the H.P. State Biodiversity Board, Shimla. Also, technical support was provided to the Arunachal State Biodiversity Board to verify 49 PBRs of the Lower Subansiri District.

- In a cluster of six villages (Jyoli in Hawalbagh block, Distt. Almora) taken up for model village development 117 house hold benefitted by adopting various livelihood enhancing NRM technologies, thereby raising their income by 68% from the September 2020 baseline.

- A total of 628 distribution records of 198 RET and endemic plant species of IHR were documented, and thematic distribution maps of 8 high-value species under climate change scenarios were developed.

- Six hundred thirty-eight medicinal plant species of Sikkim Himalaya and their medicinal properties, altitudinal zone, habitat, traditional uses, etc., were documented.

- Developed low-cost vermicompost units and mushroom cultivation units in five Lower Subansiri district (A.P.) villages and six Almora district (Uttarakhand) villages to promote alternative livelihood options.

- Estimated monetary loss of ecosystem goods (timber, fodder, fuel wood, NTFPs, MAPs, forest regeneration, etc.) due to the forest fire of 2019 in Uttarakhand and M.P. at Rs. 1,30,387 - 1,14,327 /ha of forests following orders of Parliamentary Standing Committee on S&T and Environment & Forests, Govt. of India.

- To ensure the data availability to stakeholders 10 LoAs (letter of agrements) were signed with the Indian Himalayan states to implement the ‘Himalayan Knowledge Network’ for the establishment of ‘State Chapters’ in these states.

- A total of 63 training programmes and workshops were organized, and the capacity of 1958 people across the IHR was enhanced on various aspects of environmental issues and NRM in the Himalayan Mountains.

Publications:

1. Peer Reviewed National & International Journals	-	134
2. Chapters in Books / Proceedings	-	38
3. Authored/ Edited / Books / Booklets / Bulletins / Monographs	-	15
4. Popular Articles	-	33
5. Policy Papers	-	02

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 the need of a range of stakeholders including academia, policy makers and planners, Govt. line agencies NGOs and CBOs, etc., engaged in field implementation. The R&D mandate of the Institute is broad and covers all the facets of mountain environment and development. Towards achieving this goal, in-depth knowledge generation through multidisciplinary R&D projects and integration of multiple subjects is the guiding principle. Further, the interlinking of natural and social sciences is emphasized in all the R&D projects. In this endeavour, special attention is placed on the intricate balance between the fragility of mountains, indigenous knowledge and sustainable use of natural resources. Stakeholder viewpoints and feedback are invited and considered in designing and implementing R&D activities. Adequate efforts are devoted to addressing priority environmental problems and developing and demonstrating best practices, technology packages and delivery systems for improved livelihood and socio-economic development of the people. Also, conscious efforts are made to mobilize various stakeholders (students, researchers, academicians, farmers, citizens, NGOs, policy makers, National and International funding agencies and others) to participate in Institute programmes through different initiatives and mechanisms. Training, education and awareness of various stakeholders are the essential components of all the R&D programmes. The R&D activities of the Institute are conceptualized, governed and executed through four thematic Centres and five regional Centres. Thematic Centres include (i) Centre for Land and Water Resource Management (CLWRM); (ii) Centre for Socio-Economic Development (CSED); (iii) Centre for Biodiversity Conservation and Management (CBCM); and (iv) Centre for Environmental Assessment and Climate Change (CEA&CC). The regional Centres of the Institute are (i) Himachal Regional Centre, (ii) Garhwal Regional Centre, (iii) Sikkim Regional Centre, (iv) North-East Regional Centre and (v) Ladakh Regional Centre; and (vi) To look into policy related matter of the institute across the IHR, the 6th Mountain Division Regional Centre is 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 are being implemented across the IHR and completed 10 projects. A summary of R&D activities and achievements of different Centres of the Institute during the reporting year 2021-22 is as follows:

1. Thematic Centres

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

The research and development activities of the Centre during 2021-22 were aligned with the broader mandate to provide solutions to fresh-water related issues of central Himalaya; hence, efforts are made to evolve strategies targeting integrated development of the Himalayan region. The in-house project, focusing on the scientific comprehension of spring-ecosystems functioning and conservation through Jal Abhayaranya concept, was implemented in four IHR states through four regional centres of the Institute. Along with the impetus on spring inventory development for the IHR, wherein geo-physical aspects, spring water chemistry and spring discharge information were being documented, substantial efforts are made to build the capacities of youths as Para-hydro-geologists. Moreover, the in-house project also brought a new scientific dimension to the geo-hydrology of the Himalayan springs by spatially delineating spring ecosystem boundaries over Uttarakhand. Along with the in-house project, eight externally funded R&D projects were also implemented during 2021-22, encompassing issues of water and hydrological cycles. The Kosi watershed of Uttarakhand remained the major focus of the Centre's R&D activities. One of the completed projects was related to 'Use of system dynamic modeling for water resource management' where Kosi watershed's forest cover area was analysed for fragmentation estimation. The cellular automata model was developed to understand and simulate future projections of forest cover till the year 2030, 15% increase in the forest cover of the Kosi watershed from the 2017 situation was predicted. The project targeting the revival of the spring-fed river Kosi, 'Rejuvenation of Kosi river through field interventions & people's participation', is of its own kind where the institute is working with district administration, Almora, and many other stakeholders. The project's target is to conserve the water coming through rainfalls by preparing a water conservation structure in the recharge zones of the Upper Kosi watershed. The impacts of these efforts have to be monitored scientifically in the model area identified in the Deolikhan recharge zone. In the project on 'Rainfall structure and rainfall erosivity', the monsoon heavy rainfall observations at the Kosi-Katarmal were analyzed, and the weather prediction model physics performances were evaluated. In 'Spring-shed management- a strategy for climate change adaptation' project, the inventory of springs is being carried out in different Himalayan states and Union territories. The geo-physical survey and LULC study are also conducted in the study sites. A project on the purification of domestic wastewater is being implemented where pine needles are being used as a source of material for the purification of wastewater. Being fire-prone, pine needles are generally treated as a problem in the Himalayas so wastewater treatment can be an alternative usage of pine needles. The water treatment capacity of different edible plants is also being tested under the project. One completed project was also based on the pine needle capacity (in different forms) to remove emerging pollutants. The developed materials have shown a high capacity to treat the compounds present in artificial mixtures of emerging contaminants.

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

The Himalayan biodiversity, despite being rich and representative suffers from issues of high dependence, poor management, and lack of holistic understanding. Thus, it is important to assess the likely impacts and develop adaptation strategies for both conservation and management of natural resources and safeguard

the livelihoods of the inhabitants. During 2021-22, the Centre for Biodiversity Conservation & Management has been engaged in various R&D programs related to (i) strengthening the database on plant biodiversity and mapping biodiversity-rich areas across IHR, (ii), re-assessment of long-term ecological monitoring (LTEM) sites established in different forest types of western Himalaya, (iii) developing propagation packages and promoting threatened/ endemic plant conservation (iv) assessing climate change impacts on floristic diversity and vulnerability assessment, (v) strengthening community institutions for restoration of degraded habitats and their management, and (vi) demonstrate, build capacity and sensitize stakeholder towards suitable management of forest resources and plant diversity conservation. In an ongoing in-house project on "Mainstreaming Himalayan Biodiversity for Sustainable Development," biodiversity-rich areas across the IHR have been identified and grid mapping of micro-reserves for endemic and threatened plant species of 1232 species are being prepared. Further, to strengthen the Access and Benefits Sharing (ABS) mechanism, technical support to Biodiversity Management Committees (BMCs) in the revisions of the People's Biodiversity Register (PBRs) are facilitated for adaptive resource management and implementation of the Biodiversity Act (2002). With a broad goal of ensuring sustainable use of Himalayan biodiversity, and in understanding the demand and supply, 20 potential species are prioritized for market value-chain development. At the conservation front, propagation protocol of *Paris polyphylla*, *Rhododendron dalhousieae, R. maddenii, Rheum austral, Saussurea costus, Dactylorhiza hatagirea* are developed, and a total of 30 ha area of community wastelands is brought under the plantation of *Hedychium spicatum, Zanthoxylum armatum,* and *Cinnamomum tamala* with rural participation. Through the project "National Mission for Sustaining the Himalayan Ecosystem, Task Force-3 (Phase II) intensity and direction potential changes in the structure and functioning of Himalayan forest under the influence of climate change are being studied. Re-assessment study of LTEM plots (established in 2015) covering major climatic (i.e., sub-tropical, temperate, and sub-alpine) zones in the western Himalaya deduced a significant change in vegetation attributes and floral composition (i.e., herbs and shrubs) was observed between 2015 and 2022. Likewise, forest vulnerability mapping is conducted using the Analytic Hierarchy Process (AHP) method for the district Pithoragarh, Uttarakhand. Here, the temperate and mixed forests in the region are projected to have higher forest vulnerability, whereas subtropical pine, broadleaf, and subalpine forests forest. To detect and identify the medicinally important and other economically important plant species in relation to pedological and climatic conditions, the Centre has implemented a multi-institutional project, "Hyperspectral imaging for sharper definitions of Himalayan ecosystems and its high-value plant species under climate uncertainties". Under the project, a spectral library of 302 plant species (72 families; 217 genera) from Pindari, Almora, Munsiyari regions of Uttarakhand and Dachigam National Park, Gulmarg Wildlife Sanctuary of Jammu & Kashmir UT has been generated. In line with the UN Decade of Ecosystem Restoration (2021-2030), the Centre is implementing a project entitled "Promoting restoration programs on degraded lands through medicinally important species- A participatory approach". To date, over 20 hectares of degraded land from 9 villages in the Pithoragarh district are the pilot intervention sites, where a total of 16,900 individuals of 10 medicinal tree and herb species were planted with a 69.8% survival rate after one year.

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

In the Himalayan region, over 70% of the population resides in the rural areas and needs greater attention for socio-economic development. Rural people's livelihood in the region mostly depends upon marginal agriculture, horticulture, animal husbandry, forests, pasture, water, and various wild resources. On a regional scale, the farm produce meets only about half of the annual food demand of the people, triggering migration of youth to plains for better livelihood opportunities, leaving women to bear the brunt of carrying out almost all livelihood activities. At this juncture, when socio-economic development is constrained by resource depletion and environmental degradation in the IHR, the role of appropriate technologies which promote ecologically sustainable development becomes indispensable. A critical issue is also to up-scale and out-scale cost-effective and environment-friendly rural technologies. Using locally available resources, both material and manpower, and networking is pivotal for the success of such endeavours. Therefore, CSED aims to promote equitable, inclusive, and sustained growth by safeguarding communities' economic and social interests along with environmental protection in the IHR. CSED works as an effective conduit for disseminating and demonstrating best management practices of natural resources that emerged from the Institute's R&D among the rural mountain communities through a Rural Technology Complex (RTC).

The R&D focus of CSED this year has been geared towards (i) training and capacity building of faculty of Regional Centres, village communities and representatives of CBOs in developing bio-physical and socio-economic databases of village clusters for development of resource use maps, village selection criteria and participatory developmental planning; (ii) strengthening sustainable livelihood through demonstration and promotion of on-farm and off-farm best practices in a model village cluster; (iii) capacity building of a range of stakeholders on entrepreneurial skills and self-employment opportunities on various environment-friendly and income generating activities; and (iv) popularization and sale of environment-friendly products prepared at RTC to generate income of the Institute and maintenance of various R&D based package of practices at the RTC. Interventions in agriculture (protected cultivation), horticulture, beekeeping, forestry, animal husbandry (poultry), use of Pine needles in biobriquetting, green skilling (rakhi, alpna etc.) were made through participatory approach with beneficiaries mainly belonging to weaker sections (SC, BPL, Antyodaya and COVID returnees) that generated substantial nutritional supplements (vegetables, fruits, honey, poultry products) and income through the sale of farm produce in the village cluster selected under "Transformative Work" of Govt. of India. Through the use of Pine needles, eco-friendly products such as bio-briquettes, file covers, folders, note pads, carry bags, envelopes, etc., made at RTC were popularized across a range of stakeholders (rural people, Govt. Line agencies, entrepreneurs, NGOs and others) and sold to generate income to run the enterprise sustainably. CSED is running two projects on front-running environmental issues of IHR to address priority socio-economic problems and management of natural resources, focusing on (i) valuation of economic loss due to forest fire in Uttarakhand and M.P. and (ii) Himalayan knowledge network with a philosophy of science-policy-practice interface to increase outreach across a range of stakeholders. This year, CSED organized 30 meetings/workshops/training programmes, thus increasing outreach to 799 stakeholders (M=466 , F=333), Also, live demonstrations of natural resource management (NRM) technologies were maintained/demonstrated at RTC and in

the project villages. Thus, through various R&D efforts we tried to accomplish the mandate of CSED.

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

Mountain ecosystems are remarkably diverse and imperative Centres of biological diversity due to their immense climatic, topographic, and geographical ascents. These ecosystems are receiving increasing priority on global conservation agendas such as chapter 13 of the United Nations Agenda-21, which specifically recognizes the value of mountain ecosystems. 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 to both anthropogenic and environmental perturbations. The Centre for Environmental Assessment & Climate Change (CEA&CC) caters to the Himalayan needs on these issues in tune with MoEF& CC and SDGs (Goal no. 13), which requires urgent action to combat CC and its impacts. The Centre initiated work on the project, "Fostering Climate Smart Communities in the Indian Himalayan Region," and is currently testing different climate vulnerability indices to develop a framework for the identification of vulnerable communities in the Indian Himalayan Region. To unfold the current status of Aerosol Radiating Forcing over India, and Environmental Observatory Atmospheric Chemistry Transporting and Modelling in the Himalaya, two long-term monitoring projects, "Aerosols climatology over the north-western Indian Himalayan region Himachal Pradesh & Uttarakhand," and "Gaseous Air Pollution in the Background Sites of Sprawling Urban Environment in Himachal Pradesh and Uttarakhand," is being implemented by the Centre since 2006 onwards. A consultancy project on the preparation of the State/District plan for Uttarakhand supported by the State Pollution Control Board (UKSPCB), Uttarakhand is being carried out by the Centre. In addition to that the Centre is also studying impacts and habitat degradation studies due to biotic pressure in alpine and sub-alpine grassland under the UNDP-GEF project. For investigating microbial endophytes and soil enzymes as an indicator of climate resilience with respect to Himalayan birch, and bioprospection of medicinal plants against breast cancer angiogenesis are being undertaken. Similarly, under the DBT-RA fellowship program, nano-pesticides are being biosynthesised against phyto-pathogens (such *Alternaria tenuissima*) of *Picrorhiza kurroa* to enhance the production of medicinal bioactive metabolites. As part of "National Mission for Sustaining the Himalayan Ecosystem, Task Force-3 (Phase II), the Centre is working on dendrochronological studies to understand growth dynamics and climate reconstruction of the dominant (*Cedrus deodara* and *Pinus gerardina*) tree species from the IHR.

2. Regional Centres

(i) Himachal Pradesh Regional Centre (HPRC)

During the reporting period of 2021-22, spring inventory for a total of 76 springs (55 springs from Parvati Valley and 21 springs from Khadihar and Balh-II panchayat of Kullu District) was prepared under the Spring-Ecosystem project. Physiochemical parameters of spring-water like pH, TDS, EC, Ca_2^+, Mg^+, Cl^-, F^-, SO_4^{2-}, NO_3^-, Na^+, K^+ were well within the permissible limit prescribed by BIS 2012 and WHO 2011. Under the Eco-smart Model Village Development project, a questionnaire survey was carried out using the criteria of Unnat Bharat Abhiyan. As a result, baseline data were compiled, and resource use maps were produced for a total of 256 households in the identified villages of Mandi district. In addition, 2 vermicomposter units and 71 horticulture trees were distributed to a total of 11 stakeholders for setting up demonstrations and to increase livelihood. Under the Climate Smart Communities project, a total of 50 questionnaires from 3 villages were collected for vulnerability assessment of the villagers to climate adaptation practices. Similarly, under the Mainstreaming of Himalayan Biodiversity project, mass multiplication of threatened species were carried out, wherein *Swertia chirayita* showed very good (80%) germination in 50 ppm of GA_3, *Angelica galuca* performed well in KNO_3 treatments and *Sassurea costus* shown good results in GA_3 100 ppm. A total of 10,000 seedlings of *Swertia chirayita* were raised, of which 6000 seedlings were sold to Himachal Pradesh Forest Department with a cost of Rs. 1.20 lakhs. The nursery also carried out mass multiplication trails of *Rhododendron arboreum* and *Inula racemosa*. A responsive, bilingual website of Himalayan Knowledge Network with the domain name https://hkn.org.in was developed and hosted. During the reporting period, the Centre had successfully analysed *Picrorhiza kurroa* collected from different locations of Himachal Pradesh, and large-scale cultivation was carried out at the Kullu and Chamba districts of Himachal Pradesh. A study was also conducted using the ecological niche modelling for *Taxus contorta* to identify suitable habitats in the Western Himalayan region. Under *Ex-situ* conservation and development of a gene bank of commercially important threatened medicinal plants in the high altitude areas of Himachal Pradesh, *Arnebia euchroma* and *Angelica glauca* from wild locations and from farmers' field were collected; subsequently, chemical profiling of the plant species were carried out. Plant tissue culture of *Carum carvi* was initiated in the laboratory. In order to manage and conserve traditional beekeeping (*Apis cerana*) practices in the Kullu Valley, Himachal Pradesh, 120 beekeepers were selected, and one active beehive was provided through mutual investment. Measurement of gaseous air pollution in the background sites of Himachal Pradesh is a long running activity of the Centre. Seasonal and diurnal variation of CO, SO_2, NO_2 and NO_x was quantified under the activity and numerical relationship was established between surface ozone and its precursors such as NO_x, NO_2, NO and CO. The Aerosol Optical Depth (AOD) in the Kullu valley was measured under the programme of Aerosol Climatology over the North-western Indian Himalayan region, Himachal Pradesh, and high AOD values at shorter wavelength indicated dominance of anthropogenic actives. Respirable Dust Sampler (RDS) was also used to measure PM10, which showed an average concentration of 30.26 µg/m^3 while PM2.5 showed 33.33 µg/m^3. Efforts were also made to detect LULC change in the Beas basin, and a massive increase in agricultural land, including orchard expansion, was noted. During the reporting year, 6 projects have been completed successfully.

(ii) Garhwal Regional Centre (GRC)

The Garhwal Regional Centre (GRC) of the Institute was established in 1989 at Srinagar (Garhwal) in Pauri District (Uttarakhand). The major R&D activities include model demonstration on restoration of degraded lands through action research, forest and agro-bioresource utilization for sustainable rural development, water resource management through spring sanctuary development, protected area management and people conflict resolution, eco-tourism, biodiversity conservation using modern biotechnological tools, skill development of stakeholders in simple technologies for natural resource management and livelihood enhancement, etc. Some ongoing major R&D thrust areas include climate change impact, adaptation and coping strategies, water security through spring ecosystem approach, bio-prospecting of wild resources, Biodiversity conservation and conservation genetics, promotion and cultivation of medicinal and aromatic plants, sustainable tourism, and conservation and management of protected areas and eco-sensitive zones. Garhwal Regional Centre established a Rural Technology Demonstration and Training Centre (RTDTC) at 2 ha village community land, Triyuginarayan (2000 m asl), district Rudraprayag in 2007. The centre's main objective was to cater to the needs of a wide range of stakeholders, especially the marginal section of society. Twelve (12) potential rural technologies relevant to mountain context are successfully demonstrated in the centre. So far, about 65 training programmes have been organized for the stakeholders to provide knowledge and technical support and build their capacity to make informed decisions. Garhwal Regional Centre developed an agroforestry model with a participatory approach on 3 ha village community abandoned agriculture land at village Banswara (1200 m asl) of Rudraprayag district. The tree species for plantation were selected based on the priority of local people/women to cater the need for fuel wood, fodder and other products.

(iii) 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 (2021-22), the major focus of the activities of the Centre was towards spring rejuvenation, improving livelihood and ecological security, fostering climate smart communities, biodiversity conservation, strengthening regional cooperation for transboundary landscape management and establishment of Nature Learning Centre, through the implementation of 4 in-house projects, 4 externally funded projects, 1 trans-boundary landscape programme and 2 fellowship programmes. Under the 4in-house projects, baseline data (location and physical parameters) on springs, water demand and utilization pattern, demographic survey of different blocks of south Sikkim, household survey for preparation of baseline datasets and resource-use maps, technical support and inputs in facilitating PBR, strengthen the propagation protocol of and development of thematic distribution maps of RET, medicinally and economic plants were carried out. Under the Khangchendzonga Landscape Conservation and Development Initiative (KLCDI)-India Programme, an automatic weather station was established to strengthen long-term environmental and socioecological monitoring mechanisms. Also, three nursery beds were prepared for propagating large cardamom cultivars through seeds, and 4000 suckers of high-performing cultivars were planted in the nursery beds prepared in Yuksam. Under the National Mission on Himalayan Studies (NMHS) supported Nature Learning Centre project, Orchid trail and Orchidarium development have been initiated, and 53 species of orchids have been implanted. A long-term study plot was established

inside the arboretum for monitoring ecological, biodiversity and climate change, and a network of students and teachers was created to connect students and eco-clubs. Under the Himalayan Knowledge Network (HKN) project, key issues impacting the High Altitude Wetlands (HAWs) ecosystem services were identified and the LoA with agencies for the establishment of state chapters of HKN in Sikkim, Assam and Meghalaya. Under the Mountain Division Fellowship program, indigenous soil and water conservation practices adopted by communities were documented, and approaches for cost-benefit analysis were drafted. Under the completed project on the promotion of sustainable community-based tourism, ecotourism-based recourse maps of three pilot sites, bioresource mapping and database, and stronger networking among ecotourism service providers were developed, and ecotourism-based festival for showcasing of crafts/ethnic items, training and certificate course for livelihood enhancement were organised. Under the completed Mountain Division Fellowship program (2019-22), documented 638 species of medicinal plants of Sikkim, developed distribution mapping of 4 threatened species and introduced 32 species of medicinal plants in the herbal garden for conservation. The centre also organized various workshops, awareness, training and capacity building programme for dissemination of the knowledge and extension of its activities. This year, the centre contributed towards the scientific excellence of the Institute through 40 publications, including 17 research papers, 02 policy briefs, 07 book chapters, 06 authored booklets and 08 popular articles.

(iv) North-East Regional Centre (NERC)

North-East India is well-known for its rich floral and faunal diversity and covers parts of two global biodiversity hotspots: Himalayan and Indo-Burma. Agriculture and allied activities are the main source of livelihood for indigenous communities residing in the region. The region is also rich in bioresources, which are utilized and managed by the communities for different purposes using their inherent traditional knowledge. Recently, the region's biodiversity and traditional knowledge and practices of the region are under threat of extinction due to modernization, conversion to unsustainable land uses, developmental activities, climate change and other natural and anthropogenic factors. To address these issues, the NERC's main R&D functions are (i) conservation of biological diversity (ii) sustainable socio-economic development and livelihood security (iii) adaptation/ mitigation of climate change impacts, (iv) ecotourism (v) low-cost rural technologies and (vi) networking and collaborations with other Institutes/organizations. Currently, the NERC is running 4 in-house and 2 externally funded projects. During the reporting year (2021-22), nearly 30 nos. training, awareness and capacity building programmes, webinars, field demonstrations, etc. have been conducted for diverse stakeholders, including line departments, CBOs, Gram Panchayat leaders, local NGOs, women farmers, students and teachers from different parts of Arunachal Pradesh. The subjects covered include biodiversity conservation and assessment, climate change impact, disaster management, low-cost rural technologies, alternative livelihood options, value-addition and marketing of agri-horticultural produce, ecotourism, etc. Under alternative livelihood options, hands-on training has been conducted in vermicomposting, homestay, mushroom cultivation, and pickle making. Skill-based trainings on Para-hydrology, PRA tools and village resource mapping have also been conducted during the year for local youths and students to build their green skills.

To fulfil common R&D goals as well as to organize different activities/events, the NERC also collaborated with other State Government departments and academic and research institutions, including Rajiv Gandhi University (RGU), Arunachal Pradesh, Mizoram University, Nagaland University, Manipur University, Arunachal Pradesh State Council for Science & Technology, Department of Environment& Forests, Govt. of Arunachal Pradesh; Botanical Survey of India, Arunachal Pradesh Regional Centre, Zoological Survey of India, Arunachal Pradesh Regional Centre, Arunachal State Science Centre, etc.

The NERC disseminated its research contribution in the Eastern Himalayan region through publications in national and international journals. During the reporting year, 22 publications have come out from NERC

(v) Ladakh Regional Centre (LRC)

Activities of Ladakh Regional Centre during 2021-2022 focused on policy advocacy by conducting brainstorming sessions on pertinent issues, viz., sustainability of tourism, conservation of wildlife, single-use plastic, etc., and a policy brief was developed in collaboration with policymakers and government departments. The Centre made efforts to develop and demonstrate technologies for uplifting rural livelihoods and capacity building of Women's Self-help Groups in participatory mode. Scientific demonstration and hands-on training included low-cost winter cultivation through portable poly houses, integrated mushroom cultivation, and natural resource-based skill development as off-farm activity. For wider knowledge dissemination and education, a "Rural Technology Centre" was developed with support from Ladakh Autonomous Hill Development Council, Leh, to demonstrate various models, viz., integrated pest and nutrient management, floriculture, soil-less cultivation of medicinal plants and vegetables, mini arboretum of important medicinal plants and trees of Ladakh, etc. A citizen science approach was adopted for conservation issues and awareness of Ladakh's biological diversity. On this account, collaborations were made with the Wildlife Conservation & Birds Club of Ladakh, Leh and the Department of Wildlife Protection, Ladakh UT. A total 22 amateur photographers surveyed different parts of Ladakh, and photo documentation of birds was carried out. This approach contributed to scientific advancement in the ornithology of Ladakh by adding 27 new birds from Ladakh UT. The book serves as a policy recommendation, a scientific account of ornithology in Ladakh since 1880, and serves as a field guide for the common man. A participatory approach to address water scarcity in high-altitude villages through artificial glaciers was adopted. Two community-driven artificial projects (village: Yulkham and village: Ursi) were supported through capacity building and employing local knowledge for making the artificial ice reservoirs upstream villages through people's participation. The Centre organized capacity-building programmes for women's empowerment through training on (i) the usage of natural resources (basket weaving from shrub twigs) available in their vicinity (Apricot, Seabuckthorn, Apple, etc.), (ii) value addition (jam, juice, candy), (iii) low-cost mushroom production, and (iv) vegetable cultivation during winters in portable, low-cost structures. Environmental education and Awareness programmes were also organized through brainstorming sessions on ecological restoration, migratory birds, sustainable tourism, and single-use plastic; a photo competition on nature and environment was organized, and outreach activities were conducted by celebrating days such as Women's Day, World Nature Conservation Day, International Day for Conservation of Biological Diversity, World Environment Day, International Mountain Day, etc.

in collaboration with local organizations (e.g., Ladakh Biodiversity Council, Women Alliance of Ladakh, WCBCL, LAHDC-Leh, etc.). Moreover, various competitions on environmental issues of Ladakh were organized for the school and college students. Research work carried out by Ladakh Regional Centre's staff has appeared in various journals and books.

(vi) Mountain Division Regional Centre (MDRC)

The Ministry of Environment, Forest and Climate Change (MoEF&CC) has established a dedicated unit as the 'Mountain Division' within the MoEF&CC in New Delhi as the 6th Centre of NIHE. This division operates as one of the Centers of NIHE and aims to tackle the unique challenges faced by mountain ecosystems in a comprehensive manner. It collaborates with various institutions under relevant ministries, non-governmental organizations, and academic institutions to promote the conservation of mountain ecosystems and facilitate sustainable development in 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 MoEF&CC and across the key ministries; (ii) To sharpen focus on mountain issues by bringing in "Mountain Perspective" across policies, programs, missions and schemes; (iii) To foster linkages between upstream and downstream regions by influencing policy & planning based on mutual dependence; and (iv) Develop a suitable framework of incentives for providers of ecosystem services. During the reporting period, the following six project-based studies were carried out through Himalayan Research Fellows and Associates that address various important research and policy issues across the IHR: (i) Assessment of Managed Spring Recharge as a Sustainable Solution to Water Scarcity in Sikkim Himalaya: Adaptation to Climate change; (ii) Policy imperatives of socio-economic development related environment-friendly rural technologies promoted by NIHE across the IHR: Prospects and constraints; (iii) Springs Ecosystem in Uttarakhand Himalaya: Boundary Protocol for Rejuvenation Policies; (iv) Carrying Capacity Estimation of Tourism in Leh Town Complex in Ladakh; (v) Biodiversity Policy Landscape in Indian Himalayan Region (IHR) for Conservation, Sustainable utilization and Community Livelihoods; and (vi) Understanding the Process of Change in Far-Eastern Indian Landscape Linking With Conservation and Management. Three projects were completed during the reporting period, (i) Water Quality Assessment of Existing Water Sources in the Lower Parbati Basin, (ii) Assessment and Valuation of Sub-alpine and Alpine Ecosystems of Himachal Pradesh in Relation to Climate Change, and (iii) Mapping and spatial distribution of medicinal plant species of Sikkim, Himalaya.

1. INTRODUCTION

During the year 2021-22 various R&D activities focusing on environmental conservation and sustainable development, were executed by the Institute at different locations of the IHR through its HQs at Kosi-Katarmal (Almora) and Regional Centres, viz., Himachal Regional 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 carrying out in-depth research on bio-physical and socio-economic aspects of the mountain environment, devising R&D-based strategies for natural resource conservation and management, documenting traditional practices of NRM, promoting livelihood opportunities, developing approaches for biodiversity conservation, devising mitigation measures to the impact of climate change, biotechnological applications for conservation of important plant taxa, etc. The Institute implements its activities through core funds provided by the MoEF&CC, Govt. of India, and the projects financed by external funding agencies (National and International). The Institute also funds the R&D activities of partner Institutions in different Himalayan states through the Integrated Eco-development Research Programme (IERP) and National Mission on Himalayan Studies (NMHS). The Scientific Advisory Committee (SAC) of the Institute reviews the progress of existing projects annually and guides the development of new R&D programmes. All these R&D projects are implemented through the four 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) Himachal Regional Centre (HRC), (ii) Garhwal Regional Centre (GRC), (iii) Sikkim Regional Centre (SRC), (iv) North-East Regional Centre (NERC), (v) Ladakh Regional Centre (LRC), and (vi) Mountain Division Regional Centre (MDRC) housed at MoEF&CC, New Delhi.

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 to bring out policy imperatives to handle front-running environmental issues of the region. This report presents a brief account of academic and other activities, along with the statement of accounts for 2021-22 carried out under various in-house and externally funded projects. The Institute would be most grateful to receive critical comments and suggestions for improving the quality of outputs of various R&D activities.

2. MAJOR EVENTS

Migratory birds of Ladakh

A workshop in collaboration with Wildlife Conservation and Birds Club of Ladakh, Leh was organized by the LRC on 8 May 2021 in virtual mode. Nearly 40 participants from Ladakh and other parts of the country participated in the event. Sh. Preet Pal Singh, Chief Wildlife Warden/ Chief Conservator Forest, was the chief guest. Experts from different parts of the country delivered their lectures on the importance of Bird Migration in the Himalayas, particularly Ladakh. In addition, the speaker, Sh. Lobzang Visuddha, Dr. Tsewang Namgail, Dr. Khursheed Ahmad, Dr. Geeta Padata, and Dr. Suresh Rana cover a wide range of topics, including local culture and high altitude bird migration and their ecology, the impact of climate change on migratory birds and the role of citizen science in the understanding of their ecology and conservation. On the occasion, the booklet entitled "Migratory Birds of Ladakh: A Brief" was released by the Chief Guest, Sh. Preet Pal Singh.

International Day for Biological Diversity

A webinar was organized on the theme "Biodiversity conservation research in IHR: a futuristic view for solutions" in which 21 subject experts from different organizations, 4 teachers' resource persons, and 11 CBCM alumni and researchers participated. Dr. I. D. Bhatt, Scientist 'F' & Centre Head, CBCM, NIHE started the webinar. Opening remarks were given by Er. Kireet Kumar, Director, NIHE. He paid his heartfelt tribute and homage to Dr. R.S. Rawal. He highlighted the importance of Biodiversity Day to create awareness among the people, and talked about biodiversity targets, Sustainable Development Goal (SDGs) and need to analyses our progress towards achieving them. Programme was divided into three parts i.e. setting the stage, panel discussion and way forward session. Dr. G. S. Rawat, Former Director, Wildlife Institute of India(WII), Dehradun, said that we all are supposed to ponder about our understanding and awareness about biodiversity issues, and about the kind of research we can do. He talked about various missions which aim to bring biodiversity and conservation to the forefront of Indian science, policy, and society's attention. Thereafter, panel discussion with various subject experts from different research organizations, universities, and schools was organized. After this, Dr. G.C.S. Negi, Scientist 'G' & Head, CSED, NIHE talked about implementation of BD Act 2002. During the way forward session, experts suggested various areas where research could be undertaken and require immediate attention. A total of 36 participants were present. Two competitions i.e. popular article competition and drawing competition were also organized during this event. Dr. Veena Pandey (Research Associate, NIHE) conducted the webinar and compiled the entries of various competitions. All the centres (GRC, HPRC, LRC, SRC, and NERC) of the Institute, celebrated the day on the theme "We're part of the solution" and various seminar and competitions organized.

Consultation meeting for identification of biodiversity rich areas in IHR

An online expert consultation meet was organized HQs Almora (May 27, 2021) with the following objectives: (a) to identify the high biodiversity rich areas based on the richness, uniqueness and representativeness. (b) to share the location specific details on threatened and endemic species and specific groups in the IHR. (c) to discuss and propose the mechanism of conservation for the identified areas. Around 20 experts from different organization participated in the event. The webinar started with the welcome address by Dr. I.D. Bhatt, Scientist 'F' & Head, CBCM, NIHE. Dr. K. Chandra Sekar, Scientist 'E', CBCM, NIHE provided a brief overview of the programme. In his opening remarks, Dr. G.C.S. Negi, Scientist 'G' & Head, CSED, NIHE emphasized on threats to biodiversity, expanding Protected Area Network, conservation goals, value addition of agro-biodiversity etc. Dr. S.S. Samant, Director, Himalayan Forest Research Institute (HFRI), Shimla highlighted the rich and unique biodiversity of IHR. Dr. Samant specially stressed the need of documentation of lower plants group of biodiversity rich zones and also suggested prioritization of PAs in IHR. Dr. A.A. Mao, Director, Botanical Survey of India (BSI) talked about piracy of vital bio-resources, illegal collection and trades, and importance of local community in conservation. Dr. G.S. Rawat, Former Director, Wildlife Institute of India (WII) suggested that to identify important biodiversity rich areas we would have to overlay floristic sub-regions, important plant localities, type localities, endemic sites and several other areas of unique vegetation in a geo-spatial domain and map these sites in reference to the existing protected areas. This will require massive exercise in local field surveys as well as consultations with the local stakeholders who hold tremendous knowledge about their own backyard. Two Technical session was organized; one for the identification of biodiversity rich areas of Western Himalayas which was chaired by Dr. G.S. Rawat, and second on Eastern Himalayas which was chaired by Dr. A.A Mao. Around 97 biodiversity rich areas including 49 in Northeast Himalaya 48 in Western Himalaya were identified. A total of 31 participants attended the event.

Consultation meeting on value chain development & value addition of MAPs in IHR

A webinar on "Identification of potential Himalayan plants for value chain development" was organized at HQs Almora (June 2, 2021) with the aim to identify some of the potential species from the different Himalayan states for value chain development so that the biodiversity based enterprises in the region could be endured. Dr. I.D. Bhatt, Scientist 'F' & Head, CBCM, NIHE said that webinar is basically designed to initiate the promotion of biodiversity based enterprises in the Himalayan region. Dr. Vikram S. Negi, Scientist 'E', NIHE highlighted the achievements of the institute on medicinal plant research and promotion of MP based livelihood. Dr. M.C. Nautiyal (Professor, HAPPRC, H.N.B. Garhwal University, Srinagar, Uttarakhand) suggested different criteria's for selection of plants and recommended plants for value chain development based on availability, economic potential and market demand. Dr. Arun Chandan (Regional Director, National Medicinal Plants Board, Himachal Pradesh) emphasized on the need of cultivation practices, market chain, new agro-techniques and buy back mechanism for farmers of the Himalayan region. He suggested *Saussurea costus*, *Picrorhiza kurrooa*, *Nardostachys jatamansi* and *Inula racemosa* as potential species for value chain development. Dr. S.S. Samant (Director, Himalayan Forest Research Institute, Shimla, Himachal Pradesh suggested various criteria and indicators for identifying medicinal plants for value chain development and recommended *Trilium govanianum*, *Dactylorhiza hatagirea* and for value chain development in the IHR. Thereafter, a panel discussion with various subject experts from different research organizations was

organized. They suggested Nearly 20 potential species for value addition and value chain development. A total of 24 participants participated in the webinar.

World Environment Day

World Environment day was celebrated in the HQS and all the regional centres of the Institute (June 5, 2021). At HQs, the day was celebrated with the farmers at Bamni gad village where villages were aware about the importance of cultivation of medicinal plants in the region. Plantation drive of the medicinal plants was also organized and species like *Hedychium spicatum, Cinnamomum tamala, Valeriana jatamansi,* etc., were planted at farmers field and community land. At Ladakh Regional Centre, a webinar on the "Ecological Restoration in Ladakh: Needs & Opportunities" was organized in collaboration with the Wildlife Conservation and Birds Club of Ladakh, and the Women's Alliance of Ladakh. During this webinar, various experts with their vast experience of working in the trans-Himalayan landscape of Ladakh shared their experiences dealing with the issues of restoration in two sessions. The first session focused on Issues, Technology, and Education and the second was based on Social Integration. A total of 88 participants including Er. Kreet Kumar, Director In charge of the NIHE, and other prominent citizens including Prof. Farooq Ahmed, Rector, University of Ladakh, Er. TseringTashi, Founder director, Ladakh Science Foundation, Sh. Lobzang Vissudha, Chairman of Wildlife Conservation and Bird Club of Ladakh, Dr.Subrat Sharma, Head of Ladakh Regional Centre, scientists, and school students participated in the event. A book entitled "A Comprehensive Account of the Birds of Ladakh" published by Ladakh Regional Centre, in collaboration with Wildlife Conservation and Birds Club of Ladakh and Department of Wildlife Protection, UT Ladakh was also released. At Sikkim, an online brainstorming workshop was organized on "Prioritizing Actions for Ecosystem Restoration of High Altitude Wetlands in Sikkim Himalaya". During the workshop, a keynote lecture was delivered by Prof. J. K. Garg, Governing Body Member, Wetland International-South Asia, New Delhi on "Restoration and Management of High-Altitude Wetlands". Thereafter, various panelists and resource persons deliberated on status, vulnerability, ecosystem services, temporal changes, and priorities for ecological restoration and conservation of Himalayan wetlands with special reference to Sikkim. A total of 73 participants from various organizations attended the workshop. Also, Garhwal Regional Centre and Himachal Regional Centre organized webinars on "Ecosystem Restoration",and different speakers/subject experts from HNB Garhwal University and local farmers actively participated.

Training program on community driven environmentally sustainable villages

Organized six days training program on community driven environmentally sustainable villages (14^{th}-19^{th} July 2021) under the In-house Project-2 in Jyoli village cluster for selected village CBOs and youth (Male 04, Female 08). The major participants were change leader youth and village representatives which were trained towards forest resource inventory, identification of invasive alien species in village area and its assessment along with waste disposal mechanism and utilization of animal dung towards bio-gas generation. A newsletter on the community driven environmentally sustainable village program was also published on the training program's proceedings.

Talk series under Bharat Ka Amrut Mahotsava

NIHE-NERC organized a 5-day long talk series on different topics related to ongoing R&D programmes of the Institute on online platformfrom 2nd August to 6th August 2021. This particular event was organized to celebrate the 'Bharat ki Azadi Ka Amrut Mahotsava'. It was attended bymore than 125 researchers/ students/government officials and knowledge was imparted on different subjects including techniques for biodiversity assessment, climate change trend and its impacts in Northeast India, concept of eco-smart model village in NE India, agrobiodiversity and other topics.

Online consultation meeting on 'Identification of potential plants in Arunachal Himalaya for value chain development'

An online consultation meeting on 'Identification of potential plants in Arunachal Himalaya for value chain development' was organized by NIHE-NERCon August 18, 2021. In this meeting, experts from different universities, research institute, state forest department and NGOs working on the plant diversity of Arunachal Pradesh and sustainable utilization of plant products have participated. All the experts agreed that Arunachal Pradesh is rich in biological diversity and contains a huge potential for their market values. They suggested 13 species of plants for value chain development on which latter a review meeting was carried out to prioritize the species for the value chain development.

Scientific Advisory Committee Meeting (SAC)

The 28th Meeting of the Scientific Advisory Committee (SAC) was held on 24 August 2021, through Video Conferencing (VC) at the Institute HQs, Kosi-Katarmal, Almora. Keeping in view the current pandemic advisories, all Covid regulations were strictly observed. The following SAC members attended the Meeting. The SAC meeting was chaired by Dr. Eklabya Sharma, Vice Chancellor, TERI University. Among the SAC members, Prof. Arun Kumar Saraf (Member), Prof. R. M. Pant (Member), Prof. Sandeep Tambe (Member), Dr. Kalachand Sain (Member), Dr Lalit K Sharma (Representative of Director, BSI), Er. Kireet Kumar, Director (I/C) NIHE (convener) and Institute members Dr. G.C.S. Negi (NIHE Nominee), Dr. Rajesh Joshi (NIHE Nominee), and Dr. Arun Jugran (NIHE Nominee) participated. During the meeting Institute Scientists presented their R&D progress and the SAC members suggested useful comments / inputs on the presentations for better R&D outputs of the Institute.

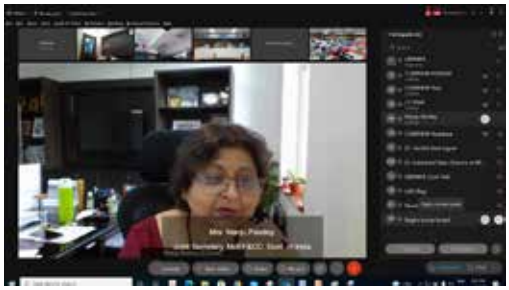
Regional Webinar on prioritizing actions for yak rearing and management

To strengthen the transboundary cooperation, a regional webinar on prioritizing actions for yak rearing and management was organizedon 9 September 2021,where 30 (male 22 and female 8) representatives from Bhutan, Nepal, and India, including different state representatives from Indian Himalayan Region (Arunachal Pradesh, Sikkim, Uttarakhand, and Ladakh), and ICIMOD, Nepal participated in the programme through online mode. While interacting, various stakeholders shared background of yak rearing status in the region and sensed as one of the key components of the Himalaya, and identified the action priorities for its sustenance.

Annual Day celebration

The annual Day of the Institute was celebrated at Institute HQs and al the regional centres (Garhwal Regional Centre, Srinagar Himachal Regional Centre, Kullu; Sikkim Regional Centre, Pangthang; Northeast Regional Centre, Itanagar' and Ladakh Regional Centre, Leh) on September 10, 2021 on occasion of 134th birth anniversary of Pt. Govind Ballabh Pant and the foundation day of the Institute. A 27th G.B. Pant Memorial lecture was also organized at the Institute HQs Almora and various popular lectures across the regional Centres. Shri. Ajay Tamta, the Member of Parliament inaugurated the event and appreciated the contribution of the Institute to solve various environmental problems in the Himalayan region. He particularly stressed on the work carried out by the Institute on the livelihood improvement, biodiversity conservation, water security and the climate change. Dr. Raghavendra Rao, FNA and honorary Scientist, Indian National Science Academy delivered 27th G.B. Pant Memorial lecture on "The Himalaya - Biogeography, Biodiversity & Bio-resources: Concerns & Strategies". He emphasized that the Himalayas

with their enormous natural resources are a real boon to the country. With such a vast flora having great potential for economic development and growing expertise in biotechnology and molecular biology, certainly India will emerge as a strong and powerful nation in the years to come. To realize this goal our priority agenda in the 21st century should be to identify the right bio-resource and convert the biological wealth into economic wealth following intense bio-prospection and global level product development. Dr. Rao underlined the importance of self-reliant India, the Jeevan Jyoti Mission for water security, and income growth for farmers, rural empowerment, and the National Himalayan Mission. The institute's contribution at national and international priorities was also mentioned. Director in charge, Er. Kireet Kumar gave brief presentation and highlighted the efforts made by the institute in the areas of land and water resource management, biodiversity conservation, social and economic development, environment impact analysis and climate change. The special Guest Shri Kalyan Singh Rawa, Padamshree appreciated the efforts of the Institute in different contemporary issues of the Himalayan region. Mrs Manju Pandey, Joint Secretary, MoEFCC said the Ministry will be happy to extend full support for the research and development activities of the Institute. Over 200 delegates from different organizations attended the event including Prof. A.N. Purohit, Former Director, NIHE, Dr. J.C. Bhatt, Former Director VPKAS ,Raghu Kumar Koddali, MoEF&CC, Dr. Kalachand Sain, Director Wadia Institute of Himalayan Geology, scientists, administrative staff, and research scholars of the institute. At SRC, the Annual Day was celebrated at Pangthang. Also, 8th Himalayan Popular Lecture on "Rural-tourism for sustainable development in Eastern Himalaya" was delivered by Prof. R.M. Pant, Centre for Management Studies, North East Regional Institute of Science & Technology. He explained the impacts, threats, management of increased tourist influx in Sikkim and other northeast states of India. He reflected that rural tourism in Sikkim such as, Dentam Rhododendron Festival, Mellidara Gram Panchayat, Lachen and Lachung Dzumsa Villages of North Sikkim, etc., are getting more attraction among tourists. During the event, three publications of the Sikkim regional centre, i.e., Books entitled "Diversity of Orchids in Prakriti-Kunj: The Nature Interpretation Centre", and "Sikkim Chetriya Kendra ki Shodh Evam Vikash Yatra: Paridrashya Evam Uplabdhiyaan" and newsletter entitled "Sangju" on Transboundary Landscape programme were released. A total of 45 participants attended the event. At Garhwal Regional Centre, Prof. C.M. Sharma, former vice chancellor, UUHF, Bharsar, Uttarakhand was the chief guest of the function. He appreciated the efforts made by the Institute on the sustainable development and conservation of natural resources of Himalaya. Dr. Ramesh Chandra, former director, Anthropological Survey of India, NWRC, Dehradun delivered 8th Himalayan Popular Lecture on "Environmental Climate Change Anthropogenic Factors in Himalayan Development". The Annual day celebration and 8th Popular Lecture were also organized at NERC, Itanagar. Dr. R.S.C. Jayaraj (IFS), Director Rain Forest Research Institute, Jorhat, Assam delivered the Popular Lecture on "Prospects of Agarwood Cultivation and Utilization in Northeast India".Shri Ravindra Kumar (IFS), & former PPCF & CWLW, Govt. of Arunachal Pradesh graced the event as the Chief Guest. Above 50 participants from ZSI- APRC, BSI-APRC and State Council for Science &Technology, Dept. of Environment & Forest, Govt. of Arunachal Pradesh, CSIR- North East Institute of Science and Technology, Arunachal Pradesh State Council for Science & Technology, Centre of excellence for Bioresource and Sustainable Development attended the programme.



Series of Webinars on 'Springscape'

A series of webinars on the Himalayan spring hydrodynamics 'Springscape' were organized during 4-7 October, 2021. The four lectures were delivered by Dr. V. S. P. Sinha, Professor, TERI School of Advanced Studies, New Delhi; Er. H.P. Uniyal, and former Chief General Manager of Uttarakhand Jal Sansthan; Dr. Sumit Sen, Associate Professor, IIT Roorkee, Uttarakhand; and Er. Vanita Pandey, Assistant Professor, North Eastern Regional Institute of Science and Technology (NERIST), Itanagar, Arunachal Pradesh. The lectures were focused the spring hydrology, monitoring protocols, data analysis, rejuvenation protocols, community participation for spring conservation, and importance of science based and data driven spring revival techniques.

National Wildlife Week

National Wildlife Week was celebrated at two schools of Almora district namely P.G.S. Inter College, Jyoli and GIC Hawalbag on 06-07 October 2021, respectively, in which a thematic lecture on 'Biodiversity and Wildlife' was organised followed by Drawing competition (6^{th} – 8^{th} class), MCQ/Quiz competition (9^{th} – 10^{th} class), and Essay competition (11^{th} – 12^{th} class). A total of 61 students (18 Male; 43 Female) from P.G.S. Inter College, Jyoli and 67 students (31 Male; 36 Female) from GIC, Hawalbagh participated in various competitions.

Workshop on Reducing single use plastic in Ladakh: Options and Challenges

A brainstorming workshop in collaboration with Ladakh Autonomous Hill Development Council, Leh (LAHDC-Leh) was organized by the Institute on 11 October 2021 at Ladakh Regional Centre, Leh. The workshop was organized to celebrate the iconic week of the Ministry of Environment Forest and Climate Change (MoEFCC), Government of India under the campaign "Awareness programs to avoid the use of single use plastic" as part of 75-week long campaign i.e., Azadi Ka Amrit Mahotsav. Sh. Tashi Gyalson, Hon'ble Chief Executive Councillor, LAHDC, Leh, was the chief guest and Sh. Jamyang Tsering Namgyal, Hon'ble member of Parliament, Ladakh UT was the Guest of Honour. A total of 25 experts, government officials and local stakeholders participated in the workshop. The main aim of workshop was to strengthen various efforts in phasing out the use of single use plastic in Ladakh UT, to find out the innovative ways to use the plastic as a resource than as a waste and also develop some policies for the management of single use plastic and other associated pollutions in Ladakh.

Training on resource mapping using PRA tools

A six-days training programmeson "Resource Mapping using PRA tools" was conducted from 31st October to 5th November, 2021 in six villages viz. M'Pen II (7th, 8th and 9th mile), Lama, Bodhisatta I and Bodhisatta II located at Deban area of Miao circle, Changlang district. The villagers and students were selected for the work. A total of 43 participants (Male=37; Female=6) attended the programme. The basic tools and techniques of PRA were demonstrated. The participants were explained about use of resource mapping to identify their assets and resources, and use of this information to have a better insight into one's agricultural development/growth, cropping pattern, productivity etc.

Institute Governing Body Meeting

The 43rd meeting of Governing Body of G.B. Pant National Institute of Himalayan Environment (NIHE) was held on November 26, 2021 under the Chairmanship of Shri R.P. Gupta, Chairman, Governing Body NIHE, and Secretary, MoEF&CC through Video Conferencing. Following were present in the meeting: The meeting was chaired by Shri R.P. Gupta, Secretary, MoEF&CC (Chairman) and attended by Shri Subhash Chandra, Director General of Forest (DGF), Smt. B.V. Umadevi, Additional Secretary, MoEF&CC (Member), Shri Sanjay Pandey, Joint Secretary and Financial Advisor, MoEF&CC (Member), Smt. Manju Pandey, Joint Secretary, MoEF&CC (Member), Dr. V.P. Dimri, Former Director & CSIR Distinguished Scientist, Hyderabad (Member), Prof. S.K. Mishra, Professor & Former Head, Indian Institute of Technology, Roorkee (Member), Shri Hem Pande, Dwarka, New Delhi (Member), Shri B.M.S. Rathore, Bhopal, M.P. (Member), Shri. Raghu Kumar Kodali, Scientist-F/Director, MoEF&CC (Special Invitee), Er. Kireet Kumar, Director Incharge, NIHE (Member Secretary).

Webinar on Tourism in Western Himalaya: Challenges and Opportunities

As a part of the International Mountain Day, a webinar on "Tourism challenges and opportunities in Ladakh" was organised by the Himachal Regional Centre (HRC), Mohal, Kullu, in collaboration with Ladakh and Garhwal Regional Centre on 9th December 2021. Ms. Sonam Angmo delivered a lecture on "Tourism challenges and opportunities in Ladakh". Subsequently, Prof. Prashant Gautam, Panjab University, delivered a lecture on "Tourism in Indian Himalayas: Himachal perspective". Sh. Rajesh Bhandari, District Tourism Development Officer, Kullu, Himachal Pradesh talked about the need of environment sustainability amidst increasing tourist load.

Regional Workshop on mainstreaming landscape approaches for conservation and sustainable livelihood

A regional workshop-cum-stakeholders meet on mainstreaming landscape approaches for conservation and sustainable livelihood-sharing of lessons and wise practices from Khangchendzonga landscape, India was organized on 9 December 2021, wherein 74 (male 57, female 17 participants) stakeholders participated. During the panel discussion session, achievements of implementation phase-I of KLCDI-India programme were shared; gaps and priorities for Phase II were identified through multi stakeholders' consultation.

A one day exhibition on "good practices for conservation and sustainable livelihood in Khangchendzonga Landscape-India - showcasing knowledge products, value addition and success stories", was organized by Sikkim Regional Centre at MG Marg, Gangtok on 10 December 2021 under KLCDI-India programme. Hon'ble Minister, Shri LokNath Sharma,

Agriculture, Horticulture, Animal Husbandry and Veterinary Services Department, Government of Sikkim inaugurated the exhibition in presence of MLA, Gangtok constituency Shri Y.T. Lepcha. Through this exhibition, Institute showcased and promoted identified good practices for conservation and sustainable livelihood from the Indian part of the KL wherein crafts, herbal products, medicinal plants, products made from plastic waste material, bamboo based products, large cardamom based products, knowledge products, etc., were exhibited by NIHE in association with institutions such as BSI, ICRI, RARI, KCC, MLAs and some of the progressive farmers/ entrepreneurs from local community. Total 12 exhibition stalls were displayedduring the exhibition.

International Mountain Day

As a part of the International Mountain Day, a webinar on "Sustainable Tourism in Ladakh: Opportunities and Needs" was organized in collaboration with the Ladakh Autonomous Hill Development Council, Leh (LAHDC-Leh) and Department of Tourism, Ladakh UT at LRC Leh. Ms. Sonam Angmo delivered a lecture on "Tourism challenges and opportunities in Ladakh". At Himachal Regional Centre, the day was was celebrated with a theme "Sustainable Mountain Tourism". Mr. Aishwarya Raj, IFS, Deputy Conservator of Forests, Parvati Division, Kullu (H.P.), Mr. Sandeep Minhas, State Secretary of Himalaya Niti Abhiyan among others the dignitaries attended the event. Scientists, researchers, entrepreneurs, start-ups, teachers, students, panchayat members also attended the event. On his remarks, special guest of the program Mr. Sandeep Minhas highlighted the importance of community based initiatives for development of sustainable tourism in Himachal Pradesh. The chief guest of the program Mr. Aishwarya Raj, IFS highlighted the importance of mountains specifically Himalaya as Water Tower. He briefed about various activities and initiatives taken by the Forest Dept. of Parvati division, Kullu for the development of sustainable tourism in the Kullu district of Himachal Pradesh. At North-East regional centre a popular lecture on the topic '"Eco-Tourism as a Sustainable Livelihood in North Eastern Himalayas – Learning from Arunachal Pradesh" was organized. Er. M.S. Lodhi, Head NERC delivered lecture and discussed on the various issues and potential of tourism in the Arunachal Pradesh. He particularly focused on the promoting ecotourism in the Arunachal Pradesh. Subsequently, the home-stay beneficiaries at M'Pen II (8th mile) village, Miao circle of Changlang district were made aware about the potentiality of promoting sustainable mountain tourism for better socio-economic growth of their communities residing in and around the Namdapha National Park. Total 24 participants participated in the programme.

Workshop on 'Himalayan Biosphere-Atmosphere-Hydrosphere Interactions'

As part of the Azadi Ka Amrut Mahotsav celebration, a workshop on 'Himalayan Biosphere-Atmosphere-Hydrosphere Interactions: Status, Challenges, and Way Forward' was organized on 14 December, 2021. The workshop was focused on in-depth scientific comprehensions, numerical quantifications of feedback

processes within biosphere, atmosphere and hydrosphere with knowledge of the gaps and challenges. The workshop was chaired by Prof. V. K. Gaur, Emeritus Scientist, CSIR 4-PI, Bangalore. Two invited lectures were presented by Prof. S. N. Tripathi, Chair Professor, IIT Kanpur, India, and Prof. R. Murtugudded, University of Maryland, U.S.A. followed by open discussions.

State Level Exhibition of R&D Outcomes of NERC

Under the 'AzadikaAmrutMahotsav'NIHE-NERC organized a state level exhibition to showcase its research outcomes and success stories in the form of knowledge products such as books, research papers, posters, brochures, etc. on the 24th December, 2021. The exhibition was held at Arunachal Pradesh Science Centre, Itanagar. In addition to the knowledge products, the NERC also showcased some products related to alternative livelihood development which are promotedby the institute through trainings and demonstrations. In addition, two ecotourism models, in Lower Subansiri and Changlang districts were also showcased through posters. Local people, government officials and students visited the exhibition.

Training – cum – Workshop on Biodiversity Conservation

A 2 days online Training – cum – Workshop on Biodiversity Conservation was organized during 14-15 February, 2022. The main objective of the program was to generate awareness on biodiversity conservation, threat on biodiversity, assessment techniques and conservation approaches (*in situ* & *ex situ*), enhance knowledge, and build capacity of college students towards different aspect of biodiversity conservation. In the program, various sessions including, introduction of biodiversity, Threats on biodiversity, Conservation approaches, and Herbarium Techniques, Remote Sensing and GIS techniques for vegetation mapping were covered. In theprogram expert from Botanical survey of India, Sikkim Himalaya Regional Centre,Gangtok, Sikkim University, and scientists of Institute served as resource person for the program.

Science Expo on at MG Marg

As a part of "Azadi ka Amrit Mahotsav" programme of Government of India, a scientific exhibition, themed at VIGYAN SARVATRA PUJYATE (SCIENCE IS REVERED ALL OVER) declared by the Department of Science and Technology, Government of India, was organized at MG Marg, Gangtok during 22-28 February 2022 in partnership with DST, Government of Sikkim. In the exhibition, Sikkim Regional Centre of the Institute exhibited various knowledge products developed from different R&D activities (such as research papers, books, booklets, articles, technical manuals, annual progress reports and posters) for dissemination of scientific knowledge among different stakeholders particularly the school and college level students of Sikkim. Apart from this, the livelihood based products

developed under different projects (e.g. the bamboo products like mugs, baskets, trays and traditional Lepcha Hat; Nettle fiber bags, Vermi-Compost and Bio-Composts, etc.) were also displayed in the exhibition.

Training Programme on Horticultural and Food Processing Management Techniques

A three-day training programme on "Horticultural and food processing management techniques" was organized at Himachal Regional Centre Kullu from March 2-4, 2022. The training was designed for farmers in the Khadihar Panchayat. The first day of the training focused on various food processing techniques for generating income. Various lectures on the subject was delivered by eminent speakers from different departments i.e., horticulture department and KVK, Bajaura. Hands-on training in pruning procedures was also provided to the participants. The training was attended by a total of 25 participants including 6 males and 19 females.

World Wildlife Day

A Training-cum-Awareness Programme on Wildlife Monitoring was organized Sikkim Regional Centre on March 4, 2022 under the theme: Recovering key species for ecosystem restoration. The main objective of the programme was to generate awareness on wildlife monitoring, threats on wildlife, and its conservation approaches (in situ & ex situ), and to enhance knowledge and build capacity of school students towards different aspect of wildlife conservation. The programme was conducted at Government Secondary School Damthang, South Sikkim. A total of 65 students and the teachers have participated.

Hands on Training and Capacity Building on Vermicomposting

A one day hands–on-training for capacity building vermi-composting and bio-composting for improving farm yield was organised on 5 March 2022 to develop skill among villagers of Mamlay watershed on preparation of vermin-compost and bio-compost for improving yield in organic farming. In this training programme the importance of vermi-compost practice and its market demand in Sikkim was highlighted. The demonstration of the preparation of vermi-compost was done in nearby field. Under this training total of 40 villagers from Lower Jaubari participated.

Workshop on Environment and Development Perspective: Women in Ladakh

A workshop on the Environment and Development Perspective: Women in Ladakh was organized by the LRC, Leh on 8 March 2022 on occasion of International Women Day. In the brainstorming workshop prominent women of Ladakh were invited for panel discussion on the role of women in environmental conservation. During the discussion, a need for comprehensive understanding and awareness was highlighted to map the avenues of opportunities for women in Ladakh. It was further highlighted that women issues are rarely discussed in policymaking thus there is need to establish a platform for regular discussions on concurrent issues and emerging needs, and providing solutions to women centric problems. An inclusive growth of children in developing good human being, and to strengthen the mental health to combat situations arises in distress conditions, e.g., COVID Pandemic, mental stress in domestic and professional situations is need of the hour. Various issues like inclusive growth, strong contextual teaching, scientific temperament among students, alternative education system, access-benefit sharing, access to clean energy, green infrastructure development etc. were discussed. On the occasion dignitaries including Dr.Tsering Landol, Padma Shri, Padma Bhushan, Mrs. Konchok Angmo, Deputy Rector, University of Ladakh, Mrs. Rigzin Angmo, 2nd Command, CRPF, Mrs. Thinles Chorol and Mrs. Nilza Angmo, Nari Shakti Puruskar awardees were present.

International Conference on Extreme Weather Events under Changing Climate

A two days International Conference on Extreme Weather Events under Changing Climate was organized by the Himachal Regional Centre, Mohal Kullu, in collaboration with CSIR-4PI Bangalore and District Disaster Management Authority, Kullu, during March 10-11, 2022. A total of 11 keynote speakers from all over the world presented their talks, and 24 research papers were presented both virtually and physically. A total of 110 participants including scientists, researchers, college students, school teachers, and staff of NIHE, CSIR-4PI, and the local administration of Kullu district, H.P., India, attended the event.

Awareness & Training program on Para-hydrologist with special reference to spring rejuvenation

A daylong training on Para-Hydrology with special reference to spring rejuvenation was organized under In-house project no. 01 at Ziro, under Lower Subansiri District of Arunachal Pradesh on 24th March, 2022. The training was attended by 20 participants from the Kalung and Bulla villages of Ziro, Lower Subansiri. Er. M.S. Lodhi, Head NERC & PI of the project, delivered a talk on ground hydrology, natural springs, and the importance and approaches of spring rejuvenation. He also shared the field experience and different techniques of spring's rejuvenation. Later, a consultation meeting was also held with member(s) of Panchayat, and All Kalung Development Committee for their inputs and suggestion on proposed sites for spring rejuvenation. The Zilla Panchayat Member (ZPM) Shri Subu Lento graced the occasion and expressed his views on the importance of water resources for Ziro Valley. The representative(s), Shri KalungTani and Tailyang Sera, Secretary General and Chairman respectively, of All Kalung Development Committee, were also present during the event.

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

S.No.	Date (S)	Title of Event	Venue	Total Participants
1	April 27-30, 2021	Identification and Nomenclature of Plants	NERC, Arunachal Pradesh	20
2	June 30, 2021	Identification of potential Himalayan plants for value chain development	HQs, Almora	24
3	July 8, 2021	Value-Addition & Marketing of Agri-Horticultural Produce	NERC, Arunachal Pradesh	50
4	July 19, 2021	Training program on community driven environmentally sustainable villages	HQs, Almora	12
5	July 29, 2021	Training-cum-training on propagation and conservation of Satwa (Paris polyphylla)	Sikkim Regional Centre, Sikkim	14
6	August 6, 2021	Wild edible; Current status and future prospect	Himachal Regional Centre, Kullu	40
7	September 15-17, 2021	Hands-on training program on Pickle making from local agri-horticultural produce	NERC, Arunachal Pradesh	42
8	September 24, 2021	Capacity building on Biodiversity conservation and Management	Garhwal Regional Centre, Srinagar	50
9	September 25, 2021	Workshop on climate variability/ change impact on natural resources and possible adaptation strategies	Garhwal Regional Centre, Srinagar	60
10	September 28, 2021	Training program on low-cost environment friendly rural technologies	HQs, Almora	34
11	September 30, 2021	Promoting the cultivation of high altitude Rajmash for livelihood enhancement of the farming community	Garhwal Regional Centre, Srinagar	20
12	October 9- 10, 2021	Enhancing the yield of high altitude Rajmash through application of bioinoculants	Garhwal Regional Centre, Srinagar	45
13	October 10, 2021	Tree plantation and Cleanness drive on the occasion Bharat kiAzadikaAmrutMahotsav	Garhwal Regional Centre, Srinagar	42
14	December 7, 2021	Awareness programme and cleanliness drive	NERC, Arunachal Pradesh	20

15	December 9, 2021	Mainstreaming landscape approaches for conservation and sustainable livelihood-sharing of lessons and wise practices from Khangchendzonga landscape, India	Sikkim Regional Centre, Sikkim	74
16	January 31, 2022	Training-cum-demonstration Workshop	Himachal Regional Centre, Kullu	9
17	February 25-26, 2022	Training program on Livelihood generation through Beekeeping and Poultry farming	Garhwal Regional Centre, Srinagar	68
18	March 4, 2022	Training on medicinal plants cultivation for livelihood enhancement	Sikkim Regional Centre, Sikkim	45
19	March 4-5, 2022	Training programme on mushroom cultivation and plantation of horticulture plants	Garhwal Regional Centre, Srinagar	64
20	March 5, 2022	Hands–on-training for capacity building on vermi-composting and bio-composting for improving farm yield	Sikkim Regional Centre, Sikkim	40
21	March 14-19, 2022	Field demonstration and training on low-cost rural technologies	NERC, Arunachal Pradesh	20
22	March 15-16, 2022	Hands on Training on Mushroom Cultivation at Miiring village	NERC, Arunachal Pradesh	27
23	March 22, 2022	World Water Day	HQs, Almora	58
24	March 25, 2022	Training program on “Enhancing the yield of high altitude Rajmash through application of bioinoculants	Garhwal Regional Centre, Srinagar	46
25	March 28-30, 2022	In Harmony with Nature	Sikkim Regional Centre, Sikkim	30

CENTRE FOR LAND AND WATER RESOURCE MANAGEMENT (CLWRM)

Land and water resource management have remained a major R&D activity of the Institute since its inception, and various programs have been implemented to address pertinent issues of land and water resources of the Indian Himalayas. Subsequently, substantial experience gained over the years in fields of mountain hydrology, water resource augmentation, glacier dynamics and hydrometeorology, geo-tectonics and landslide restoration, catchment area treatment, soil and water conservation technologies saw its culmination in the form of the establishment of a dedicated Centre for Land and Water Management (CLWRM) in the Institute in the year 2017. In recent years, challenges posed by globalization and climate change, melting of glaciers, increasing incidents of drought and waterborne disasters, continued outmigration of Himalayan people for livelihoods, and improved understanding of the existence value of Himalaya as a water tower, climate regulator, and ecosystem service provider to the entire North Indian plains, have further corroborated the need for more focused R&D for conservation and management of land and water resources of the Himalaya. Therefore, the activities of the Centre were contemplated to cover the concurrent themes of interest like spring ecosystem, water security, rainfall-induced disasters, livelihood and water pollution, keeping in view their societal relevance and conformity to the policy environment. The objectives of the Centre are to (i) conduct studies on land and water and related eco-sociological processes operational at watershed to the regional level, including upstream-downstream linkages; (ii) develop tools and techniques of sustainable land management considering various developmental interventions; and (iii) provide inputs to government and other policymakers for bringing in mountain perspective in land and water resource management policies.

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

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

Objectives

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

Achievements

1. Baseline spring inventory of 652 springs across seven study sites located in four Himalayan states (Uttarakhand, Himachal Pradesh, Sikkim and Arunachal Pradesh) was prepared wherein information pertaining to geo-physical aspects, spring water chemistry and spring discharge were collected and documented in a Geo-database. Spring water quality was monitored at a seasonal

time scale and examined against the BIS 2012 and WHO 2011 standards. The spring discharge variability was documented through spring hydrographs, FDC and recession curve analysis. All the studied water quality parameters were found under permissible limits (as per BIS norms) in most of the areas. The ecosystem health indicators, such as spring discharge dependency to rainfall and normalized memory effect, were analyzed for the Chudadi spring of Kantli, Almora, Uttarakhand.

2. To implement the spring rejuvenation plan under Jal Abhayaranya model, potential groundwater recharge zone mapping was carried out through hydro-geological investigation and mapping geomorphology, lineament density, lithology, soil class, LULC, drainage density, rainfall, etc., and using RS and GIS tools. An attempt was made to delineate the spring ecosystem boundary for the Lohaghat block of Uttarakhand using biotic and abiotic parameters (Fig. 1).

3. A total of 12 dissemination and outreach programs were organized across four states that, included capacity building-cum training programs, awareness programs, workshops, and field demonstrations wherein 355 stakeholders participated and were overviewed on water scarcity issues and spring shed management. Among 355 stakeholders, 166 participants were trained as 'Par-hydrogeologists' through lectures and field demonstrations with special reference to spring shed management.

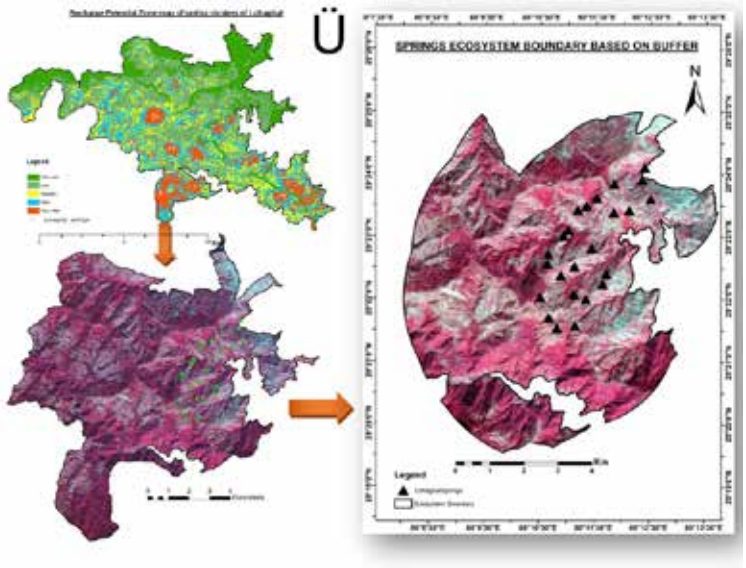


Fig. 1: (a) Recharge potential zone map of springs clusters of Lohaghat block of Uttarakhand, (b) Spring ecosystem boundary delineation for springs clusters of Lohaghat block of Uttarakhand, and (c) Groundwater potential zone identification for Lower Subansiri district in Arunachal Pradesh

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

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

Objectives

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

Achievements

1. Data on water quality and active soil layers were collected to investigate total and dissolved organic carbon (TC/DC, TOC/DOC) and inorganic carbon and nitrogen (TIC and TIN).

2. Tsokar, Tosmoriri, Changla, North Pullu and Upper Ganglas areas indicated alkalinity of water with pH values of more than 8.5 that exceeded the norms of permissible limit of drinking water. Zinc concentration was higher in the water samples collected from the permafrost areas and was highest near Chang La (25 g/L) along with some sites of North Pullu. The hot water samples collected from the Tsokar area and Puga contained a higher amount of dissolved inorganic carbon (DIC). DOC was higher in Warila, Changla, Tsokar Lake area and Puga hot water. TIN was highest in the Tsomoriri area (Fig. 2).

3. In case of active layer soil samples, DOC was highest in Tsokar area, followed by Down Warila. DIC was highest in Tsokar area. Total nitrogen (%) was highest in Tsokar Mounts, followed by Changla and near Tsokar Lake. The highest sulphur content was in Tsokar Mounts. The highest carbon content was in Tsokar Mounts, followed by Tsokar Lake. Sodium and potassium contents were found to be highest in the Tanglang La area. The highest phosphorus content was in Down Warila followed by Tsoltak Changla. The highest zinc content was in the sampling sites of North Pullu, Sashe (near the weather station) and Tsokar Lake.

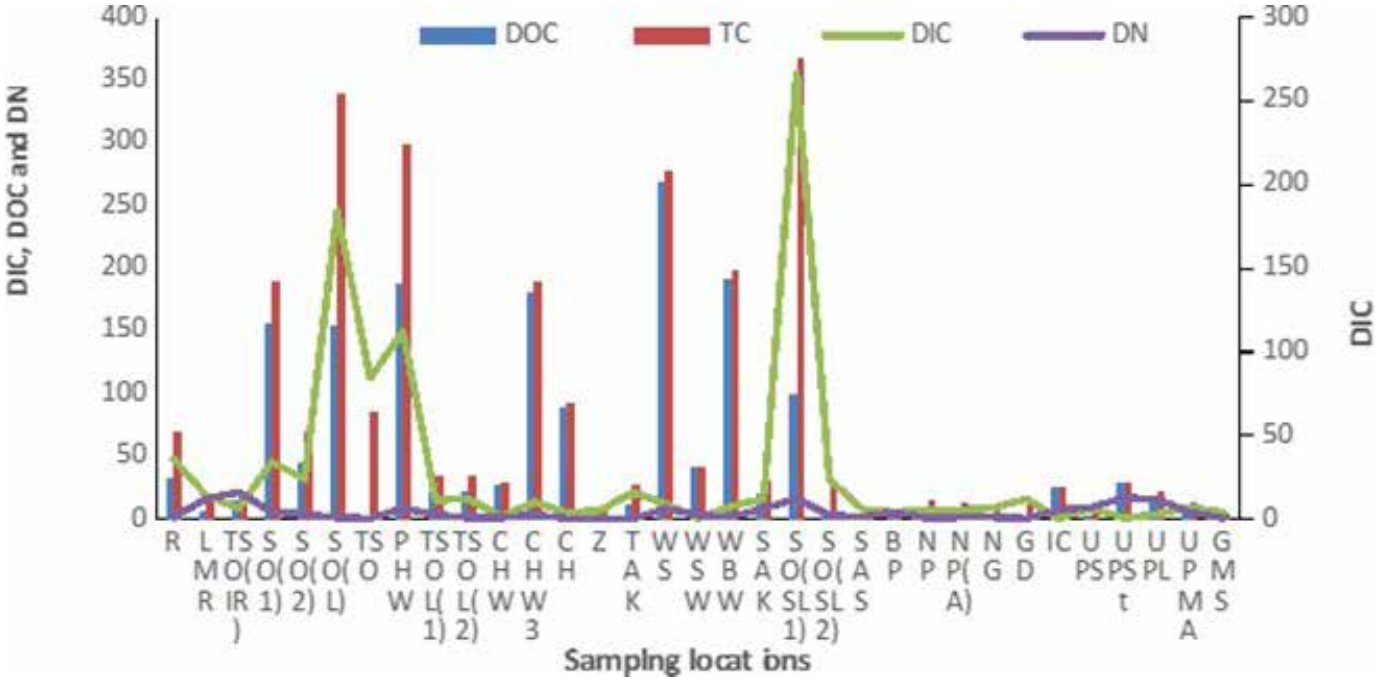


Fig. 2: Total inorganic carbon, total organic carbon and total nitrogen in water samples collected from different permafrost regions of Leh, Ladakh

Investigation of rainfall vertical structure and rainfall-induced erosivity over a Garhwal Himalayan station using in-situ observation and modeling (SERB, DST, GoI, 2019-2022)

The rainfall process is significantly modulated over the complex terrains of the Himalaya, often leading to extreme precipitation events or cloud bursts. Although the proposed mechanism for such extreme rainfall events indicates the orographically induced formation of deep convection within a land-locked valley due to moist thermal instability, in-situ observations of rainfall vertical structure (VSR) and integral rainfall parameters (IRP) at a very high frequency during such extreme precipitation events over the western Himalayan region is seldom investigated. In fact, investigation of VSR and IRP of normal (< 20 mm/day) and light monsoon seasonal rainfall (<10 mm/day) events of western Himalaya are inadequately investigated. Therefore, this research proposal uses in-situ observations and dynamical modelling to assess IRP and VSR over the western Himalaya. The dynamical modeling of accumulated rainfall at hourly, 3-hourly and 6-hourly time scales during the extreme precipitation events is anticipated to establish the physical mechanism of extreme precipitation events along with the identification of suitable cloud micro-physical and convective parameterization schemes for enhancement of forecast accuracy.

Objectives

1. To investigate vertical profiles of rainfall and integral rainfall parameters during monsoon seasons using an in-situ Micro Rain Radar and Disdrometer measurement.
2. To establish relationship between the rainfall intensity and kinetic energy for deduction of erosivity.
3. To assess performance of WRF-ARW cloud microphysical schemes with respect to in-situ observations on simulating vertical profiles of integral rainfall parameter/s during selected rainfall events of monsoon season.

Achievements

1. The extreme rainfall event of 17-19 October 2021, over Uttarakhand was investigated using raingauge observations and a vertically pointing Ka-band micro rain radar. It was noted that the event was triggered by an intense western disturbance resulting around 313.18 mm rainfall over Almora, Uttarakhand. Analysis of the radar reflectivity profiles indicated persistent extreme stratiform rain with consistently high presence of the bright bands (average of 46.8 (±14.3) % bright bands) with maximum bright bands (63.38 %) present on 19th October. The maxima of rain rates near the ground were 18.78, 71.56, and 41.51-mm h-1, respectively, indicating the event was not a cloud burst as the rain rate never

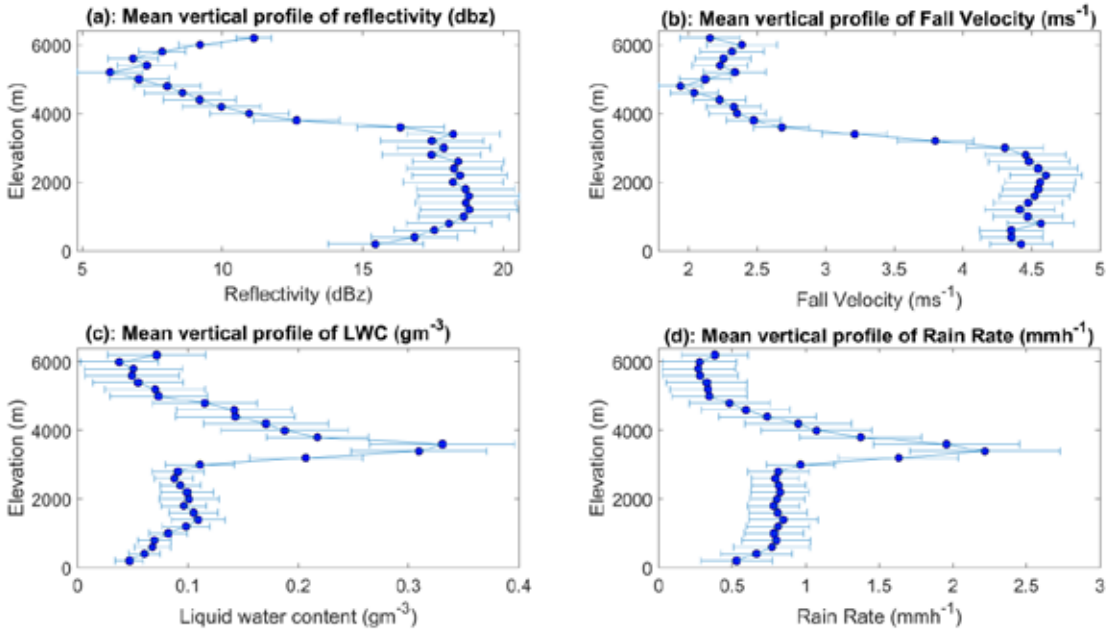


Fig. 3: Mean vertical profiles of (a) radar reflectivity (dBZ) (b) fall velocity (ms−1) (c) liquid water content (gm−3) and (d) rain rate (mmh−1) during active bright band periods of theOctober, 2021, event are presented.

exceeded 100 mm h-1 threshold. However, the largest drop size during the bright band periods was 5.1 mm, which was marginally higher than earlier reported values associated to winter disturbances. The highest fall velocity (vf) during bright band events was 4.6 (±0.26) ms−1, and was observed at 2200 m above ground where melting layer signature was the strongest (Fig. 3).

2. Six kinetic energy-intensity parameterisations were evaluated using the monsoon season-2021 rainfall intensity data at 60 min intervals to establish the relationship between the rainfall intensity and kinetic energy. We find that all the parameterisations converge to a smooth enhancement of kinetic energy when the rainfall intensity threshold is > 11.43 mm h-1, the same threshold for the eastern Ghats was noted to 6.0 mm h-1. The higher value of the rainfall intensity threshold indicates that the existing parameterizations may not be suitable for the central Himalaya.

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

There is an increasing common perception that Himalayan Pine (Pinus roxburghii) stands may systematically be replaced with Oak (Quercus leucotrichophora) forests, and subsequently, the paradigm of water, climate and biodiversity is expected to change significantly from its current state. However, a thorough assessment of differences in hydro-meteorological properties, hydrological budgets and ecosystem exchanges of carbon and water over these forests including their anticipated changes in a warmer climate are seldom carried out. Moreover, a recent study based on long-term direct measurement of net ecosystem exchange (NEE) from Pine and Oak dominated forest patches indicate that Pine dominated forest ecosystem may have higher carbon sequestration rate than an Oak dominated forest ecosystem, indicating potential for a detailed study. Therefore, this proposal is framed such that it would address multiple research and policy issues pertaining to the hydrometeorology and ecosystem services of Pine-Oak systems of the IHR.

Objectives

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

Achievements

1. Assymetric impacts of daily rainfall on the ecosystem carbon exchanges of Chir-Pine and Banj-Oak forests of central Himalayan were noted using 734 and 610 days of observations, respectively. Generally, the higher rainfall amount in monsoon resulted from higher carbon assimilation by the Chir-Pine ecosystem than the Banj-Oak ecosystem.

2. During the consecutive rainy-days, the highest daily carbon assimilations by the Chir-Pine and Banj-Oak ecosystems (NEE = -4.67 $\mu mol.m^{-2}.s^{-1}$ and -3.67 $\mu mol.m^{-2}.s^{-1}$) were noted on the 5th and 4th days, respectively when 0th day indicates no rain (Fig. 4). The soil efflux measurements of 200 days from an open Chir-Pine surrounded and Banj-Oak ecosystems indicated higher efflux from Chir-Pine system (6.50 ± 1.86 $\mu mol.m^{-2}.s^{-1}$) than the Banj-Oak systems (3.43 ± 1.3 $\mu mol.m^{-2}.s^{-1}$).

3. During the stable atmospheric conditions of the winter season, the vapour pressure deficit and air temperature were noted to have a higher positive correlation with xylem sap flow for Chir-Pine stands than Banj-Oak stands, indicating higher water loss through Chir-Pine stands than Banj-Oaks. Similarly, the water use efficiency of the Chir-Pine ecosystem (mean = 0.89) was lower than the Banj-Oak ecosystem (mean = 1.35), indicating higher water loss through transpiration.

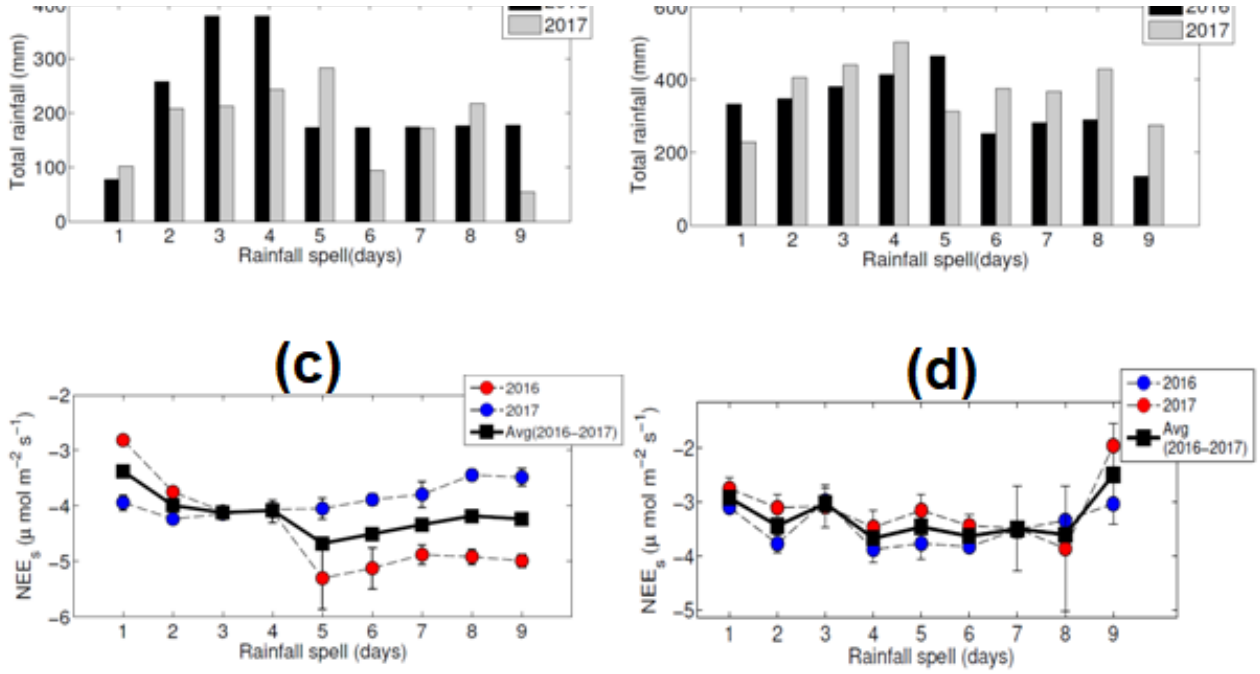


Fig. 4: subplots (a and b) show total rainfall of the monsoon seasons of 2016-2017 for successive rainfall spell upto 9th day from 0th day of initiation where 0th day implied no rain for Chir-Pine and Banj-Oak ecosystem. Subplots (c and d) show average NEE of the monsoon seasons of 2016-2017 for successive rainfall spell up to 9th day from 0th day of initiation.

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

Mountain natural springs are the main fresh water sources which serve to nearly 40 million people across the Himalayas. Over the years, these precious resources are increasingly drying up, or becoming seasonal due to varying natural and anthropogenic reasons, inducing untold misery to both rural and urban inhabitants of the IHR. Subsequently, many programs were undertaken by different agencies to revive these drying springs using various concepts but resulted in limited success. Therefore, there is an urgent need for implementing spring rejuvenation programmes developed on the scientific basis of successful good practices/models across IHR in a mission mode. NIHE, through its various partners, is taking the lead in developing demonstration models of Jal Abhyaranya (Water Sanctuary), ensuring at least one sustainable source of water within the village in one Aspirational District identified in each 12 IHR States by Niti Aayog.

Objectives

1. To develop at least one Jal Abhyaranya demonstration model in each Aspirational District of all 12 Himalayan States
2. 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. Total 32 springs and cluster of springs were selected across the study sites distributed in 11 states and 1 UT of Himalayan region for the implementation of Jal Abhayaranya demonstration model. Baseline spring inventory that includes geo-physical aspects, seasonal spring water chemistry and spring discharge measurement data, was prepared through primary and secondary sources, and questionnaire survey. Water demand status and water scarcity periods and problems were identified in respective study sites. Initial village level water security plan was prepared for study site in Uttarakhand. Two Village Water Security Committees were created at the study sites of West Bengal, and village facilitators for implementation of the programme was identified and trained.

2. Primary intervention plans for spring revival, i. e. bio-engineering and social engineering measures

with supporting geological investigation and mapping, GIS based preparation of LULC, DEM, aspect, soil, geology, drainage, contour maps were completed for all the 12 study sites. Intervention for spring rejuvenation was initiated at Arunachal Pradesh, West Bengal, Manipur, Tripura and Nagaland.

3. A total of 21 programmes that includes capacity building workshops, awareness programme, training and meetings under Azadi ka Amrut Mahostav, Swachhta Pakhawada, and World Water Day were organized across 12 sites wherein 400 stakeholders participated. Through training and field demonstration, a total of 240 participants were trained as a "Para-hydrogeologists" towards creating a cadre of skilled human resources for spring rejuvenation mission.

Rejuvenation of the Kosi River of Kumaun Himalayas Through Field Intervention and People's Participation (NMHS, GoI, 2019-2022)

Kosi watershed of Kumaon Himalaya falls within the Almora and Nainital districts of Uttarakhand. The Kosi River originates from Pinath peak north-west of Kausani, within the Almora district, and flows down towards the discharge point at Kosi Barrage (Ramnagar, Nainital). Geographically, the catchment covers about 1868.64 km^2 area. The absolute relief of the catchment ranges between 349 m to 2758 m from the mean sea level. Over the year, the flow of water in the river is decreasing drastically due to the climate change, anthropogenic activities, infrastructural changes etc. In view of this, various initiatives and campaigns for the rejuvenation of Kosi River have been started by the government and other organization such as Uttarakhand Forest Department, Eco Task Force of the Army, and NIHE. This project is part of this initiative and aims to monitor Devalikhan and Simtola recharge zone for assessing water availability and water quality, and for assessing the possibilities of construction of water conservation structures to recharge springs within the area.

Objectives

1. To supplement and support water conservation activities for rejuvenation of the Kosi River.
2. To monitor the water availability in the Kosi River and its tributaries through flow and discharge measurements along with quality measurements.
3. To develop the conservation models in selected villages and schools in 2 recharge zones of Kosi watershed.
4. Creation of an institution for monitoring Kosi River system.
5. Skill capacity building of the local youth (SC/ST/ Women) as a tourist and other activities in the upper Kosi- watersheds.

Achievements

1. To assess the infiltration rate of water from water conservation structures, soil infiltration rate measurement were carried out at various location (G1, G2, G3, G4 and G5) of Deolikhan recharge zone using grid maps. Among the sampling sites, the highest infiltration rate was observed at G3 location (Figure 5) due to the excessive rock weathering rate resulting in higher soil cover thickness at the location. The infiltration rates at other places were comparatively lower due

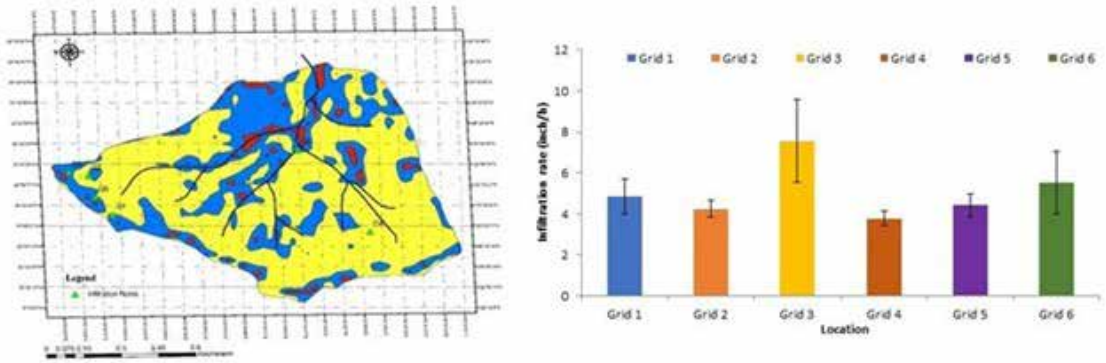


Fig. 5: Grid-wise infiltration rate in the study area of Devalikhan recharge zone

to lower weathering rate and rock exposure to surface.

2. Out of total 10 springs of Deolikhan recharge zone, 9 springs were found to be influenced by rainfall pattern. The major spring water facies were changing seasonally in the Deolikhan study area, and in pre-monsoon season, it was of Ca-HCO3 type while in post monsoon, it was of Mg-HCO3 type.

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

Greywater is the wastewater usually generated from the kitchen sink, shower, laundry or washing machine, etc., which is considered as environmental waste. However, greywater can be reused by a simple and cost-effective treatment technique. The domestic consumption of fresh 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 greywater for several purposes like irrigation, firefighting, toilet flushing, etc. There would be a great dependency on the quantum of greywater in the near future as freshwater consumption is not at par with freshwater availability. Greywater Treatment methods mostly include coarse sand, soil, and membrane filtration. Chemical treatments of greywater include coagulation, photocatalytic oxidation, ion exchange and granular activated carbon. Biological treatment includes chlorination and disinfection. Use of activated carbon for the treatment of greywater is considered to be an attractive pathway. Studies have reported using 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 to treat grey wastewater. Thus, this project aims to utilise the pine needles to treat grey water in combination with other known wastewater treatment processes.

Objectives

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

Achievements

1. Installation and successful testing of treatment of grey water in the designed pilot plant (Fig. 6)

2. The material designed using pine needles have shown a good capacity to remove emerging pollutants (e. g. caffeine, bis-phenol A) under study up to 970 mg/g. The coagulant dose of 0.1g/100mL removed 100% turbidity from real grey water at the agitation speed of 180 rotations per minute.

3. The efficiency of COD removal was very high (more than 85% in Mentha spicata L. and 60 % for Brassica Juncea L.) plant species, even in the presence of high input COD values (up to 610 mgL-1).

Fig. 6: Process for establishing pilot plant for grey water treatment

Summary of Completed Projects / Activities

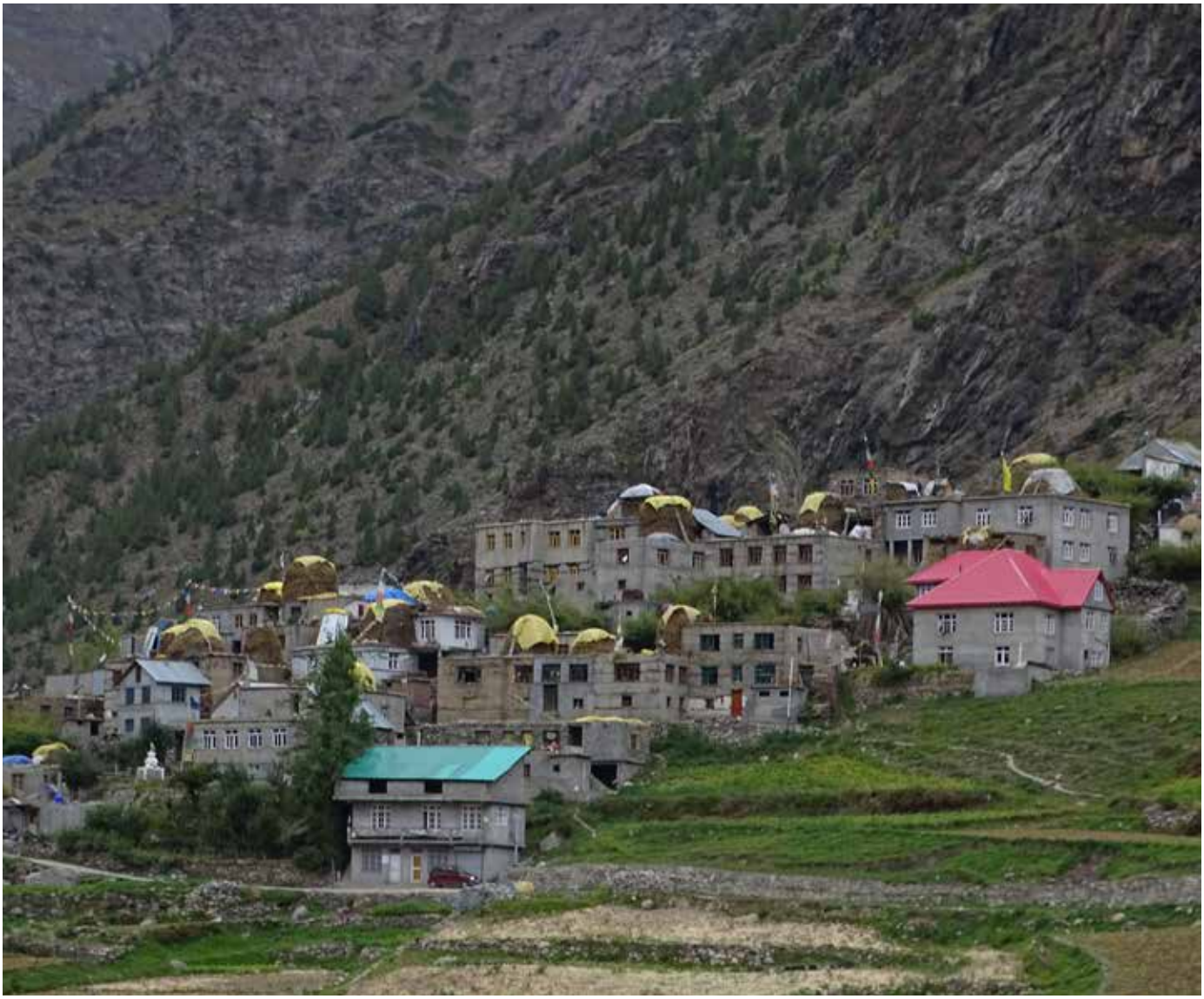
Integrated System Dynamical Model to design and testing alternative intervention strategies for effective remediation & sustainable water management for two selected river basins of Indian Himalaya (NMHS, GoI, 2018-2021)

The project focused on the assessment of changes in the land and water resources of the Kosi-watershed and envisaged the development of a system dynamic model for water resources. As the research partner to University of Kashmir and CSIR 4-PI for developing a system dynamic model for sustainable water management, the specific multi-disciplinary tasks assigned to NIHE were to collect, collate and compile land and water resource data of Kosi watershed, Uttarakhand, to be used for dynamical modeling. In order to quantify past and future changes in land and water resources, two specific issues were studied, (i) past and future changes in the winter wet days over Himalaya; and (ii) past and future changes in the forest fragmentation characteristics. For better management of water resources within the Kosi watershed, two specific studies were conducted, (i) prioritization of sub-watersheds of Kosi watershed using morphometric parameters and (ii) development of a machine learning based model for prediction of spring high-flows. Additionally, base line hydrometeorological data, spring distribution and discharge properties, and socioeconomic data on water demand and availability were compiled for the Kosi watershed. One of the major achievements of the project carried out at NIHE includes the development of a data-driven model for predicting joint-fracture and depression-type spring high-flows of the Kosi watershed. The model is expected to be beneficial for long-term sustainable water management of the region. Similarly, a Cellular Automata based dynamical modeling for forest resources within the Kosi watershed was carried out under the 'business as usual' condition till 2030 to simulate expected changes in forest cover. The expected changes in the winter period rainfall gain under global warming scenarios of RCP 4.5 and 8.5 were evaluated using the CSIRO-CORDEX South Asia dynamic model simulations. Moreover, the water demand and availability data of 427 HHs distributed over 33 villages in Suyal sub-watershed of Kosi watershed were prepared. The monthly spring discharge and water quality data for January, 2019 to December, 2021 of six springs across the Kosi-watershed were compiled along with geo-tagging of 113 springs. The surface meteorological data (i.e. air temperature, radiation, rainfall, wind speed, and PM10) of Kosi-Katarmal station were compiled for 2017-2021 over the earlier compilation of 2012-2016. The study found that the winter wet days would reduce significantly over north-western Himalaya; hence, there is a need for building community-level climate change adaptation and better management of water resources. One way for better management of water resources could be better prediction of spring high-flows that could be stored for lean period use. The forest fragmentation status produced in this study could be used by the state forest department for targeted plantation activities. The outcome of the project are (i) a data driven model to predict spring high-flows for the central Himalayan springs, and (ii) a cellular Automata based dynamical model for predicting forest resources within the Kosi watershed

Removal of Pharmaceuticals and Personal Care Products (PPCPs) from Contaminated Water Using Pine Needle-based Activated Carbon/Biological Activated Carbon (DST-WTI, 2016-2020)

Pharmaceuticals and personal care product (PPCPs) are widely detected in natural surface and ground water, and have emerged as environmental contamination with potentially widespread environmental effects. PPCPs wide range has been detected in a variety of environmental samples at levels ranging from ng kg^{-1} up to g kg^{-1}. Over the past few years, there has been increasing awareness of the unintentional presence of PPCPs in various compartments of the aquatic environment (e.g., water, sediments and biota) at concentrations capable of causing detrimental effects to the aquatic organisms. This has become a major concern because PPCPs are extensively and increasingly used in human and veterinary medicine as well as in cosmetics resulting in their continuous release to the environment. There is an urgent need to develop material for removing these groups of compounds from wastewater. Target of the present project was to develop pine needle based activated and biological activated

carbon having capacity to remove PPCPs from waste water. The four target compounds of our study were caffeine, bisphenol-A, estriol and ibuprofen. The best activated carbon had shown maximum adsorption capacity of about 987.77mg/g for caffeine, 996.45 mg/g for BPA and 18.63mg/g for ibuprofen while checking the capacity at bath mode study. The process had followed pseudo second order kinetics and intra-particle diffusion. Isotherm studies had shown to follow Langmuir isotherm confirming monolayer adsorption during the removal of contaminants. Furthermore, thermodynamic study had shown the Gibb's free energy (ΔG) -27.85 kJ/mol, entropy (ΔS) of -19.79 J/mol and enthalpy (ΔH) of -33.70 J/mol. The value of enthalpy was indicating towards the physical adsorption during the removal of contaminants. The emergent pollutant/PPCP compounds degradation capacity psychrotolerant bacteria was checked and the compound specific bacterial strains were identified. The best performing bacteria and activated carbon sample were taken for the preparation of bacterial activated carbon, which was used for adsorption-based studies for the removal of targeted PPCP compounds. Around 99.9% of targeted contaminants were adsorbed before the breakthrough points. Based on the fixed bed studies with model contaminants mixture, final blue print of lab-scale wastewater treatment setup wa`s developed. The outcomes of the project are (i) pine needles-based adsorbents developed, which are having very high surface area and adsorption capacity of targeted contaminants, (ii) the psychrotolerant bacteria, isolated from Higher Himalayas, were identified, which are having the capacity to degrade targeted contaminants under specific conditions.



CENTRE FOR BIODIVERSITY CONSERVATION AND MANAGEMENT (CBCM)

Recognizing that the Himalaya is: (i) one of the hotspots for biodiversity and (ii) a provider of ecosystem goods and services to large population in the Indian subcontinent, biodiversity conservation and management deserve a major thematic thrust in the IHR. In keeping with these facts and realizing that: (a) biodiversity conservation and its sustainable use has emerged as one of the global priorities in the aftermath of Rio Earth Summit (1992), (b) the Conference of Parties to Convention on Biological Diversity (February 2004) has adopted 'Mountain Biodiversity' Programme of Work, and (c) India is among the selected countries in the world that have developed their own National Biodiversity Targets aligned with global targets (i.e., Aichi Biodiversity Targets), the Institute since its inception has identified Himalayan Biodiversity Conservation as a major thematic thrust. The R&D contributions made over the years by the Institute faculty and researchers have been recognized from local to global level, and as per the SCOPUS database, the Institute ranks number one in the world w.r.t. number of scientific publications on Himalayan biodiversity and conservation. With this strong base, the Institute has established Centre for Biodiversity Conservation and Management (CBCM) to play a more proactive role in the Himalayan biodiversity sector. The aim is to strengthen science-based understanding of Himalayan biodiversity further to promote its conservation and ensure a sustained flow of its services for human well-being under global change. Over the years, the CBCM has expanded its scope of R&D activities from devising both in-situ and ex-situ packages of practices on biodiversity conservation approaches and scaling up these approaches among a wide range of stakeholders spanning from rural landscapes, school children and research community, forest department and policymakers and practitioners. The participatory models of biodiversity conservation and management are being promoted particularly among the rural communities by taking up pilots on medicinal and aromatic plants (MAPs) cultivation and wasteland restoration on community lands. In this process, the capacity and skills of stakeholders are built, and opportunities to replicate such models are ensured to achieve the mandate of CBCM. Thus, CBCM has set in the following objectives for executing its R&D activities: (i) mainstreaming of Himalayan biodiversity knowledge in conservation decision-making at the local/state/national level, (ii) establishing representative long-term ecological monitoring sites/plots so that LTEM data becomes part of regional synthesis and long-term predictions, (iii) promoting partnership and collaboration for knowledge networking and capacity improvement to address issues of biodiversity conservation at local to sub-national level, and (iv) standardizing protocols/approaches for sustainable utilization of bioresoures (i.e., harvesting, nutritional and therapeutic potential assessment, propagation and cultivation packages, etc.).

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

Indian Himalayan Region comprises enormous ecological and economic wealth and exhibits evidence of rapid biodiversity loss. With a broad goal of ensuring the conservation and sustainable use of Himalayan biodiversity for human well-being and improved ecosystem health, the project intends to conserve biodiversity through (i) strengthening BMCs and PBRs, (iii) promoting threatened/ endemic plant conservation through ex situ approaches, (iii) identifying biodiversity-rich areas outside the protected areas, and (iv) restoring degraded habitats through a plantation of native and useful species. Capacity building and sensitization of people towards biodiversity conservation and sustainable utilization is also an important measure for engaging and inspiring many people towards biodiversity conservation. All this will help protect the region's biodiversity and improve the livelihoods of local people.

Objectives

1. To facilitate BMCs and PBR formation for implementation of Biodiversity Act (2002) in selected villages of IHR.
2. To develop and demonstrate applicability of ex situ conservation of selected endemic and threatened plants in IHR.
3. To identify and map selected biodiversity rich areas for promotion of in situ conservation in the IHR.
4. To establish market value chains of selected high value medicinal plants and wild edibles in the IHR.
5. To engage and inspire diverse stakeholders towards biodiversity conservation through conservation education and green skill building programme.

Achievements

HQs (Kosi-Katarmal)

1. An expert consultation was organized to identify biodiversity-rich areas outside the protected areas, and a total of 97 locations of IHR (49 in Northeast Himalaya and 48 in Western Himalaya) were identified. All these locations were further reviewed, and 20 locations have been identified as biodiversity-rich areas in the IHR. Field validation of the selected areas is in progress.

2. Towards geocordinating the distribution of 1232 endemic species representing in the 484 genera and 103 families in the IHR (298 in Western Himalaya and 944 in Eastern Himalaya), a grid map of 200 species of Western Himalaya is developed, and 645 species from Eastern Himalaya were identified.

3. Various plantation activities were organized in the different villages of project sites (Jeoli village clusters, Bamnigad, Almora and Kamad, Pithoragarh), and a total of 30 ha area brought under plantation towards promoting conservation of *Hedychium spicatum*, *Zanthoxylum armatum*, *Cinnamom tamala*, *Quercus* spp., etc. A total of 263 villagers (146 male; 117 female) participated in these activities.

4. A consultation meeting on value chain development and value addition of MAPs in IHR was organized, and 20 potential species were prioritized for value chain development. Value addition through analysis of anti-aging and sun protective factors in 11 species such as *Berberis aristata, Ficus auriculata, Ficus semicordata, Rhododendron arboretum, Thalictrum foliolosum, Paeonia emodi, Tinosphora cordifolia, Ficus palmata, Morus alba, Pyracantha crenulata,* and *Rubus ellipticus* was done. The results show that these species can potentially be used to prepare various anti-ageing formulations.

5. Eight webinars and awareness programmes were organised to sensitise school students and teachers of different blocks of Almora district for biodiversity conservation. A total of 1588 participants (705 male and 883 female) attended the programs.

Himachal Pradesh Regional Centre

1. Mass multiplication of threatened species was also carried out, wherein *Swertia chirayita* showed very good (80%) germination in 50 ppm of GA_3 (Fig. 7), *Angelica galuca* performed well in KNO_3 treatments, and *Sassurea costus* showed good results in GA_3 100 ppm. A total of 10,000 seedlings of *Swertia chirayita* were raised, out of which HP Forest Department purchased 6000 seedlings at the cost of Rs. 1.20 lakhs. Mass multiplication trails of *Rhododendron arboretum*, *Inula racemosa* were also carried out at the nursery.

2. Based on a review of existing literature discussion with biodiversity experts and forest department officials, 4 biodiversity-rich areas of Himachal Pradesh were identified to promote in-situ conservation of threatened taxa.

3. Under the biodiversity conservation education program of the project, nine webinars and other educational programs were organized for the school children of Kullu district. A total 400 (students, teachers etc.) were sensitized about biodiversity conservation and its role in sustainable development.

4. A total of around 500 stakeholders, particularly farmers/medicinal plant cultivators, were sensitized about biodiversity conservation, particularly medicinal plants, threatened species conservation, honey bee conservation and livelihood development of bioresources in the various villages of Himachal Pradesh. The capacity

building cum skill development activities were carried out with the support of the HP Forest Department, JICA Project, Earthwatch Institute, GIZ, HIMCOSTE and other organizations.

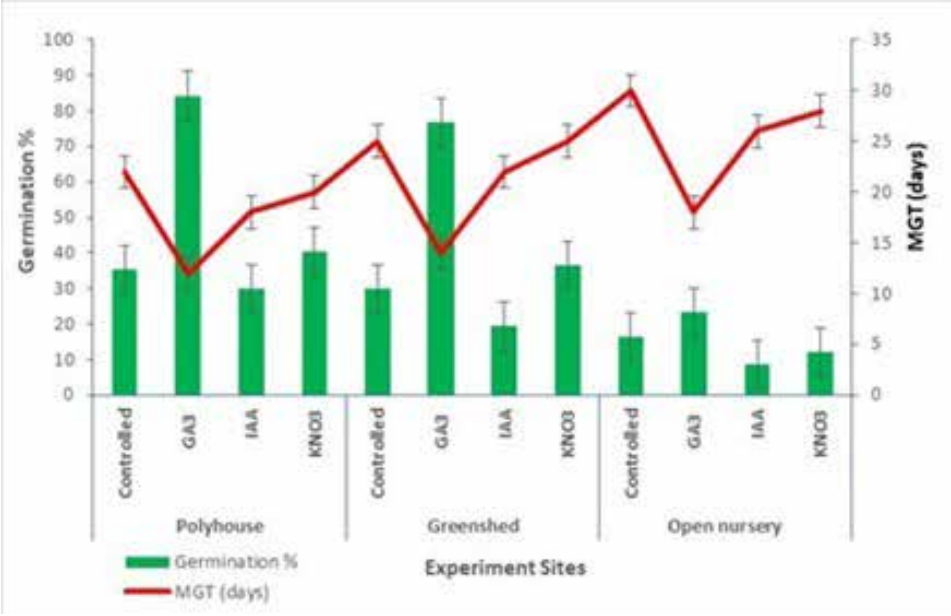


Fig.7: Optimization of propagation and mass multiplication protocols of Swertia chirayita

Garhwal Regional Centre

1. Based on the review of target species (*Malaxis acuminata, M. muscifera,* and *Rheum australesyn. R. emodi*), MAP-rich sites were assessed, and information was validated with primary data. Total 7 sites (Lata-khark, Dronagiri, Pawali katha, Tungnath, Pinadri, Kafni and Sunderduga) for *R. australe* and *M. muscifera*, and 34 sites in Uttarakhand for *M. acuminata* have been identified as potential medicinal plants conservation and development.

2. Nursery of high-value medicinal plant species such as *Rheum australe* (Dolu) and *Saussurea costus* (Kuth) were initiated at a small scale at RTC, Triyuginarayan village at 2200m asl since climatic conditions are more conducive for their large-scale cultivation.

4. Under the awareness programme on Biodiversity conservation & management and medicinal plant cultivation for livelihood enhancement, a total of four training/meetings were organized at selected sites Jakholi block Rudraprayag (Okaranand Inter collage Jakholi and Bajeera inter collected Jakholi) and Joshimath block, Chamoli (Lata village and Tolma Village) in which a total of 155 participants (89 women's and 66 men's) from different villages are benefited.Initially, a total of 10 farmers of Lata villages adopted the techniques and started cultivation of medicinal plants (*Allium stracheyi*) in 10 Nali land.

Sikkim Regional Centre

1. Providing technical support and inputs in facilitating PBR (2 nos.) for implementation of Biodiversity Act (2002) to Sikkim Biodiversity Board.

2. Developed and strengthened the propagation protocol of Sikkim Himalaya endemic plants, i.e., *Rhododendron dalhousieae, R. maddenii* and *Paris polyphylla*, for large-scale production.

3. Produced >200 nos. plantlets of *Rhododendron grande* and *R. maddenii* using existing propagation protocol and distributed to different stakeholders (BSI-Gangtok, Bhojhogari Sr. Sec. School, Samdong Sr. Sec. School and Penlong Sec. School)

4. The distribution records of threatened and endemic plant species of Sikkim Himalaya from the regional herbarium, published literature and online database (i.e. GBIF) were included for grid-based mapping of biodiversity-rich areas. The point records from online databases and secondary literature were transformed

into geographical coordinates using Google Earth high-resolution satellite data and Arc GIS software. A total of 628 distribution records of 198 RET and endemic plant species complied.

5. A total 594 distribution records of 8 threatened, endemic, medicinal and economic plants species (*Phoenix rupicola, Zanthoxylum armatum, Satyrium nepalense, Swertia chirayita, Hippophae salicifolia, Myrica esculenta, Rheum nobile* and *Bergenia ciliata*) complied for IHR and Hindu-Kush Himalayan region and developed thematic distribution maps using ENM and GIS platforms in current climate and future climate change projection scenarios (Fig. 8).

6. Organized 6 training programme cum workshops, where in 371 nos. (233 Females and 138 males) students and local people of Sikkim Himalaya were sensitized towards the conservation of natural resources

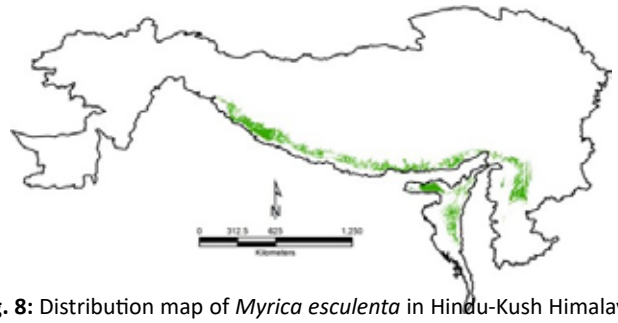


Fig. 8: Distribution map of *Myrica esculenta* in Hindu-Kush Himalaya for current climate condition

North-East Regional Centre

1. 49 PBRs were revised and submitted to the Arunachal Pradesh Biodiversity Board.

2. The list of high-value medicinal plants was prepared with an online expert consultation meeting on 'Identification of potential plants in Arunachal Himalaya for value chain development'. Saplings of 32 different medicinal sapling plant species were collected from Van Vigyan Kendra, Chesa and Ayurvedic Research Institute, Itanagar, and cultivated in the Rural Technology Centre.

3. To identify the biodiversity-rich areas in IHR, 861 locations of 376 different plant species from Arunachal Pradesh were recorded. Raster datasets of 31 different environmental variables have been generated for IHR and a richness map of mammals in Northeast India has been created.

4. Through various awareness programmes, two hundred thirty-nine people were made aware of different aspects of biodiversity and its conservation.

Promotion conservation and utilization of *Dactylorhiza hatagirea* (D.Don) Soo and *Paris polyphylla* Smith using biotechnological and ecological approaches in Western Himalaya (UCOST, Dehradun; 2019-22)

One of the world's most well-known and distinctive biodiversity repositories is the Indian Himalayan Region (IHR), which makes up a significant portion of the Himalayan Biodiversity Hotspot. The region has long been significant to local healthcare providers, the pharmaceutical industry, and plant explorers since it is home to several medicinal and aromatic plants (MAPs). Conservationists and ecologists, however, are gravely concerned about declining natural populations, which are generally the result of ever-increasing harvesting pressure and bottlenecks in species biology (such as long seed dormancy, declining pollinators, preferential towards micro-climatic conditions, habitat uniqueness, etc.). Only 7% of MAPs are commercially grown, despite the fact that there is a great worldwide demand for them. Approximately >80% of MAPs are directly collected from the wild using destructive harvesting techniques. As a result, the Himalayan MAPs protection and sustainable use merit top importance. The only possible solution in this situation is the widespread dissemination, demonstration, development of propagation packages, and protection of MAPs. The project attempts to develop up-scaled propagation packages, understand their eco-physiological responses and develop species-specific recovery plans. Apart from these awareness and sensitization programs, the local stakeholder's utilization of the target species is envisaged.

Objectives

1. To develop propagation and multiplication techniques for mass propagation
2. To assess the eco-physiological responses and determine the inherent mechanism of survival, growth, and development of progeny
3. To promote the reintroduction of the target species and the development of species-specific recovery plan
4. To raise awareness and impart training on the conservation and utilization of the target species.

Achievements

1. An efficient rhizome fragmentation method was developed for the propagation of *P. polyphylla* using different concentrations of gibberellic acid (GA_3), naphthalene acetic acid (NAA),and indole butyric acid (IBA); as a result of which, the best concentration was found to be GA_3 + IBA (1000µM; 24h) with 83.33% sprouting and 74.66% rooting rate respectively. Of all the rhizomes planted, 91% could sprout successfully and form complete and mature plants after 90-120 days of sowing with increased biomass. The regenerated plants were also found to flower in subsequent seasons, and standardization of explants establishment has been completed for *P. polyphylla*.A species-specific recovery plan for *P. polyphylla* is initiated.

2. In the case of *Dactylorhiza hatagirea*, tuber longitudinal slitting approach was followed. Of the various concentrations of indole acetic acid (IAA), indole butyric acid (IBA), and naphthalene acetic acid (NAA), NAA with 100 µM proved to be the best with rest to percent sprouting (34.33%), and new tuber emergence (33.66%). The maximum survival percent (35.18%) was recorded with IAA with 100 µM, followed by NAA also with 100 µM concentration. Further, standardization establishment plants are now under acclimatization, and the hardening method is in progress.

3. Eco-physiological responses for *D. hatagirea*, along the altitudinal gradient (3200 m to 3800 m) were briefly studied. The extent of variations among biochemical profiles and eco-physiological responses along the altitudinal gradient was thoroughly investigated. With an increase in altitude from 3200 m to 3800 m, a significant ($p<0.05$) up-regulation in antioxidant enzyme activity was recorded. Briefly, H_2O_2 accumulation and lipid peroxidation (MDA) activity significantly ($p<0.05$) increased (1.37 mg g^{-1} FW and 1.91 mg g^{-1} FW) with altitude from 3200 m to 3600 m, while an insignificant increase between 3600 m to 3800 m was recorded. For antioxidant enzymatic such as catalase (CAT), peroxidase (POD) and super oxide dismutase (SOD) was recorded highest (0.26, 3.57, 3.54 U min^{-1} g^{-1} FW) at 3800 m followed by at 3600 m (0.23, 3.1, 3.21 U $min^{-1}g^{-1}$ FW), while minimum activity was recorded at 3200 m (0.11, 2.25, 2.18 U $min^{-1}g^{-1}$ FW). Based on correlation (r) analysis, altitude revealed positive and significant ($p<0.05$) correlation with POD ($r = 0.979$), SOD ($r = 0.970$) and H2O2 ($r = 0.975$), while bear negative

and insignificant correlation with Gs (r = -0.882), WUE (r = -0.902), Chl-b (r = -0.330), and T-Chl (r = -0.161).

4. For field re-introduction, a germplasm repository of plants (conventional methods) was maintained at Suryakunj (1150 m asl) and Sri Narayan Ashram (Distt. Pithoragarh; 2,734 m), an established ex-situ site under the project. Under the ambit of 'Bharat Amrit Mahotsav' conservation awareness program and hands-on training for the cultivation of high-value medicinal plants was conducted in the Chaudas valley (Distt. Pithoragarh) from 06th Aug 2021 to 08th Aug 2021. A total of 43 participants involving 25 males and 18 females from 4 villages (i.e., Niyang, Pasti, Sosa, and Himkhola), were the key stakeholders (Fig. 9). The aim and purpose behind the program were to sensitize key issues related to conservation and sustainable utilization of resources to reduce pressure on the wild populations and inherit cultivation practices to create opportunities for livelihood enhancement.

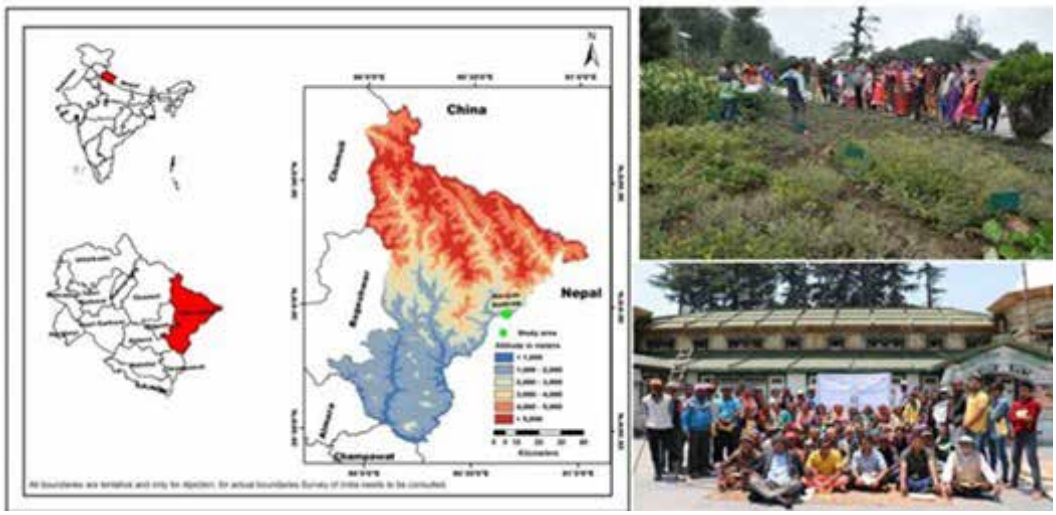


Fig. 9: Awareness cum interaction programme with the villagers on conservation and sustainable utilization of the Himalayan bioresources.

Himalayan Alpine Biodiversity Characterization and Information System – Network (NMHS, GoI; 2019-2022)

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

Objectives

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

analytics and data/information dissemination for planning and management.

Achievements

1. A total of 938 quadrats were laid for assessing the alpine plant diversity in Bageshwar (Sundardunga-90) and Pithoragarh (Chiplakedar-465, Munsyari-30, Johar Valley-15, Athasi-143 & near Panchachuli-195) districts and a total of 186 plants are identified till now.
2. In Chiplakedar, Pithoragarh dominant species were *Viola biflora* with density (individuals/m²) (3.09), *Anemone obtusiloba* (2.57), *Oxygraphis polypetela* (2.25), *Bistorta vaccinifolia* (2.06), *Parnassia nubicola* (2.05). The least dominant species were *Swertia chirayata* (0.02) and *Impatiens brachycentra* (0.04)
3. In Khaliya Top, Munsyari, Pithoragarh, the dominant species were *Danthonia cachemyriana* with density (individuals/m²) (1.4125), *Viola biflora* (1.425), *Trachydium roylei*, *Geum elatum* (1), and *Cyananthus lobatus* (0.8875). Least dominant species were *Delphinium vestitum* (0.012) and *Anaphalis nubigena* (0.01)
4. In Athasi, Pithoragarh dominant species were *Bistorta affinis* with density (2.32), *Trachydium roylei* (1.99), *Geum elatum* (1.97), *Viola biflora* (1.94) and *Cynanthus lobatus* (1.87). Least dominant species were *Saxifraga brunonis* (0.013) and *Erigeron multiradiatus* (0.006)
5. A total of 20 soil samples from Sundardunga. Bageshwar from different communities of the alpine region were collected at depth i.e., 0-10 cm & 10-20 cm at different elevations and further analysed for physico-chemical properties. It was observed that with the increase in elevation, Soil pH value ranges from (4.31-7.37) having a maximum value at 3224m and minimum value at 3400m. Soil water holding capacity (%) value ranges from (53.05-86.91) having maximum and minimum values at 3400m and 3128m, respectively. Similarly, the values of Nitrogen content (g/kg) range from (0.57- 2.37), with a maximum value of 3080m and a minimum of 3304m.

Promoting restoration programmes on degraded lands through medicinally important species- A participatory approach (NMHS, GoI; 2019-2022)

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 the 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 help reduce the pressure on natural resources, play an important role in biodiversity conservation, uplift people's economic condition and provide ecosystem goods and services for the well-being of people. The NIHE, under the NMPB-funded project initiated land restoration activities on the degraded land through medicinally important species.

Objectives

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

Achievements

1. A total of 29 meetings/ workshops were organized in all three pilot sites, in which 941 villagers (575 male, 366 female) from 38 villages participated in these meetings. A total of 20 hectares of degraded land from 9 villages at three different pilot sites were selected to develop the restoration model. To protect the restoration model at different sites, fencing was done in 8 ha of lands of 4 villages (Digtoli, Naikina, Rawalgoun, Kamad).
2. A total of 16,900 individuals of 10 medicinal

tree and herb species were planted, surviving at the rate of 69.8% among three pilot sites after One year of plantation. From plant growth monitoring, we have generated baseline data for future reference towards a successful restoration programme

3. The capacity building of 554 villagers (334 Male and 220 Female) from 38 villages was enhanced through hands-on training programmes on plantation and nursery techniques, moisture and water conservation work, CRA technique and Plant growth monitoring. Three block-level synergy-building events were organised to converge with various Line agencies working in the landscape on restoration activities.

Summary of Completed Projects / Activities

Hyperspectral imaging for sharper definitions of Himalayan ecosystems and its high-value plant species under climate uncertainties (NMHS, GoI; 2019-2022)

In recent decades satellite based investigations using advanced RS and GIS tools and techniques have become very popular among scientific communities. In the field of plant science these techniques are very useful to locate the distribution and assess the population dynamics of any plant species. Under the current climate change scenario, that has affected and threatened many high value plant species, it is necessary to know the exact status of any species. In the Himalayan region most of the highly valued medicinal plant diversity is facing threat due to various drivers of change. Some of the species have gone extinct; some are critically endangered, endangered and vulnerable. Most of the high value medicinal plant species generally grow in the alpine and subalpine regions of Himalaya. The alpine terrains and landscapes of Himalaya are very difficult to approach physically; hence working with sophisticated equipment becomes unfeasible. Besides this, due to lack of proper routes and conveyance and harsh climatic conditions it becomes difficult to carry heavy and expensive equipment to those regions. In this regard the role of RS and GIS technology becomes very crucial. Commencement of modern RS and GIS technologies has made it possible to detect and quantify the biophysical and biochemical parameters of different vegetation types for assessment of population using hyperspectral imaging technologies. Hyperspectral acquisition provides spectral response in narrow and continuous bands with significant improvement compared to broad band in terms of spectral resolution. The spectral profile obtained through a spectro-radiometer can be used to create a spectral digital library and subsequently for detecting and monitoring high value, rare and threatened plants. Besides this, the forward and inverse modelling approach of Hyperspectral remote sensing can be further used to estimate phenolic contents in different plant species.

Achievements

1. Spectral library of 302 plant species (72 families; 217 genera) from Pindari, Almora, Munsiari regions of Uttarakhand and Dachigam National Park, Gulmarg Wildlife Sanctuary of Jammu & Kashmir UT has been generated.

2. Among these, 94 species (43 families; 78 genera) were medicinally important and 48 species (29 families; 38 genera) were economically valuable.

3. One Critically Endangered species (*Nardostachys jatamansi*) and three endangered species (*Aconitum hetrophyllum, Pittosporum eriocarpum* and *Taxus wallichiana)* were also sampled for spectral library preparation.

4. *Hyperspectral indices* have been developed for deduce anti-cancerous Taxol content in the Himalayan region.

Assessing climate change impacts on Floristic diversity of alpine regions in West Himalaya (NMHS, GoI)

Over the last three decades, climate warming has been a major concern for ecologists and environmentalists, with 74% of the observed temperature increase caused by human-induced radiative forcing and less than 26% by unforced internal variability. Model projections of climate change impacts on floral diversity have suggested that habitats of plants, specifically the alpine life zones, could change drastically, causing species range shifts and reshuffling of species composition and abundances. Furthermore, the Himalaya are reported to be warming much higher than the global average, making it a hotspot for climate change studies. However, as per IPCC, the region remains data-deficient in terms of long-term climate data, specifically on account of compatibility mismatch due to instrumentation and methodology. Hence, through this project one long-term ecological monitoring (LTEM) sites was established and two former sites were resurveyed following the Global Observation Research Initiative in Alpine Environments (GLORIA) protocol in alpine summits of Uttarakhand, west Himalaya to assess dynamics of plant diversity and composition under changing climate through periodic monitoring. Across the

GLORIA target regions, Lata TR inhabited 124 plants (91 genera and 37 families), Chaudans TR inhabited 115 plants (80 genera and 34 families) and Byans TR inhabited 47 plants (34 genera and 25 families), with a total of 16plant species under various threat categories as per IUCN, CAMP and RDB. Species richness ranged from 31 (PUL) to 56 (KHR) in Lata, 27 (SKN) to 78 (BHT) in Chaudans and 22 (EUR) to 31 (KUT) in Byans. Further more, a continuous decline in species richness and diversity was observed with increasing altitude in all target regions. In order to periodically monitor the permanent observation plots, Chaudans and Byans target regions were resurveyed in 2019 and 2021 to analyze changes in floristic diversity and its relation to temperature trends. Temporal trends in soil temperature showed a significant decreasing trend over a four-year period ($p<0.05$; decrease of 0.82 ^{o}C from August 2015 to July 2019) in Chaudans, while in Byans the trend was significantly increasing ($p<0.01$; increase of 0.38^{o}C from October 2015 to September 2021). Temporal patterns in vegetation were represented by a significant increase of 6.7% in plant cover in all sites while species richness increased in KHA, GAN and SKN in Chaudans. While species richness decreased in north and west, in south it increased significantly and remained same in east. However, in Byans, there was a significant ($p<0.05$) increase in plant cover, richness and diversity in all summits. Relating vegetation indices with soil temperature across the two surveys exhibited a significant positive correlation between species richness and diversity (r from 0.3 to 0.6, $p<0.05$) in both valleys. However, plant cover percent showed no significant relationship with temperature trends in Byans valley, while it was positive in Chaudans. Thus, temporal trends in richness and diversity were related to corresponding temperature trends in both valleys, plant cover changes did not show significant relation with temperature trends in Byans valley. Of the total 105 species, a total of ten species (such as *Bistorta affinis, Bupleurum falcatum, Carexsetosa, Poa alpina, Polygonum filicaule*, etc.) showed significant increase in their plant cover in 2019 as compared to that in 2015, while seven exhibited a significant decrease (such as *Kobresia nepalensis, Taraxacum officinale, Rumex nepalensis*, etc.). Similarly, seven species exhibited a significant increase in their cover (%) from 2015 to 2021 in observation plots in Byans, among which the most predominant was *Danthonia cachemyriana* which increased in all the summits. We suggest that the observed trend in plant community dynamics responds to short term temperature and precipitation variability and time lags in plant community response. It may take much longer than one decade for the observed trends to become stable and statistically significant. Our study provides an important foundation of documenting profound changes in alpine plant communities, as global climate change continues.

Promoting Conservation of threatened plant species in the west Himalayan Region - A participatory approach (NMHS, 2018-2022)

The conservation of medicinal plants is receiving attention all across the globe keeping in view the resurgence of interest in herbal medicines. With the increasing demands, medicinal plants are being explored from their natural source, which is affecting their availability in nature. This has promoted the conservation of such species through *in-situ* and *ex-situ* methods to improve their availability for end users and release the pressure of exploitation from their natural habitats. In addition, it is pertinent to establish germplasm repositories to fulfill the need for planting material for the cultivation process in farmer's fields and establishment of market strategies for uplifting the economic condition of local inhabitants.

Objectives

1. To develop species-specific protocols for recovery/ reintroduction of threatened species
2. To establish a demonstration of threatened Himalayan medicinal plants at different altitudes
3. To promote the cultivation of threatened medicinal plants at farmer's fields
4. To develop market linkages for selling of cultivated produce
5. To sensitize diverse stakeholders group towards promoting conservation of threatened medicinal plants

Achievements

1. A need base assessment survey was conducted in the fourteen different villages of Chaudas area, Pithoragarh district, and documented the requirements of villagers. As a result, seven potentially medicinal plant species namely *Allium stracheyi, Angelica glauca, Cinnamomum tamala, Hedychium spicatum, Picrorrhiza kurrooa,*

Saussurea costus and *Valeriana jatamansi* were selected and identified for cultivation at farmer's fields (900-2750 m asl).

2. Germplasm of 15 high value threatened Himalayan species are maintained in the Sri Narayan Ashram, and functioned as a demonstration site and capacity build center.

3. A total of 172 farmers of 11 villages initiated cultivation of seven medicinal plant species i.e. *Allium stracheyi, Angelica glauca, Cinnamomum tamala, Hedychium spicatum, Picrorrhiza kurroa, Saussurea costus* and *Valeriana jatamansi* in 2.5 ha (125 nali) land.

4. A comparative assessment of morphological, physiological, and phytochemical attributes of in vitro raised plants of Valeriana jatamansi were investigated between Suyra-Kunj, an ex-situ conservation site at Almora (1200 m) and high-altitude nursery, Sri Narayan Ashram at Pithoragarh (2750 m). The study's findings revealed that plants growing at a high-altitude nursery (2750 m) showed better growth performance, physiological responses, and phytochemical attributes than the Surya-kunj (1200 m).

5. A total of 3000 seedlings of *Cinnamomum tamala* (Family: Lauraceae) were used for rehabilitation of degraded land slopes and strengthening livelihoods of Gaysku, Jaykot & Pangla villages of Chaudas valley, of district Pithoragarh through participatory approach.

6. A total of 21 awareness programmes, field-orientation workshops and agro-techniques-based hands-on trainings on medicinal plant cultivation were conducted with total 1579 stakeholders (male 1111; female 468) as local beneficiaries towards awareness raising on conservation and promotion of the identified threatened medicinal plants.

Science Awareness Activities/Exposure Visits/ Hands on Training (UCOST, 2021-22)

The "Science Awareness Activities/Exposure Visits/Hands-on Training" project was initiated in Uttarakhand to promote scientific awareness, education, and entrepreneurship in the region. The program covered a diverse range of events, including Science Popularization, Entrepreneur Development Programs (EDP), Nature Walks, Workshops on Scientific Paper Writing, and Socially Concerned Programs (SCP) focusing on drinking water and its impact on health conditions in tribal communities.

Objectives

1. Increase public awareness and understanding of scientific principles through the celebration of National and International Scientific Days.
2. Enhance scientific communication skills among participants through specialized workshops on scientific paper writing.
3. Promote entrepreneurship and skill development among participants through the Entrepreneur Development Programme (EDP).
4. Raise awareness about the significance of clean drinking water and its direct impact on the health conditions of tribal communities in the Kumaun region.

Achievements

1. A total of 1192 stakeholders (Male-663; Female-529) were actively participated during the various workshops, awareness campaign, events in the Uttarakhand.

2. Awareness on different aspects of biodiversity conservation and management imparted across diverse stakeholder groups (students, teachers, researchers and farmers) where a total of 908 people (male 493; female 415) were sensitized.

3. Awareness improved across (04) targeted tribal communities where as total of 252 people (male 147 and 105 female) were sensitized on usage of clean drinking water and its impact on health.

4. Exposure on different rural and mountain technologies (RSC UCOST Dehradun, Surya-Kunj & RTC Almora) was given to local farmers (32) for livelihood enhancement.

CENTRE FOR SOCIO-ECONOMIC DEVELOPMENT (CSED)

Rural livelihood in the Himalayas depends on the location-specific natural resources, ecological and socio-economic factors. The local people have their own indigenous knowledge system for managing bio-resources. However due to population pressure, subsistence economy and poverty natural resources are being over exploited leading to human - wildlife conflict, aggravating climate change processes and leading to disasters like forest fire, landslides, cloud bursts that threaten the ecological balance and sustainable development in the region. Therefore the Centre for Socio-Economic Development was established to provide solutions to the challenges faced by rural mountain people for safeguarding their natural resources and augment their livelihood. The centre has core competence in: (i) Natural resource assessment and management; (ii) Bio-resource characterization, monitoring, conservation and management; (iii) Sustainable use of natural resources; (iv) Wasteland development and rehabilitation; (v) Demonstration of low cost technologies like protected cultivation; and (vi) Location specific eco-development programme. The Centre works to fulfil the following Objectives to (i) strengthen environmental management and sustainable development through resource planning and management and livelihood up-gradation, (ii) build stakeholder's capacity and skills for socio-economic development and natural resource management, and (iii) adopt technologies created elsewhere into forms that will be readily acceptable by society and demonstrate at appropriate locations.

Community Driven Eco-smart model village development to Improve Livelihoods and Foster Ecological Security in the Himalaya (In-House Project-2, 2020 - 2025)

In the IHR over 70% populations still live in the villages. Govt. of India has employed several approaches for development of model villages through interventions in livelihood, education, infrastructure, agriculture, water, forests, health and sanitation and other sectors with a vision of New India by 2022 "Sabka Saath, Sabka Vikaas, Sabkaa Vishwas". Countrywide 117 Districts (17 districts from IHR) are chosen by Niti Aayog based on poverty, poor health, education and basic infrastructure deficit as "Aspirational Districts" for "Transformative Change" to comply to the SDGs. MoEF&CC has given us the mandate for 2020-25 to prepare "Eco-smart model village" development plans (200 nos. 50 villages each across H.P., Uttarakhand, Sikkim and A.P.), household / village database and resource-use maps (50 villages; 10 villages each across the 4 States) and development of eco-smart model villages (4 village clusters) that will serve the purpose of demonstration for various stakeholders including Govt. Line Depts. through community-driven process following Input, Output, Outcome and Impact (IOOI) framework.

Objectives

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

Achievements

HQs (Kosi-Katarmal, Almora)

1. In Jyoli village cluster, Almora Distt. during the year 2021-22 various environment-friendly, livelihood and income generating technologies with people's participation were implemented among 225 HH that earned a net profit of Rs. 3,23,671.0 through sale of vegetables from 41 polyhouses (500 kg of more than 10 species), poultry products, honey, bio-briquettes and handmade traditional items thereby increasing the farmers income by 68% over the baseline value in 2020 (Table 1).

2. Popularized Pine needle based 3055 products (e.g., file covers, file folders, carry bags, envelops,

handmade paper sheets and bio-briquettes, etc.) among 51 organizations/NGOs/individuals, and earned Rs. 35605.00 through sale of these products and also contributed in the control of forest fire.

3. In Jyoli village cluster from the 15 bee colonies given to the farmers in 2020 winter the honey yield was estimated worth Rs. 81000. A demonstration on bee pollination services on plum (*Prunus domestica*; Fig. 10) and mustard (*Brassica compestris*) crop was made. In mustard the grain yield increased by 32.5% (190 vs. 140 g/m2) in control over treatment (honey bee excluded plots) that motivated the people to adopt bee keeping.

4. Ecological Security Indicators with their corresponding measurement units, their functional relationship with sustainability, SDGs and data sources at District level for the year 2015 and 2018 for hill districts of Uttarakhand have been collected.

5. At the Rural Technology Complex (RTC) 08 training programmes, workshops, etc. were organized (following COVID SoPs), and capacity of 277 stakeholders (Male= 230, Female= 47, 04 Govt. line agencies / 2 NGOs) was built on various environment-friendly, livelihood promoting and income generating technologies.

Fig. 10: Bee pollination experiment in Jyoli village cluster on Plum trees.

Table 1: Summary table showing number of interventions and household beneficiaries, and input and output in terms of money and net earnings in Jyoli village cluster.

	Number of beneficiary households									
	Jyoli	**Khadkuna**	**Kaneli**	**Bisra**	**Kujyari**	**Dilkote**	**Total Households**	**Total earning (Rs.)**	**Total expenditure (Rs.)**	**Net profit (Rs.)**
Polyhouse	26	-	13	06	18	03	66	135039-00	50800-00	84239-00
Poultry farming	22	-	10	06	26	07	71	300084-00	81252-00	218832-00
Bee-keeping	05	04	01	03	10	02	25	81000-00	117000-00	-
Bio-briquetting (Pine needles)	-	-	07	06	16	01	30	5000-00	4800-00	200-00
Vermi-composting	-	-	01	01	-	01	03	9600-00	19000-00	-
Green skilling (Aipan/ Rakhi)	08	04	04	05	01	03	25	21900-00	1500-00	20400-00
Horticultural plantation	-	-	01	03	-	-	04	-	14850-00	
Plantation (Community land)	1-5 ha.	-	-	-	-	-	-	-	20000-00	330 trees
Pine needle check-dam (Community land)	10	-	-	-	-	-	-	-	15000-00	1177 ton soil conserved
Rain-water harvesting model	-	-	-	-	-	01	01	-	21000-00	-
Sum total	61	08	37	30	71	18	225	552623 (Income increased Rs. 2455 per household ½	345202	323671

Himachal Regional Centre

1. Unnat Bharat Abhiyan Questionnaire Survey for baseline dataset collection and resource use maps generation for eco-smart model village development for sustainable resource utilization and livelihood improvement are completed for Piun, Kashna, Kingash, Khamradha, and Nau villages in Mandi District (H.P.). Household survey completed for a total of 256 households in the identified villages of Mandi district.

2. Distribution of 2 vermi composting units and 71 horticulture trees (persimmon, plum, apple) to 11 stakeholders for setting up demonstration for increasing livelihood.

3. A total of 128 stakeholders from various panchayats participated in six capacity building and training programmes organized in the project site.

Garhwal Regional Centre

1. In the project villages 4 training programmes were conducted for the livelihood and income generation for villagers on Biocomposting, Bio-briquetting, Decomposers and Jiva Amrit, Beeja Amrit demonstration and livelihood generation through beekeeping and poultry farming in which a total 81 males and 162 females were trained.

2. Total 4 villages were surveyed and data collected (Fig. 11) using the Unnat Bharat Abhiyan questionnaire. This baseline household survey contains population, income, livestock, landholdings and cultivation system in the project villages.

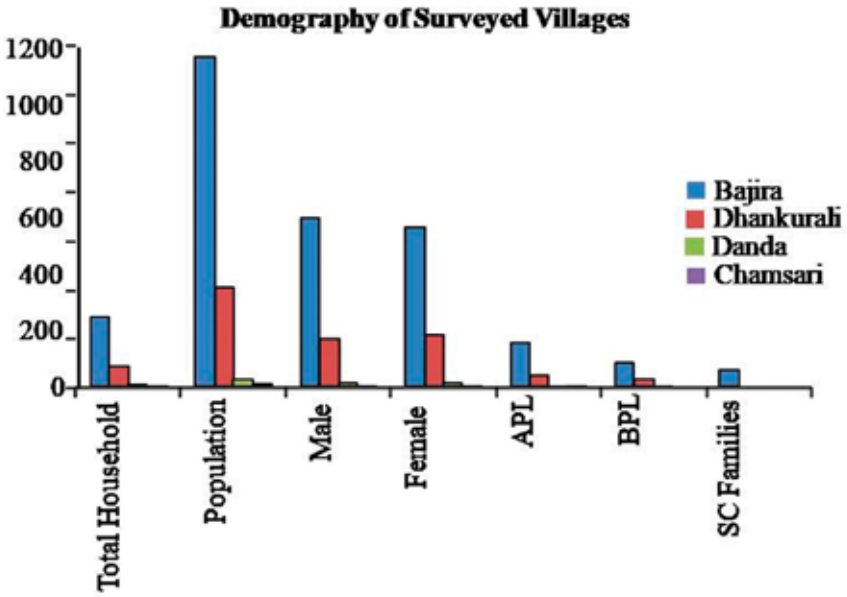


Fig. 11: Baseline household survey data of project villages in Rudraprayag Distt. Garhwal

Sikkim Regional Centre

1. Household survey data collected on annual income revealed that contribution of other occupation was comparatively higher in villages of South Sikkim, which was mainly due to engagement of locals in tourism related activities like, hotel, homestays and transport business. However, contribution of farming was singificantly higher in Pungitar village. In the villages of North Sikkim District income from job/ waged labor was highest than other sources followed by farming and livestock. However, contribution of farming was exceptionally higher in Gairee Village.

2. Total number of livestocks were found comparatively higher in 5 selected villagers of North Sikkim District as compared to 5 selected villages of South Sikkim district. Among the differnet cattles in South Sikkim, cow is prefered followed by Poultry. In selected villages of North Sikkim District, goat and pigs is also prefered cattles. Fodder assessment carried out in these 10 villages based on available cattle population revealed that Pungitar, Chemchey Lower Jaubari and Lower Lingchom village have high requirement of fodder (Fig. 12).

3. A one day consultation meeting with village representatives and State Government Officials in Namchi (02/03/2022). The main objective of the program was to identify ongoing efforts by government and non-governmental agencies for development of project implementation site. Furthermore, need assessment was carried out for the identification of technological intervention in the area. This need assessment will be further validated through data obtained by household survey and village resource-use map development.

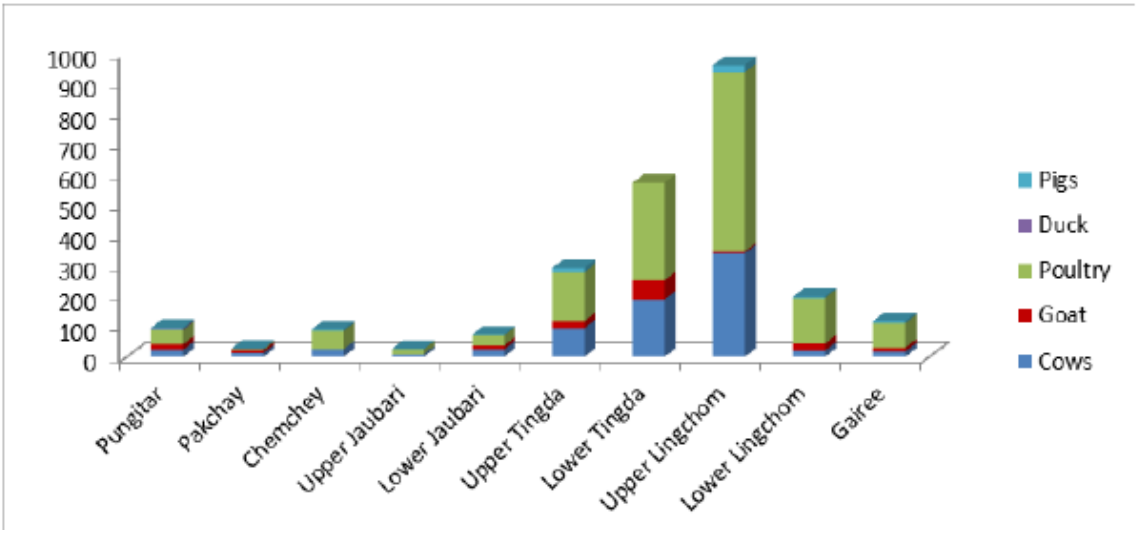


Fig. 12: Occurence of domesticated animals for livelihood enhancement in targetted villages of North and South Sikkim.

North-East Regional Centre

1. Two women Self-Help Groups (SHGs) consisting of 15 members representing all the 5 villages in the model village cluster have taken up the pickle preparation from wild fruits, chilly, dried fish, and other locally sourced raw materials. First batch of 100 pickle packets have been produced and sold out and generated Rs. 3500/- for the village people (Fig. 13).

2. Unnat Bharat Abhiyan Questionnaire Survey for baseline dataset collection and resource use maps generation for eco-smart model village development for sustainable resource utilization and livelihood improvement are completed for another two village's during the period viz., Dikopita (36 Household) and Manipoliang villages (37 Household) and two more village surveys are ongoing.

3. Four vermi-composting units in four villages' viz., Dikopita village, Manipoliang Village, Byapin village and Siichusi village of the cluster village in lower Subansiri Distt. A.P. has been set up. From Miiring vermi-compost unit, a total of 200 kg of Vermicompost has been taken out and sold @ Rs.35/- per kg. Another unit, i.e., Siichusi Vermi Compost Unit also have produced 70 kgs of compost.

Fig. 13: Different types of pickles prepared by the women Self-Help Groups of cluster villages

Estimation of Economic Loss in Real Term Per Hectare Basis Due to Forest Fire in Uttarakhand and Madhya Pradesh (CAMPA- GoI, 2020-2022)

Forests provide a range of goods and services such as fuel, timber, fodder, wild edibles, medicinal and aromatic plants, bio-products, greenhouse gas regulation, air, water supply, carbon storage and nutrient cycling those are utilized by human beings for their well-being. Owing to the important ecological and climate services provided by forests, the conservation of forests has been widely adopted as an important policy goal for environmental protection. Forest fire (FF) is an important disturbance factor shaping forest vegetation worldwide. Every FF brings with it significant losses of various types: social, economic, resource reduction etc. and such alteration produces severe impacts on human society, along with greenhouse gas emissions increase, change of climate patterns, and loss of ecosystem attributes and environmental services. In spite of this fact the monetary loss due to FF is either grossly underestimated or least valued in monetary terms. Keeping all these factors in mind the Parliamentary Standing Committee on S&T, Environment & Forests, Govt. of India visited Uttarakhand following the massive forest fires in 2019 and held consultations with a range of stakeholders and mandated to a consortium of R&D organizations (NIHE, Almora; FRI, Dehradun; FSI, Dehradun; ICFRE, Dehradun; WII, Dehradun; TFRI Jabalpur and NIH Roorkee) to come up with proper methodology to arrive at the realistic monetary loss due to FF in Uttarakhand and Madhya Pradesh.

Objectives

1. To identify the value of ecosystem component affected due to forest fire for different forest types.
2. To generate baseline /ground truth data on the status of the selected ecosystem components affected due to fire incidents.
3. To quantify the forest loss in terms of total economic value using the data generated for real time monetary value on per hectare basis.

Achievements

1. In the identified polygons in the forests affected due to FF in U.K. (42) and M.P. (49) provided by Forest Survey of India a total of 2860 study plots for trees, 5720 for shrubs and 8580 for herbs were laid out during pre-and –post rainy seasons in burnt and un-burnt forests in which a total of 171 and 166 plant species (trees, shrubs and herbs) were recorded in U.K. and M.P., respectively.

2. To assess the monetary value of loss due to FF (fodder, fuel wood, NTFPs, MAPs, wild edibles, litter fall, and forest regeneration etc.) apart from using the Forest Deptt. rates 35 meetings in U.K. (230 M; 136 F) and 31 stakeholders meetings in M.P. (316 M; 29 F) were organized among the villages nearby these studied polygons that involved altogether a total of 323 forest officials/ field staff and 817 local people including women.

3. Mean fuel wood volume loss due to FF across all the studied sites was measured 2.48 m3/ha in Uttarakhand and in 0.35 m3/ha in Madhya Pradesh. The monetary loss of MAPs and wild edibles using the rates of Forest Dept. was computed Rs. 1980/ ha; Rs. 2655/ ha and Rs. 9091/ ha; Rs. 2856/ ha in U.K. and M.P., respectively. Similarly, the loss of Pine resin in U.K. was computed Rs. 6809/ha and Tendu leaves in M.P. Rs. 3064/ha (Table 2).

Table 2: Summary of major parameters of data collected during field work across fire affected forests of Uttarakhand and Madhya Pradesh

S. No.	Parameters	Uttarakhand	Madhya Pradesh
1.	Number of FF affected polygons of 2019 selected for study	42	49
2.	Number of polygons studied	39 (pre-monsoon) 27 (post-monsoon)	47 (pre-monsoon) 30 (post-monsoon)
3.	Area of polygon (ha)	4.23- 883.12	3.607-3108.53

4.	Altitudinal ranges of polygons (m asl)	230–2488	252-930
5.	Total species recorded	171	166
6.	Timber/ wood volume loss due to forest fire (m^3/ha)	5.86	1.74
7.	Quantity of fuel wood loss due to FF (t/ha)	2.48	0.35
8.	Monetary loss of fuel wood (Rs. /ha)	14627	2005
9.	Monetary loss of MAPs (Rs. /ha)	1980	2655
10.	Monetary loss of wild edibles (Rs. /ha)	9091	2856
11.	Total plot sampled in burnt and unburnt polygons-		
	Herb	3960	4620
	Shrub	2640	3080
	Tree	1320	1540

Himalaya Calling- Bridging Science, Policy and Practice to Foster Sustainable Development in the Indian Himalayan Region (NMHS, GoI, 2019-2022)

The initiative envisages in bringing all stakeholder groups together spread across science, policy and practice domains to deliberate upon and delineate policies and programmes for the ecologically rich and climate sensitive Indian Himalayan states. It has been observed that despite having strong institutional strength (115 Universities, 82 R&D Institutes, and 7307 Non-government organizations), the region is referred as data-deficient (IPCC, 2007). It appears that there exists a gap in synergy and convergence across disciplines, sectors and actors working in the region. In an attempt to build an interface among different actors of the region, Himalayan Knowledge Network (HKN) formally invited scientific councils and universities to contribute in HKN by signing LoAs for establishing HKN State Chapters and executing a set of well deliberated activities in their respective states. The major activities of HKN for each state include, organisation of State level workshops; identification of two priority areas on issues of environment and development; development of thematic reports on the identified two priority areas; strategic meets for development of data sharing mechanism; development of youth forums to increase outreach across the region and documentation of success stories.

Objectives

1. To foster an effective and collaborative network of different constituencies (from policy, science and practice), academic institutions and universities, and local communities working within and outside of IHR for sustainable mountain development.
2. To create evidence-based knowledge and learning that is communicated to influence policies and practices bringing decisions that enhance sustainable development in the IHR region.

Achievements

Head Quarters, Kosi, Almora

1. A HKN web portal (https://hkn.org.in) has been established at NIHE-Himachal Regional Centre of the Institute that contains information and data base on wide ranging aspects of Himalayan environment and development. Nine new HKN State Chapters have been established across IHR, namely, J&K, Ladakh, Uttarakhand, Sikkim, Manipur, Mizoram Nagaland, Meghalaya, and Assam raising the number to 11 HKN State chapters across the region including Himachal and Arunachal Pradesh.

2. Five State level workshops (Total Participants-206) were organized for identification of two State priority areas for development of Thematic reports (Fig. 14). A total of 12 State priority issues have been identified in 06 IHR States. Three draft

thematic reports have been prepared on State priority issues so far by HKN Ladakh (Wildlife: Birds of Ladakh); HKN Himachal ("Biodiversity of Himachal Pradesh, Status, Issues and Suggestions"); and HKN Sikkim (Wetlands).

3. 21 strategic meetings for developing data sharing mechanism have organized by Ladakh (06), Himachal (01), Sikkim (05), Arunachal (08) & Jammu & Kashmir (01). Also, Youth Forum development has been initiated by organizing awareness and outreach programmes in Ladakh (06), Himachal (04), Jammu and Kashmir (01) and Sikkim (04).

4. A comprehensive Subject Experts Database working in different Universities (Vol. 1), Research and Development organizations (Vol. 2) and Non Government organizations (Vol. 3) has been developed for easy access and retrieval of the information by stakeholders across the region.

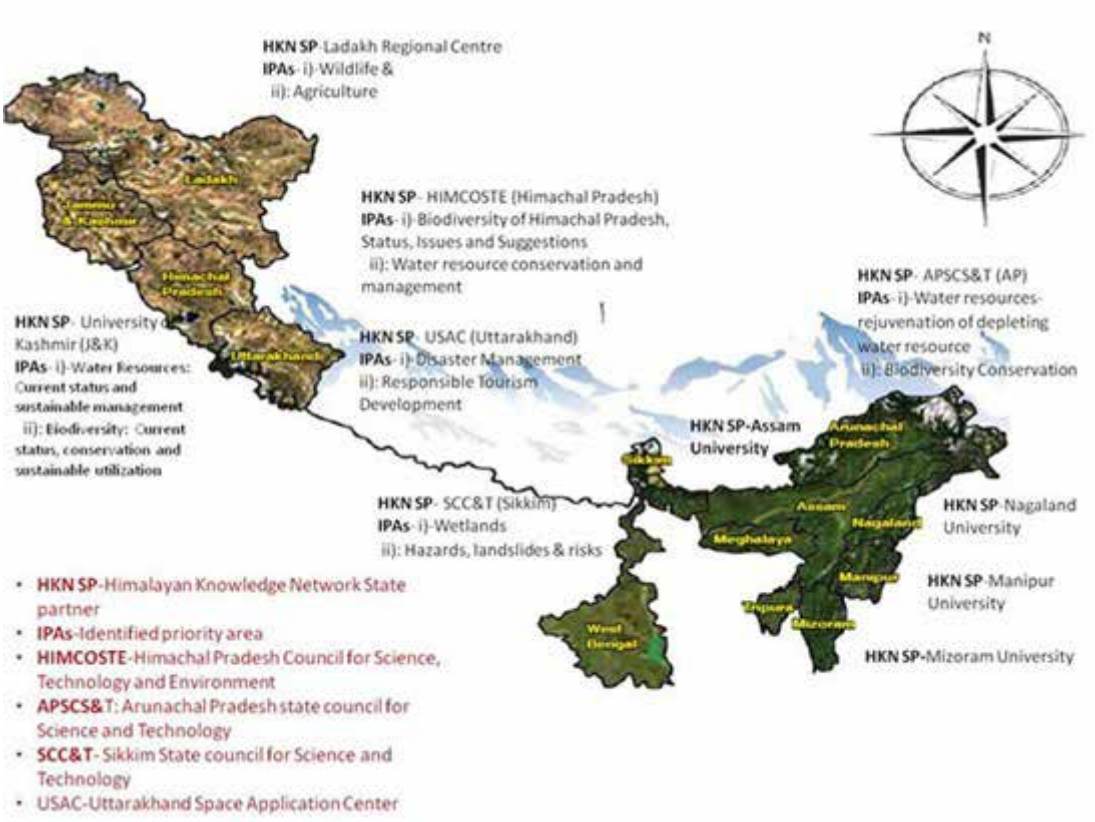


Fig. 14: Location of HKN State Chapters and two major priority areas for developing policy documents across the IHR States.

Himachal Reginal Centre

1. A responsive, bilingual website of Himalayan Knowledge Network with the domain name https://hkn.org.in/ was developed and hosted. This virtual platform stores information about the IHR and covers the activities performed under HKN.

2. A final draft of the state specific thematic report on Biodiversity Conservation and Management was prepared by network partner HIMCOSTE.

3. Drafts of success stories on themes "Biodiversity Conservation and Management" and "Water Resource Conservation and Management" were prepared.

4. Two webinars were organized on the occasion of International Day for Biological Diversity (May 22, 2021) and on World Environment Day (June 05, 2021) to discuss robust data sharing and utilization mechanism.

Sikkim Regional Centre

1. Based on the deliberations of the regional workshop on 'Prioritizing Actions for Ecosystem Restoration of High Altitude Wetlands (HAWs) in Sikkim Himalaya' organized on 5th June 2021,

identified some of the key issues that impact the HAWs ecosystem services (like unsustainable tourism influx, solid waste management, erratic rainfall, etc.) in Sikkim.

2. A State specific thematic document on High Altitude Wetlands (HAWs) in Sikkim Himalaya-Conservation and Management perspectives has been drafted. The document includes state of art knowledge on High Altitude Wetlands (HAWs) of Sikkim, knowledge gaps, and recommendations on the plan of action for conservation and management of HAWS in Sikkim.

3. Signed the Letter of Agreement (LoA) with Sikkim State Council of Science & Technology, Department of Science and Technology, Sikkim; Assam University, Silchar, Assam; State Council of Science, Technology & Environment (SCSTE), Meghalaya for implementation of HKN activities in the respective Himalayan states. Hence, the state chapters of HKN in Sikkim, Assam, and Meghalaya have been established.

Northeast Regional Centre

1. During the year 2021-22, the NERC has extended the work in 3 more states of North East India namely Manipur, Mizoram and Nagaland. NERC has signed 3 different LoAs in the month of November and December 2021 with its state chapters in each state. Manipur University, Mizoram University and Nagaland University were the partner institutions for formation of state chapters in their respective states.

2. For Nagaland state, state-level consultation was done to identify priority thematic areas. Biodiversity conservation and water security thematic groups were identified as priority working area. Currently, thematic report writing is under process.

3. For Mizoram state chapter, database of all departments/organizations functioning in Mizoram such as state government departments, academic and research institutions, NGOs has been done. Communications has been sent from the state chapter to all the institutes/ organizations for nomination of nodal person. State-level consultation is yet to be organised.

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

Different environmental factors including climate change influence an ecosystem, which is further exacerbated by human induced perturbations. Changes in climate regime over the last few decades have already started affecting natural resources worldwide including mountain regions, subsequently, natural resources of the Himalaya have become vulnerable. Now it is known that climate change (CC) is 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 Centre for Environmental Assessment & Climate Change (CEA&CC) caters to the Himalayan needs on these issues in tune with MoEF& CC and SDGs (Goal no. 13), which requires urgent action to combat CC and its impacts. The broad approach for achieving these goals include: (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 Citizen Science approach in research, and adaptation and mitigation strategies, (iv) practice-Science-Policy-People connect through integration of community level experiences (acclimatization/ adaptation/ coping mechanism) in policy framework, and (v) collaboration with other organizations / Universities on CC projects. The objective of the CEA&CC is therefore to assess and monitor physical, biological and socio-economic environmental parameters for the development in the IHR, and design measures for CC mitigation and adaptation by communities and developing ecosystem resilience to cope up with CC risks. Thus, our vision is that the in Centre become due course of time reasonably self-sustaining and playing 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 in the Himalaya.

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

Climate change is a pressing worldwide issue that is currently affecting a disadvantaged and disenfranchised set of individuals at an unprecedented rate. Concern over the changing climate in the Indian Himalayan Region (IHR) extends beyond just the mountain regions themselves to the lowlands that depend on them in diverse ways. These changes affect mountain social-ecological systems, which also affect how populations perceive risk and react to changing climatic circumstances. In order to comprehend human and societal responses to climate change, it is vital to identify the components and factors that influence risk perception in mountainous places. In this context, "vulnerability" is defined as a system's "propensity" or "predisposition" to suffer damage. In some regions of the states of the IHR, vulnerability assessment may aid in identifying its drivers and may even support adaptation initiatives.

Objectives

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

Achievements

HQs (Kosi-Katarmal, Almora)

1. A climate vulnerability index (CVI) with three main dimensions—exposure (indexing climate variability and natural hazards), sensitivity (health, water, food, socioeconomics—has been tested on common intervention sites in the Hawlbagh block, Almora district, namely Bisra, Jyoli, Khadkuna, Kujyari, Kaneli, and Dilkot (livelihood strategies, social network and coping strategies). The CVI for Dilkot, Khadkuna, Kaneli, Jyoli, Kujyari, and Bisra was 0.558, 0.541, 0.547, 0.536, 0.556, and 0.540. This suggests that the people who live in common intervention locations fall into the group of moderately vulnerable people.

2. 03 bio-composting pits were constructed at Jyoli, Dilkot and Jyoguda villages. Carried out field work in Jyoli, Jyoguda and Dilkot villages and provided training on the management of microbial bio-composting pits.

3. The long-term near-surface air temperature record for the Almora District, Uttarakhand, from 1948 to 2014 has been examined. The study's findings revealed that the region's air temperature is rising during the post-monsoon (+0.92°C), winter (+0.62°C), and monsoon (+0.21°C) seasons. Pre-monsoon temperatures, however, show a decreasing tendency (-0.19°C).

4. The Rishiganga River Basin in Uttarakhand was evaluated for near-surface air temperature, precipitation, variation in snow cover, and vegetation cover (2010-11 to 2019-20). The findings indicated that all aspects of temperature, including summer precipitation, had increased significantly at seasonal and yearly scales. These included minimum temperature (+) 0.40°C in winter, (+) 0.38°C annually, and (+) 0.36°C in summer seasons; maximum temperature (+) 0.54°C in summer, (+) 0.53°C annually, and (+) 0.49°C in winter seasons.

Himachal Regional Centre

1. According to the questionnaire survey, the Lug Valley in Kullu district's varied altitudinal zones' cropping patterns and productivity are negatively impacted by temperature change, rainfall, and high chemical use. According to research on the carrying capacity of tourism in the Tirthan Valley, the Tirthan River, GHNP, and other natural resources are vulnerable due to the heavy strain of tourism-related activities.

2. Night Soil composting (L&S), Kath Kuni architecture, and other climate-smart success stories have been documented (Kullu). Farmers from transformative places who are marginalised have been exposed to the adaptability of organic manure and crops with a high level of climatic resistance.

Garhwal Regional Centre

1. In order to lower carbon emissions and promote clean energy in the area, a biobrequetting unit was established in the town of Pangroli. This unit will provide training and live demonstrations on how to prepare pine needles for biobrequetting while also reducing carbon emissions.

2. The most families (11 hh) in the village of Bajira and the least (03 hh) in the village of Bachwar chose to engage in mushroom farming, according to an inventory done to count the number of households who chose this choice for a means of subsistence. The Bajira village had the highest financial gain, computed at Rs. 14400/hr/year, followed by Pangroli and Kapanya, each receiving Rs. 10800/hr/year and Rs. 9200/hr/year.

Sikkim Regional Centre

1. Based on a review of the literature, consultation with experts, and discussions with key stakeholders, including the Department of Science and Technology (DST), the Government of Sikkim, a list of parameters was created. A draft framework for block and district level vulnerability assessment was created based on literature reviews, data accessibility, and consultations. It includes five major categories: physiographic features, socioeconomic and livelihood factors, institutions and infrastructure, biophysical factors, and environmental factors.

2. For the secondary data collection, the initial fieldwork was carried out in 8 different blocks (Namchi, Ravong, Sumbuk, Namthang, Poklok-Nandu Gaon, Sikkip, Temi, and Yangyang) of South Sikkim district. The Namchi sub-division has the largest percentage of literate people, followed by Namthang-Rateypani and Ravong sub-division. The Sumbuk Block has the least amount of literate people. Namchi has the greatest female literacy percentage out of the other 8 blocks. The majority of principal cultivators are concentrated in Namchi's rural districts, followed by Namthang and Ravong. The Namchi urban areas have the fewest major cultivators overall, with Poklok block having the fewest. In decreasing order, the marginal cultivators are Ravong, Namchi, and Namthang. The majority of main and marginal agricultural labourers are located in Namthang block, with Ravong having the second-highest concentration.

North-East Regional Centre

1. A questionnaire study was carried out in 21 Villages

with 105 random samples for the purpose of assessing vulnerability. Rainfall and temperature data from the Ziro block were evaluated for three decades. For the considered period (1990 - 2020), the average annual rainfall is 1821 mm, and there are 93 wet days on average. Six deficient monsoons (1992, 1996, 1997, 2005, 2016, and 2020) and one excess monsoon (1990) occurred in Ziro over the time period under consideration. According to the LST analysis, LST has significantly increased during the last three decades. According to the LULC map of Ziro Valley, forest land makes up 78.02 percent of the total area, followed by agricultural at 13.48 percent and water bodies at less than 1 percent. The remaining space is made up of human settlements and barren land.

2. The vulnerability analysis reveals that towns are the least sensitive to climate change, semi-towns are moderately vulnerable, and rural villages are extremely vulnerable. Various activities under the project are depicted (Fig 15)

Fig. 15: Various activities conducted under the project in Uttarakhand (a,b), Himachal (c), Sikkim (d), and Arunachal Pradesh (e).

Aerosols climatology over the north-western Indian Himalayan region Himachal Pradesh & Uttarakhand (ISRO-SPL, Thiruvananthapuram; 2005-06 & Onwards; Long-Term Study)

Climate change has become one of the major challenging issues on the Earth. Green House Gases (GHGs), deteriorating atmosphere due to aerosols has been responsible for Climate Change. Aerosols are produced by a variety of natural as well as anthropogenic activities. These get dispersed into the atmosphere through turbulent mixing and transport and result in large variability in their size distribution. Mohal-Kullu in the Kullu valley in Himachal Pradesh and Katarmal-Almora in Uttarakhand, have two different sites being observed for aerosol and radiative forcing studies. Tourist influx and an ever-increasing number of native populations have affected the Himalayan climate. The perturbation in the earth's radiative balance results in scattering and absorption caused by anthropogenic aerosols. This is termed as direct aerosol radiative forcing. Hence, the shorter atmospheric lifetime of aerosols results in more localized effects and regional differences in aerosol properties. Aerosols and radiative forcing provide information about the change in radiation budget in the top of the atmosphere (TOA), atmosphere and surface. Similarly, black carbon aerosol if deposits on snow and ice, darkens their surface and reduces albedo and melts faster the snow, and decreases snowpack along with a decrease in precipitation and increase in temperature. Columnar aerosol optical depth in another way defines extinction in solar radiation reaching the earth's surface. The present study therefore aims to unfold the current status of aerosol optical depth (AOD) in the delicate and fragile topographical region of the Himalaya.

Objectives

1. To obtain variations aerosol optical depths (AODs) at UV, visible and NIR spectrums (380-1025 nm) using Multi-Wavelength Radiometer (MWR) and Microtops-II sunphotometer,
2. To obtain Black Carbon Aerosol concentrations

using Aethalometer.

3. To relate AODs with the meteorological parameters with the help of Automatic Weather Stations (AWS) installed at Mohal, and
4. To estimate Radiative Forcing using different models.

Achievements

1. AOD values at shorter wavelengths are higher indicating increase in the anthropogenic activities. A multi-wavelength radiometer (MWR) and Aethalometer set up for aerosol measurements. Mean AOD500nm in 2021 stood to be 0.35± 0.03 (Fig. 16 a & c). Mean value of AOD (2006-2021) at 500 nm was found to be 0.31, while the same was observed maximum 0.44 in 2020, and minimum 0.22 in 2007.

2. Mean black carbon from January 2014 to December 2021 shows a bimodal peak with average concentration peaked 1858.3±122.80 ng m^{-3} in 2021 and 1791.8±127.1 ng m^{-3} in 2019 (Fig. 16 e).

3. Respirable Dust Sampler (RDS) for PM10 was operated on 8-hourly basis, thrice a day which showed average concentration of 52.9 µg m^{-3} while PM2.5 showed 32.1 µg m^{-3}.

4. At Kosi-Katarmal, Almora (1225 m amsl), Maximum AOD at wavelength 500 nm was observed to be 0.64 in July 2019, whereas minimum AOD stood to be 0.17 in February 2022 (Fig. 16 b & d).

5. Average mean concentration of BC was 1248 ± 300 ng m^{-3} from April 2021 to March 2022 while maximum concentration of diurnal BC was 6859 ± 411 ng m^{-3} in March, 2022 at 08:00 hrs IST. The percent change in BC from 2019-20 was 44%, from 2020-21 with 13% and from 2019-21 was 28%. Mean concentration of BC during forest fire from April 2019 to March 2022 stood to be 3189 ± 718 based on 69 samples. While this value during non-forest fire days was 928 ± 345 based on 903 (Table 3).

6. The measured ambient air pollution data were compared with the calculated values using Fixed Box model. These pollution data in the study area was predicted using Fixed Box Model having relative error ranging between 0.02 and 0.04. These were found to be appropriate.

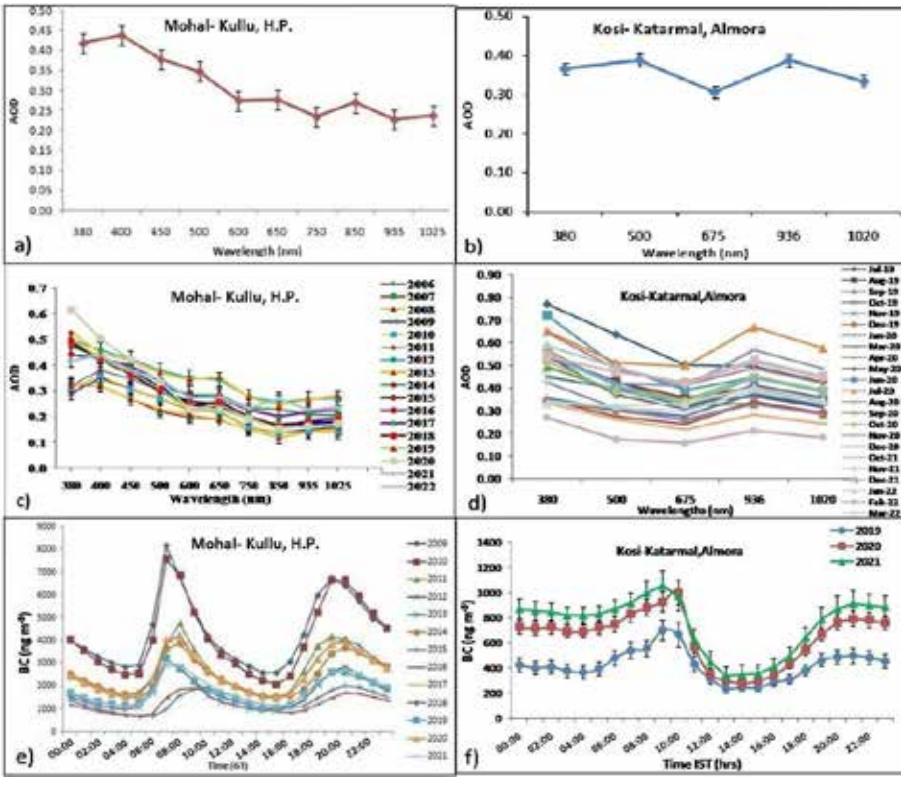


Fig. 16 (a & b) AOD from April 2021 to 2022 at Mohal and Almora, (c & d) yearly and monthly AOD in Mohal and Almora, (e & f) Concentration of Black carbon at Mohal from 2009 to 2021 and Kosi- Katarmal, Almora from 2019 to 2012.

Table 3: Black carbon status at Katarmal, Almora, Uttarakhand during forest-fire and non-forest-fire days.

Year	Samples during forest fire days	Mean concentration during forest fire days (ng m^{-3})	Samples during non-forest fire days	Mean concentration (ng m^{-3}) during non-forest fire
2019	13	5303 ± 740	242	839 ± 79
2020	21	663 ± 173	337	643 ± 89
2021	19	597 ± 741	250	877 ± 653
2022 (till March)	16	4787 ± 888	74	2625 ± 2051
Avg. (2019-March 2022)	69	3189 ± 718	903	928 ± 345

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; Long-Term Study)

Surface ozone or ground level ozone is a secondary pollutant. Primary pollutant such as Nitrogen oxides (NO+NO2) are released from natural as well as anthropogenic sources. NO is a short-lived pollutant and react with atmospheric oxygen to produce NO2. This further leads to photochemical reaction leading to production of surface ozone and other harmful pollutants. The relation between O3 and its main precursors represents one of the major scientific challenges associated with gaseous pollutants. Ozone concentration depends on the absolute and relative concentration of its precursors and the intensity of solar radiation. Other trace gases such as SO2 also react in atmosphere and leads to production of secondary pollutant such as PM10 and PM2.5 which adversely affect the environment. Regular air quality monitoring is essential to know the background values to improve the air quality.

Objectives

1. To measure the important 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.
2. To observe local meteorological parameters and relate these with gaseous pollutants and analyze in the background of long-range transport sources.
3. To suggest some feasible mitigating measures implementing at policy level.

Achievements

Mohal- Kullu, Himachal Pradesh

1. Seasonal Diurnal variation of CO, SO_2, NO_2 and NO_x was established showing highest concentration in winters and lowest in monsoon (Fig. 17 a-d). CO showed highest average concentration 0.66±0.03 ppm in January 2021 and lowest 0.05±0.07 ppm in September 2021. SO_2 showed highest average concentration of 2.15±0.01 ppb in the month of December and lowest as 1.15±0.01 ppb in August 2021.

2. NO_2 showed highest average concentration of 5.44±0.413 ppb in December and lowest concentration of 2.78±0.09 ppb in August in the year 2021.

3. Negative relationship was established between surface ozone and its precursors like NO_x, NO_2, NO and CO, rainfall and relative humidity. While positive correlation was found with air temperature.

4. Ground level observation of pollutants such as CO, SO_2 showed a decrease by 40.67% and 17.17% concentration during lockdown 2021 when compared to pre-lockdown period. Similar results found with fixed box model which predicted concentration of CO as 1.49 ppm in pre-lockdown while 0.94 ppm during lockdown. On the other hand, SO_2 was predicted 9.84 ppb in pre-lockdown which decreased to 8.26 ppb during lockdown. All

the parameters were within prescribed limits of NAAQS throughout the year.

Kosi-Katarmal Almora

1. Mean columnar ozone from April 2019 to March 2022 found to be 86.3 ± 37.9 DU. It was maximum 168.6 ± 20 DU, while minimum stood to be 23.4 ± 6.5 DU. Columnar ozone and AOD500 show inverse relationship (Fig.17 e & f). Percent change for gaseous pollutants (NO_2, SO_2, and NH_3) from April 2019 to March 2022 is 51, 41 and 11 respectively at Kosi-Katarmal, Almora.

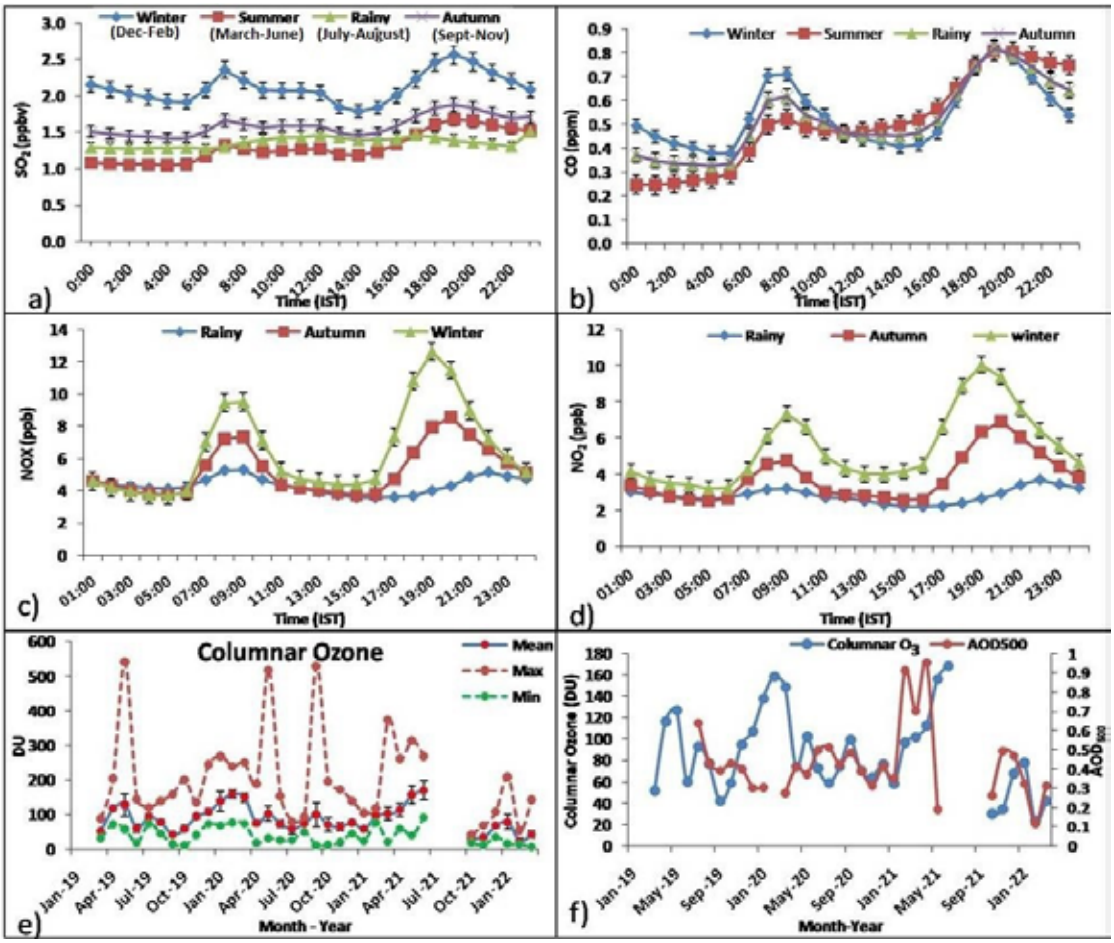


Fig. 17(a-d) Seasonal variability of SO_2, CO, NOx, and NO_2 at Mohal-Kullu in 2021, and (e & f) Columnar ozone and its relation with Solar Flux at Kosi-Katarmal

Bio prospecting of medicinal plants of Sikkim Himalaya against breast cancer angiogenesis (DBT, Govt. of India, 2019- 2022)

Breast cancer is the most common cancer among women with high mortality rate worldwide. India is no exception for the incident of breast cancer having 27% patients diagnosed every year and mortality rate has reached to 21.5% indicating its severity. Breast cancer associated angiogenesis is a critical regulator of aggressiveness, chemo resistance and relapse; the currently available treatment regimens are insufficient to increase the survival period of patients. Majority of the target based anti-breast cancer agents evaluated up to now have failed to show significant inhibitory activity on cancer associated angiogenesis and relapse. Current anticancer therapies like radio- and chemo-therapies are often met with the burden of high cost, serious side effects, toxicity and tumor relapse; therefore, it is imperative to look for novel therapeutic agents with lesser side effects urgently to address the breast cancer associated angiogenesis. In recent years, use of plant derived compounds has gained tremendous attention for the use as natural anticancer agent. In India, it has been a long tradition to use plant resources for their medicinal properties. The flora of north-east India, especially Sikkim is rich in plants having medicinal values. The present study

aimed to investigate potential medicinal plants of Sikkim Himalayan region against breast cancer angiogenesis and subsequent identification and isolation of biologically active molecules and lead structures that can be used to develop effective anti-angiogenic or anti-breast cancer drug leads.

Objectives

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

Achievements:

1. Five endemic species of Sikkim Himalaya viz. *Berberis sikkimensis, Primula sikkimensis*, *Rhododendron dalhousiae, R. ciliatum* and *R. maddenii* were investigated for phytochemical compounds and antioxidant activity. Five different solvents viz., methanol, ethanol, ethyl acetate, dichloromethane and hexane were used for the extraction.

2. Preliminary results revealed that the polar solvents such as methanol and ethanol are the optimal solvents to extract the high content of bioactive components from all the three species of Rhododendron, since the high content of tannins, flavonoids, terpenoids, glycosides and phenols were obtained by using these polar solvents. The present study also showed that non-polar n-hexane and DCM solvent extracts had moderate and low number of steroids, respectively.

3. 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 Rhododendron extracts.

Nano-pesticide biosynthesis and their impact assessment on secondary metabolism of endangered medicinal plant *Picrorhiza kurroa* (DBT- RA programme, 2020-2022)

Picrorhiza kurroa is an important endangered medicinal plant, which is endemic to the alpine Himalayan region of India. It is extensively used as traditional pharmacological agent. The medicinal values of this plant are due to its secondary metabolites (especially monoterpene glycosides). In the sustainability of *P. kurroa*, unscientific excessive harvesting, limited cultivation and attack of pathogens are major problem. The considerable yield loss of *P. kurroa* is observed with the attack of fungal pathogens such as Alternaria tenuissima (Alternaria leaf spot disease) etc. Although, pathogens attack can be managed with the use of traditional chemical pesticides, but these pesticides create resistance in the pathogens and found harmful to non-targeted plants, humans and the environment. In recent years, nanotechnology is exponentially increasing to develop nano-pesticides that overcome the above-mentioned problems and sequentially improve the crop productivity. A number of studies have been reported about fabrication of nano-pesticides and their activity against various pest and pathogens, but research about nano-pesticides impact on pathogen's host plant growth and development is still in infancy stage. There is a huge gap between the development of nano-pesticides and their commercial availability. In this study, we aim to biosynthesize nano-pesticide against the pathogens of *P. kurroa* and also to evaluate the impact of formulated nano-pesticide on secondary metabolites production in Picrorhiza. This study will provide a new way of improve pharmaceutical bioactive metabolites production and yield enhancement of valuable endangered plant *P. kurroa* that are facing high risk of pathogens attack and low yield of secondary metabolites.

Objectives

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

Achievements

1. On the basis of previous observed colour change and UV-vis spectrum, silver nanoparticles (AgNPs) (synthesized using *Ajuga bracteosa* and *Pittosporum eriocarpum)* were characterized with SEM, EDX, FTIR and XRD analysis (Fig. 18).

2. *A. bracteosa* and *P. eriocarpum* synthesized AgNPs were crystalline in nature, round shape and average ~ 43.6 nm and 51.4 nm in size, respectively.

3. *Picrorhiza kurroa* plant sample was collected from Pothivasa (2200 m asl, 30˚28˚N Latitude and 79˚16˚E Longitude), Uttarakhand, India during the month of October, 2021 and experiments were initiated to establish in-vitro plantlets under laboratory conditions. MS medium fortified with 5 mg/L TDZ was found suitable for undifferentiated callus proliferation from leaf disc cultures of *P. kurroa.*

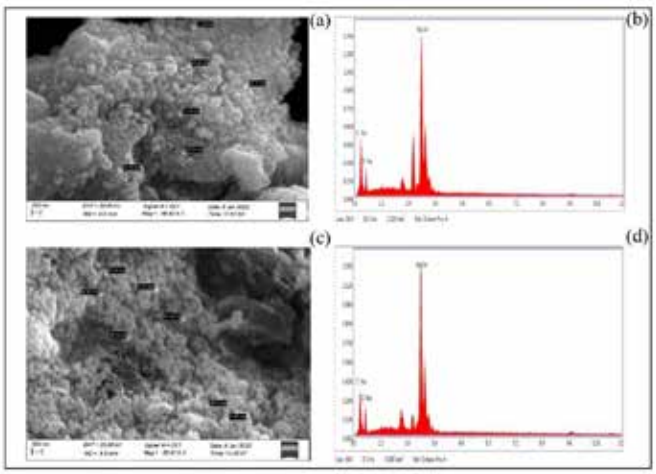


Fig. 18 *Ajuga bracteosa* and *Pittosporum eriocarpum* synthesized silver nanoparticles (a and c) SEM images, and (b and d) EDX spectra.

Preparation of District/State Environment Plan for the State of Uttarakhand (UKPCB, 2020-2022)

Hon'ble National Green Tribunal (NGT) vide order, dated 26/09/2019 in O.A. No. 360 of 2018 filed by Shree Nath Sharma Vs. Union of India and Others directed that Central Pollution Control Board (CPCB) shall facilitate the District Magistrates in preparation of the District Environmental Plan (DEP) by placing a model plan on its website. This model plan may be adopted as per local requirements by all districts under the supervision of the District Magistrate. There are diverse environmental issues that address our key responsibilities to the community and its surrounding environment. As a set of target, fourteen areas. These 15 areas were regarding compliance to rules for solid waste including legacy waste, bio-medical waste, Construction & Demolition waste (C&D), hazardous waste, Electronic waste (E-waste), polluter stretches, non-attainment cities, Industrial clusters, the status of Sewage Treatment Plants (STPs) and re-use of treated water, the status of Common Effluent Treatment Plants (CETPs)/ Effluent Treatment Plants (ETPs), ground water extraction/ contamination and re-charge, air pollution including noise pollution, illegal sand mining, and rejuvenation of water bodies. In addition, plastic waste was also assessed based on consultative workshops with the state government including State Pollution Control Board (SPCB). The present environmental plan describes the status quo of 15 thematic areas and sets out strategies to mitigate their impact on different environmental parameters and human health. It briefly touches upon the basic need for bringing in mountain perspective in developmental planning. Implementation of this plan based on selected indicators will resolve different environmental issues. Also, it will meet compliance of different departments within a district. It will also allow a variety of environmental opportunities associated with different activities to be further undertaken from a view point of sustainable development. We hope this document will act as a noble reference for various stakeholders interested in sustainable development planning for each districts. Moreover, it will help to develop comprehensive understanding of the environmental planning process in view of socio-economic and financial situation of the district.

Objectives

1. To examine the current status of the thematic areas as identified, on the basis of the data or information provided by the concerned departments.
2. To assign a desirable level of compliance for the district in terms of the laws governing each thematic pertaining to the fact that each thematic is governed by several set of statues.
3. To study the gaps in the current status of compliance with the desirable level of compliance as per notified in set of rules by the various departments of Government of India.
4. To bring forth a proposal to fulfill the gap within

stipulated timeline for each district/Urban local body.

5. To Completion of the District/State Environmental Plan.

Achievements

1. Prepared and modified the data collection format provided by UPCB and shared data collection format for 15 thematic areas provided by NGT, UPCB and NIHE to all district officials of Uttarakhand.

2. Prepared Ten Environmental Plans (Almora, Bageshwar, Chamoli, Champawat, Haridwar, Pithoragarh, Rudraprayag, Tehri, Udham Singh Nagar and Uttarakashi) according to Uttarakhand Pollution Control Bopard (UKPCB).

3. Solid waste generation in the Garhwal region more than 1068 Metric tons/day (MTPD) and Kumaon region 470.33 MTPD. Maximum waste generated from plain district approximately 80% in both regions (Table 4).

4. Partial source segregation has been observed in some ULBs in both region (U.S. Nagar Nainital and Haridwar, Pauri Garhwal) have not initiated source segregation.

5. Other three districts Environmental plan (Dehradun, Nainital and Pauri Garhwal) are under progress.

6. Organized workshop with district officials at different District Magistrate office in some districts of Uttarakhand for guidance and their role to completion of this plan .

Table 4: Inventory of solid waste generation in the Garhwal and Kumaon region of Uttarakhand, India

District Name	Population	No of wards	Solid waste generation (MTPD)			
			Dry waste	Wet waste	Other waste	Total waste
Garhwal Region						
Chamoli	83079	10	7.2	8.42	3.2	18.82
Uttarakashi	56575	06	9.4	9.59	1.76	20.75
Rudraprayag	22513	05	4.25	3.44	0.72	8.4
Tehri	85871	10	13.78	18.86	03	35.63
Pauri	90026	06	37.33	43.28	2.41	83.1
Dehradun			171.01	269.45	11	506.5
Haridwar	607283	10	57.65	122.92	3.45	395.1
Kumaun Region						
Pithoragarh	90820	05	16.5	18.5	0	35
Almora	71028	07	11.45	10.36	3.3	25.11
Bageshwar	30410	03	5.5	4	0	9.5
Champawat	48195	04	8.3	5.31	3.96	17.57
Nainital	416881	08	78.86	75.22	2.18	156.26
US Nagar	695339	16	89.03	109.48	29.29	227.8

National Mission for Sustaining the Himalayan Ecosystem Task Force No. 3 (Phase IInd) entitled "Forest Resources and Plant Biodiversity" (NMSHE, DST, New Delhi; 2020-25)

The Himalayas are the youngest and loftiest among the mountain systems of the world. They represent a highly complex and diversified system both in terms of biological and physical attributes. The region has a discrete geographic and ecological entity accented by the unique climate of the region. As a result, we find an inimitable landscape driven by systemic changes in climatic variables over very short distances. Further, these ecosystems reflect a mosaic of biotic communities at various spatial and organizational levels. However, over the years, the vulnerability of these Himalayan ecosystems has been humongous, thus a matter of serious concern. To an estimate, billions of people, both upstream and downstream, benefit or depend upon biodiversity to meet their livelihood needs. Therefore, sustaining biodiversity in the region also means protecting the interests of the people. Immediate actions are required to ensure the sustenance of the ecosystem. Among others, this ecosystem needs to be protected against both improperly conceived developmental activities and yet-to-be-assessed consequences of climate change. Further, given the pressing need for conservation of biological diversity in totality, sustainability of Himalayan Ecosystems has gained paramount importance. Hence, the National Mission for Sustaining Himalayan Ecosystems (NMSHE) is one of India's eight missions under National Action Plan on Climate Change (NAPCC).

Objectives

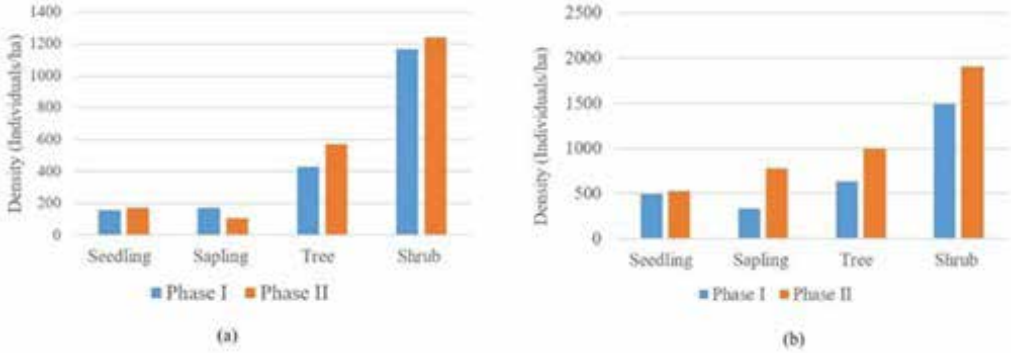
1. Strengthen database on forest resources and plant biodiversity in IHR using field datasets and geospatial platform.
2. Establish effective monitoring system for plant diversity and forest resources in relation to changing climate.
3. Assess climate change vulnerability of ecologically and economically important plants and forests.

Achievements

1. A complete list of 718 vascular plants (Angiosperms, Gymnosperms and Pteridophytes) of Himachal Pradesh belonging to 125 families and 325 genera is prepared. The list contains 106 families, 363 genera and 664 species of Angiosperms; 03 families and 06 genera and 09 species of Gymnosperms; 16 families, 25 genera and 45 species of Pteridophytes.

2. Out of the total 456 threatened plant taxa in IHR, 85 taxa (41 trees, 34 herbs, 3 shrubs, 3 mosses, 2 vines, and 2 bryophytes) belonging to 56 genera under 41 families were documented under high-risk category and prioritized for conservation.

3. Of the six Long Term Monitoring Sites (LTEM) established in the Phase-I of the project, four LTEM sites (i.e., Chodyar, Chitgal, Kanara and Hat-Kalika) were revisited after a span of five years. Briefly, the comparison studies highlights, in the phase-I of the project, the seedling density varied from 160 ha−1 to 495 ha−1, while in the phase II the seedling density ranged between 170 ha−1 to 525 ha−1 (Fig.19). Similarly, in the case of sapling density varied from 170 ha−1 to 922 ha−1 (phase- I), while in phase II the sapling density ranged between 110 ha−1 to 780 ha−1. The shrub density in phase- I varied from 715 ha−1 to1490 ha−1, which in phase II the shrub density ranged between 350 ha−1 to 1910 ha−1. Lastly, the tree density ranged between 430 ha−1 and 1430 ha−1, while the same in the recent field revisit ranged between 270 ha−1 and 1000 ha−1.



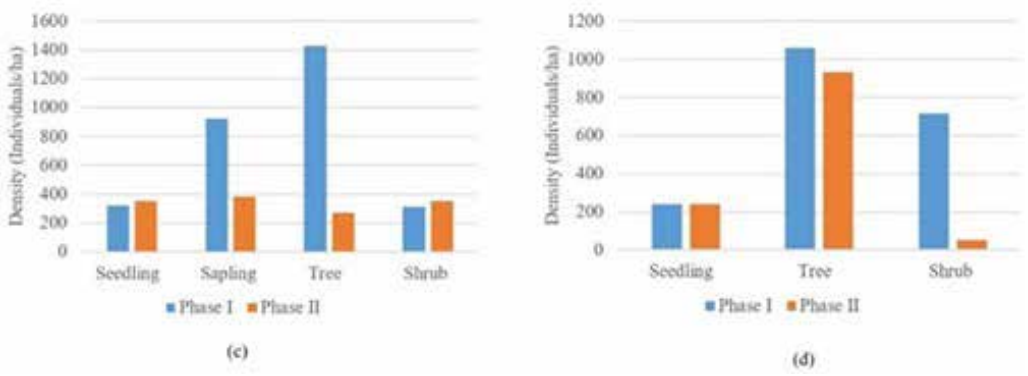


Fig. 19. Species richness of different life forms in the LTEM plots, (a) Hat-Kalik, (b) Chodyar, (c) Kanara, and (d) Chitgal

4. Forest vulnerability using vegetation data and spatial mapping were determined for the district Pithoragarh using Analytic Hierarchy Process (AHP), a multi-criteria decision method. Nine forest vulnerability indicators were chosen for the decision making that include biological (species richness, and Normalized difference vegetation index (NDVI)), climatic (temperature, rainfall), topographic (slope, aspect, elevation), disturbances (forest fragmentation), and social (dependent population).The results obtained highlights, forest grids with a medium vulnerable profile had the highest percentage (37.54%) of vulnerability grids followed by grids with a highly vulnerable profile (31.14%), while grids with a low vulnerable profile accounts to only 21.12%. In general, temperate and mixed forests in the region have higher forest vulnerability, whereas subtropical pine, broadleaf, and subalpine forests have lower forest vulnerability (Fig. 20). The finding revealed that elevation (15.4%), population density (15.1%), slope (14.5%), rainfall (13.7%), forest fragmentation (12.9%), temperature (12.3%), and aspect (11.4%) are the main drivers of forest vulnerability in the region.

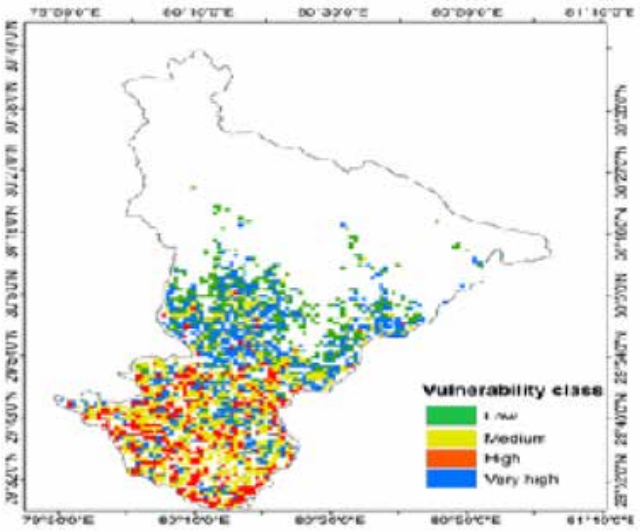


Fig. 20. Forest vulnerability profile of Pithoragarh district

Summary of Completed Projects/ Activities

Microbial Endophytes and Soil Enzymes as Indicators of Climate Resilience with Respect to Himalayan Birch: A Critically Endangered Timber Line Species (NMHS, GoI, 2018-2021)

The present study concluded with first hand baseline data on birch root microbial diversity, colonization, rhizosphere microbial activity (soil enzyme activity and rhizosphere effect), and soil nutrients. Birch root exert suppressive effect on the rhizosphere microbial population (negative effect). The root inhabiting various microbial colonization including mycorrhizae, dark septate, bacterial and some unidentified nematode like structure. Seasons and altitude affect the soil enzyme activities and root microbial colonization. The maximum microbial root colonization was contributed by dark septate endophytes in growing season and by fungal mycelium in dormant season. Total 10 culturable microbial endophytes including 6 bacterial and 4 fungal endophytes were isolated, characterized and assessed for the various biotechnological potential in particular to plant growth promoting activities and secondary metabolites productions (Fig. 21 a&b). These microbial endophytes belong to genera *Bacillus, Paenibacillus, Ewingella, Serratia, Pseudomonas, Penicillium, Pezicula and Paraconiothyrium. Isolated endophytes* were *psychrophiles* in nature due to temperature tolerance potential upto 5ºC. All isolated endophytes exhibited various Plant Growth Promoting (PGP) traits such as P-solubilization, IAA, siderophore, ACC deaminase, ammonia, HCN, biocontrol activity. Temperature affects the in vitro quantification of P-solubilization, siderophore production, IAA production. The quantitative assessment of various plant growth promoting traits were performed in three different temperatures (15, 25 and 35 ºC). The temperature affects these traits significantly and optimum activity varied from species to species. The microbial endophytes as bioinoculant also showed positive significant effect on the growth parameters like seed germination, root and shoot biomass of two agriculturally important crop i.e., black soyabean and maize (Fig.22). The endophytic fungal extracts are huge potential source of various secondary metabolites including host specific compound betulin. It is suggested that development of microbial inoculant and its consortium may helpful in elicitating seed germination and seedling establishment. To develop an appropriate strategy for the conservation and management of Betula utilis, monitoring of population using standard ecological methods and development of conventional and in-vitro propagation protocols for the mass multiplication of these species for their establishment and maintenance in the in-situ and ex-situ conditions are urgently required. Further use of microbial resource for the production of host specific compound may reduce the over exploitation threat.

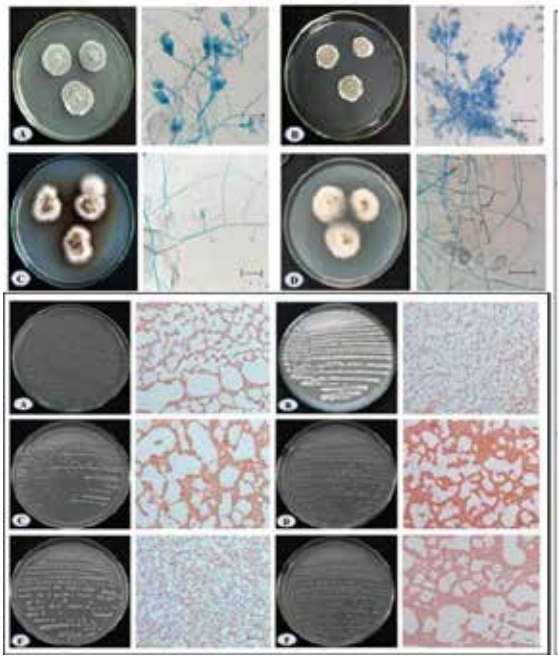


Fig. 21 (a) Colony morphology and microscopic image of endophytic fungi (bar=5 µm). (A) GBPI_beF1, (B) GBPI_beF2, (C) GBPI_beF4, (D) GBPI_beF5. (3b) Macroscopic (colony) and microscopic image of endophytic bacteria (bar=2 µm) (A) GBPI_be1, (B) GBPI_be3, (C) GBPI_be4 (D) GBPI_be5 (E) GBPI_be6 and (F) GBPI_be7

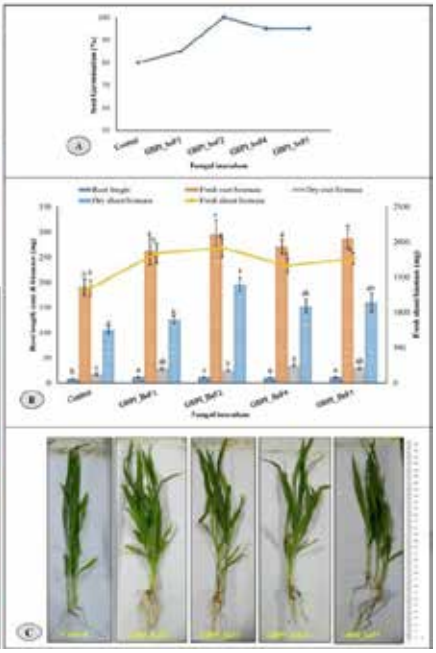


Fig. 22 Effect of fungal inoculation on growth properties of Zea mays. (A) Effect on seed germination; (B) effect on root and shoot length and biomass; and (C) Six-week-old plants (non-inoculated (control) and inoculated)). Alphabets in bar indicate significant difference ($p<0.05$) calculated using Duncan's multiple-range test. Values are represented as mean ± standard error (n= 15)

HIMACHAL PRADESH REGIONAL CENTRE (HPRC)

The broader vision of the Himachal Regional Centre (HRC) is to strive for excellence in research, assessing the effectiveness of policies in sustaining and promoting ecosystem services and empowering stakeholders for the conservation and management of natural resources in the Indian Himalayan region. Hence, the Centre undertakes innovative research on environmental problems and related knowledge intervention towards the sustainable development of the North-Western province of IHR. The HRC caters to the need of entire Himachal Pradesh state. The focus of the centre is entire Himachal Pradesh state covering parts of north western Himalayan Bio-geographic province. The region is recognized for its ecological and economic values manifested by ecosystem integrity, adaptability and ecosystem services. Its protective and productive functions for both upland and lowland dwellers are well known. As a result, 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; assessment of water resources; ambient air quality monitoring; eco-tourism; environmental impact assessment; sustainable rural livelihood and rural development; entrepreneurship and green skill development and capacity building of indigenous mountain communities. The broad objectives of the centre are (i) vulnerability assessment of biodiversity of Himalayan ecosystems in Trans and North Western Himalaya under biological, anthropogenic and climate scenarios for conservation and management, (ii) assessment, characterization and valuation of ecosystem services and natural resource management for sustainable development of the native communities, (iii) promoting environmentally sustainable income generating activities for livelihood enhancement and socio-economic development in the region, (iv) development and strengthening of institutional mechanism for information sharing and capacity building of the stakeholders for environmental management, (v) to build a body of scientific and traditional knowledge through demand driven action research and technological innovations, (vi) development of strategies for monitoring and management of water resources, ambient air quality under climate change scenario, (vii) assessment, monitoring and management of agricultural crops/farming systems for sustainability along an altitudinal gradient in North Western Himalaya, and (viii) assessment and sustainable management of eco-tourism through entrepreneurship development.

Identification of Elite Planting Material of Selected Temperate Medicinal Plants, Mass Multiplication, Field Demonstration and Post- Harvest Processing (DBT, New Delhi; 2018- 2022)

For centuries the local communities of Himalaya were considered custodians of natural biological resources and were freely accessing those resources for their day-to-day needs and livelihoods. However, the imposition of legal restrictions on the collection of medicinal plants from natural habitats has caused not only economic constraints on the local communities but also resulted in shortage of raw material for pharmaceutical and herbal drug industries. This shortage has led to illegal procurement, substitution and adulteration in raw material of medicinal plants. Therefore, production of quality herbal raw material by maintaining chemical/genetic purity would go a long way in providing a sustainable solution to the problem. In the present study, high value medicinal plants such as *Picrorhiza kurrooa, Nardostachys jatamansi, Rubia cordifolia* and *Swertia chirayita* have been selected for cultivation and conservation.

Objectives

1. Identification of elite planting material of Rubia cordifolia and Nardostachys jatamansi grandiflora as per API standards of Ayurvedic industries and contents of desired chemical constituents in herbal extracts from different locations of H.P. and Uttarakhand.
2. Establish Genetic Resource Centre of elite material for target species, *Swertia chirayita, Rubia cordifolia, Picrorhiza kurroa* and *Nardostachys jatamansi* at research stations of HPRC, Kullu, H.P.
3. Mass multiplication of already identified elite planting material of *Swertia chirayita* and *Picrorhiza kurroa*.
4. Optimizing post-harvest primary processing of herbal raw material of *Swertia chirayita* and *Picrorhiza kurroa*.

5. Training farmers for proper harvesting, drying, storage, and packaging of herbal plant material as per industry requirements.
6. Arranging buy-back mechanism and capacity building of primary growers to set up Marketing Federation.
7. Exposure visits of selected farmers to user industries and major markets.

Achievements

1. API analysis of *Picrorhiza kurroa* collected from different locations of Himachal Pradesh (2 from Chamba and one from Kullu) were carried out. The results are presented in Table 5. The results indicated that all the samples of complies as per specification of API in all parameters. On the basis of the API results, *P. kurroa* population of Sainj, Kullu was selected for raising the elite planting material.

2. Large scale cultivation of *Picrorhiza kurroa* medicinal plants was carried out at Kullu and Chamba district of Himachal Pradesh. Medicinal plant cultivators/farmers of Kullu district have cultivated endangered *Picrorhiza kurroa* in around 20 bigha land under the support of the project and earned around Rs. 15 lakhs during the year 2021 from the sale of *Picrorhiza kurroa* medicinal plant. Mass multiplication and large scale cultivation of *Swertia Chirayita* was also carried out at villages of Kullu district.

3. Around 8 Trainings programs were organized to sensitize around 160 farmers/medicinal plants cultivators on the cultivation and post-harvest processing of *Picrorhiza kurroa* and *Swertia chirayita* medicinal plants. Kutki material of Shangarh village was harvested by the progressive farmer. The entire process of post-harvest management process of Kutki was documented.

Table 5: API analysis of different population of *Picrorhiza kurroa* of Himachal Pradesh

Parameters	Specification as per API (Rhizome)	Chamba-1	Chamba-2	Sainj, Kullu
Identification (Macroscopic, Microscopic)		Complies	Complies	Complies
Acid Insoluble ash (% w/w)	NMT 1%	0.21%w/w	0.46%w/w	0.28%w/w
Foreign matter (% w/w)	NMT 2%	0.55%w/w	0.08%w/w	0.46%w/w
Water Soluble extractive (% w/w)	NLT 20%	31.92%w/w	31.24%w/w	41.35%w/w
Alcohol Soluble Extractive (% w/w)	NLT 10%	10.34%w/w	8.95%w/w	6.78%w/w
Total Ash (% w/w)	NLT 7%	4.49%w/w	3.15%w/w	5.25%w/w
Loss on Drying (LOD)		5.64%w/w	5.88%w/w	6.88%w/w

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

The West Himalayan Yew (*Taxus contorta Griff.)* has suffered a population decline of up to 90% in the IHR, mainly because of overexploitation for its medicinal properties, especially for the commercial extraction of the anti-cancer drug Taxol. The last population assessment of *Taxus* in Himachal Pradesh was conducted in 2008 in Khokhan Wildlife Sanctuary, and the current extent and possible locations of this species is not known. Hence there is a need to assess and map the current distribution using species niche modeling technique. There is an urgent need to develop and standardize mass multiplication protocols and plantlet establishment involving the forest department and the local people for successful planting for *ex-situ* conservation of

Taxus species. Such community based interventions would generate livelihood and income for the local people, conservation of endangered Himalayan yew, and this would develop into a self-sustaining conservation strategy.

Objectives

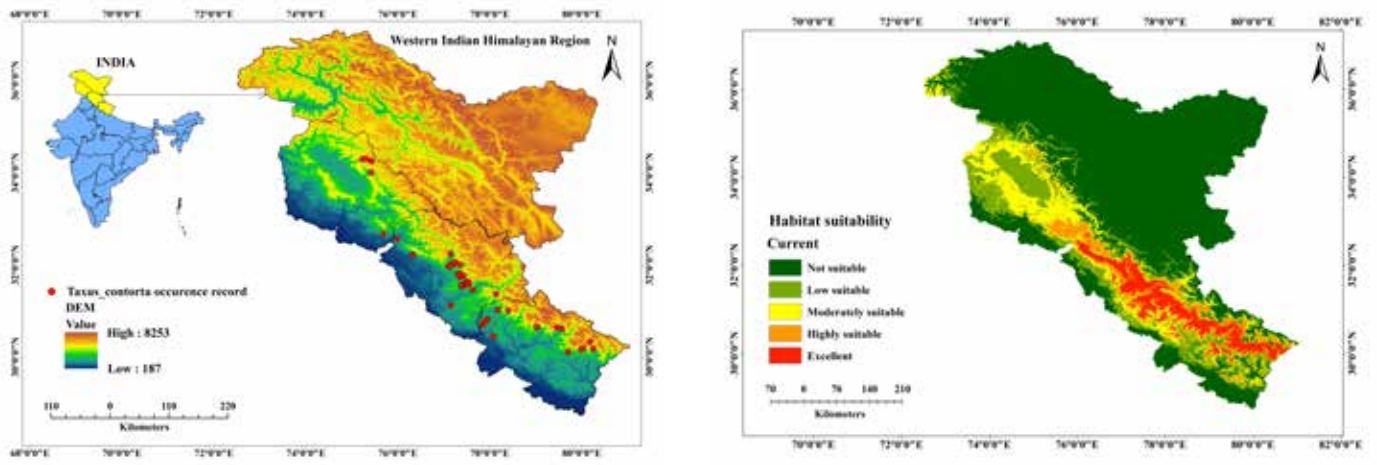
1. Assessment and mapping of populations of *Taxus* in Shimla and Kullu districts.
2. Investigation of the physicochemical and biotic factors associated with regeneration of *Taxus*.
3. Development and standardization of protocols for mass multiplication of *Taxus* and comparison of its phytochemistry relative to natural individuals.
4. Establishment of plantlets of *Taxus* involving the forest department and the local communities.

Achievements

1. Ecological niche modelling of *Taxus contorta* species was carried out for the identification of suitable habitats in the Western Himalayan region. Total 61 occurrence records were taken from primary and secondary data (Research papers, GBIF, Herbarium records). In order to remove the auto-correlation among the records they were spatially rarefied and a total of 30 records were used for modelling purpose. ENM data showed 4.73 % area comprising highly suitable area followed by 4.57 % area moderately suitable, 10.14% low suitable and 80.57% area not suitable (Fig. 23).

2. Technical support was provided to the Himachal Pradesh Forest Department on the mass propagation technique of *Taxus contorta* species. HRC has also developed around 15000 saplings of *Taxus* contorta cuttings at Dohra Nala and Mohal nurseries of the Institute.

3. A total of 05 awareness-cum-training programs were organized on the conservation and mass propagation of *Taxus contorta* for various stakeholders of different villages of Kullu district. Around 180 stakeholders were sensitized about the importance and conservation needs of *Taxus* species.



(a) Occurrence records of *T. contorta* **(b)** Habitat Suitability map of *T. contorta*

Fig. 23: Ecological niche modelling of *T. contorta* in the Western Himalaya

Ex-situ conservation and development of gene bank of commercially important threatened medicinal plants in the high altitude areas, Himachal Pradesh (GoI, 2019-2022)

The rapid increase in the demand of herbal species for preparation of different formulations against the treatment of various diseases was observed at the global level. At the global level, economic value of the medicinal plants and herbal medicines is estimated to be US$800 billion a year, and the same for traditional Indian system of medicine is about Rs. 4000 crores per year. Due to overexploitation and habitat deregulation, a large number of medicinal and aromatic plants are under different threat status. In India, at least 90% of the raw material is extracted from the wild population to fulfil the demand of pharmaceutical industry. Today the need for the conservation of commercial exploited

threatened medicinal species was much realized not only to reduce pressure on the forest wealth but also to increase opportunities for income generation, employment and earning foreign exchange. The Indian Himalayan Region (IHR) supports over 1748 plant species of known medicinal value. Himachal Pradesh has 643 medicinal plants, out of which 269 are native, 374 non- native, 17 endemic, 131 near endemic, 12 critically endangered, 21 endangered, 27 vulnerable, two near threatened and 3 data deficient recorded. Large-scale overexploitation from wild and habitat destruction of commercially important medicinal plant species of the Himalaya has resulted a considerable reduction in their populations. Therefore, *in-situ* and *ex-situ* conservation of these rare, endangered and threatened species of the region is very important. This study focuses on the conservation of three species namely; *Angelica glauca, Caram carvi* and *Arnebia euchroma*.

Objectives

1. Morphological studies of selected wild population and collection of different accession of selected commercially important threatened medicinal plants.
2. Establishment of a gene bank, field cultivation, chemical and molecular characterization of the target species.
3. Selection of elite accessions from the cultivated species, their multiplication (by conventional and tissue culture techniques).

Achievements

1. Survey was conducted in Tirthan Valley (Shrunger; 2363m, Shilhi; 2289m, Ghaliyad; 2336m) of Kullu and Rohtang Pass, different locations of Lahaul & Spiti (Gyspa; 3271m and Peukar; 3270m) and collected different accession of *Angelica glauca* from wild and from farmers field and sent to CSIR-IHBT Palampur for chemical profiling.

2. Nurseries raised were matured. Plants of Angelica glauca in the agricultural fields of Kullu district and Lahaul Valley survived till matured stage.

3. Plants of *Arnebia euchroma* was collected from the Darcha region of Keylong (3750m), and Peukar (3555m, 3871m) of Lahaul Valley and transferred to CSIR-IHBT, Ribling Centre, for further hardening and chemical profiling.

4. For the mass awareness among stakeholders and local people four training cum awareness programmes were organized during September and October, 2021. The seeds of *Caram carvi* were also distributed among the farmers for its cultivation in their fields/kitchen gardens.

Conservation and Management of Traditional Beekeeping *(Apis cerana)* Practices Through Development of Honeybee Based Sustainable Livelihood Chain in The Kullu Valley, Himachal Pradesh (NABARD, 2021-2023)

Beekeeping with indigenous honeybee (*Apis cerana*) is a century old practices in the most part of the Himalaya and also still being practiced in the selected rural areas of Himachal Pradesh. The Himalayan Honeybee (*Apis cerana*) is wild in nature and its colony prefers wild habitats i.e. tree trunks, rocks etc. Beekeeping is agriculture and horticulture based industry in which honeybees are kept and managed. In the last one or two decades there has been an apparent decline in the indigenous honey bee population mainly due to construction of modern houses, habitat degradation, heavy use of agro-chemicals, pesticides, climatic changes, introduction of European honeybees in hilly areas and lack of management practices. In India, Kullu valley is well known for the cultivation of more than 40 pollinator dependent cash crops. Therefore, to conserve these species in its natural habitat, while educating locals on its management and linking the activity with entrepreneurial activity, this century old practice can be revived in the region. This will benefit in terms of both economic and environment aspects while conserving the species.

Objectives

1. Conservation of declining populations of the indigenous honeybee (*Apis cerana*).
2. Plantation of prioritized highly preferred native honeybee plants.
3. Promotion of high demand and cost effective monofloral honey.
4. Promotion of 100% pure honey production using super chamber beehives in native honeybee keeping.
5. Value added enterprise development.

6. Awareness/capacity building for role of native honey bees' pollination aspect.

Achievements

1. Extensive field visits and interactive meeting with potential beekeepers of the panchayat were done and selected 120 beekeepers during the period. All the 120 beekeepers were imparted 2 days training on the various aspects of beekeeping, its management, division, harvesting and post harvesting techniques.

2. Trained beekeepers were given one active beehive individually with 70 % contribution under project and 30% from the beekeepers. Minor bee hive tools such as bee veil, brush, hive tool, gloves, queen cage, queen gate were distributed among the beekeepers. Honey harvesters were also given to the group for quality honey extraction.

3. Awareness and training programme on harvesting techniques of honey and other value added products were also organized.

4. One technical manual in Hindi on basics of beekeeping were developed, published and distributed among the beekeepers group.

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

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

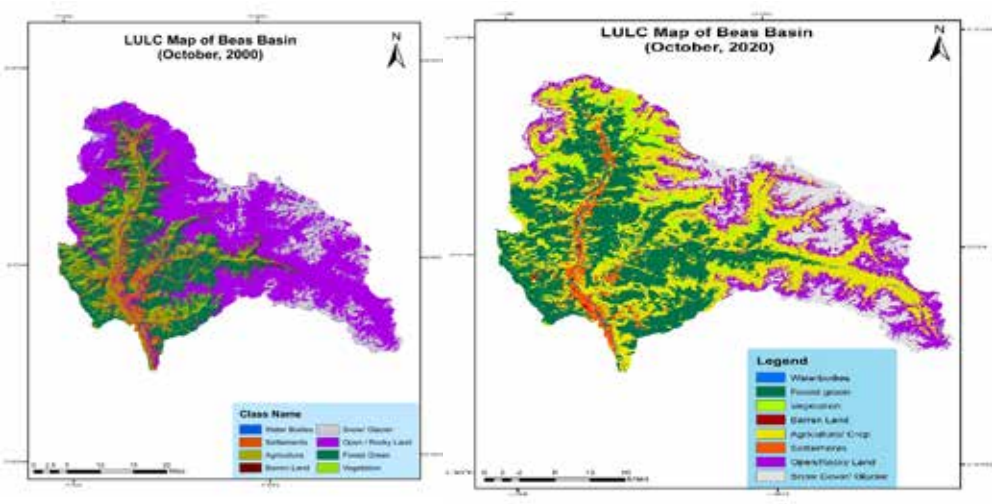
Objectives

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

Achievements

1. LULC change detection over 21 years revealed that a massive increase in agricultural land, including orchard expansion, of 123 % occurred during the year 2020 than that of 2000 in Beas Valley of Kullu district. Also, there's a sharp increase of 40.63 % in settlement areas which includes the tourism activities such as hotels, restaurants, etc. during the year 2020 than that of 2000. Moreover, it is also observed from LULC change detection wherein there was a sharp decline in the shrub vegetation and grassland comprising of about 45% during the year 2020 in comparison to 2000. Further, the forest green area and snow cover area during the year 2020 are declined by 5.61 % and 6.28 %, respectively (Fig. 24).

2. Temporal change detection of major air quality parameters using MERRA-2 reanalysis indicates that there was an increase of 15 % in the average monthly surface concentration of CO over 20 years. At the same time the spatial distribution maps of average monthly SO_2 column mass density showed a rise of 15.87 % in 2020 than 2000. Whereas, the average concentration of particulate matters such as PM2.5, PM10 showed a massive increase of 41.30 % and 60.32 % respectively in 2020 than that of 2000.



LULC Categories	Area in Sq. Km. (Oct, 2000)	Area in Sq. Km. (Oct, 2020)
Glacier/Snow covered area	331.6	312
Open/Rocky Land	1002.4	584.2
Water Bodies	26.3	15.6
Forest Green area	1063.2	1006.7
Vegetation/Scrub/ Grass land	194.8	134.4
Barren land	81	16.9
Built-up/ Settlements	96	135
Agriculture/Plantation Area	480	1076

Fig. 24: LULC maps of Beas Basin and change detection for year 2000 & 2020

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, and operational and management practices. After selecting suitable environmental mitigation measures, the cost required for implementing various management measures will also be worked out. An EMP for implementation during project construction and operation phases has been estimated to oversee the environmental safeguards, ascertain the agreement between prediction and reality, suggest remedial measures not foreseen during the planning stage but arising during operation, and generate data for further use. The Sainj Hydro-Electric Project (100 MW), a run of the river development on river Sainj, a tributary of river Beas in Kullu district and located at Neuly in Sainj Valley. It is located in the periphery of the Great Himalayan National Park. The main purpose of the EMP is to determine the project's environmental impacts and give an idea about how to mitigate the adverse impacts, their effects and their monitoring periodically after the project becomes operational.

Objectives

1. To assess the soil quality, erosion and siltation around Sainj HEP
2. To assess the change in migration pattern of aquatic and terrestrial fauna
3. To check the change in landuse pattern of the study area
4. To assess status of aquatic ecology
5. To identify the remedial issues and suggest suitable management options for the Sainj HEP

Achievements

1. Secondary data collection on Sainj hydroelectric project and its impacts on surrounding environment from different government and Non- govt. agencies were carried out.

2. Baseline preliminary data were generated.

3. Around 20 soil samples were collected from different locations from the study sites and analyses are being conducted.

4. Eight LULC categories were identified and used in current study using different temporal high satellite datasets.

Summary of Completed Projects/ Activities

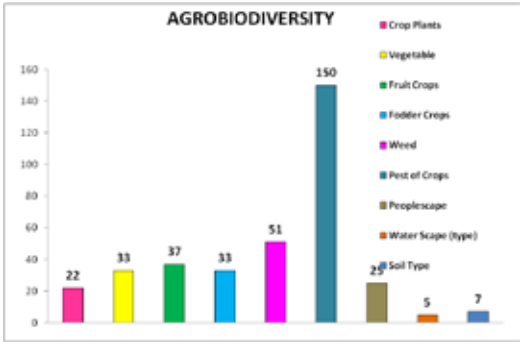
Preparation of Peoples' Biodiversity Register of Selected Panchayats in Kullu and Mandi District, Himachal Pradesh (Himachal Pradesh State Biodiversity Board, 2019-2021)

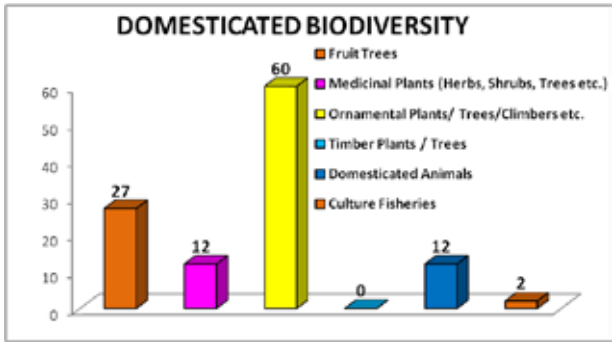
Following the National Biodiversity Authority (NBA) initiative, Himachal Pradesh State Biodiversity Board (HPSBB) Shimla has initiated the process of PBR preparation with the help of Technical Support Groups (TSG) at panchayat, block and district level involving Biodiversity Management Committee (BMCs). NIHE, Himachal Regional Centre is also identified as a TSG to develop PBR of selected BMCs of Kullu and Mandi district. The Kullu district of Himachal Pradesh lies at the 31° 20' 25" to 32°25' 0"N Latitudes and 76° 56 30" to 77° 52' 20"E Longitudes which covers an area of 5,503 km^2. Mandi district of the state lies at 31° 43' N Latitude and 76° 58' E Longitude covering an area of 3,951 km^2. Under the Phase II of the project, 22 panchayats of Kullu and Mandi district namely; Badagran, Bhalyani, Danogi, Gahar, Gojra, Karjan, Kothisrari, Malana, Manali, Nasogi, Palchan, Garda, Nau, Maloh, Bobar, Jaral, Salapar, Chhamyar, Lower Rewalsar and Neoli were selected for PBR preparation and final PBR of these panchayats has been submitted to Himachal Pradesh State Biodiversity Board, Shimla. PBR documents some of the important medicinal plants (Fig. 25) such as *Angelica glauca, Aster thomsonii, Bergenia ligulata, Dactylorhiza hatagirea, Delphinium denudatum, Geranium wallichiana, Taxus baccata, Trillium govanianum, Thymus linearis* and *Viola canescens*. In some of the BMCs some of the unique diversity of such as *Mengifera indica, Persea americana*, etc. were documented.

Fig 25: Biodiversity in different Panchayat of Kullu district

Preparation of Peoples Biodiversity Register of Kullu district with its representative blocks (Himachal Pradesh State Biodiversity Board, 2020-2021)

To conserve and protect biodiversity, National Biodiversity Authority (NBA) has initiated to develop Peoples' Biodiversity Register (PBR). Following the initiatives of NBA, Himachal Pradesh State Biodiversity Board (HPSBB) has initiated to document PBR at village, panchayat, block, district and municipality level in selected districts of Himachal Pradesh by Biodiversity Management Committees (BMC) and Technical Supporting Group (TSG). The present study was proposed in Kullu (31°13'50' to 32°04'30"N and 76°37'20" to 77°23'15"E) district of Himachal Pradesh along with all representative blocks. Kullu district is divided into 4 tehsils, 5 blocks and 172 villages covering an area of 5,503 km^2. According to Census, 2011 total population of the district is 4,37,903. The district is known for its breath taking beauty, snow clad mountains, beautiful forests, free flowing rivers, waterfalls, rich culture, local architecture and trekking routes. Major occupation of the people in the district is agriculture followed





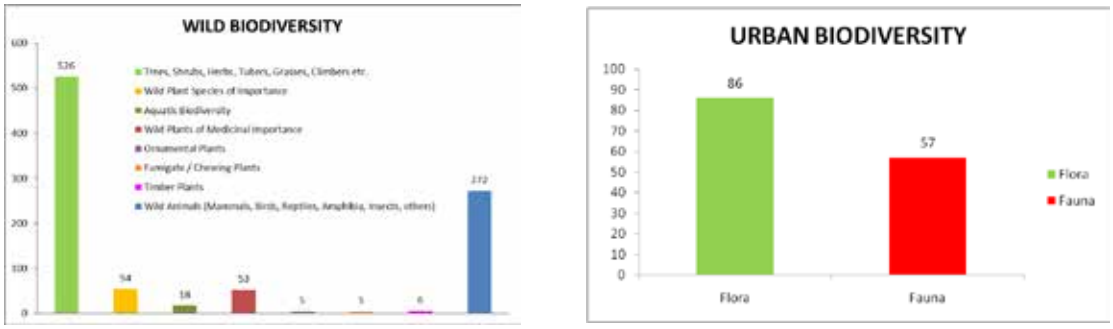


Fig. 26: General biodiversity of Kullu District

by horticulture and tourism. Forest area of the district is mainly temperate vegetation comprising broadleaved evergreen, deciduous and coniferous trees like *Cedrus deodara, Pinus wallichiana, Juglans regia, Aesculus indica, Quercus oblongata*, etc. In this context, PBR of Kullu district and its 5 blocks namely; Kullu Block, Naggar Block, Anii Block, Banjar Block and Nirmand Block were prepared and submitted the same to Himachal Pradesh State Biodiversity Board, Shimla (Fig. 26).

Development of sustainable rural livelihood options utilizing locally available bioresources through transformative rural technologies in the Indian Himalayan Regions of Himachal Pradesh and Sikkim (NMHS, GoI 2018-2021)

Seabuckthorn (*Hippophae* spp.) is a perennial, thorny bush with yellow or orange color berries found in the cold desert area of Lahaul & Spiti in Himachal Pradesh. The plant grows naturally in the region is rich in pharmaceutical, therapeutic and cosmetic values and is one of the major sources of multivitamins and food supplement. Despite of so many benefits, seabuckthorn plant is still being neglected in the region by local inhabitants mainly due to the unawareness and lack of technological interventions. Therefore, in order to create a mass awareness and value chain of the seabuckthorn in the region current project activity was being carried out. As a result, one Technology Incubation Centre was established in the region with all the modern facilities for the primary processing of the seabuckthorn products. Seabuckthorn leaves tea and berries pulp juice were developed (Fig. 27) and marketed through various regional or state level agencies. Geographical Indication (GI) of the species was also recommended for its uniqueness. For the overall sustainability of the seabuckthorn based enterprise collaborative efforts among the farmer group, society, government and scientific institutions, marketing agency is also recommended. Further, entrepreneurial activities of the seabuckthorn through scientifically proven methods can add to the overall socioeconomic development of the region through creation of niche market of the produce.

Fig. 27: Processing/Value addition of Seabuckthorn leaves and berries.

Microbial endophytes and soil enzymes as indicators of climate resilience with respect to Himalayan Birch: A critically endangered timber line species (NMHS, GoI 2018 – 2021)

Betula utilis represents unique association of plants and microbes. However, due to over exploitation, over grazing, natural calamities and changing environmental conditions, this economically important species has become vulnerable and habitat alterations have started taking place. The present study was conducted in two districts of Himachal Pradesh i.e., Kullu and Kinnaur. In Kullu, the

assessment of representative populations of B. utilis was done at 34 sites with altitude ranging between 2850 – 3760 m, amsl. The population assessment was done in Fozal valley (04 sites), Hamta Pass (16 sites) and Kheerganga (14 sites). Five tree communities namely, *Acer acuminatum, Abies pindrow, Betula utilis, Betula utilis-Abies pindrow* mixed and *Quercus semecarpifolia from Hamta Pass and Four (4)* tree communities namely *Abies pindrow – Quercus semecarpifolia* mixed*, Acer caesium – Abies pindrow* mixed*, Abies pindrow - Acer caesium* mixed and *Quercus semecarpifolia-Betula utillis* mixed community from Fozal sites. Five plant communities were identified from Parvati valley which are A*bies pindrow* community, followed by *Betula utilis, Taxus wallichiana, Pinus wallichiana* and *Taxus wallichiana - Abies pindrow* mixed. In Sangla valley of Kinnaur district total 22 sites were surveyed during the period. The sites were located between 3130–3619 m amsl. Total four (4) tree communities (*Betula utilis community, Pinus wallichiana, Salix denticulata* and *Betula utilis- Abies pindrow* mixed) communities were identified. Soil samples were collected from all the assessed sites of B. utilis populations in Kullu and Kinnaur District. The physico-chemical properties like pH, moisture content, percent organic carbon, available nitrogen, phosphorous and potassium were analysed. All the assessed populations of the Betula utilis had acidic type of soil. The forest communities near to human habitation were more vulnerable than the communities distant from the human habitation. Total 06 numbers of capacity building-cum awareness programs were conducted in Kullu, Kinnaur and Lahaul & Spiti districts of Himachal Pradesh.

Springshed management: A strategy for climate change adaptation through inventory and revival of springs (DEST, GoHP, Shimla, HP, 2018-2022)

Springs are the primary source of water in the Indian Himalayan Region (IHR) by which both domestic as well as agricultural water demands are meet out. Recent years witnessed the problem of drying of these springs due to climate change, disturbed hydrological cycle and developmental activities in hilly regions. The project was taken to carry our rejuvenation of the spring and suggesting the best land management options under threat of climate change in the Seraj and Barot valley of Mandi district. Village-wise water resource inventory was prepared with the help of GPS, Geo-referenced satellite data and field observations. The springs in the study areas did not contain any contaminants in its origin. All the spring-water physiochemical parameters like pH, TDS, EC, Ca_2^+, Mg^+, Cl-, F^-, SO_4^{2-}, NO_3^-,Na^+, K^+ were well within the permissible limit prescribed by BIS 2012 and WHO 2011. The measurement of discharge indicated that 75% of the observed springs had discharge less than average discharge value of 51 L per minute (lpm), 25% springs had discharge more than the average discharge value 51 L per minute (lpm) in Barot valley while in Seraj valley 74% of the springs had discharge less than the average discharge of 26 lpm whereas 26% of the springs had discharge more than the average discharge of 26 lpm. Sites for the intervention were selected in the study area on the basis of status, location, importance and people reception for the revival plan of springs in the Bari Jharwaar and Dharangan in Barot valley of Mandi district. In order to identify favorable regions for construction of artificial recharge structures, remote sensing and geographic information system (GIS) approach was attempted to delineate groundwater potential zones (Fig.28). A GIS approach was used to integrate five contributing factors: lithology, land cover/land use, lineaments, drainage, and slope. Subsequently, different intervention structure like construction of check dams, percolation pits and plantation of suitable species to augment the spring water discharge was carried out in the Bari Jharwaar and Dharangan in Barot valley with the help of local stakeholders and the state forest department.

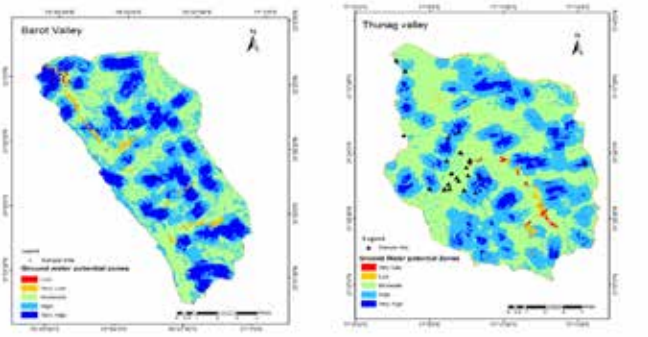


Fig. 28: Groundwater potential zone map

GARHWAL REGIONAL CENTRE (GRC)

The major R&D activities of Garhwal Regional Centre include model demonstration on restoration of degraded lands through action research, forest and agro-bioresource utilization for sustainable rural development, water resource management through spring sanctuary development, protected area management and people conflict resolution, eco-tourism, skill development of stakeholders on simple technologies for natural resource management and livelihood enhancement, etc. Some of the ongoing R&D thrust areas include climate change impact, adaptation and coping strategies, tracer technique in spring recharge, bioprospecting of wild resources, promotion and cultivation of medicinal and aromatic plants, sustainable tourism, conservation and management of protected areas and eco-sensitive zones and reconstruction of disaster-affected rural landscape of Kedar valley. The objectives of the centre include (i) Empowering communities in social, and local governance on natural resource management, (ii) Promoting environmentally sustainable income generating activities for livelihood enhancement and socio-economic development, (iii) Model demonstration on innovative, improved and best practices and skill development of farming communities through onsite action research and training, and (iv) Organizing an open and continuing dialogue between diverse stakeholders (local people, NGOs, scientists, educationists and policy planners) across societal strata for developing hill/ mountain specific policies.

Protocol for rejuvenation of springs in Uttarakhand with due preparedness for climate change (NMHS, GOI, 2020-2022)

Mountain springs are the primary source of water for rural households in the Himalayan region. A major proportion of drinking water supply in the mountainous parts of Uttarakhand is spring based. Despite their pivotal role, springs have not received their due attention. Many natural springs and water bodies are drying up. Spring discharge are declining due to mismanagement of recharge areas, land use change, and ecological degradation. Due to climate change theier is rise in temperature and precipitation patterns are also changing along with decline in winter rain, the problem of dying springs is being increasingly felt across Uttarakhand. The tradition recharge structures like old chal-khal and naulas are drying up. The concept of spring shed management entails that recharge areas be correctly identified through the use of simple field-based study of hydrogeology, community knowledge and appropriate recharge measures are then undertaken to revive the springs.

Objectives

1. Identification of depleting spring sources and geo-tagging of 160 springs in four selected developmental blocks (40 springs each) in two rain deficient districts of Uttarakhand. The criteria for selection of source will be maximum population coverage with maximum depletion in discharge.
2. Actual action plan for rejuvenating selected 4

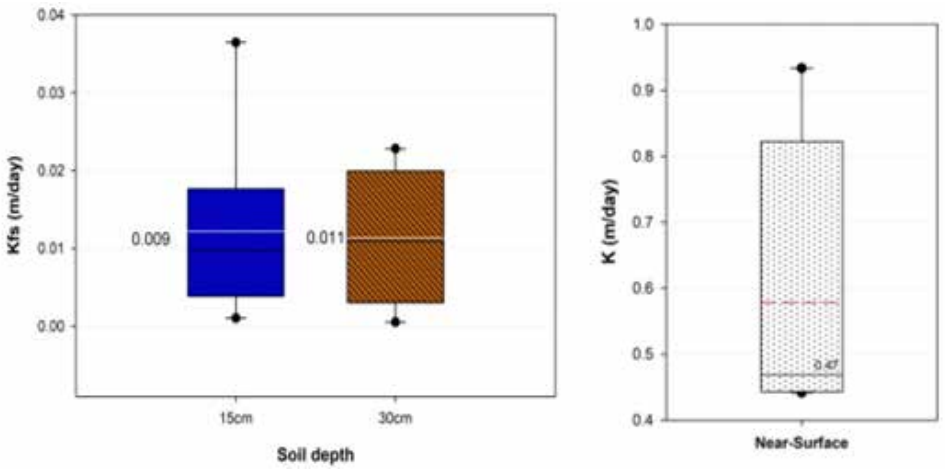


Fig. 29. The boxes of soil hydraulic conductivity represent the inter-quartile range, with the black line across each box indicating the median value. The white line represents the arithmetic mean, and the whiskers represent the 5th and 95th percentiles.

springs to test the efficacy of interventions in spring shed and to monitor during the project period.

3. Developing strategy for spring shed management protocol, its sustenance, protection and maintenance with active involvement of local communities and other stakeholders.

Achievements

1. Soil hydraulic conductivity measurements as well as soil texture analysis in the abandoned fallow land were measured using Mini Disk Infiltrometer (MDI), GUELPH Permeameter (GP) and sieve analysis. The in-situ near-surface as well as auger-hole up to 15 cm and 30 cm depth was used to measure reliable hydraulic parameters of soil formation overlying the fractured metasedimentaries (Fig. 29).
2. Details satellite-based mapping of catchment area, its landuse and spring inventory was carried out in the Kaphalna village spring catchment.
3. Findings withlimited observation highlight that the near-surface, topsoil and the sub-soil are showing very low hydraulic conductivity which indicate 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 watershed of western Nayar show rainfall intensity of less than 2.5 mm/hour(light intensity) dominates the monsoon rainfall event and likely to cause overland flow in most of the rainfall event under saturated condition of soil.

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

The Himalayan Mountain belt is a hub of freshwater and the terrain is these regions are potential for hydropower generation. New plans of hydropower projects always raise environmental concerns. The Himalayanregion is also known for its rich natural resources and varied ecosystems, both terrestrial and aquatic. The Himalayan diversity needs to be looked with special attention with respect to sustainabledevelopment in future. However, most of the Cumulative Impact Assessment (CIA) studies inIndia have been evaluated on the basis of hydrological approaches only. Some recent CIA studieshave advancements by habitat simulation including regional aquatic lifeforms, however notenough to complete the picture. Regardless of recognition of ecosystem components asdifferent aspects under consideration, the existing practices are still not based on it. This proposal is focused on development of standardized evaluation of CIA methodologiesby making an understanding on underwater and landscape micro-environments and impactsfrom hydrological extremities.

Objectives

1. To conduct Morphometric analysis of Kameng (Arunachal Pradesh) and Rispana (Dehradun) and Nayar River Systems using remote sensing and GIS techniques.
2. To manufacture low-cost robotic technology with sensors and communication systemfor measuring micro-environment underwater and nearby land surface ecology forinaccessible river reaches
3. To conduct physical hydraulic experiments for underwater micro-environmentcharacterization by measuring parameters (velocity, turbulence, temperature anddissolved oxygen (DO).
4. To improve Building Block approach of CIA by using long term hydrologic dataset andecological relationships for Himalayan Rivers.
5. To develop a Network Approach of CIA by considering landscape connectivity andimpact rating in Himalayan Catchments.

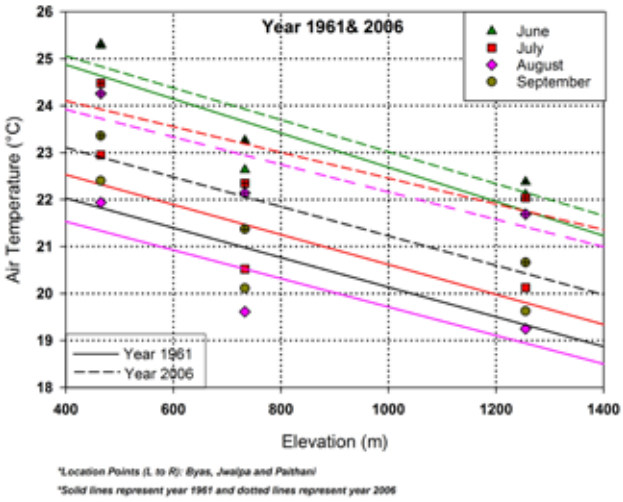


Fig. 30. Temperature Lapse rate chart highlighting the temperature variance with gradient change from June to September, for the year 1961 & 2006.

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

Achievements

1. Initial assessment of air temperature in Western Nayar River Basin till its confluence to Ganga River in Garhwal Himalaya was made using satellite-based temperature data (Aphrodite gridded and ERA5) for the years 1969 and 2006 to decipher the near-surface temperature lapse rate(TLR).
2. Monthly to biweekly year-round insitu water temeperature measurements for the year 2011 of W.Nayar, Nayar and River Ganga temperature were combined into average seasonal (pre-monsoon, monsoon, post-monsoon and winter) temperature data which indicate seasonal differences arise due to the snow-melt contribution during the pre-monsoon and monsoon season in the Ganga River whereas the river Nayar represents a groundwater-dominated system (Fig. 30).

Standardization of propagation protocols for mass multiplication, biochemical assessment and elite identification of *Malaxis muscifera* and *Malaxis acuminata* in Western Himalaya (NMPB, 2019-2022)

The Indian Himalayan Region (IHR) is well known for its rich biodiversity and socio-cultural heritage and unique ethnic diversity, which covers approximately an area of 4,19,873 Km^2.Due to the vanishing biodiversity of IHR, it becomes essential to generate a combined informational dataset covering all aspects of such plant species which are depleting rapidly or are at high risk of being extinct. Two such endangered species are *Malaxis muscifera* and *Malaxis acuminata*, which have been selected for the extensive study. Both the target species are medicinally important plants belonging to the family Orchidaceae which makes an important ingredient of the Ashtavarga group of plants and are used in the formation of many polyherbal ayurvedic formulations like "Chyawanprash". *Malaxis muscifera* is categorized as critically endangered species while *Malaxis acuminata* is categorized in endangered species by IUCN Red Data Book. During the second-year research period we have tried to cover maximum study sites for field exploration, germplasm evaluation, accessioning, morphological and ecological analysis and performed soil analysis of the samples collected from the study locations to have a detailed knowledge of all the necessary requirements needed for cultivation of the target species. Along with the above-mentioned work details, micro-propagation experiments using the tissue of the plant have been initiated for *ex situ* conservation of the species.

Objective

1. Exploration, population status assessment and germplasm collection of *M. muscifera* and *M. acuminata* in Western Himalaya
2. Identification of elite germplasm of *M. muscifera* and *M. acuminata* using qualitative and quantitative morphological and phytochemical variations
3. Standardization of micro-propagation techniques for elite germplasm of *M. muscifera* and *M. acuminata*
4. Development of domestication protocols for target species

Achievements

1. From all the enlisted/recorded sites, a total of fifty-two study locations, 40 for *M. acuminata* and 12 for *M. muscifera*, from 11 districts of Uttarakhand state have been covered in the survey and exploration for study till second year progress of project work. Along with the enlisted study sites, we have discovered eight new sites (Sirakot, Gangolihat, Mayawati Ashram, Jarmola, Radi top, Dol Ashram, Lweshal and Jakholi) in which M. acuminata is reported for the first time. This would be helpful in population assessment of the species. These species were also explored for morphological assessments.

2. As one important objective of the project work is to make cultivation trials/practices for the target species, therefore, soil analysis becomes an important step prior to cultivation practices. Soil samples have been analyzed for some physical as well as chemical parameters.

3. For *ex situ* cultivation, some individuals were planted in the open field area for evaluation in Triyuginarayan, District Rudraprayag, Uttarakhand. Till date the plants are surviving

well in the cultivated fields. For in vitro micro-propagation, experiments for callus induction followed by shoot regeneration and plantlets development have been started in the tissue culture laboratory of Garhwal Regional Centre, Uttrakhand. Some of the culture tubes have started showing callus growth which will later be used for in vitro plantlet development of the target species.

Characterization of Kidney Bean (Rajmash) Rhizosphere microbiome from Higher Altitude of Indian Central Himalaya and its Field Applications (NMHS, GOI, 2019-2022)

Kidney bean or Rajmash (*Phaseolus vulgaris* L.) is a high value cash crop in Indian central Himalayan region. Traditionally, Rajmash is mostly grown in the hilly region of Himalaya during kharif season with acreage of about 7350 hectares with production of 7358 thousand tonnes. The average productivity is 874 kg/hectare as compared to 1217- 1430 kg/ hectare in planes of India. Although, Rajmash is also cultivated in planes of India but local cultivar growing in hills are known for theirpremium quality, unique taste and nutritional values. But still no information has beendocumented for the impact of latitude or longitudes on Rajmash variety in Uttarakhand state. Only few studies have beenperformed on nutritional analysis of Rajmash variety in Uttarakhand. Presently, the farmers areunable to commercialize the crop due to low productivity. The reasons for low productivity arephosphate and nitrogen deficiency in soil, lack of genetic resources and poor agronomic practices. Nevertheless, department of Microbiology has carried out in depth genomics and proteomicsstudies of kidney bean rhizosphere microbiome from higher altitudes during the last decades.Based onthe past experience, it is being proposed to select commercial Rajmash land races that are highly adapted to local climatic conditions. Furthermore, characterization and exploration ofrhizospheremicrobiota from kidney bean (Rajmash) growing in higher altitude can lead toenhanced soil health and productivity levels. Therefore, introduction of bioinoculants and diseasemanagement can provide livelihood security to hill farmers.

Objectives

1. Selection of highly adapted kidney bean cultivation sites
2. Field demonstration of elite cold adapted bioinoculants
3. Monitoring, yield assessment and documentation
4. Determination of Rajmash rhizosphere micro biome at selected sites

Achievements

1. Morphological assessment of 152 accessions (raw & cooked) of Rajmash and biochemical assessment (nutritional) of Rajmash accessions for carbohydrate (152), antioxidant activity (152), protein (80), proline (100), and methionine (130) have been completed.

2. Application of bioinoculants (MP1 & N26) showed improvement in Rajmash yield in comparison to the untreated samples in the year 2021 as well but the production was reduced due to infection and heavy rainfall at the time of flowering.

3. Genetic diversity assessment of 119 Rajmash samples using chloroplast microsatellite markers showed considerable amount of genetic diversity which will further aid to identification of elite variety of local Rajmash from Uttarakhand.

4. Three training programs have been organised under NMHS project to generate awareness among farmers regarding the use of bioinoculant to promote cultivation of high altitude Rajmash with the great participation of 111 farmers (24 men & 87 women).

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 depended on natural resources for their livelihood. Endowed with rich natural resources, Sikkim Himalayan region form 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 feature, environmental issues of the region are at the forefront of the scientific debate. Further, over-extraction and utilization of the natural resources demands immediate measure to reverse the trend of degradation. Besides, it also needs strengthening, participatory management, enhancement of livelihood and self-sufficiency and policy review/ analysis and capacity building. Considering the abovementioned priorities of the Sikkim state, Sikkim Regional Centre of the Institute has been working on environmental and socioeconomic issues of the Sikkim Himalaya which includes 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.

Khangchendzonga Landscape Conservation and Development Initiative (KLCDI)-India (ICIMOD; 2017-2021)

The Khangchendzonga Landscape (KL) is one of six transboundary landscapes identified by the International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal in the Hindu Kush Himalayan region. With a unique transnational destination, the KL covers a total area of 25,085.8 km2, shared by India (56%), Bhutan (23%), and Nepal (21%), offering life support systems to over 7.25 million people (87% in India, 11% in Nepal and 2% in Bhutan).It facets many challenges and posing collective opportunities towards the common interests, such as human-wildlife conflicts, limited livelihood options, natural resources management, and climate change. The KL-India covers an area of 14061.7 km2 with altitudinal gradients of 40-8586m which comprises Sikkim state and northern part of West Bengal (Alipurduar, Darjeeling, Jalpaiguri and Kalimpong). The region comes under the biodiversity hotspot having significant floral (4500-5000 species) and faunal (> 4000 species) diversity as a home of many endemic and threatened species.

Objectives

1. To improve ecosystem management system and conservation of natural resources through inclusive and equitable benefit sharing of local bioresources, community-based approaches, and economic valuation and incentive mechanisms
2. To enhance well-being of women, men, and children living in the landscape
3. To strengthen local and national level mechanisms for evidence-based decision-making processes through long-term environmental and socio-ecological monitoring; and
4. To strengthen regional cooperation for transboundary landscape management in the Khangchendzonga Landscape

Achievements

1. A total of three nursery beds have been prepared by applying proper agro-techniques for propagating large cardamom through seeds. Besides, 4000 suckers have been selected from high performing cultivars (Varlengy and Sawney) and planted in the nursery beds prepared in Yuksam, West Sikkim, in order to produce high quality distribution material.

2. To strengthen the ongoing document focusing culture and traditions of Lepcha community, practitioners of traditional bamboo based product making were interviewed through field survey and/or virtual meetings organized under KLCDI-India programme. The interview indicated that the population of main Goopey bans

(Cephalostachyum sp.) is decreasing in the wild which needs a conservation priority in order to sustain this bamboo based craft.

3. Carried out morphological characterization of existing large cardamom cultivars. A total of 20 villages of KL-India including Sikkim and Kalimpong district of West Bengal were surveyed. So far, 252 flowering plants and 1200 flowers were monitored to collect flower morphology. From the investigation, it was observed that the cultivars like Ramsey, Sawney, Varlangey, Seremna and, Dzongu Golsey are commonly grown across the sites (Table 6).

4. Strengthened mechanism for long-term environmental and socioecological monitoring (LTESM), the established automatic weather station (AWS) is continuously logging the climatic data from the Dzongu pilot site. In the year 2021 monitored LTESM site and collected AWS data. Based on the observations, the maximum mean temperature was observed in the month of September (21.96 ºC) with average maximum temperature (27.93ºC) and average minimum temperature (18.62ºC). The average relative humidity value was recorded maximum in the month of August (98.35%) and minimum in the month of February (80.11 %). The Precipitation was recorded maximum in the month of July (2219.2 mm) and minimum in the month of January (26.8 mm).

Table 6. Morphological characterization of flower for large cardamom cultivars

Cultivars	Elevation range (m)	Flowering month	Flower colour	flower/ spike	Bud/ spike	Lower lip midrib colour	Upper tip colour	No. of petals
Varlangey	900-2100	April-May (<1500 m) & June-July (>1500 m)	Yellow	1-6	13-55	Dark orange	Green	4
Seremna	1100-2100	March-May (< 1500 m) & June-July (>1500 m)	Yellow	1-4	30-60	Light orange	Green	4
Sawney	1000-1900	April-June	Yellow	1-4	19-47	Bright orange	Green	4
Ramsey	1300-1900	March-April (<1400 m) &May-June (>1400 m)	Yellow	1-3	20-60	Orange	Green	4
Golsey	500-1300	March-April	Yellow	1-4	14-30	Yellow	Green	4

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

Sikkim state is located in the adobe of Eastern part of Himalayan biodiversity hotspot, which is rich in floristic biodiversity. However, lack of awareness on biodiversity results in management and therefore it is imperative to educate and create awareness among diverse stakeholders towards nature conservation. There have been few scanty initiatives taken by various departments towards creating awareness and sensitizing people on nature conservation; these are often isolated efforts and thus need a concentrated and focused efforts through a dedicated Nature Learning Centre (NLC). Keeping in view, a NLC is being established at Pangthang campus. The major activities of the NLC include, development of learning model and knowledge products,

capacity building of stakeholders on nature conservation; development of conservation and demonstration site for different representative taxa of the region; promotion of citizen science approach for conservation education; and create a cadre of nature enthusiasts in the state through capacity building.

Objective

1. To develop a learning and interpretation centre for biodiversity conservation through various interactive models.
2. To develop and demonstrate best practices on sustainable models such as forest management practices, waste management, composting, water harvesting, etc
3. To promote participatory conservation action and efficient utilization and management of natural resource base for livelihood generation
4. To promote eco-tourism for biodiversity conservation for livelihood generation
5. To build capacity of diverse stakeholders on conservation of resource base and develop of knowledge product for dissemination and awareness generation

Achievements

1. Strengthened Orchid trail by adding Orchid species to the trail in the arboretum of SRC. The trail currently houses 51 orchid species, of which 11 belongs to *Dendrobium,* 7 *Coelogyne, 6 Bulbophyllum,* 4 *Epigeneium,* 3 *Cymbidium and Otochilus,* 2 *each of Liparis, Eria, Pholidata and Pleione* and 1 each of *Acampe, Agrostophyllum, Cleisostoma, Cryptochilus, Gastrochilus, Oberonia, Thunia, Uncifera* and *Vanda* genus respectively. Further, a *Rhododendron* trail has been initiated with 11 different *Rhododendron* species in order to facilitate ex situ conservation of *Rhododendron* diversity of the State (Fig. 31). Additionally, to promote conservation and sustainable utilization of medicinal plants, a total of 40 species of medicinal plants belonging to 25 families, 35 genera have been conserved in herbal garden.

2. A long term study plot is established inside the arboretum/ NLC of SRC with the aim to (i) inventorize the flora and imparting knowledge on vegetation assessment, (ii) Long term phenological study of the tree species, (iii) Plant biomass study, (iii) Carbon stock estimation, (iv) Soil and litter analysis. A plot of size 100m x 50m is demarcated inside the arboretum inside which five subplot of 10 x 10 m^2 are demarcated for study on trees, 5 x 5m^2 for shrub and saplings and 1 X 1 m^2 for herbs.

3. A network of students and teachers has been created connecting students and eco-club In-charge of four schools and one college. A WhatsApp group has been created wherein students and teachers of eco-clubs of schools and colleges are encouraged for nature conservation and awareness on participatory conservation efforts. Through the established group, regular interactions, online workshops, competitions, nature camps, etc., are conducted with the students of eco-clubs.

Figure 31. Development of Rhododendron trail in SRC, Pangthang, Sikkim

Summary of Completed Projects/ Activities

Promotion of Sustainable Community Based Tourism in the Khangchendzonga Landscape: Linking Livelihoods with Nature Conservation (NMHS, GoI 2018-2021)

Tourism development in the Indian Himalayan Region (IHR) has experienced continuous growth. Thus, tourism promotion and development in IHR can diversify local economy through employment opportunities and by engaging locals in income generation activities. However, large scale tourism promotion and development in IHR poses threat to the natural and cultural heritages. Therefore, to bring tourism into the main stream of development agenda, it needs to consider region-specific opportunities and challenges. Further, to introduce sustainability into the discourse of tourism development in IHR invites different forms of tourism those can intervene in areas such as; equity, efficiency, innovations and carrying capacity. This discourse was brought into the Khangchendzonga Landscape (KL) of IHR by the implementation of this project. The Indian part of KL harbours 17 protected areas, including recently inscribed the Khangchendzonga National Park a UNESCO World Heritage Site, rangelands and alpine-pastures, rich biodiversity and ethnic diversity. Hence, it sets a suitable platform to introduce community-based tourism in the landscape to generate employment, income and conserve local cultural and natural heritages.

Objectives

1. Assessment and promotion of community-based ecotourism with equitable benefit sharing;
2. Strengthening community-based tourism by integrating traditional knowledge; iii. Promotion of sustainable tourism through integration of (i) Livestock and horticulture, (ii) handicraft products and
3. iii) knowledge management of water resources; and build critical mass of informed and skilled youth for harnessing tourism potential and working for conservation of nature through sensitization and capacity building.

Achievements

1. Developed ecotourism based recourse maps of three pilot sites (3 Nos.), Bio-resource mapping and database (2,345 plant species) and stronger networking among ecotourism service providers. Organized eco-tourism based festival (3 Nos.) and Showcasing of crafts/ethnic items for promotion of eco-tourism and provided various training (12 nos.) and Certificate course (2 nos.) in different aspects to local peoples for livelihood enhancement.

2. For strengthening the community-based ecotourism, region-specific best practices and developing the Homestay model, 8 training programmes was organized at Dzongu and Barsey-Singhalila pilot sites of Khangchendzonga Landscape with the support from KLCDI programme.

3. A total of 879 (485 Females & 394 Males) stakeholders were benefited through various aspect of capacity building/training programme of this project and 31 beneficiaries were able to generate income at Rs. 10,000-12,000/ month during the peak tourist period (April-June & Sep-December).

NORTH EAST REGIONAL CENTRE (NERC)

The North-East Regional Centre (NERC) of the institute has been functioning from Itanagar, Arunachal Pradesh since 1997 (previously in Nagaland since 1989). The entire NE region is known for its rich diversity of flora, fauna, socio-cultural, linguistic and ethnic communities. The local communities possess rich indigenous knowledge in 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, warranting to develop viable, replicable and effective community based resource management initiatives to conserve it. To conserve the biodiversity as well as ensure sustainable utilization of the resources, the NERC has been working on the following focal research areas include (i) People-Centreed 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 building to local people of North-East India through training, demonstration and knowledge products.

ICIMOD funded Project: "Landscape Initiative for Far-Eastern Himalaya (Hi-LIFE)" (ICIMOD; 2018-22)

The Far-Eastern Himalayan Landscape is one of the most intact and rich trans-boundary biodiversity landscapes that stretches over an area of 71,452 km2 across three countries i.e. China, India and Myanmar. It is recognized as a "Centre of Plant Biodiversity" and "Eastern Asiatic Regional Centre for Endemism" and is the meeting ground of three global biodiversity hotspots namely Himalaya, Indo-Burma and Mountains of Southwest China. A total of eight important PAs are present within the landscape out of which four are trans-boundary in nature. Besides this, the landscape is a rich eco-cultural zone, with various micro-cultures living together. The HI-LIFE landscape in the Indian region that includes the Namdapha National Park (NNP) and other adjacent PAs harbors a number of endemic/threatened species of which some are keystone species such as Tiger, Hoolock gibbon, Takin etc. Besides this, a variety of ethnic communities reside in and around Namdapha National Park (NNP) viz. Singphos, Tangsas, Tutsas, Lisus, Nochtes, Oeories, Tibetans, Chakmas, Hajongs, Mishmi, Nepali etc. A number of sacred sites (protected for worship) are also found within the park. In recent times the region is becoming an attractive spot for eco-tourism especially for sports tourism (with the introduction of Rafting Boats and Angling rods). With such rich biodiversity and diverse cultures, effective measures need to be taken towards strengthening of park-people relationships and promoting both conservation of resources of the park as well as livelihood of the communities living in fringe areas. The addendum of Letter of Agreement (LoA) was signed between NIHE and ICIMOD in the year 2021 with the prospect of developing an integrated eco-tourism model and capacity strengthening of concerned stakeholders through training, demonstration, exposure trips and activities.

Objectives

1. Enable resilience-building of local communities through improved delivery system of strengthened network of institutions that promote inclusive livelihood approaches, green technologies and skill building following mutually inclusive conservation and development principles at landscape scale.
2. Enhance understanding of biodiversity resources, socioeconomic status, and how ecosystem goods and services are used by the

communities and conservation partners for effective management of the landscape.

3. Improve biodiversity conservation and ecosystem management through capacity building, promoting new technologies and approaches, institutional strengthening
4. Bring inter-sectoral convergence and develop partnership for achieving common shared vision of integrated landscape management.

Achievements

1. Towards improving the homestay facilities in two selected villages viz. M'Pen II (2 nos.) and Lama village (3 nos.); besides provision of basic requirements for homestay functioning such as bedding items, crockery items etc., running water facility was also provided to the homestay beneficiaries. Framed signboards were also set up in the 5 home-stays to facilitate tourists. In addition, two huts were constructed near the riverside of Noa-Dehing for tourists to enjoy the scenic beauty of the area that would help in enhancing eco-tourism development in the region.

2. During field survey period, information was collected on market rates of 29 locally grown food itemscultivated (16 nos.) and non-cultivated (13 nos.). Information on seasonal vegetables (19 nos.) and paddy varieties (25 nos.) in six selected villages were also collected along with their sowing and harvesting period.

3. During the field period i.e. October to December, 2021; documentation of different ethnic cuisines of varied communities was carried out. A total of 21 cuisines were recorded: Tangsa = 2 nos., Singpho = 3 nos., Chakma = 10 nos., and Lama = 6 nos. This study would help to improvise the local food systems and agro-biodiversity, local economy growth and health of communities.

4. A programme on 'Linkages with Tourism Operators' was organized on 9th November, 2021 at Namdaphajungle camp, Miao in which homestay beneficiaries and local tour operators were invited. Through this interactive session, tour operators agreed on bringing in tourists to the area for sight-seeing, bird-watching and other sports tourism such as river rafting and angling and also for halting purpose in the homestays. This would result in more inflow of tourists as well as proper functioning of the homestays. In this way, a mutual benefit linkage was established between the local tour operators and homestay beneficiaries (Fig. 32).

5. Awareness related programmes such as 'Sustainable Mountain Tourism' and 'Wildlife and their significance towards eco-tourism development' was conducted on 13th and 16th December, 2021 respectively among villagers and students tosensitizethem to conserve the mountain biodiversity and endemic/threatened species harboring the area to enable tourist attraction and mountain tourism. This would also help in local youths attain employment that would uplift the socioeconomiccondition of the inhabitants.

6. Distribution of river rafting boats (2 nos.) and angling rods (2 nos.) with necessary accessories to the selected beneficiaries on 15th December, 2021 in the presence of Tourism Information Officer (TIO) of Miao and local NGO partner (SEACOW).

7. A six days workshop was conducted on 'Resource Mapping using PRA tools' from 31st October to 5th November, 2021 across six selected villages viz. M'Pen II (7th, 8th & 9th mile); Lama, Bodhisatta I and Bodhisatta II respectively. During the survey, it was recorded that due to poor storage facility, farmers were shifting from paddy to Areca catechu cultivation which requires less management and has long-term benefit facility.

Fig.32: Development of Integrated Eco-tourism Model in HI-LIFE project site

LADAKH REGIONAL CENTRE (LRC)

Ladakh became a Union Territory on the 31st 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 as cold desert. The region is endowed with rich diversity of culture, unique biodiversity elements and significantly large wetlands/water bodies (lakes). Although, the communities inhabiting these areas have adapted for extremely harsh climate and resource poor living conditions, they face numerous challenges. Especially under changing climate scenario, when impacts are expected to be more intense in higher altitudes, the Trans Himalayan landscapes and people are likely to face more severe challenges. This calls for 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 scenario. 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

Natural Resources based Livelihood Options and Off-farm Employment in Rural Landscape of Ladakh (In-house, 2021-2022)

In the high altitudes of Ladakh (usually above 3000m asl) the growing season for plants is restricted between April to September, thus, agriculture is confined within this period. However, Ladakh is largely devoid of natural vegetation (often referred to as Cold Desert), and some of the natural/ grown plants (i. e., Sea buckthorn, Fescue grass, Salix, Poplar, etc.) are available at many places, and cultivation of Apple and Apricot is common. Various local products are in use from these natural resources initially used for self-consumption and few have begun commercialization on a smaller scale. So, the main aim is to utilize time (other than agricultural activities) available with village women of Ladakh in developing skills through hands-on training /value addition techniques to utilize locally available natural resources in their surroundings.

Objectives

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

Achievements

1. Skill development through hands-on practice and on-site trainings to villagers and self-help groups were provided in two districts (Leh and Kargil) of Ladakh UT (Table 7) which include mushroom cultivation through simple low-cost inputs (8 villages), value addition and introduction to new products (Apricot and Seabukthorn - 2 villages), and basket/dustbin/container making through twigs of shrubs (1 village, Fig. 33). Total beneficiaries were 278 individuals and training duration ranged from 1 to 8 days.

2. Hands-on trainings and field demonstrations of low-cost portable polyhouse for extended cultivation designed by the Ladakh Regional Centre were conducted at various places (villages and organizations) for adoption and dissemination of knowledge. Total such 9 demonstrations and training on making were conducted which were participated by 133 individuals/members of Women Self-Help Groups.

Table 7:Hands on trainingconducted in different villages of Leh and Kargil districts.

S.No	Type of Training/Village& Locality	Participants (no)	Duration
A	**Mushroom cultivation**		
1	District Leh – Stok,Sumoor,Chamshen,Shenam, Skara	88	1 Day
2	District Kargil - Khumbathang, Kanoor, Minjee	107	1 Day
B	**Apricot &Seabuckthorn – Value Addition**		
4	District Leh –Wanla,Matho	77	1 Day
C	**Making of Basket, Container, Dustbin, etc.**		
C	District Leh –Matho	10	8 Day

Fig.33: Hands-on training cum practice on making of various products from local shrubs

Low- Cost Farming Techniques for Extended Cultivation in Ladakh (In-house, 2021-2022)

Most of India's cold arid area (90% to be precise in Ladakh) remains cut-off for more than five months during the winter season. Major populations are socially and economically marginalized and are more vulnerable to food shortages due to isolation. However, Ladakh imports high volume of vegetables and fruits from other parts of the country but most of the people of Ladakh do not have much access to leafy and fresh vegetables during winters, which may lead to nutritional issues. To overcome the production and availability issues during winters, there is a need to develop some innovative and low-cost technologies, and also create additional livelihood opportunities in the region.

Objectives

1. To develop additional rural livelihood opportunities through simple and low-cost technologies in cold arid environment.
2. Strengthening approaches to address issues of limited agro-cultivation.
3. Exploring new avenues for extended cultivation during harsh winters.

Achievements:

1. In continuation with successful experimentation of low-cost portable polyhouse in the winters of 2020-21, focus was on improving heat retention capacity using various low-cost materials. Consequently, additional inner cover through woolen blankets in Polyhouse (P1) and bubble wrapping, (P2), and by warming the polyhouse through heat generated by three barrels of organic compost (P3) and hot air from adjacent vermi-composting bed and inside cover of blankets (P4) was made. Daily Air temperature was monitored from October 2021 to March 2022 which showed marked difference (usually above zero) in all the treatments from that of ambient temperature (Fig. 34). For a very short period, daily air temperature in polyhouses was observed below zero degree.

2. In extended period of winters (till 26 November 2021) growth in transplanted leafy vegetables (Mungol, *Beta vulgaris* subsp. *vulgaris*, and *Pakchoi*, *Brassica rapa* subsp. *chinensis)* in P1 polyhouse was observed. Average leaf length

increased (1.8-3.98cm) in different plants of Mungol between 15 Oct and 26 Nov 2020 while in Pakchoi this length was observed between 1.38cm and 1.71cm in different plants. Similarly, leaf width was also increased in both the crops (1.3-2.6cm for Mungol, and 0.92-1.27cm for Pakchoi). It was observed that old leaves of a plant died during harsh winters but plant remained alive and new leaves appeared.

3. Floricultural crops were grown in three different temperature retention experiments (polyhouse -30 bulbs, and low tunnels within that polyhouse made of bubble wrapper- 35 bulbs and normal polythene- 35 bulbs) during winters (bulbs sown on 2 December 2021) to realize the potential of bulbaceous crops (saffron and lilium) in warm soil (Fig. 35).The first appearance of lilium was on 10 March 2022 in both the tunnels,while in polyhouse itappeared on 20 April 2022. Germination percent of lilium bulbs was more in the low tunnel made of bubble wrapper (45.7%). Germination in Saffron bulbs was first appeared on 5 Feb 2022 in both the tunnels but in contrast to lilium more germination (60%) was occurredin tunnel made of polythene.

4. An experiment was set up in collaboration with Himalayan Geo-Energy Private Limited who constructed a poly-carbonate enclosure around a geo-thermal activity (hot spring) in Chumathang (4350m amsl). The temperature in the enclosure remained above 25° C and below 45° C for rest of the five months during extreme winters in Tibetan plateau (Chumathang) where usually ambient temperature remained below -18°C in peak winters.

Fig. 34: Air temperature (daily average oC) during extreme winters (7th October 2021 - 25th March 2022). For abbreviation, please see text.

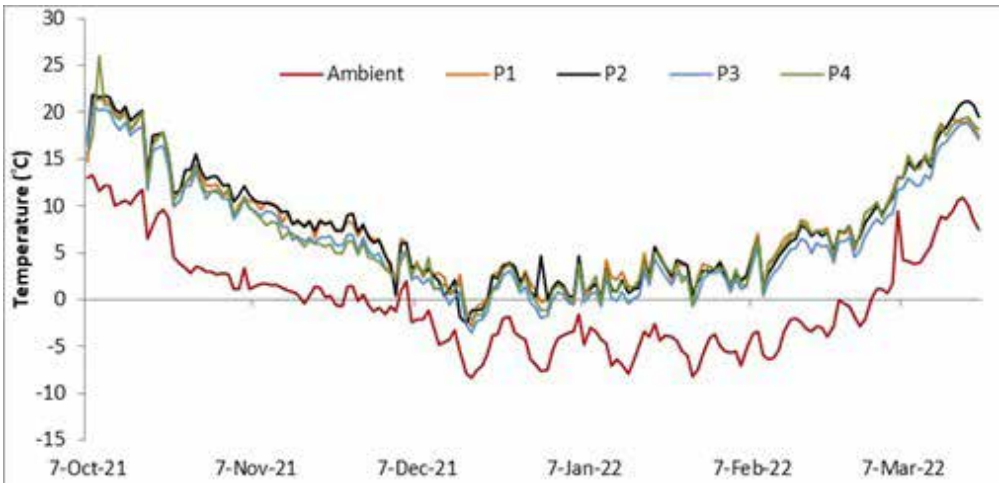


Fig. 35: Soil temperature (daily average oC) during extreme winters (November 2021 - March 2022) in two tunnels and polyhouse. For details, please see text.

Rural Technology Centre-Leh (RTC-Leh)

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 educational facility for the local people and others visiting to Leh town for various purposes, and LAHDC-Leh provided ~0.25 ha land with fencing for developing a "Rural Technology Centre (RTC)" within the Council Secretariate Complex. After the removal of pandemic restrictions work was started and RTC was made functional by the Ladakh Regional Centre on 19 August 2021. Initially the area was highly degraded barren land filled with flood debris of Ladakh disaster 2010. Subsequently, through various interventions and re-habitation mechanisms, Rural Technology Centre (RTC) had emerged as a knowledge Centre for education and awareness to harness the rural livelihood opportunities through natural resources. At present, RTC is attracting various stakeholders i.e., policy makers, farmers, entrepreneurs, students, academician, etc. RTC hosts variety of technological demonstrations, natural products, and local plants for education and awareness purposes.

Objectives

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

Achievements

1. Development of low-cost simple technologies for extended cultivation and alternate livelihoods was the main aim of the RTC. A low-cost (total cost Rs 13,000/-) portable polyhouse with dimensions 10'x30'x7' was designed with locally available material. Besides, demonstrations in RTC included cultivation of vegetables in shaded low-tunnel, bio-composting units, drip-irrigation, integrated pest and nutrient management, intensive crop cultivation, integrated mushroom cultivation with vegetable, etc. (Fig.36), and attracted various visitors (Fig. 37) since 19 August 2021.

2. Keeping in with the paucity of arable land and limited cultivation season, an independent Solar-Powered Hydroponic model was developed which was housed in portable polyhouse. Thus, total cost of model reduced substantially. This model was used to cultivate different vegetables and medicinal plants. Tomato, Cucumber, Bottle Gourd (fruity vegetable crops) were grown in soilless medium (hydroponic) to demonstrate efficacy in land scare areas and in manipulated environment. Germinated seedlings of tomato were transplanted to hydroponic pots on 3 June 2021, and first harvested done on 20 September 2021. Total tomato production was 14.59 kg (average 0.70 gm + 0.33 gm per plant). Cucumbers were first harvested on 13 August 2021 and total production was 4.58kg from (average 0.65 gm + 0.93 gm per plant). Bottle Gourd was first harvested on 20 September 2021, and total production was 2.20kg (average 0.44 gm + 0.88 gm per plant).

3. Two species (*M. longifolia and M. peperita*) of a

Fig. 36: Different glimpses of new RTC-Leh (a) Portable Polyhouse (self-fabrication, low-cost, locally available material) for integrated farming, (b) Integrated Pest and Nutrient Management, and (c) Independent Solar-Powered low-cost Hydroponic Cultivation

medicinal plant (Mentha sp.) were grown in the hydroponics (water as medium) to realize the cultivation potential for commercial demand as well as conservation measure. Three harvests were done from two pots of each species in the month of 10th August, 21st September 2021 & 20th October 2021. Total yield (fresh biomass) in each harvest was 3.9 kg, 1.2 kg & 1.7 kg for *M. longifolia* (total 6.8 kg), and for *M. peperita* it was 3.2 kg, 2.7 kg & 1.3 kg (total 7.2 kg) for three harvests from 2 pots of each species over the period of four months. The plants were multiplied through vegetative propagation.

4. "Herbal Garden" having 22 high value medicinal plants, germplasm from Ladakh, Uttarakhand and Himachal Pradesh and "Mini Arboretum" with 8 important tree species were developed.

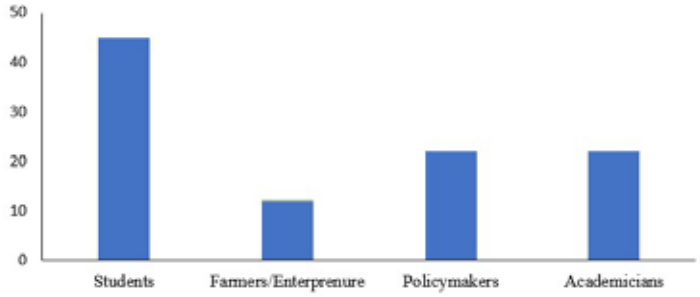


Fig. 37: Type of visitors to RTC, Leh (August 2021 to March 2022). The y-axis shows number of visitors.

Addressing Water Scarcity through artificial Ice Reservoir through Peoples' Participation (Inhouse, 2021-23)

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

Objectives

1. To demonstrate participatory approach in providing solutions to local problem as water availability for various purposesin this case.
2. To demonstrate local adaptation strategy, implement location specific modifications, andcapacity building of the villagers for green area development.

Achievements

1. Mapping of need assessment and resource requirement was done with villagers of Yulkham and Ursi village on the request received from Councillors of LAHDS-Leh, and making of artificial glacier was selected as the activity. In creating artificial glacier, participatory approach was adopted and contributions were identified at the initial stage of planning for creation of artificial ice reservoir during winters (commonly known as artificial glacier). Logistics, technical know-how, and monitoring were done by the Institute, and ground work was executed by the villagers for creation of artificial glacier (Fig. 38).

2. At Yulkham village volume of the glacier reached to a maximum of 495.75 cubic meter at the end of the eleventh week (77 days). On an average 21,940 l/day of water from artificial glacier was made available to the village during a total of 110 days from 3rd March 2021 to the complete melting of the glacier on 23rd June 2021. Beside

the physical achievements (i.e., additional water, timely availability, and area brought under plantation) major outcomes of the initiative were capacity building of villagers (21 households, 103 individuals) in making of artificial glacier (without any energy investment) through modified location specificsolutions and developing irrigation infrastructure.0.2 ha of barren area brought under plantations in 2021 (to meet futuristic wood and fodder requirements) and additional area is planned during 2022, additional con-benefit accrued in 2021 was recharging of groundwater.

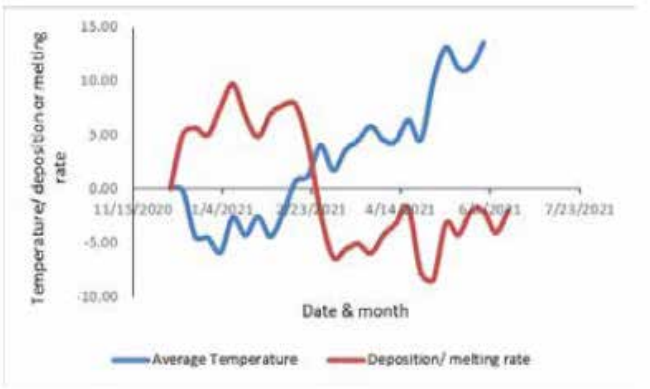


Fig. 38: Relationship between air temperature (^{0}c) and deposition melting rate (Cu. m./ day) of artificial glacier at Yulkham Site.

Sustainable Development: Prioritization of Issues and Environmental Education (In-house, 2020-2023)

Development of knowledge products and outreach programs are prerequisite for environmental education to achieve environmental and economic sustainability. Education and discussion dialogue are two pillars to address issues of sustainable development in the region. Various activities were initiated in this year with diverse stakeholders to realize path of the sustainable development in the Ladakh.

1. Under the Azadi Ka Amrit Mahotsav, an effort to develop policies for sustainable development for Ladakh UT, collaborative workshops were organised in collaboration with 'Ladakh Autonomous Hill Development Council, Leh'. Efforts are made for solid waste management (Reducing single use plastic in Ladakh: Options and Challenges") under the campaign "Awareness programs to avoid the use of single use plastic". Prof R. Vasudevan, Padma Shri, (often known as Plastic Man of India) elaborated modern technological innovation under the concept of 'Waste to Wealth' and provided different possibilities like efficient waste segregation, disposal, management and use of the plastic as an economic source in construction industry. Expansion and sustainability of tourism in Ladakh was addressed through a meeting on Sustainable Tourism in Ladakh: Opportunities and Needs with stakeholders of the tourism industry and policy makers. Sustainable practices and responsible tourism was identified to achieve sustainable tourism in Ladakh.
2. For sensitization and education awareness about ecology and sustainable development in Ladakh, various programs were organized in collaboration with other organizations. To realize Ladakh as a habitat of global importance for birds and its unique richness, different experts of the country elaborated on migratory birds found in Ladakh and experienced were shared by local birders on diversity of the migratory birds of Ladakh. A book entitled "A comprehensive Account of the Birds of Ladakh" has been published as field guide for general public and bird enthusiasts. On issues related to desertification in Ladakh, experts elaborated on potential technological interventions and role of education in ecological restoration of the cold desert landscape of Ladakh. Second Himalayan Popular Lecture: Ladakh series was on the theme "Water: Pollution and remediation"by Prof. S.K. Mehta, Vice-Chancellor, University of Ladakh. Published lecture, booklet, was disseminatedfor general awareness. Among the mass awareness activities, exhibition on Wildlife of Ladakh and Environment Photographer Award 2021 were made in the market of Leh Town, and various competitionswere organized for students.

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

Tourism is considered among the most dynamic economic activities that generate 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 community. Tourism has both the 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. Aim of the study is to assess tourism carrying capacity of Leh Town to provide baseline information and strategic suggestions to formulate policies, and action plan for development of sustainable tourism in Union Territory of Ladakh.

Objectives

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

Achievements:

1. Ladakh became a Union Territory on 31 October 2019 after the reconstitution of the erstwhile Jammu and Kashmir state as separate entities.The high-altitude region of Ladakh UT attracts both domestic and foreign tourists, is being emerged as an important global tourist destination. However, due to rapid anthropogenic pressure on account of increases in urban populations, enormous seasonal tourist inflows, ever-increasing hospitality industry operations and an influx of a huge migratory labour force during the summer season, generation of waste is major concern.

2. Strategic location hindered it for many years

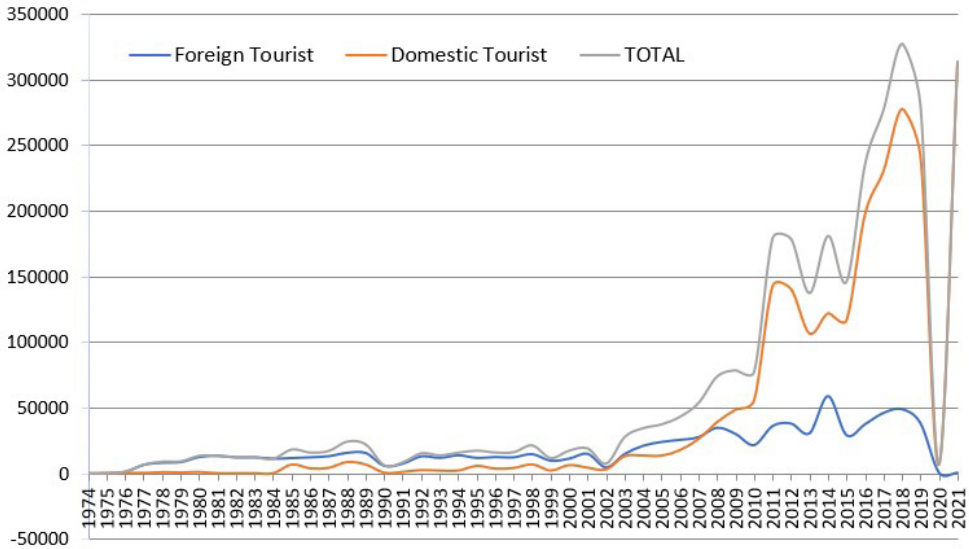


Fig. 39: Growth of tourists in Ladakh UT (Source: Directorate of Tourism, Ladakh UT)

for tourists and opened in 1974 for tourism purposes. Since then, the tourism industry is largely contributing to revenue and employment generation, and its recognized potentials are the creation of employment opportunities and the generation of income on a large scale. Prime attractions are physical (landscape, wildlife, lakes, adventure, winter sports, etc.) and socio-cultural environments (monasteries, heritage sites, etc.). In 1974, when the area was opened for tourists, nearly 527 visitors travelled to the Ladakh region and most of them were foreign travelers (500 in number) while domestic visitors were only 27. This trend continued till 2008 when the number of domestic tourists surpassed the number of international visitors (Fig. 39). Since 2010, Ladakh is witnessing a several-fold increase in the number of tourists and reached above 3,00,000 persons in 2021.

3. A workshop was organized on the theme "Sustainable Tourism in Ladakh: Opportunities and Needs" with stakeholder of the tourism industry in Ladakh, and recommendations in the form of a policy brief was released by the LAHDC-Leh, Department of Tourism, Ladakh UT. A documentary on "Scope of Wildlife Tourism in Ladakh" was aired.

Summary of Completed Projects/ Activities

Characterizing Patterns and Processes of Alpine Ecosystem in Indian Himalaya (Space Application Centre, ISRO, 2016-2022)

Alpine landscape has highest level of sensitivity to changes in temperature as they are thriving at the threshold of their climatic limits. Least influenced by anthropogenic activities the alpine ecosystems can be considered as "natural laboratories" for observing changes due to climatic fluctuations. In the alpine ecosystems the transition zones (ecotones) are most sensitive spots and changes can be observed there in minimum turnaround time. This study was carried out to understand the alpine ecotone structure and function through space based and in-situ observations and to assess nutrient dynamics along elevational gradient in alpine treeline ecotone. For study of treeline ecotone, Two HIMADRI sites were selected namely, Nan Pakhwa (NPK) and Pakhwa (PKW) situated in Bageshwar district of Kumaun Himalaya. Total 96 species, 70 herbs, 18 shrubs and 8 tree species were reported from overall study sites. Similarity indices studies revealed that within treeline ecotone, species composition in case of herbs, shrubs and trees highly differs while going from below treeline to alpine meadow, maximum dissimilarity was reported in between above treeline (i.e., meadows) and below treeline and similarity in vegetation gradually decreased on going from below treeline to alpine meadows or above treeline plots. Similarity indices also revealed similarity in vegetation of north and west aspects as well as in between vegetation of south and east aspects. The nestedness component i.e., β-sne was found to be biggest contributor to the overall dissimilarity, nearly similar values of total dissimilarity i.e., β-sor and turnover i.e., β-sim was recorded in all cases, which indicated that the dissimilarity between species among all aspects of both study sites is generally because of richness difference i.e., nestedness and less importantly because of species replacement i.e., turnover. Tree density varied between 12.50 and 227.50 ind. ha-1 in allover the study sites. Total basal area of trees varied between 1.36 and 56.02 m2ha-1. Both tree density and tree basal area was reported lowest above treeline sites. Regeneration status showed poor regeneration above treeline of PKW, fair regeneration at treeline of PKW and good regeneration below treeline of PKW. In NPK site regeneration showed a different pattern with fair regeneration at above treeline as well as at treeline and good regeneration below treeline plots, which indicated upward shift of treeline at NPK site in future. In the present study, total tree biomass ranged from 1.36 to 56.02 t ha^{-1}. To the total tree biomass, trees of NPK site contributed 50.9 % and remaining 49.1% biomass to total tree biomass was contributed by trees of PKW site. Like tree density, density of shrubs also reported lowest above treeline sites. Mean cover of herb species ranged from 76.8% to 91%, mean cover of herb species showed an increase with decreasing elevation i.e., reported higher below treeline sites as compared to above treeline sites. Soil properties also showed variation with elevation. Soil temperature, pH, bulk density and total potassium of soil decreases with elevation while soil moisture, water holding capacity, total organic carbon, total nitrogen, total phosphorus, soil microbial biomass carbon and soil microbial biomass nitrogen was reported increasing with elevation. Analysis of leaf traits of dominant tree species showed positive correlation between chlorophyll-a, chlorophyll-b and leaf dry matter content. Leaves of *A. spectabilis* were reported with highest leaf water content and total carbon content. Leaves of *Q. semecarpifolia* were reported with highest specific leaf area, leaf dry matter content and total nitrogen content. Highest chlorophyll content was reported for the *R. barbatum* followed by *R. arboreum*. Fluctuating trend of leaf traits was reported in both sites without any linkage of elevation. The study was able to establish three long term monitoring sites in the alpine region of Kumaun Himalaya and continuously monitored soil temperature since 2015. Patterns of expansion of woody vegetation in the alpine region of the Himalaya were identified where aspect and soil contributed to the biodiversity of the region.

MOUNTAIN DIVISION REGIONAL CENTRE (MDRC)

Considering the importance of the Himalayan region as a unique treasure of environmental goods and services and a rich repository of biodiversity, including cultural and ethnic diversity, and realizing its sensitivity to natural disasters, climatic and anthropogenic perturbations, MoEF&CC has established a dedicated unit as "Mountain Division", the 6th centre of NIHE within the MoEF&CC. The Mountain Division addresses 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 a group of project based studies are launched through Himalayan Research Fellows and Associates.

Assessment of Managed Spring Recharge as a Sustainable Solution to Water Scarcity in Sikkim Himalaya: Adaptation to Climate change (Mountain Division, 2021-24)

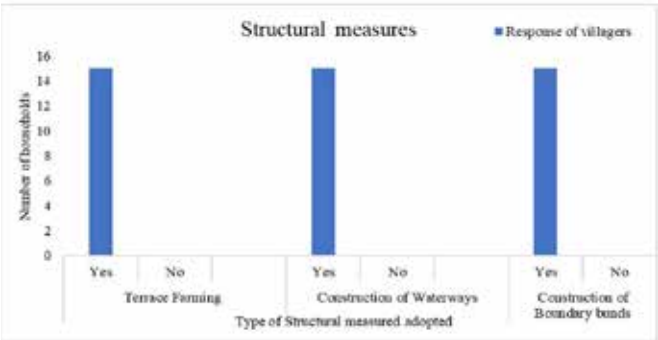
Mountain springs, the primary source of water for rural households in the Himalayan region, are drying up due to increased water demand, land use change, and ecological degradation. With climate change and rising temperatures, rise in rainfall intensity and reduction in its temporal spread, and a marked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

Objectives

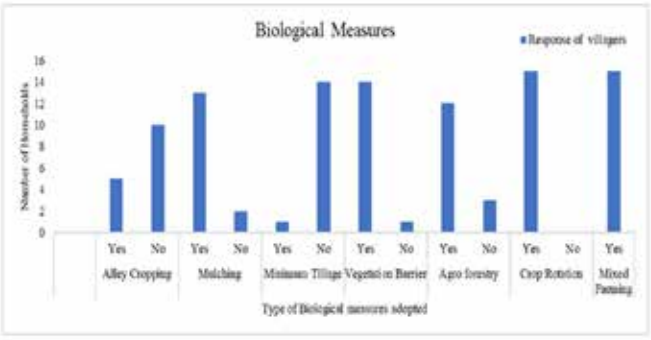
1. To document good practices of water conservation in Sikkim Himalaya as adaptation to climate change
2. To study water balance (demand - availability) and water governance of selected spring sheds and analyze factors of spring outflow drying
3. To assess effectiveness and cost benefit of managed spring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

Achievements

1. Sixteen (16) different indigenous soil and water conservation practices, adopted by the communities in Sikkim, are complied, and literature review based evaluation of the documented practices has been accomplished (Table 8). Primary survey-based 10 different good practices of water conservation from the study site (Alley village) in South Sikkim (Fig. 40) and people's perception on climate change and its impacts on water resources have been documented. The people's perception on climate change was validated with the published station data of rainfall for South Sikkim.
2. Selection of spring(s) and springshed for the detailed study has been completed. Primary data on pattern of water demand-availability for the Alley village springshed has been collected. Water governance with a focus on the role of institution towards management of water resources in the study site has been investigated.
3. A systematic review on approaches for cost-benefit analysis (CBA) has been completed and the methodology for CBA of managed aquifer recharge activities was drafted.



(a) Structural



(b) Biological

Fig 40. Soil and water conservation practices adopted by communities in Alley Village, South Sikkim

Table 8. Evaluation of Soil and Water Conservation practices in Sikkim Himalaya

Practices	Effectiveness	Replicability	Main Strength
Terraces	+	+	Prevent soil erosion
Bunds/contour bunding	*+*	*+/0*	*Prevent soil erosion and nutrient loss*
Construction and maintenance of waterways	+	+	Irrigation, diversion of surface runoff
Gully control	+		Availability of plant species and stones
Diversion channels	0	0	Adequate channel slope
Stone barrier	0	0	High availability of stone
Alley cropping	0		Utilization of each parcel of land
Mulching	+	+/0	High availability of mulching material
Minimum tillage	0	0	Protects soil erosion and moisture retention
Crop rotation	+	+	Soil fertility
Mixed cropping	+	+	Good crop cover and diversified production
Vegetative barriers	+	+	Runoff control and provides fodder and fuel-wood
Agroforestry	+	+	N2 fixing and runoff control
Spring-shed development (Natural springs)	+	+	Ground water recharge, major source of drinking water
Farm yard manure (FYM)	+	+	Availability of dung and organic material
Green manure	+	+	High availability of plant species

Policy imperatives of socio-economic development related environment-friendly rural technologies promoted by NIHE across the IHR: Prospects and constraints (Mountain Division, 2022-24)

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

Objectives

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

Achievements

1. Literature reviewed on the various rural technologies popularized by RTC (GBP-NIHE).

2. Review of the feedback forms available at RTC(NIHE) since 2001 was carried out and analyzed for willingness of stakeholders for adoption of technologies to come up with the suitable technologies in the mountain region. Technologies adopted by the stakeholders are presented in Fig. 41.

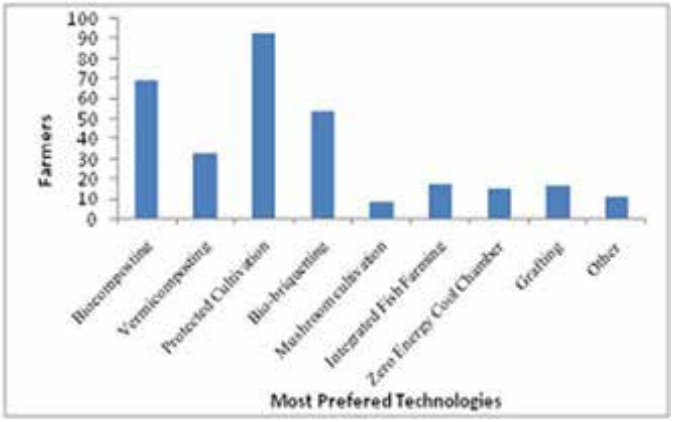


Fig. 41: Technology adoption by stakeholders

Springs Ecosystem in Uttarakhand Himalaya: Boundary Protocol for Rejuvenation Policies (Mountain Division, 2022-24)

Spring is one of the most important sources of fresh water. The Indian Himalayan region is source to million springs which are also source to many big and small rivers in this region. People in the Himalayas, heavily depend on the springs for household, livestock and irrigation water needs. Various studies conducted in the last few decades have reported that the discharge of the springs in general has declined and the quality of water has also degraded due to the changing 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 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 has 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. Ministry of Jal Shakti, GoI, 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 in view of the anthropocentric approach. A healthy spring possesses great potential for thriving healthy ecosystem. This study focuses on the restoration of spring dependent ecosystem and its dynamics.

Objectives

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

Achievements

1. Collection and compilation of springs database wass completed. Indicators of springs ecosystem services was been identified and methodology for delineation of ecosystem boundary based upon different services (provisional, regulatory, supporting and cultural) was developed.

2. Based upon the identified indicators, GIS based Layers for regulator; support and cultural services was developed. However, influence area of spring's ecosystem was worked out based on leaf area index (LAI) as a proxy used for springs impact of leaf area index (Fig 42), the task of delineating boundary for provisional services is under process.

3. After the careful quantification and verification of each ecosystem service, production of total ecosystem map is under progress which will be developed via spatial model and would be standard for delineation of springs ecosystem in Himalayan region.

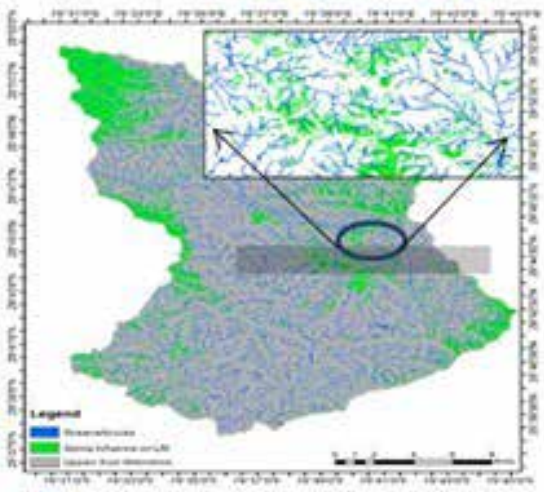


Fig 42: An overview of Ecosystem boundary layer based upon Leaf area Index in Upper Kosi Watershed

Carrying Capacity Estimation of Tourism in Leh Town Complex in Ladakh (Mountain Division, 2021-24)

Tourism is one of the fastest growing sectors across the globe. During the last few decades remarkable growth has been seen in the global tourism industry. Ladakh is no exception to this global trend where the influx of tourism has increased many folds during last few decades. The year 2021 has made history in terms of surpassing all previous records of tourist's arrivals in the region with 3.1 Lacs tourists. Every place has a carrying capacity in terms of number of tourists it can serve without compromising on quality of tourism and the local environment. For sustainability of tourism, each tourist destination must have their carrying capacity assessed with the aim to check exploitation. The proposed study is therefore planned to understand the role of tourism, perception mapping of diverse stakeholders in Leh Town, and identification of critical factors for sustainability of town and its environment. In this study a geo-spatial database, using crowd sourcing, for spatial planning and management in vital sectors of Leh Town will be developed to support the decision-making process and for planning and management. Status report on carrying capacity of tourism on the basis of critical factors will be developed with an orientation towards environmental sustainability of Leh town. It is expected that output of the project will provide a framework for action plan and guidelines for sustainable tourism in Ladakh region to achieve environmental sustainability in tourism and allied sectors of Leh town complex.

Objectives

1. To understand the role of tourism, perception mapping of diverse stakeholders in Leh town, and identification of critical factors for sustainability

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

Achievements

1. In the initial phase of the project, the study was focused on collection of secondary data from different offices and departments of Leh district of Ladakh i.e., Tourism Department (for tourist arrival/departure data and No of Hotels/ Home stays registration data), Municipal Committee (solid waste generation data), Airport Authority (for tourist arrival/departure data), ARTO (vehicle registration data), Forest Department (for Fuelwood consumption data), Public Health Engineering Department (for water consumption data), Deputy Commissioner (for revenue collection data from tourist), etc.

2. As per compiled data analysis on tourist inflow in Ladakh over the years, it was noted that the tourism industry in Ladakh is 48 years; to date around 30,87,753 tourists have visited Ladakh which comprises 8,88,348 foreigners and 21,99,405 home tourists (Fig 43).

3. After showcasing the tourism potential in the year 2009 through media, a significant increase in domestic tourism in Ladakh was recorded. However, the tourist flow decreased in 2020 due to the outburst of global pandemic Covid 19.

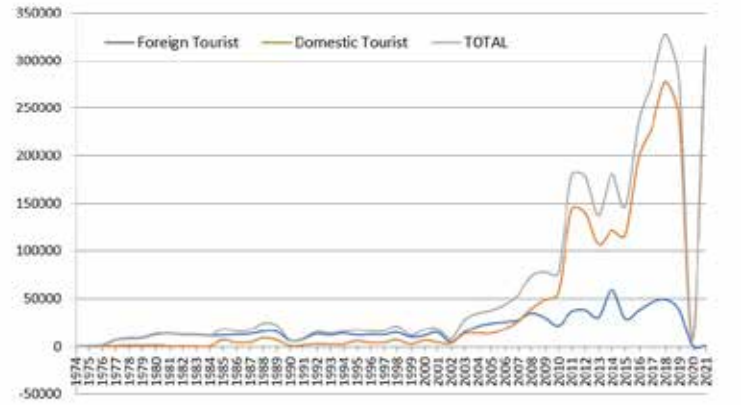


Fig. 43: Tourist flow (Domestic and Foreign) in Ladakh from 1974 to 2021

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

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, concept of livelihood enhancement, livelihood diversification, and alternative livelihood needs to be a part of conservation projects or policies. Considering this, the present study is proposed to analytically review the existing policy arena along on biodiversity landscape in the Indian Himalayan Region (IHR) along with documentation of successful bio-resource based livelihood models.

Objectives

1. Collection and compilation of National and State level policy documents with respect to biodiversity conservation.
2. Analysis and synthesis for development of National and State level policy chapters through review and consultative workshop.
3. Documentation and analysis of successes stories on bio-resources based enterprises through individual consultation.
4. Recommendation for strengthening the policy landscape.

Achievements

- A preliminary data on 27 numbers of National policies/rules/acts and 41 numbers of State level policies/rules/acts with respect to biodiversity conservation of Uttarakhand and Himachal Pradesh were collected.

- Information on the National/State level policies/rules/acts with regards to forest, wildlife, air & environment, water, wetland and farmers & seeds were collected. However, the analysis is under process. Programmes were organized to motivate farmers for medicinal plant cultivation and conservation.

Understanding the Process of Change in Far-Eastern Indian Landscape Linking With Conservation and Management (Mountain Division, 2019-23)

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

Objectives

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

Achievements

1. Chakma and Singhpho communities are more dependent on handicraft as compared to other communities of the district such as Lama, Lisu,In 2. In Chakma community there are various types of handicraft products made by bamboo and cane, some of them are: Bera, Bareng, Halung, Tholoi, khurum, Hasingetc. In every household the daily used products are made by the people living in the household only. Chakma people also make some agriculture tool which are used in agriculture, such as Nangol, Jungol (used for ploughing). Along with that fishing nets are also prepared by the Chakma community; these are called as Phasi-Jal (winter time) and Hub jal (summer time).

3. Based on the survey, a cost benefit assessment was also carried out for handloom and handicraft products of the local communities. Table 9 gives detail information on cost of production and selling price (in local market) of 14 different such items. The cost-benefit analysis clearly informs that after adding labour and raw material costs, the craftsmen are selling the items on very low cost and hardly any income for their skill.

4. As per the field observations it was found that a total of 28 agriculture crops (including fruits and vegetables) are being cultivated in the agriculture fields (settled and jhum) which are used for food and medicinal purposes.

Table 9: Cost analysis and selling price of important handloom and handicraft items prepared by local communities of Changlang district (Arunachal Pradesh).

S. No.	Name of the Product	Raw material & its quantity	Cost of Raw material (Rs.)	Man-days required (Per Unit)	Selling price
1.	Bareng (Basket)	Bamboos (6 nos.)	50/- per unit	2 to 3 days	400/-
2.	La bareng or Halong	Bamboo (5 nos.)	50/- per unit	10 days	800/- to 1000/-
3.	Bera	Bamboo(1 no.)	50/- per unit	2 days	60/- to 70/-
4.	Tholoi (Bamboo Mat)	Bamboos(6 no.) 4 * 6 inch	50/- per unit	12 days	1000/- to 1500/-
5.	House building satai (Bamboo Mat)	Bamboo (30 nos.) 6 * 7 inch	50/- per unit	1 day	
6.	Bijon (Hand fan)	Bamboo (1 no.) for 11-12 piece	50/- per unit	1 day	40/- to 50/-
7.	Hulo	Bamboo (1.5 nos.)	50/- per unit	4-5 day	500/-
8.	Salon	Bamboo (1 no.)	50/- per unit	2 day	250/-
9.	Le khalong or Lai	Bamboo (1 no.)	50/- per unit	2 day	300/-
10.	Thulung	Bamboo (3 nos.)	50/- per unit	4-6 days	300/- to 600/-
11.	Pinon	Yarn (9-12 muthi*)	40/- per muthi *	15-20 days	1500/- to 2500/-
12.	Hadi	Yarn (4-8 muthi*)	40/- per muthi *	10-15 days	1000/- to 1500/-
13.	Horsal	Yarn (2-4 muthi*)	40/- per muthi *	7-10 days	1000/- to 1300/-
14.	Mekhla	Yarn (8-10 muthi*)	40/- per muthi *	5-10 days	4000/- to 5000/-

SUMMARY OF COMPLETED PROJECTS

Water Quality Assessment of Existing Water Sources in the Lower Parbati Basin (Mountain Division, 2018-21)

The Parbati basin is one of the major sources of water in Himachal Pradesh, hence, there is a need to analyze the water quality, quantity, environmental flow, water use pattern, drainage pattern and management possibilities to preserve the natural ecosystem. The present study was primarily conducted in the Parbati River and its tributaries wherein water quality assessment was carried out at selected sites. In addition, socio-economic survey for water use pattern of the river Parbati was carried out in villages around the river. Water Quality Index (WQI) computation for all the water sources like (river, streams, springs) from the selected sites were done to compute the quality status related to the suitability for human consumption. Hydrogeochemical analysis of the river water samples, spring water samples and stream water samples were done to interpret major ions, facies to identify the different chemical processes and to detect the effects of mixing water within the different litho logical framework. The concentrations of major cations and anions, Ca_2^+, Mg_2^+, Na^+, K^+, HCO_3^-, Cl^-, SO_4^{2-}, NO_3^- etc., of collected water samples were analyzed to check the level of contamination in the study area. Systematic outcomes did not demonstrate any deterioration in the surface water quality; all the parameters were under desirable limits recommended by WHO (2011) and BIS (2012) for domestic purposes. The overall WQI of river Parbati falls under 'B' category i.e. good water quality index for all three years 2018-19, 2019-20 and 2020-21. Whereas, WQI of springs and streams samples collected from the basin were found in excellent to good category for drinking purposes and domestic use. According to the questionnaire survey, there is change in climatic accompanied by increased forest fire followed by deforestation and fuel wood burning. Springs are the major source for drinking water in the study area and the water scarcity mainly occurs during summer season due to drying up of the natural water sources. The long-term decreasing trend in rainfall could have major implications with regard to drinking water supply from springs. The rise in temperature could lead to increased evaporation. Decreased rainfall and rise in temperature may have an adverse effect on soil moisture in the long term.

Assessment and Valuation of Sub-alpine and Alpine Ecosystems of Himachal Pradesh in Relation to Climate Change (Mountain Division, 2018-2021)

The climate change has been recognized as one amongst the most confounding factor in shaping the future of mountain ecosystems, and also the rural communities. The present study was carried out in the sub-alpine and alpine areas of Himachal Pradesh. A total 41 sites (Himbri and Runga, Fozal valley, Kheerganga, Parvati valley, Sarchi, Sainj valley, Rohtang Pass of Kullu district, Khoksar of Lahaul district and Sangla valley of Kinnaur district) were surveyed during the study period with altitude ranging between 2204m– 4340m amsl. For sub-alpine region, total 29 sites were surveyed during the study period with altitude ranging between 2204–3624 m amsl. Habitat conditions varied from shady moist (9), followed by dry (8), followed by bouldary (03), followed by moist (3) followed by riverine (03), followed by moist (3), followed by shrubby open (1), and rocky (1). A total of 7 sites were having North aspect, 5 in NorthWest, 4 in NorthEast, 4 in West, 2 in East, 2 in South aspect, 3 in SouthEast and 3 in Southwest. The slope varied from 10^0-65^0. Dominant species were *Abies pindrow, Quercus semecarpifolia, Prunus cornuta.* Major associates were *Aesculus indica, Acer caesium, Prunus cornuta, Juglans regia, Betula utilis, Rhododendron campanulatum, Quercus semecarpifolia, Rhododendron arboretum, Abies pindrow, Picea smithiana, Rhus javanica.* On the basis of questionnaire survey, decrease in apple yield and shifting of apple orchards to higher elevation, decrease in snowfall and increase in the temperature regime were observed by the local communities in the high altitude areas of Himachal Pradesh.

A negative trend is observed between species richness with altitude. Maximum species richness was recorded between 2700-3600m altitudes with least species richness (14) between 4200-4500m. The physicochemical analysis of soil showed more acidic nature of soil. Maximum organic carbon and nitrogen content in soil was found in *Betula utilis* and *Abies pindrow* community respectively and lowest moisture content was found *Salix* community, phosphorus and nitrogen content in Abies pindrow community site. The pH was negatively correlated (-0.28) with altitude indicating increase in acidity

from sub-alpine to alpine soil. The high proportion of native, critically endangered and endangered species species at sites surveyed near Rohtang pass and Khoksar, Lahaul valley. These sites can be proposed for long term ecological monitoring and impact of climate change on floristic diversity.

Mapping and spatial distribution of medicinal plant species of Sikkim, Himalaya (Mountain Division; 2019-22)

Sikkim state spread over 7,096 sq km geographical area (0.2% of India) is a land of vast variation in altitude within very short distances ranging from around 300 to 8585 m asl. The region harbours variety of medicinal plants whose values have been well recognized by local people as well as by different pharmaceutical, insecticidal and perfumery sectors. In this project, inventorisation and documentation of medicinal plant related traditional knowledge, mapping of population distribution in the region and ex situ conservation through establishment of germplasm bank, was carried out. A total of 638 species of medicinal plants belonging to 169 families found in the Sikkim Himalayan Region were documented (Fig. 44). The dominant families of medicinal plants were recorded as, Asteraceae, Ranunculaceae, Zingiberaceae, Euphorbiaceae and Poaceae. It is vital to understand the distribution area of a threatened plant species for its better conservation and management planning. Based on distribution records, Maxent species distribution modelling algorithm was used to simulate the current distribution and possible range shift in projected future climate scenarios of 4 selected medicinal plant species (*Aconitum heterophyllum, A. violocium, Paris polyphylla* and *Myrica esculenta*). A set of 19 bioclimatic variables from WorldClim database were used to predict the potential suitable habitats in current climatic condition and four Representative Concentration Pathway (RCP 2.6, 4.5, 6.0, and 8.5) scenarios by integrating five General Circulation Models (GCMs) for future distribution modelling of species for the years 2050 and 2070. Under future climate change scenarios, the total suitable habitat of most of the species (*Paris polyphylla* and *Myrica esculenta*) will increase slightly in the Himalayan region and likely to migrate towards northward (for all four species). Maxent modelling approach indicates that warming climates could significantly affect the potential habitats of these threatened species and hence suitable conservation measures need to be taken to protect this threatened orchid species in wild conditions. Also, 32 species of medicinal plants were introduced in herbal garden of the institute for conservation.

Fig. 44. A. Major medicinal plant found in Sikkim Himalaya. B. Percentage of different plant species used for treatment of various ailments.

Major outcomes

1. A total of 638 species of medicinal plants belonging to 169 families (dominated by Asteraceae, Ranunculaceae, Zingiberaceae, Euphorbiaceae, Poaceae, Polygonaceae and Solanaceae) were found in the Sikkim Himalayan Region.
2. From the documented medicinal plants majority of the plants are used to cure fever, cold & cough, asthma, piles, jaundice, anti-diabetic and blood pressure etc. Altitudinal zone between 1000 to 2000 m asl supported maximum diversity of medicinal plants. Among these, a total of 53 species were recorded as threatened under different threat categories.
3. Based on distribution records, population distribution mapping across the Himalaya was caried out for 4 threatened species (*Aconitum heterophyllum, A. violocium, Paris polyphylla* and *Myrica esculenta*).
4. A total of 32 species of medicinal plants were introduced in herbal garden of the institute for conservation.

APPLICATION OF R&D OUTPUTS IN DEMONSTRATION AND DISSEMINATION

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 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 nationwide to provide national scenarios to the international set up, INFOTERRA Programme, of the UNEP.

Objectives

1. To collect, collate, compile and build qualitative and quantitative database of information related to various aspects of Himalayan Ecology.
2. 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.
3. To develop, up-grade and maintain 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 covering important segments, e.g., demography, literacy, land, water, agriculture, horticulture, forest cover, protected areas, weather profiles, etc. and also compiled data on subject experts and important web links related to Himalayan Ecology.

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

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

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

Integrated Eco-development Research Programme (IERP) in the Indian Himalayan region (MoEF&CC, Govt. of India; Long Term Scheme)

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

Objectives:

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

Achievements

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

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

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

Central Laboratory Services

Institute has centralized facilities for physicochemical, biological, heavy metal analysis of fresh and waste water, soil and plant produces. Quantification of organic compounds (mainly volatiles) of water, soil and plant samples is done using Gas chromatograph (Chemito, Ceres 800plus), elemental analysis (carbon, hydrogen, nitrogen, and sulphur) of solid samples is carried out using CHNS analyzer (Elementar, Vario EL-III). The heavy metals in the liquid samples (such as water, digested samples of soil and plant) are detected through Atomic Absorption Spectrophotometer (Varian AA280Z, equipped with graphite tube atomizer). Along with this, central facility is equipped with various other minor instruments such as UV-VIS spectrophotometer (Shimadzu), flame photometer (Systronics), digestion systems (Pelican, India), extraction units (MAC, India) etc. The Institute has extended these services to other organizations (NGOs and Government Organization) on payment basis. Individuals (researchers, villagers) are also using the facility for sample analysis. In the financial year 2021-22, Institute had collected Rs. 3,33,232 /- as a Central laboratory service charge from different organizations including four public organizations, three private organizations and one requests came from individuals. Apart from this, the Central Lab has also facilitated Institute research work (In-house and external funded projects) in the form of sample analysis using AAS, GC & CHNS. Fig. 45 shows month wise income of central lab.

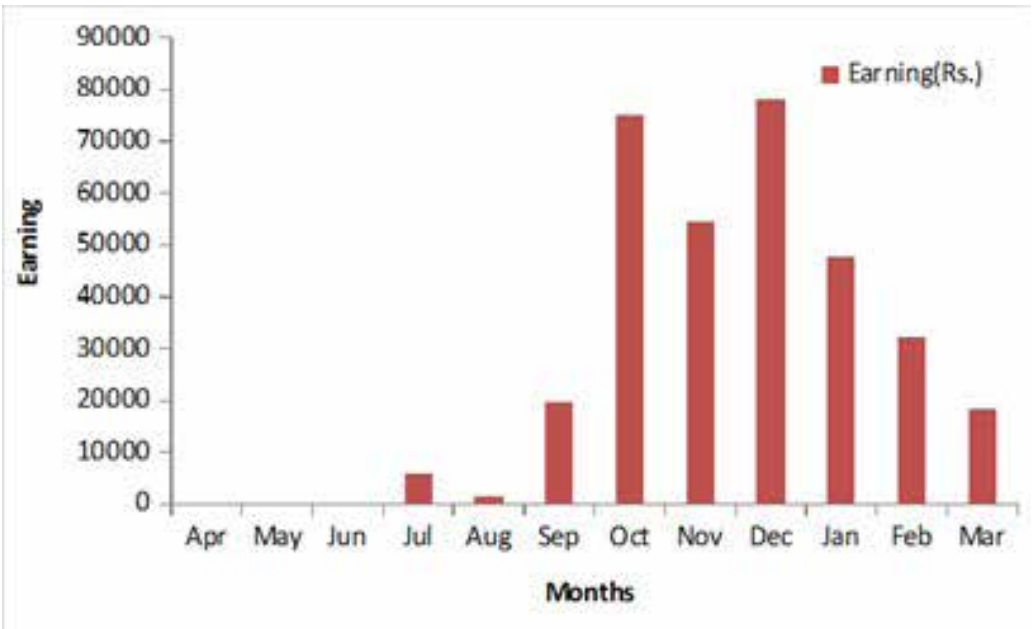


Fig. 45: Month wise Income generated through sample analysis

MISCELLANEOUS ITEMS

SCIENTIFIC PUBLICATIONS

1. SCIENTIFIC JOURNALS:

INTERNATIONAL

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ANIL SHALINI & ASSOCIATES
CHARTERED ACCOUNTANTS

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INDEPENDENT AUDITOR'S REPORT

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

Opinion

In our opinion and to the best of our information and according to the explanations given to us, the financial statements of **G.B. PANT NATIONAL INSTITUTE OF HIMALAYAN ENVIRONMENT (A Institute of Govind Ballabh Pant Himalaya Paryararan Evam Vikas Society)** for the year ended **March 31, 2022** 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 2022.

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

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

Bases of Opinion

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

Key Audit Matters

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

Key Audit Matters	Auditor's response
None	None

Emphasis of Matters or Other Matter

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

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

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

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

Auditor's Responsibility

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

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

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

Report on Other Legal and Regulatory Requirements

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

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

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

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

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

Date: 24.08.2022

Place: Almora

For Anil Shalini & Associates
(Chartered accountants)

24/8/22

Anil Kumar Shukla
FCA, DISA
M NO.075418
FRN. 009960C
UDIN: 22075418APTPJY2201

03

G.B.PANT NATIONAL INSTITUTE OF HIMALAYAN ENVIRONMENT
KATARMAL, KOSI (ALMORA) UTTARAKHAND
BALANCE SHEET AS ON 31ST MARCH 2022

PARTICULARS	SCHEDULE	CURRENT YEAR (₹)	PREVIOUS YEAR (₹)
LIABILITIES			
CORPUS / CAPITAL FUND	1	2,39,17,363.46	3,08,94,764.45
RESERVE AND SURPLUS	2	37,49,15,263.25	42,83,48,583.79
EARMARKED / ENDOWMENT FUNDS	3	-	-
SECURED LOANS & BORROWINGS	4	-	-
UNSECURED LOANS & BORROWINGS	5	-	-
DEFERRED CREDIT LIABILITIES	6	-	-
CURRENT LIABILITIES AND PROVISIONS	7	26,20,63,391.65	1,45,40,39,455.31
TOTAL		**66,08,96,018.36**	**1,91,32,82,803.55**
ASSETS			
FIXED ASSETS	8	37,49,15,263.25	42,83,48,583.79
INVEST. FROM EARMARKED/ENDOWMENT FUND	9	68,76,296.82	1,79,34,931.17
INVEST. OTHERS	10	-	-
CURRENT ASSETS , LOANS, ADVANCES ETC.	11	27,91,04,458.29	1,46,69,99,288.59
MISCELLANEOUS EXPENDITURE			
TOTAL		**66,08,96,018.36**	**1,91,32,82,803.55**
SIGNIFICANT ACCOUNTING POLICIES	24	-	
CONTINGENT LIABILITIES & NOTES ON ACCOUNTS	25		

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

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

DATED : 24.08.2022
PLACE : KOSI- KATARMAL, ALMORA
UDIN: 22075418APTPJY2201

(Prof. SUNIL NAUTIYAL)
DIRECTOR

(DR. PAROMITA GHOSH)
D.D.O

(L. M.S. NEGI)
ACCOUNTS OFFICER

G.B.PANT NATIONAL INSTITUTE OF HIMALAYAN ENVIRONMENT
KATARMAL, KOSI (ALMORA) UTTARAKHAND
INCOME & EXPENDITURE A/C FOR THE YEAR ENDED 31ST MARCH 2022

PARTICULARS	SCHEDULE	CURRENT YEAR (₹)	PREVIOUS YEAR (₹)
INCOME			
Income from Sales/Services	12	3,24,946.00	4,67,314.00
Grants/Subsidies(net off exp)	13	23,91,10,125.72	60,89,63,494.67
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	5,23,667.00	11,75,398.00
Other Income	18	1,03,52,833.64	49,82,433.28
Increase (decrease) in stock of Finished goods and work in progress)	19	-	-
TOTAL (A)		**25,03,11,572.36**	**61,55,88,639.95**
EXPENDITURE			
Establishment Expenses: a) Institute	20	12,97,67,657.00	12,18,75,008.00
b) Projects		2,18,57,861.00	3,63,26,949.00
c) F.C (Projects)		8,32,159.00	9,56,200.00
Administrative Expenses :a) Institute	21	5,18,90,810.46	4,79,77,005.77
b) Projects (As per Annexure)		2,19,82,565.26	39,48,08,908.74
c) F.C (Projects)(As per Annexure)		68,35,354.00	55,22,162.00
Expenditure on Grants, Subsidies etc.	22	59,43,719.00	14,97,261.16
Interest			
Depreciation (Net Total at the year-end-as per Sch. 8)		3,92,22,252.49	4,57,08,448.60
TOTAL (B)		**27,83,32,378.21**	**65,46,71,943.27**
Balance being excess of Income over Expenditure (A - B)		**(2,80,20,805.85)**	**(3,90,83,303.32)**
Transfer to special Reserve			
Transfer to/ from General Reserve			
BAL.BEING SURPLUS TRF.TO CORPUS FUND (Other Income)		**(2,85,44,472.85)**	**(4,02,54,074.32)**
BAL.BEING SURPLUS TRF.TO CORPUS FUND (Corpus Interest)		**5,23,667.00**	**11,70,771.00**
Fund		**3,92,22,252.49**	**4,57,08,448.60**
Interest income of other Saving Accounts.			
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	25		

(Prof. SUNIL NAUTIYAL)
DIRECTOR

(DR. PAROMITA GHOSH)
D.D.O

(L. M.S. NEGI)
ACCOUNTS OFFICER

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

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

DATED :
PLACE : KOSI- KATARMAL, ALMORA
UDIN: 22075418APTPJY2201

G.B. PANT NATIONAL INSTITUTE OF HIMALAYAN ENVIRONMENT
KOSI-KATARMAL, (ALMORA) UTTARAKHAND
RECEIPTS & PAYMENTS A/C FOR THE YEAR ENDED 31ST MARCH 2022

RECEIPTS	CURRENT YEAR	PREVIOUS YEAR	PAYMENTS	CURRENT YEAR	PREVIOUS YEAR
I. Opening Balances			**I. EXPENSES**		
a) Cash in hand	1,04,076.70	88,374.34	**a) Establishment Expenses**		
	-	-	**I) Institute**	12,09,45,130.10	10,97,84,604.41
b) Bank Balances		-	**b) Administrative expenses**	-	-
	-	-	a) Institute	4,39,99,954.85	5,66,97,854.80
i) In current accounts	-	-	b) R&D(Rev) expenses	81,83,302.60	94,36,029.60
ii) In deposit accounts (Corpus Fund)	1,79,34,931.17	4,25,89,138.17	c) Payments for current liabilities(gratuity/leave)	41,24,841.00	1,48,61,681.00
iii) Savings accounts	12,65,58,337.18	32,96,04,045.52	**C. Capital expenditure**	-	-
c) Advances & Others	7,79,16,197.40	1,26,46,64,382.26	a) Purchase of Fixed Assets	66,26,795.00	2,02,01,267.04
(As per annexure Attached)	-	-	b)Expenditure on Capital Work in Progress	1,00,00,000.00	30,52,411.00
F.C. ACCOUNT	-	-	c) Acquirement of land (Lease money)	-	-
A) Cash in hand	4,026.33	4,976.33	**II Payments made against funds for various proj.**	-	-
b) Cash at bank	37,69,774.03	57,81,763.46	**Expenditure State govt. projects**	-	-
c) FC Advances	15,15,331.00	13,15,331.00	a) Capital	2,01,77,183.00	2,51,17,089.00
II. Grants Received	-	-	b) Revenue:	-	-
a) From Government of India	24,00,00,000.00	16,70,00,000.00	Establishment exp	2,18,57,861.00	3,55,16,897.00
i) Institute & IERP	-	-	Administration exp	2,23,35,956.26	39,44,55,517.74
Contribution corpus from CPF	25,11,903.00	27,05,613.00	**Expenditure FC projects**	-	-
b) From Other agencies	8,54,89,050.00	37,35,95,999.80	**a) Capital**	3,55,430.00	3,07,680.00
c) From other sources [from FC]	56,29,452.41	81,55,008.41	**b) Revenue:**	-	-
III. Income on Investments from	-	-	Establishment exp	8,32,159.00	9,56,200.00
a) Corpus Fund(Received from Institute)	-	-	Administration exp	67,04,682.00	53,89,812.00
IV. Interest Received	-	-	**IERP grant released**	59,43,719.00	14,97,261.16
a) On Bank deposits savings a/c		-	**III Investments and deposits made**	-	-
b)On term deposits a/c	-	-	Pension trust (out of corpus fund)	2,06,90,750.63	2,86,05,551.00
c) Loans, Advances etc.	7,027.00	4,627.00	**IV Refund of Surplus money/Loans**	-	-
d) Interest income Corpus Fund	5,23,667.00	11,70,771.00	a) To the Government of India	-	2,78,64,419.00
V. Other Income	-	-	b)To Others/ security/ caution money)	-	-
Received in Corpus Fund	65,96,546.28	3,18,200.00	Refund to MoEF&CC (HBA/MCA)	-	9,60,025.00
(As per annexure Attached)	-	-	**V Other payments**	-	2,43,240.00
VI. Amount Borrowed	-	-	Other Payment to Instt. FC Proj.	-	-
VII. Any other receipts.	40,81,233.36	52,27,844.28	Unspent Balance (FC)	-	-
Interest Received in NMHS Payable to Government	-	1,79,63,253.73	Payment of Current Libilities	-	-
	-	-	Refund of EMD	-	-
Other Receipt FC a/c	-	-	Fund transfar to Corpus fund	65,96,546.28	3,18,200.00
a)Performance Guarantee	-	-	**VI Closing balances**	-	-
b) Receipts Current Liabilities	-	-	**a) Cash in hand**	1,59,812.56	1,04,076.70
c) IERP grants refunded by grantee Org.	-	-	**b) Bank Balance**	-	-
d)Construction Fund	-	-	i) In Current account	-	-
e) Corpus Fund FDR'S	-	-	ii) In deposit accounts [Corpus Fund]	68,76,296.82	1,79,34,931.17
f) Caution Money		-	iii) In savings accounts	18,79,96,538.02	14,78,43,362.41
g) Security Deposit	-	-		-	-
h) EMD		-	**C) Advances and others**	7,27,39,956.31	1,31,28,02,693.12
i) Royalty	-	-	**FC Project**	-	-
j) Sales Tax / GST	-	-	a) Cash in hand	0.33	4,026.33
k)Service Tax/GST	-	-	b) Bank Balance	44,87,658.62	37,69,774.03
	-	-	c) Advances and others	9,15,331.00	15,15,331.00
		-	Adjustment of previous year closing Advances	91,648.48	9,49,393.79
TOTAL	**57,26,41,552.86**	**2,22,01,89,328.30**	**TOTAL**	**57,26,41,552.86**	**2,22,01,89,328.30**

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

21/8/22

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

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

DATED :
PLACE : KOSI- KATARMAL, ALMORA

(Prof. SUNIL NAUTIYAL)
DIRECTOR

P. Ghosh

(DR. PAROMITA GHOSH)
D.D.O

(L. M.S. NEGI)
ACCOUNTS OFFICER

06

G.B.PANT NATIONAL INSTITUTE OF HIMALAYAN ENVIRONMENT
KOSI-KATARMAL, (ALMORA) UTTARAKHAND
ANNEXURE FORMING PART OF BALANCE SHEET AS ON 31 MARCH 2022

CURRENT ASSETS

BANK BALANCES (SAVINGS A/C) **ANNEXURE"D"**

ARTICULARS	CURRENT YEAR (₹)
C.B.I Kosi A/c No. 3173366206	47,805,900.43
S.B.I Almora A/C No. 10861359986	20,468,303.67
S.B.I Tandong A/c No. 11226047758	4,023,328.81
S.B.I Kullu A/c No. 10792147561	6,508,730.64
S.B.I Itanagar A/c No.10940060114	828,325.99
S.B.I Srinagar A/c No. 10972182864	1,935,169.51
S.B.I Ladakh A/c No. 39128027055	88,215.65
U.B.I. Ladakh A/c No. 78020500003	1,072,016.54
S.B.I Tandong A/c No. 37000934072 (NMHS IHTP DK	2,767,393.10
C. B. I. Kosi A/c No. 3604013559 (GIA- General)	15,927,730.66
C. B. I. Kosi A/c No. 381883348 (GIA -Creation of capital assets)	14,440,547.00
C. B. I. Kosi A/c No. 3818842358 (GIA -Salaries)	25,018,258.57
S. B. I. Kosi A/c No. 36883992887 (NMSHE TF-03 New Account)	36,522,452.00
S.B.I Srinagar A/c No. 3690636305 (NMHS ST KK)	1,005,326.24
S.B.I Almora A/c No.10861359975 (F.C)	4,487,658.62
C.B.I Kosi A/c No. 3561532026 (ENVIS New Account)	1,282,300.00
S. B. I. Kosi A/c No. 36959540111 (NMHS ST KK)	6,344,597.57
S. B. I. Kosi A/c No. 36935490949 (NMHS Fellowship)	58,338.30
S. B. I. Kosi A/c No. 36935414822 (NMHS JCK)	368,645.34
S. B. I. Kosi A/c No. 36935498701 (NMHS IHTP GCSN)	5,017.00
S. B. I. Kosi A/c No. 36944701949 (NMHS IHTP S. Sharma)	17,838.00
S. B. I. Kosi A/c No. 36944702502 (NMHS IHTP Rajesh Joshi)	29,782.00
S. B. I. Kosi A/c No. 36944702987 (NMHS IHTP R. S. Rawal)	58,008.00
S. B. I. Kosi A/c No. 36959556518 (NMHS D. S. Rawat)	199,670.00
Cheque in tran Regional Centre N.E.	-
Regional Centre H.P.	400,000.00
Regional Centre Sikkim	820,643.00
Regional Centre Garhwal	
Fund Transfer to Core Grant Account	-
	192,484,196.64

DUE FROM STAFF **ANNEXURE"E1"**

PARTICULARS	CURRENT YR. (₹)
Adv. a/c of Tribhuwan Rana (GRC Unit)	25,000.00
Adv. a/c of Shri Heera Singh Computer Advance(GIA General)	15,000.00
Total:	**40,000.00**

DUE FROM OTHERS **ANNEXURE"E2"**

PARTICULARS	CURRENT YR. (₹)
Adv. a/c of TATA Motors Ltd. Core	2,836.00
Adv. a/c of Meterological Department Core	8,000.00
Adv. a/c of NRSC Hydrabad Proj. 04 Core	24,000.00
Adv. a/c of M/s International Trade link Core	34,328.00
Adv. a/c of VPKAS Almora Core	26,560.00
Adv. a/c of STUP Consultant Haldwani Core	(7,435.00)
Adv A/C E.E. RES Almora Core	1,571,000.00
Advance a/c of CCU (GIA Creation of capital assets)	10,000,000.00
Adv. a/c of NIH Roorkee Core	100,000.00
Adv a/c NICSI New Delhi Core	112,946.00
Employment news New Delhi Core	48,287.00
Adv a/c M/S Sigma Aldrich Chemicals Core	10,590.00
Adv A/C NRSA Hydrabad Core	35,300.00
Adv a/c M/S R.K. Nanda & Sons Core	28,517.00

Anil Shalini & Associates Chartered Accountants DELHI 009500C

Adv. a/c of Sh. Manoj Tiwari (Advocate) Core	20,000.00
Adv. a/c of INSA New Delhi Core	30,000.00
Recoverable from Unit Core	4,772.00
Adv. a/c NRSA Hydrabad (DST LMS ILTP)	48,000.00
Adv. a/c of WWF New Delhi (UNDP CCF PKS N. E. Unit New)	(31,930.00)
Adv. a/c of E E. RES Almora (HRDI IDB)	59,000.00
Adv. a/c of NRSC Hydrabad (DST SERB GCSN)	635.00
Adv. a/c of Airport Handling Services (SERB JCK H. P. Unit)	18,371.00
Adv a/c of Airport Handling Noida (SERB-Dr. Sandeepan Mukharjee)	187,154.00
Adv. a/c of NRSA Hydrabad (ISRO GBP S. Sharma)	350,000.00
Adv. a/c of M/s Vankta Enterprises (Cop 11 MoE & F NBA)	7,100.00
Adv. a/c Siltep Chemicals Ltd. (Biotech-III)	408.00
Adv. a/c of NRSA Hyerabad (DST KK I)	7,400.00
Adv. a/c Forest Vardhanik Uttaranchal (NMHS-IDB)	360,000.00
Adv. A/c M/s Moets Catering Services, New Delhi(Mount. Divn.)	64,574.00
Adv. a/c of Sustainable Development (Mountain Division)	25,000.00
Adv. a/c IMI New Delhi.(Mount. Divn.)	900,000.00
Adv. a/c Mizoram University (IERP)	300,000.00
Adv. a/c of Finance Officer Mizoram University (Core)	92,250.00
Adv. a/c of H.N.B Gharwal University, Srinagar (ICSSR RKM G. Unit-New)	970,822.00
Adv. a/c of M/s Airport Handling (NMSHE TF-03)	35,420.00
Adv. a/c of Meghalaya (GIA General)	398,125.00
Adv. a/c of NEIST, Manipur (NMHS JCK)	41,830.00
Adv. a/c of B.S.N.L. Ltd	99,415.00
Security Deposit CET Sikkim Core	11,000.00
Adv. a/c of D S Bisht (NMHS-DSR)	(40.00)
Security Deposite N.E. Unit Core	1,750.00
Adv. a/c of IIT Guwahati (NMHS-S.Tarafdar)	48,578.00
Adv. a/c of National Remote Sensing Centre, Hydrabad (UNDP-JCK)	69,738.00
Adv. a/c of Executive Engineer CE-IICCU(NMHS-NILC-IDB)	5,111,247.00
Adv. a/c of IIT-ROORKEE(NMHS-PINE OAK-SM)	1,796,521.00
Adv. a/c of NIT-ROURKELA(NMHS-PINE OAK-SM)	804,601.00
Adv. a/c of JNU NEW DELHI(NMHS-PINE OAK-SM)	1,351,280.00
Adv. a/c of IIT MUMBAI (NMHS-PINE OAK-SM)	1,304,314.00
Adv. a/c of DIRECTOR U SAC DEHRADUN (NMHS-HIMALAYA CALLING	400,000.00
Adv. a/c of National Remote Sensing Agency Core)	73,544.00
Adv. a/c of Regional Science Centre (Core)	89,936.00
Adv. a/c of Sikkim College (Core)	430,000.00
Adv a/c of IIT Mandi(NMHS Vaibhav E. Gosavi Project (New) Project A/c)	1,361,600.00
Adv. a/c of FRI Jorhat (NMHS Vaibhav E. Gosavi Project (New))	1,361,600.00
Adv. a/c of Sikkim University (NMHS Vaibhav E. Gosavi Project (New))	1,361,600.00
Adv. a/c of NIT Silchar (NMHS Vaibhav E. Gosavi Project (New))	1,361,600.00
Adv, a/c of Institute of Nature Res Meghalaya (NMHS Vaibhav E. Gosavi Project (New))	1,361,600.00
Adv. a/c of Institute of Technology Manipur (NMHS Vaibhav E. Gosavi Project (New))	1,361,600.00
Adv. a/c of NIT, Nagaland (NMHS Vaibhav E. Gosavi Project (New))	1,361,600.00
Adv. a/c of Univesity of Mizoram (NMHS Vaibhav E. Gosavi Project (New))	1,361,600.00
Adv. a/c of Univesity of Tripura (NMHS Vaibhav E. Gosavi Project (New))	1,361,600.00
Adv. a/c of SKUAST, Srinagar J&K (NMHS Vaibhav E. Gosavi Project (New))	1,361,600.00
Adv. A/c of NIRDPR (Mount .Div)	322,271.00
Adv. a/c of Delhi Productivity Council (Core)	114,932.00
Adv. a/c of Manipur Institute of Technology (core)	273,125.00
Adv. a/c of Nagaland College (Core)	120,000.00
Adv. a/c of NIT Assam (Core)	650,000.00
Adv. a/c of Tripura College (Core)	95,000.00
Adv. a/c Airport Handling charges (Cold Lab SM)	1,170,273.00
Adv. a/c of University of Kashmir (RCS Himalaya Calling)	400,000.00
Adv. a/c of University of Mizoram (RCS Himalaya Calling)	300,000.00
Adv. a/c of University of Manipur (RCS Himalaya Calling)	300,000.00
Adv. a/c of University of Nagaland (RCS Himalaya Calling)	300,000.00
Adv. a/c of University of Assam (RCS Himalaya Calling)	400,000.00
Adv. a/c of UCSTE (RCS Himalaya Calling)	400,000.00
	45,937,345.00

Institute Faculty (2021-22)

Head Quarter

S.N.	NAME	DESIGNATION	AREA OF SPECIALIZATION
1.	Er. Kireet Kumar	Scientist-G	Environmental Engineering; Hydrology
2.	Dr. J.C. Kuniyal	Scientist-G	Development Geography: Waste Management
3.	Dr. G.C.S. Negi	Scientist-G	Forest Ecology; Watershed Management; EIA
4.	Dr. I.D. Bhatt	Scientist-F	Plant Physiology; Physiochemistry
5.	Dr. Paromita Ghosh	Scientist-F	Plant Science; Soil Science
6.	Dr. K. Chandra Sekar	Scientist-F	Plant Taxonomy; Animal Taxonomy
7.	Dr. Vikram Singh Negi*	Scientist- E (Adhoc)	Forest Ecology; Rural Ecosystem
8.	Dr. S.C. Arya	Scientist-D	High Altitude Ecolgy
9.	Dr. Vasudha Agnihotri	Scientist-D	Soil Science; Plant Analysis; Instrumentation
10.	Dr. Mithilesh Singh	Scientist-D	Plant tissue culture; Bioprospecting
11.	Dr. Sandipan Mukherjee	Scientist-D	Climate Change; Ecosystem Services
12.	Mr. Ashutosh Tiwari	Scientist-D	Remote Sensing & GIS
13.	Dr. Sumit Rai	Scientist-C	Soil Science; Soil & Water Conservation
14.	Dr. V.E. Gosavi	Scientist-C	Hydrology; Watershed Management
15.	Dr. Harshit Pant	Scientist-C	Forest Ecology
16.	Dr. Shailaja Punetha	Scientist- C	Agriculture; Horticulture
17.	Dr. Kapil Kesharwani	Scientist- C	Cryosphere; Atmospheric and Environmental Science
18.	Dr. Aseesh Pandey	Scientist -C	Biodiversity Conservation; Alpine ecology; Phyto-chemistry; Conservation Education
19.	Dr. Subodh Airi	Tech. Gr. IV (3)	Forest Ecology; Biotechnology

Garhwal regional Centre

1.	Mr. Soukhin Tarafdar	Scientist-E	Weather & Climate Change; glaciology; Hydrology
2.	Mr. A.K. Sahani	Scientist-E	Social Science; Anthropology
3.	Dr. Arun Kumar Jugran	Scientist-D	Plant Biotechnology
4.	Dr. Lakhpat Singh Rawat	Technical Assistant (II)	Socio Economic Development
5.	Dr. Paromita Ghosh	Scientist-F	Plant Science; Soil Science

Sikkim Regional Centre

1.	Dr. Rajesh Joshi	Scientist-E	Mathematical Modelling
2.	Dr. Devendra Kumar	Scientist-D	Climate Change
3.	Dr. Sandeep Rawat	Scientist -C	Biodiversity Conservation; Conservation Genetics; Biochemical and Nutritional Analysis
4.	Dr. Mayank Joshi	Scientist -C	Tectonic Geomorphology
5.	Dr. Y.K. Rai	Sr. Technical Officer (III)	Rural Ecosystem
6.	Dr. K.S. Gaira	Technical Assistant (II)	Biodiversity Conservation

Himachal Regional Centre

1.	Er. Rakesh Kumar Singh	Scientist-F	Information Technology
2.	Dr. K.S. Kanwal	Scientist-D	Strategic Environmental Assessment
3.	Mrs. Sarla Shashni	Scientist-D	Rural Entrepreneurship and Small Business
4.	Dr. Kesar Chand	Scientist -C	Climate Change; Environmental Pollution nd Disaster Management
5.	Dr. Kishore Kumar	Technical Officer	Pollination Biology; Conservation Education

North East Regional Centre

1.	Mr. M.S. Lodhi	Scientist-E	Environmental Assessment
2.	Dr. Wishfully Mylliemngap	Scientist-C	Climate Change and Environment Pollution
3.	Ms. Tridipa Biswas	Scientist-C	Ecosystem Services
4.	Dr. Mriganka Shekhar Sarkar	Scientist-B	Ecology, Genetics
5.	Mr. Om Prakash Arya	Technical Officer	Biotechnological Application
6.	Mr. Sandeep Kumar	LDC	Ecology, Biotechnology

Ladakh Regional Centre

1.	Dr. Subrat Sharma	Scientist-F	Agro Ecology; Remote Sensing/ GIS
2.	Dr. Puroshottam Garg	Scientist-C	Geology
3.	Dr. Suresh Kumar Rana	Scientist-B	Biogeography; Evolutionary Ecology; Bio curation
4.	Dr. Lalit Giri	Technical Assistant (II)	Biotechnology

Institute supporting staff
Headquarter

S.No.	Name	Designation
1	Mr. Anil Kumar Yadav	Administrative Officer
2	Mr. Surya Kant	Finance Officer
3	Mr L.M.S. Negi	Accounts Officer
4	Mrs. Sarita Bagdwal	Stenographer
5	Mr. Jagdish Kumar	Stenographer
6	Mrs Mamta Higgins	O.S.
7	Mr Heera Singh	O.S.
8	Mr. K.K. Pant	U.D.C.
9	Mrs. Hema Pandey	U.D.C.
10	Mr. Mayank Verma	UDC
11	Mr. Atul Bisht	L.D.C.
12	Mr. Vipin Chandra Sharma	L.D.C.
13	Mr. Sanjeev Kumar Arya	Driver
14	Mr Pan Singh	Group 'C'
15	Smt Ganga Joshi	Group 'C'
16	Mr. Gopal Singh Bisht	Group 'C'
17	Mr. Ajay Pawar	Group 'C'
18	Mr. Govind Singh Malwal	Group 'C'

Garhwal Regional Centre

S.No.	Name	Designation
1	Mr. D.P.Kumeri	U.D.C.
2	Mr. M.P Nautiyal	Tech Gr. II (2)
3	Mr. J.M.S. Rawat	Tech Gr. II (2)
4	Mr. R. Nainwal	Tech Gr. I (4)
5	Mr. R.P. Sati	Technical I (3)

Himachal Regional Centre

1	Mr. Daulat Ram	Group 'C'
2	Mr. Ajay Pawar	Group 'C'
3	Mr. Jagdish Kumar	Driver

Sikkim Regional Centre

1	Mr. R.K. Das	L.D.C.
2	Mr. Jagnnath Dhakal	Tech Gr. I (4)
3	Mr. P.K. Tamang	Tech Gr. I (4)

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

Prof. Rajive Mohan Pant
Director
National Institute of Rural Development (NIRD) & Panchayati Raj Jawaharnagar, Khanapara, Guwahati, Assam

Dr. Sandeep Tambe, IFS
Professor
Indian Institute of Forest Management (IIFM) Nehru Nagar Bhopal, M.P.

Peer Institutions

Director/or his representative
Director
Wadia Institute of Himalayan Geology 33, General Mahadev Singh Road, Sewla, Kalan, Majra, Dehradun Uttarakhand

Director (or his nominee at Senior Scientist Level)
Director
Zoological Survey of India
Prani Vigyan Bhawan, M Block, New Alipore Kolkata, West Bengal, India

Institute Faculty

Dr. G.C.S. Negi
Scientist-G
NIHE, Kosi-Katarmal, Almora, Uttarakhand

Dr. Rajesh Joshi
Scientist-E
Sikkim Regional Centre (SRC), NIHE, Pangthang, Sikkim

Dr. Arun K. Jugran
Scientist-C,
Garhwal Regional Centre, NIHE, Srinagar, Uttarakhand

Convener

Director
NIHE, Kosi-Katarmal, Almora, Uttarakhand

PROJECT EVALUATION COMMITTEE

Chairman
Prof. Saroj Kanta Barik

Director
CSIR-National Botanical Research Institute, Rana Pratap Marg Lucknow

Members

Prof. Rajive Mohan Pant
Director
National Institute of Rural Development (NIRD) & Panchayati Raj Jawaharnagar, Khanapara Guwahati, Assam

Prof. M.C. Nautiyal
Dean, Agriculture & Allied Sciences High Altitude Plant Physiology Research Centre, HNB Garhwal University Srinagar (Garhwal), Uttarakhand

Prof. Dr. J.P. Tamang,
FNABS, FNAAS, FIAMS, FBRS
Dean, School of Life Sciences Professor Department of Microbiology School of Life Sciences, Sikkim University, Gangtok, Sikkim

Prof. Zafar A Reshi
Department of Botany University of Kashmir Srinagar 190 006, J&K

MoEF&CC Representative

Dr. Subrata Bose
Scientist-E
Ministry of Environment, Forest and Climate Change, Mountain Division, Indira Paryavaran Bhawan, Jorbagh Road, New Delhi

Member Secretary (Nominee of the Director, NIHE)

Dr. G.C.S. Negi
Scientist-G & Head, CSED
NIHE, Kosi-Katarmal, Almora Uttarakhand

About the Institute:

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

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

G.B. Pant National Institute of Himalayan Environment,

(An Autonomous Institute of Ministry of Environment, Forest and Climate Change, Government of India)

Kosi-Katarmal, Almora, Uttarakhand- 263643

(**Code** +91-5962) 241015 (**Office**), EPABX: (05962) 241041, 241154 Fax: (05962) 241014, 241150

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