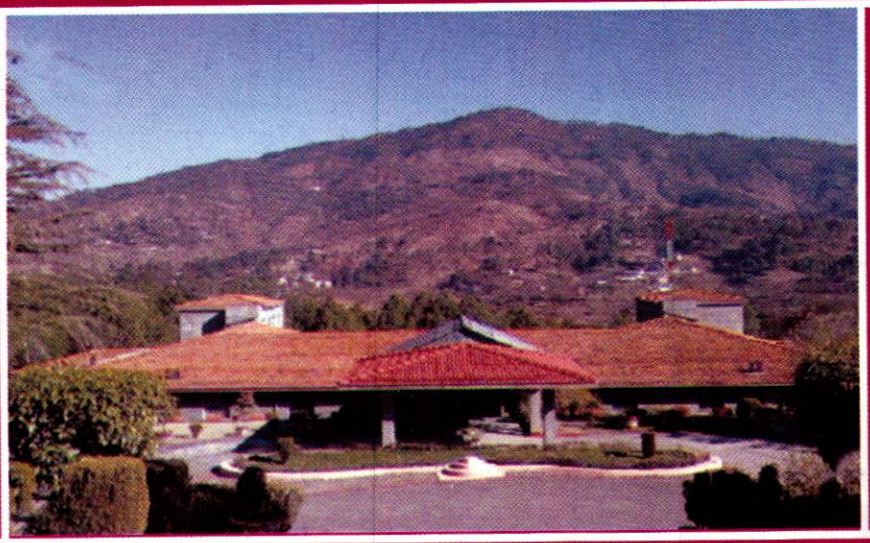
ANNUAL REPORT
2011-2012



G.B. Pant Institute of Himalayan Environment & Development
(An Autonomous Institute of Ministry of Environment and Forests, Govt. of India)
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Scientist 'G'/Scientit-in-Charge
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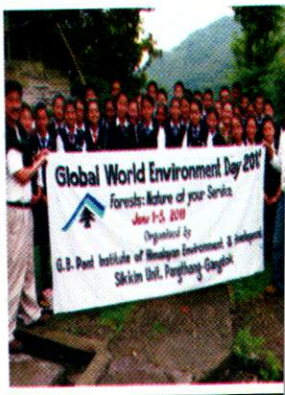
CONTENTS



FOREWORD

The Indian Himalayan region (IHR) is home to a significant population of mountain inhabitants and contains a number of biodiversity hotspots. The IHR, as a whole, is a very important ecosystem service provider to a large downstream region of the Indian subcontinent. The fragile Himalayan Mountains are sensitive to climate change and anthropogenic activities, and paradoxically some of the ongoing developmental activities do cause inherent disturbance in the natural aura of the pristine Himalayan mountains. Addressing the complexities of Himalayan environment and development is, therefore, a daunting task and requires a careful & balanced approach.

Given the global relevance of the Himalayan mountains, the institute continues to work towards documenting and quantifying the ongoing and expected changes in the environment. The institute is fostering research on the state of natural resources, environmental issues and ensuring societal change in the IHR by looking at new findings, archived secondary data and the use of integrated modelling strategies and adopting inter-disciplinary approaches.

During the reporting period (2011-12), the institute has made significant progress towards achieving its R&D targets. Some of the major achievements include: (1) Development of a model on "Integrated Agro-Silvicultural Cultivation" by the North East Unit. The model has been adopted by the Government of Arunachal Pradesh and is being practised in three districts to address the complicated issues of shifting agriculture under the CAMPA programme. (2) The data base has been strengthened for air quality monitoring and aerosol climatology over North Western Himalayan region. (3) Testing of pollination-deficit protocol for apple (Himachal Pradesh, STEP site), mustard, cucurbits (Kosi-Katarmal, STEP site) and large cardamom (Sikkim, STEP Site) was completed. (4) Integrated Decision Support System (DSS) has been developed for generating water supply scenario for different years and up to 2030 in upper Kosi watershed as a pilot site. In a world of growing water scarcity, it is urgent that the knowledge and understanding of present and future mountain water resources and fresh water supply gets improved. (5) Sacred landscape model was implemented in Kolidhaik village of District Champawat to demonstrate eco-restoration and biodiversity conservation through religion. (6) Quantification of and valuation of various ecosystem goods and services in the Central Himalayan mountains have also been done with emphasis on Oak and Pine forests, in order to elucidate the way how changes in ecosystem structure and function affect the delivery of ecosystem services. (7) Besides these, standardization of ex-situ cultivation trials for critically endangered and high value medicinal herb *Swertia chirayita* has been completed by Sikkim Unit. (8) Towards promoting outreach to society, several training programmes for the stakeholders have been organized through the Rural Technology Complex (RTC) at Headquarters and Units. The regular activities undertaken include: on-site training programmes, orientation courses and exposure visits on biodiversity conservation, methods of natural resource management, disaster management, etc. The Institute celebrated with a lot of enthusiasm the Global World Environment day on the theme "Forests: Nature at your service". The International Biodiversity Day and Wildlife Week were also organized at the Headquarters and across units of the Institute. The aim of these celebrations was to spread awareness on these vital issues. Workshops were organized on various themes *viz.*, earthquake risk mitigation and management, capacity building and entrepreneurship development, tourism, and pollination *vis-a-vis* crop production.

The Institute continued to undertake collaborative national and international research supported by various agencies and participated in many network projects; these endeavours demonstrated our willingness to share ideas, resources and research facilities for mutual benefit. The scientific achievements were published in international and national journals, and the scientific prowess of the Institute was acknowledged through awards and honours received by the faculty and scholars. All this was possible due to the constant support and encouragement of the apex bodies of the Institute; their continued guidance is gratefully acknowledged.

Your inputs and constructive critique are always welcome and help us to strive for greater heights.

L.M.S. Palni
Director

MAJOR ACHIEVEMENTS

- Integrated Decision Support System (DSS) has been developed for generating water supply scenario for different years till 2030 for Upper Kosi watershed as a pilot model. Participatory water harvesting and supply scheme is developed to cater the need of 20 households in Chauna hamlet of Pachchisi village of the watershed.
- Development of a sacred landscape model for eco-restoration and biodiversity conservation accomplished in Kolidhaik village of district Champawat, Uttarakhand.
- A study on Aerosols through Multi-wavelength Radiometer (MWR) showed aerosols optical depth (AOD) at 500 nm was found to be up to 0.59 which translates atmospheric temperature rise from 0.25 to 1.37 K day^{-1}.
- Pollination Deficit Protocol for the apple (Himachal STEP Site), mustard and cucurbits (Kosi STEP Site) and large cardamom (Sikkim STEP Site) tested. Responses of the farmers obtained and analysis revealed high level of awareness on pollination and pollinators amongst farmers.
- Development of a horticultural model for diversification of on-farm rural economy at a representative village- Patharkot in district Almora.
- Quantification and valuation of various ecosystem goods and services in the Central Himalayan Mountains for two major forests, i.e. oak and pine forests.
- Based on extensive studies of various farming practices in the western Himalayan region, the multilayer crop system was found to be most remunerative with input-output ratio of 1:7.
- Database was strengthened for air quality monitoring and aerosol climatology over north-western Himalayan region.
- The contamination levels of nitrate in ground water of urban and rural areas of Kullu have exceeded the safe limit of WHO and were not suitable for the drinking purposes. The oxidative damage caused by cypermethrin and chlorpyrifos contaminated soil in cauliflower can be reduced by amending the contaminated soil with farm yard manure.
- Ex-situ cultivation trials for critically endangered and high value medicinal herb, Swertia chirayita standardized in Sikkim. Based on productivity per unit area and cost of infrastructure requirement, the cultivation on open beds is recommended as profitable.
- The model on 'Integrated Agro-Horti-Silvicultural Cultivation' developed by the NE Unit has been adopted by Govt. of Arunachal Pradesh to address various issues in shifting agriculture. The model has been put in to practice in three districts of Arunachal under the CAMPA programme.
- Towards strengthening community institutions in biodiversity conservation, Biodiversity Management Committees (constituted by the NE Unit under its GOI-UNDP CCF-II Project) is adopted by Arunachal Pradesh Biodiversity Board (APBB). This has largely strengthened the continuity and effective functioning of the BMCs, with a defined pathway for the existence of the BMCs after the exit of the project.
- Conservation of rich biodiversity of selected proposed heritage sites in Arunachal Pradesh through stronger community/local institutions like Biodiversity Management Committees (BMCs). Twenty-two (22) BMCs formed under GOI-UNDP CCF-II Project, so far, have been adopted by Arunachal Pradesh Biodiversity Board (APBB) strengthening the continuity and functionality of the BMCs.
- Sound data base on adoption/adaptation scenario of tested/innovative resource management practices, tourism potential across the IHR and contamination levels of nitrate in ground water and the residues of endosulfan sulphate, chlorpyrifos, malathion and cypermethrin in crops and dietary intake of the local population in Himachal Pradesh.
- Creation/strengthening of Community Conserved Areas (CCAs) focusing on conservation of ecologically and socially valued wild flora and fauna, sustainable extraction of timbers and NTFPs, prohibition of hunting, revival of threatened wild flora and fauna in Arunachal Pradesh.

Publications:

Peer Reviewed Journals	-	**63**
Chapters in Books/Proceedings	-	**31**
Authored/Edited Books/Booklets/Bulletins/Monographs	-	**05**
Popular Articles	-	**34**
Award and Honour to GBPIHED Faculty Members	-	**03**

laboratory project made an attempt to investigate the potential for empirical techniques such as Artificial Neural Networks (ANNs) to downscale the GCM/RCM output at an interior point. In this analysis, suitability of Artificial Neural Network (ANN) technique to interpolate rainfall data from a grid structure to interior points, in the Himalayan region, with certain accuracy has been tested for eleven districts of Uttarakhand state. The study of Indigenous Knowledge: traditional health care practices in rural areas of Uttarakhand reveals that *Vaidyas* and village elders use about 140 medicinal plants to treat ailments out of them about two dozen herbs had proven/reported therapeutic activities. In 86 traditional herbal formulations used by the village elders for treatment of human ailments cattle; diseases were documented with information containing ingredients, and use method. Validation results of herbal formulations for dissolving gall stone showed mixed result. Project on Exploration, diversity, and mapping of vegetation in the urban forests of Kumaun Himalayan towns using Remote Sensing & GIS showed that Almora town has tree cover in more than half of the town area, and Almora urban area is highly heterogeneous. Other efforts of the theme were focused on study of glaciers in Kali valley (Kumaun Himalaya) and Gangotri glacier, application of GPS and GIS through externally funded projects

Biodiversity Conservation and Management (BCM)

During revisit studies in Lata region, Garhwal and Pindari region, Kumaun of the NDBR, Uttarakhand total species richness, nativity and endemism of trees, shrubs and herbs different forest communities were recorded. Soil parameters were estimated in different forest communities and it was observed that almost all the parameters were correlated significantly with altitudes. *265 species of vascular plants were recorded* from the Nargu Wildlife sanctuary of Himachal Pradesh and analyzed for nativity, endemism and rarity and utilization pattern. Four species were endemic, 75 near endemic, 05 species critically endangered; 08 endangered, 12 vulnerable and 174 economically important. Extraction trends of fodder species (21 spp.) in 23 villages showed mean collection, PU and RUI for *Quercus leucotrichophora*, *Quercus semecarpifolia* and *Rhus javanica*, respectively. Yemtaar-Sukochuli-Neytham transect along Indo-Nepal border, western Sikkim of the KBR, was investigated. From 15 major sites, 3 major forest systems, 12 forest communities, 61 woody species, 32 fuel and 61 fodder species were recorded. *Phytosociological studies were carried out in Yewang Forest of Circle Dirang* of the Tawang-West Kameng Biosphere Reserve (proposed), Arunachal Pradesh. Total 180 quadrats of 10x10 m^2 size were randomly laid in 6 altitudinal zones and cbh of 3000 individuals of trees were recorded. Species were analysed for density, frequency, abundance, IVI, community patterns, etc. The number of species along an altitudinal gradient varied. In West Kameng district, surveys and samplings were carried out in seven grids, total 202 species were recorded. Six forest communities were delineated in Pinjoli watershed. Species richness of the communities ranged from 26-50.

Database for 476 species of medicinal plants recorded from Parbati Watershed, Chandra Valley, Upper Beas Valley, Mohal Khad watershed and Upper Banjar Valley of Himachal Pradesh, is prepared. For all the five sites, nativity, endemism and threat categories of the species have been identified. From Parbati Watershed, 13 MPs were categorized as critically endangered, 9 endangered, 27 vulnerable & 26 near threatened; Chandra Valley – 15 MPs as critically endangered, 11 endangered, 25 vulnerable & 17 near threatened; Upper Beas Valley – 7 MPs as critically endangered, 10 endangered, 12 vulnerable & 17 near threatened; and Banjar Valley – 13 MPs as critically endangered, 12 endangered, 20 vulnerable & 14 near threatened. Seed germination protocols for the *Corylus jacquemontii, Acer caesium, Buxus wallichiana* and *Pittosporum eriocarpum and* vegetative propagation protocols for *Platanus orientalis, Ulmus wallichiana* and *Tilia europea* were developed at Himachal Unit, Mohal-Kullu. Growth performance (i.e. shoot length,

EXECUTIVE SUMMARY

The institute with a strong commitment for sustainable development of the Indian Himalayan Region (IHR), is the only institute of its kind which addresses physical, biological, social and economic issues of the region and its people in an integrated manner. The R&D mandate of the Institute is broad and covers all the facets of environment and development. Towards achieving this, multi-disciplinary approach and integration are the guiding principles. The emphasis on interlinking of natural and social sciences is the major thrust of all the programmes in the Institute. In this effort, special attention is placed on the intricate balance between fragility of mountains, indigenous knowledge and sustainable use of natural resources. Design and implementation of R&D activities on priority environmental problems, development and demonstration of best practices, technology packages and delivery systems for improved livelihood of the people are the core issues covered under most programmes of the Institute. A conscious effort is made to ensure participation of local inhabitants for long-term acceptance and success of various programmes. Therefore, training, education and awareness of a variety of stakeholders are the essential components of all the R & D programmes. A brief summary of R&D activities of the Institute during the reporting year 2011-12 is as follows:

Watershed Processes and Management (WPM)

The theme Watershed Processes and Management (WPM) focuses to work on watershed services and management, land and water use policy, consequences of climatic change, improvement of Himalayan farming systems, relevant Indigenous knowledge systems, and domestic energy needs, etc. *Project on* Optimizing hydrological responses in a functional land use model for mid-elevation Himalayan watersheds *analyses the present water availability pattern and revealed that in-stream storage can only satisfy urban water demand of watershed till 2024. Large monsoon season storage (using large water retaining structure above 5 m height) may be required for the future.* Under the project Developing sacred landscape model for eco-restoration and biodiversity conservation in the central Himalayan region, data obtained on the eco-physiological health and leaf energy exchange characteristics of 20 promising tree species, when planted at the MTM project site in Kolidhaik village, revealed suitability of *under-temperature* plants for afforestation on the exposed slopes of the mountains. The study on Energy use pattern in rural domestic sector of Uttarakhand State revealed that in the state of Uttarakhand about 55% watermills were defunct and only 45% were working with an operational efficiency of 10-15%. Majority of the watermills were non-functional due to no or low availability of the water in the feeder stream. Project on Recharge area identification and estimation of mean residence time for springs in Pauri Garhwal using isotope techniques, remote sensing and GIS for implementation of artificial recharge structures reveals that spring flow show significant rise with the availability of water due to surplus rainfall in the year 2010 and normal rainfall in the year 2011, especially during the lean period. Nematode diversity in the traditional agro ecosystem of central Himalaya, their impact on soil health and crop growth was studied and a total of approximately fifty major genera have been identified. The cropping ratios of paddy and foxtail millet in *Kharif* season and wheat and mustard during *Rabi* season had significant effects on the temporal variability and hence stability of the various nematode functional groups across the study period. The variability in the bacterial and fungal feeding groups was the greatest. This suggested that manipulation of the resource base can have important multi-trophic effects. Development of analytical models through establishment of Modeling & Statistical Computing

basal diameter, number of leaves, number of floral buds and number of fruit initiation) of *Aconitum heterophyllum* populations P-1 (Jana) & P-2 (Lahaul) at Doharanala, and P-1 (Jana) & P-2 (Lahaul) at Jana under different treatments was monitored. *At Headquarters, In vitro* production protocol for phenolic contents in *Habenaria edgeworthii* was standardized. Suitable method for drying of *Valeriana jatamansi* was optimized. Among the two different conditions (shade and hot air oven at 45 °C), higher phytochemicals and more antioxidant activity in plant parts (Leaves and rhizomes) dried at hot air oven at 45 °C was revealed. Vegetative propagation protocol of *B. jaeschkeana* was developed for the purpose of mass multiplication. Seed germination protocol was also developed for *B. jaeschkeana*. Genetic diversity analysis of *Hedychium spicatum* collected from 16 populations of Indian west Himalaya showed high percentage of polymorphism which is an indicator of high level of genetic diversity. Analysis of Molecular Variance (AMOVA) revealed higher within population variation (94%). The UPGMA clustering exhibited grouping of most populations from the same or adjacent regions. *In Sikkim Unit, seed germination protocols for Juglans regia and Heracleum wallichii* were developed and growth performance monitored. Growth performance of *Swertia chirayita was also monitored. Hi*ghest survival (92 %; $p<0.05$) of the species was recorded in green house and plant biomass/individual was recorded highest (42.60 g/plant) in open. At Headquarters, total 640 specimens belonging to 456 species, 193 genera and 40 families were digitalized and edited. Good quality photographs of 20 plants were added.

The binomials were carefully checked with help of relevant floras and monographs. The complete data sets of the 640 specimens were entered as per the GBIF format and the digitalized images were incorporated along with the data sets. Pollination bibliography was prepared and website has been developed. Pollination Deficit Protocol for the apple (Himachal STEP Site), mustard and cucurbits (Kosi STEP Site) and large cardamom (Sikkim STEP Site) was tested. Responses of the farmers revealed high level of awareness on pollination and pollinators amongst farmers.

Environmental Assessment and Management (EAM)

The Theme of Environmental Assessment and Management (EAM) worked mainly on 9 projects out of which 6 belonged to in-house, 3 to externally funded projects from VSSC, SPL Thiruvanthapuram, PRL Ahmedabad and DST New Delhi. In-house projects like "Small holder farming systems- strategies for economic and environmental viability in the western Himalaya", aims to develop a horticultural model at a representative village- Patharkot in district Almora so as to diversify on-farm rural economy.

While project on "Forest ecosystem services in the Central Himalayan mountains- quantification and valuation approach" focuses on evaluation of various ecosystem goods and services from two major forests, i.e. oak and pine. The next project on "Strategic environmental assessment (SEA) and environmental impact analysis (EIA) of hydropower projects in the western Himalayan region" aims at obtaining overlapped area from one hydropower project to another in the upper River Sutlej basin in Himachal Pradesh and the Alaknanda basin, where SEA study with the help of RS & GIS is considered to be an effective tool for analysing these projects. "Urbanization vis-à-vis solid waste management and air pollution in sprawling urban towns of Himachal Himalaya" is the project which *studied background values of ambient air quality during pre-monsoon and post-monsoon in three hill towns– Hamirpur, Kangra and Chamba.* "Assessment of status and impacts of tourism for sustainability– case studies from Himachal Pradesh", incorporated assessment of economic significance of tourism especially in Dharamshala region for its sustainability. Project on "Assessment of downstream impacts of hydroelectric projects in Arunachal Pradesh: A Case of Ranganadi Hydroelectric Project" showed heavy siltation in

downslope region. The externally funded projects were mainly concerned with aerosols (solid, liquid, gas) and its impact on climate change. These projects are: (i) aerosols climatology over the northwestern Indian Himalayan region, Himachal Pradesh, (ii) gaseous air pollution in the background site of sprawling urban Environment of Himachal Pradesh, and (iii) ambient air pollution and its sources in the background sites of different hill spots in the north-western Himalaya, Himachal Pradesh.

Socio-Economic Development (SED)

During the reporting year, the projects on priority areas that were initiated during XI plan period continued, i.e. Scaling up innovative resource management practices for improved livelihood in the mid hills of the central Himalaya (HQs), Assessing the eco-tourism potential (North East, Himachal, and Garhwal Units), and *Shifting agriculture: issues and options with focus on adaptive interventions to make it ecologically, economically and socially viable,* (NE Unit), Pesticide residue contamination of food chain: appropriate monitoring and control measures from field studies in Himachal Pradesh, and Migration: socioeconomic and cultural implications in Central Himalaya (HQs). Also, multilocational approach on "Capacity building for entrepreneurship development and self employment in the Himalayan region" has continued. In addition, the group continued to strengthen the R&D of the Theme through funding generated under a number of externally funded projects that either continued from the previous year or were started afresh. The externally funded R&D projects those continued from the previous year are – Biodiversity conservation though community based natural resource management in Arunachal Pradesh, Cultural landscape: the basis for linking biodiversity conservation with sustainable development of Arunachal Pradesh, and Enhancement of livelihood security through sustainable farming systems and related farm enterprises in north-west Himalaya. The new consultancy project initiated during this reporting year is "Preparation of Wildlife management plan / Biodiversity conservation plan for Trans Arunachal Highways". One extramural research project – 'Development of baseline information and identification of potential corridors for Namdapha National Park (Tiger Reserve) and Mouling National Park in Arunachal Pradesh' (NE Unit) was successfully completed. The R&D projects of the Theme continued to strengthen/generate data base on various aspects of IHR, emphasizing on appropriate interventions and skill enhancement of the people to enable them to develop viable, replicable and effective community based natural resource management options to effectively protect and enhance the biodiversity simultaneously improving their economy and quality of life. *In principle, through R&D projects and initiatives, the group has tried to promote participation of local communities in sustainable resource management and in alternative and innovative livelihood schemes like ecotourism, agro forestry, and micro enterprises, and fill the gap in information for improving policies and knowledge base. The group created a s*trong and empirically sound data base on tourism potential all across the IHR and analysed adoption/adaptation scenario of tested/innovative resource management practices in central Himalaya. It significantly contributed in the conservation of rich biodiversity of selected proposed heritage sites in Arunachal Pradesh ensuring c*ommunity participation addressing c*ritical issues such as hunting, shifting agriculture, community welfare and alternative livelihood.

One acclaimed and recognized achievement is the adoption of all the Biodiversity Management Committees (BMCs) formed at villages under GOI-UNDP CCF-II project by Arunachal Pradesh Biodiversity Board (APBB). Towards enhancing livelihood, the group could motivate communities in Arunachal Pradesh to bring about 75 ha of land under horticultural crops. Conservation of threatened MAPs that are also economically rewarding continued to be top priority of the group by bringing about 130 ha of

land under *Taxus wallichiana* plantation. A strong interface established between state governments and various initiatives of the group is worth mentioning.

Biotechnological Applications (BTA)

During the period focus was provided towards large scale multiplication and field plantation of selected plant species using protocols that were developed earlier; two important *Rhododendron* species of Sikkim, namely, *R. maddeni* and *R. dalhousiae* were field planted and monitored. Efforts continued to standardize propagation protocols in other economically important species using both conventional and in vitro methods. Successful and reproducible in vitro protocol was developed for multiplication of large cardamom (*Amomum subulatum*), a commercially important crop of the country. Estimation of bioactive compounds and molecular characterization of two species of high medicinal value, namely, *Podophyllum* sp. and *Ginkgo biloba*, from different locations of IHR are continuing. Antioxidant potential of stem barks, leaves and fruits of *Olea spp.* were evaluated using three different *in-vitro* assays (DPPH, ABTS and FRAP). Indian olive (*Olea ferruginea*) was identified as one of the potential and rich sources of natural antioxidants, and can be exploited for pharmaceutical purposes. Exploration of microbial diversity with specific reference to plant growth promoting microorganisms and mycorrhizal associations are continuing in different regions of the IHR, including north-east India. Besides investigations on rhizosphere communities, evaluation of medicinal properties, including antimicrobial activity in leaf extracts of *Ginkgo biloba* is being carried out. Out of three groups, bacteria were found to be most sensitive to antimicrobial substances, followed by actinomycetes and fungi. In an effort to develop a centre for Microbial culture collection, pure cultures of bacteria, actinomycetes and fungi are being maintained in the Laboratory of the Institute and regularly being accessioned by various national laboratories and institutes. A number of isolates of actinomycetes were isolated from the soil samples, collected after fire operations, at agricultural sites under shifting cultivation in northeast India. More than half of these isolates were observed in viable but non-culturable state. Some of the morphologically distinct and cultivable isolates were subjected to characterization and identification. The isolates varied in cell morphology, utilization of carbon sources, sensitivity to antibiotics, and salt tolerance. Characterization of pyschrotolerant fungi with particular reference to lignin degradation under mountain ecosystem has been initiated under an ICMR funded project. Studies on phosphate solubilization and litter decomposition potential of dominant fungi, isolated from the IHR is in progress. Investigations on the possible role of mycorrhizae on gas exchange characteristics, particularly photosynthesis and water relations in three central Himalayan *Quercus* species (*Q. glauca*, *Q. leucotrichophora* & *Q. semecarpifolia)* is underway. Preliminary studies indicate that amongst these species *Q. leucotrichophora* can adapt better at wider altitudinal range. Under the pond-based integrated farming system, studies are being carried out on Saprolegniasis, a problematic fungal infection of fishes in lakes and ponds. The study involves exploration of fungal infection in fingerlings and adult fishes, and to isolate, culture, characterize and identify associated fungal species; this would help in understanding fish diseases and formulating integrated management to the farmers in the region. Initiatives on capacity building in imparting training on simple technologies to rural folks and training of students for (MSc & PhD) continued.

Knowledge Product and Capacity Building (KCB)

The knowledge accumulated, documented, or developed over a period of time in any field related to human well being through natural resource management and environmental conservation required to be transmitted or exchanged through capacity building efforts. It provides unique paradigms designed

to empower the stakeholders and enhance their institutional and human capacities for integrating environmental considerations and related issues into development planning and decision making. With greater realization of the value of this knowledge base for looking at issues linked to social process and natural resource management, there is increasing realization that in many ecological/ social situations, knowledge should be an integral part of a holistic and cost-effective approach to sustainable development.

The Institute conducted several trainings in self financing mode under the Rural Technology Centres at Hqs. and Units. Besides publications of regular documents, an attempt was made for promoting and linking tourism/eco-tourism with agro-production base and wild resource collection base and enhancing the capacities and skill of local people of the region. It empowered local people/youth in the field of simple and eco-friendly technologies for improving the yield particularly vegetables (off-season) and traditional crops. This linkages of local production and consumption systems helped people to involve themselves in tourism and make good profit from this venture. The detail ecological and socio-economic study of Dhaulchina – Binsar eco-camp (DBEC) and eco-tourism for community based natural resource management at Dhanolti has been carried out. Monitoring framework has been developed, which includes strategic thrust of the framework (i.e. critical infrastructure, critical institutions for social development) and monitoring indicators (i.e. resources and tourism, inflationary pressure, quality of services and resources provided, environmental impact factors, linkages between tourism and community, infrastructural/management factors etc). The accommodation currently available for tourist is most critical limiting factor in Upper Kedar valley. An attempt is made to popularize lesser-known tourism spots (e.g. Panch Kedar, Tungnath, Rudranath, Madmaheshwar and Kalpeshwar – Ansuya, Triyuginarayan, Kalimath, Pawalin Kantha etc.) In-depth study on dung production by pack animals and its decomposition through suitable technique i.e., vermin-culture has been carried out using various experiments under two different conditions in the field. Biochemical analysis of the decomposed dung were carried out and compared with other animal manure and management option of pack animal dung in high altitude tourist trek was suggested. Appropriate approaches & framework is developed for capacity building & skill development in the area of eco-friendly simple rural technologies. Strong linkage and network are developed with various institutions, NGOs and line departments and listed the name, address and contact number of resource persons for directory preparation for future use. The determination of various micro and macro mineral nutrients confirmed that the fruit berries of *Viburnum mullaha* can be potential source to combat the hidden hunger of micro and macro nutrient deficiencies. The good composition of carbohydrate, protein and lipids (184 mg/g) make it a very nutritional fruit that can be processed to develop various health products. The Central lab facility was provided to different stakeholders for testing of water and soil samples.

1. INTRODUCTION

During the year 2011-12 various R&D activities were executed by the Institute at different locations of Indian Himalaya through its HQs at Kosi-Katarmal (Almora) and four regional Units, namely, Himachal Unit (Kullu), Garhwal Unit (Srinagar-Garhwal), Sikkim Unit (Pangthang) and NE Unit (Itanagar). Over the years, the Institute has taken significant strides in identifying problems, developing region specific approaches, demonstrating their efficacy in the field and disseminating information to various stakeholders. The diverse problems thus addressed were related to ecology, resource conservation, traditional practices, livelihood opportunities, land restoration, propagation protocol development, biotechnological interventions, etc. The Institute implements its activities through core funds provided by the Ministry of Environment and Forests (MoEF), Govt. of India, and the projects financed by external funding agencies (National and International). The Institute also supports activities of various partner Institutions in different Himalayan states through Integrated Eco-development Research Programme (IERP). The Science Advisory Committee of the Institute reviews the progress of existing projects and provides guidance to develop new R&D programmes. Under the provisions of GBPIHED VISION-2015 and following the stakeholders' consultations across the region, including that of the Scientific Advisory Committee, the Institute developed a perspective plan for XIth plan period (2007-12). The identified thematic categories include the following programmes: (1) Watershed Processes and Management (WPM); (2) Biodiversity Conservation and Management (BCM); (3) Environmental Assessment and Management (EAM); (4) Socio-economic Development (SED); (5) Biotechnological Applications (BTA) and (6) Knowledge Product and Capacity Building (KCB).

During the reporting period various activities/projects were concluded. Summaries of these are included at appropriate places in the text. In due course detailed documents will be published and made available to the public. The progress made during the year 2010-11 on various in-house and externally funded projects under different thematic groups, a brief account of academic and other activities, along with the statement of accounts, has been presented in this report. The Institute would be most grateful to receive critical comments and suggestions for improving quantum and quality of outputs of various R&D activities.

2. MILESTONE EVENTS

GBPIHED Society Meeting

The XVII meeting of the G.B. Pant Society of Himalayan Environment and Development (GBPIHED) was held on November 23, 2011 at the Ministry of Environment & Forests, New Delhi. Smt. Jayanthi Natarajan (President of the GBPIHED Society), Hon'ble Minister of State (Independent Charge), Environment and Forests, Govt. of India chaired the meeting. Dr. L.M.S. Palni, Director, GBPIHED, made a detailed presentation on the progress of the Institute. The society took note of various activities that were conducted at the Institute and approved the draft Annual Report and Statement of Accounts of GBPIHED for the year 2010-11. Also, after detailed delibration, guidance was provided to improve Institute's outreach. Among the members, this meeting was attended by Dr. T. Chatterjee, Secretary, Ministry of Environment & Forests, Government of India; Ms. Vibha Puri Das, Secretary, Department of Higher Education, GoI; Shri B.M.S. Rathore, Joint Secretary, MoE&F; Dr. G.S. Rawat, ICIMOD, Kathmandu, Nepal; Shri Omkar Singh, ICFRE, Dehradun, Shri S.S. Garbyal, PCCF and Principal Secretary, Mizoram; Shri T.T.C. Marak, PCCF (T), Meghalaya; Shri G. Das Gupta, Director, GSI, Ministry of Mines; Dr. R.B. Lal, Director, IIFM, Bhopal; Dr. Paramjit Singh, Director, BSI, Kolkata; Shri B.S. Sajwan, PCCF, Arunachal Pradesh; Smt. Gauri Kumar, AS & FA, MoE&F; Dr. Anoop Seth, Director, Ministry of Water Resources, New Delhi; Dr. Anand Kamavisder, DST, New Delhi; Dr. D.K. Khare, Director, Ministry of Non Renewable Energy Sources; Dr. J.C. Dagar, ADG, ICAR & DARE; Shri Vivek Saxena, Director, MoE&F and Shri Raja Ram Purohit, Scientist-C, WQ Div., Ministry of Water Resources.

Governing Body Meeting

The 35th Governing Body Meeting of G.B. Pant Institute of Himalayan Environment and Development, was held on July 08, 2011 at the Ministry of Environment & Forests, New Delhi, under the Chairmanship of **Dr. T Chatterjee**, Secretary, Ministry of Environment & Forests, New Delhi. The meeting was attended by **Shri M. F. Farooqui, Additional Secretary, MoEF** (Member); **Ms Gauri Kumar, AS & FA, MoEF** (Member); **Shri B.M.S Rathore, Jt. Secretary, MoEF** (Member); **Prof. V.K. Gaur** (Member) and Dr. L.M.S. Palni, Director (Member Secretary).

The Governing Body deliberated on various issues concerning R&D of the Institute and provided valuable suggestions for improvements. Governing Body also approved the draft Annual Report and Statements of the Accounts for the year 2010-11.

Scientific Advisory Committee (SAC) Meeting - I

XVIII Meeting of Scientific Advisory Committee of GBPIHED was held on April 14-15, 2011 at GBPIHED, Almora under the Chairmanship of Prof. Jayanta Bandyopadhyay, Indian Institute of Management, Kolkata. The meeting was attended by Prof. Asha Chandola Saklani; Dr. M.P. Sah (WIHG Nominee); Shri B.S. Bisht (NABARD Nominee); Dr. R.K. Maikhuri (GBPIHED Nominee); Dr. K.K. Singh (GBPIHED Nominee); Dr. S.C. Arya (GBPIHED Nominee) and Dr. L.M.S. Palni, Director, GBPIHED. The Director highlighted the significance of the present SAC meeting w.r.t. (i) critical midterm evaluation of the progress of ongoing in-house projects; and (ii) providing guidance for possible thrusts during forthcoming plan period. He thanked the SAC members for their valuable inputs on the previous year's Annual Report.

The Chairman thanked the members of the SAC for their continuous support over the period and requested them to critically examine the progress of individual projects of the Institute and provide constructive inputs for improving the quantum and quality of outputs. He stressed upon maintaining interdisciplinarity in Institute's outlook for addressing issues of Himalayan Environment & Development. He

emphasized on the need for addressing issues of intellectual challenges in the region and felt that the Institute can take-up a leadership role in this regard. Institute faculty made presentation on the progress of individual projects. The progress was reviewed by the SAC and critical comments and suggestions offered for follow up.

Scientific Advisory Committee (SAC) Meeting - II

XIX Meeting of Scientific Advisory Committee of GBPIHED was held on March 19-20, 2012 at GBPIHED, Almora under the Chairmanship of Prof. Jayanta Bandyopadhyay, Indian Institute of Management, Kolkata. The meeting was attended by Prof. Asha Chandola Saklani; Shri B.S. Bisht (NABARD Nominee); Dr. R.K. Maikhuri (GBPIHED Nominee); Dr. K.K. Singh (GBPIHED Nominee); Dr. S.C. Arya (GBPIHED Nominee) and Dr. L.M.S. Palni, Director, GBPIHED. Dr. L.M.S. Palni, Director highlighted the significance of this SAC meeting in view of beginning of a new Five Year Plan period, which also coincides with the completion of Institute's in house projects that were approved for the 11th Five Year Plan period. Therefore, Institute would require guidance and direction of SAC for developing programmes/projects in the forthcoming plan period. Further, as the Institute is entering into 25th year of its establishment, the SAC may like to provide critical inputs on scientific progress of the Institute during this period. The SAC was specifically requested for devoting time in the present meeting to suggest a way forward for the Institute in the 12th Plan period. The SAC members were thanked for their valuable inputs in the Annual Report (2010-11).

The SAC Chairman appreciated the efforts of the Institute all through the period of the present SAC and indicated that it was a pleasure working with the Institute on the subject of Himalayan Environment and Development, a task which is professionally very challenging. He further emphasized that the area of Himalayan Environment and Development, as mandated to the Institute, is challenging and demanding which calls for cautious approach with regards to quality of work, and requires patience with respect to outputs. The presentations made by individual faculty were critically reviewed by the SAC and suggestions were offered for future improvement.

International Day of Biodiversity (IDB)

`The International Day of Biodiversity (IBD) with a theme "Forest Biodiversity" was celebrated at the GBPIHED, HQs at Kosi-Katarmal, Almora and its four regional units on May 22, 2011 with the school children and teachers of the nearby schools. In the GBPIHED, HQs, the day was celebrated at Suryakunj – Nature Interpretation and Learning Center (an *ex-situ* conservation site). Over 100 students from 19 different schools participated in the programme. Institute faculty described the intricate relationship among different biodiversity components and its importance in forest biodiversity. Dr. L. M.S. Palni, Director of the Institute briefed on the importance of technological intervention and new scientific innovations on forest biodiversity but at the same time he emphasized on sustainable use of natural resources. Besides, various activities reflecting the theme, were organized which included drawing, debate, essay writing, etc.

Global World Environment Day (G-WED)

The Global World Environment Day was celebrated at GBPIHED HQs at Kosi-Katarmal, Almora and all the four regional units as "A Day with Students" with a focus on the theme "Forests: Nature at

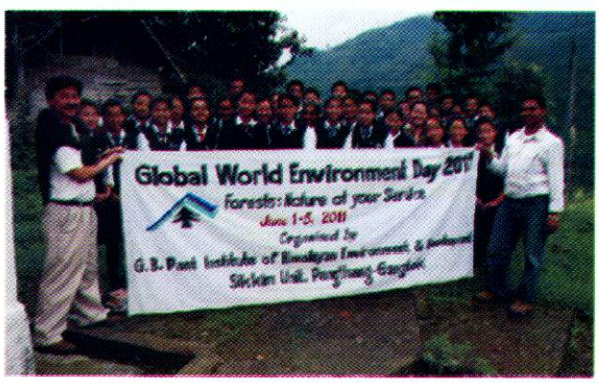


Fig.1. Celebration of Global World Environment Day – 2011.

Your Service" on 5 June, 2011. On this occasion students from various schools of the region were exposed to different laboratories of the Institute to see live demonstrations on different topics like water testing, tissue culture, bio-technology, microbiology and remote sensing and GIS, etc. Besides, various documentaries on forest, nature, space, biodiversity, etc., were shown to the students. The Director of the Institute described the importance of the 'Global World Environment Day' and its objectives. Various activities such as Declamation Contest; Poster and Slogan Competitions and Cultural programmes related to the environmental conservation were organized. Er. Kireet Kumar, Scientist addressed the participants and stressed that plantation of broad leaved native trees should be promoted as they play an important role in environmental conservation. Similar celebrations were also held at Garhwal Unit, Himachal Unit, Sikkim Unit and NE Unit of the Institute.

Annual Day Celebration

The Institute celebrated 124th Birth Anniversary of Pt. Govind Ballabh Pant and Annual Day function of the Institute at its HQs Kosi - Katarmal and all the four Units (Garhwal Unit – Srinagar; HP Unit - Kullu; Sikkim Unit - Pangthang; and NE Unit - Itanagar) on September 10, 2011. The function was inaugurated by the Chief Guest Prof. Girijesh Pant, Vice Chancellor, Doon University, Dehradun. Director of the Institute briefly highlighted the Institute's R & D activities conducted through its HQs and four regional Units. The new initiatives in the research including Glaciers study; Kailash Sacred Landscape, Climate Change, etc. were emphasized. Institute's commitment for promotion and up scaling of environment friendly and cost effective technologies in the region was highlighted. Member of Parliament, Shri Pradeep Tamta stressed on the conservation of water resources and emphasized the need on assessment of Hydropower projects in the Indian Himalayan Region. He emphasized on the need of conservation of Kosi river and appreciated the Institute initiatives in this context.

On this occasion 17th Pt. Govind Ballabh Pant Memorial lecture entitled "Symmetry and Beauty in the Living World" was delivered by Prof. Vidyanand Nanjundiah, Indian Institute of Science (IISc) and Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore. Through his lecture, Prof. Nanjundiah enlightened the audience on the importance of symmetry and its beauty in nature. His research has been concerened with phenotypic variation and social behaviour in the cellular slime

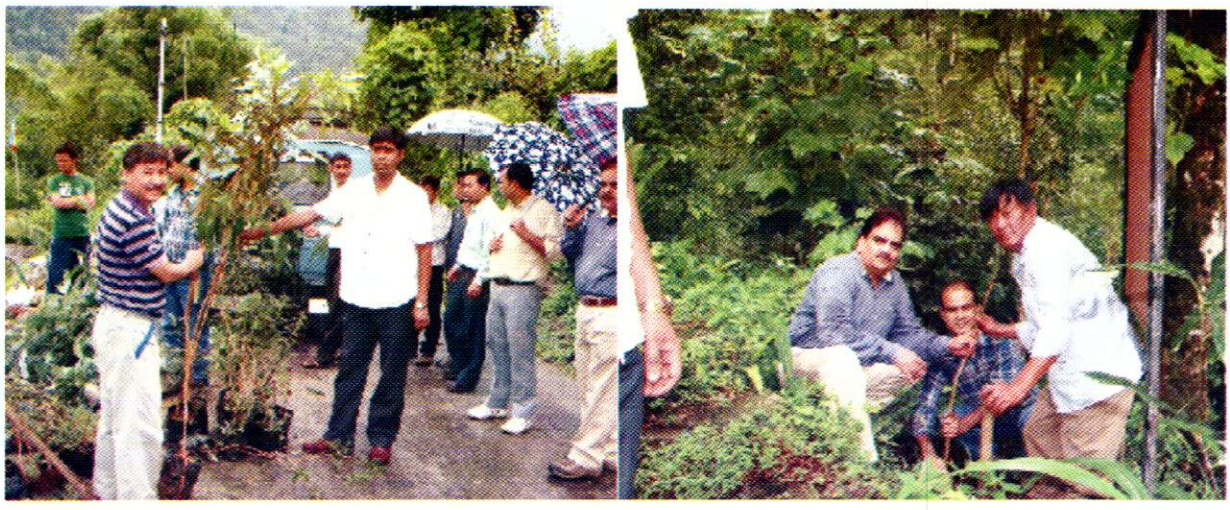


Fig.2.(a&b). Saplings being taken for plantation, Pastanga village and Plantation at the different sites along the footpath, Mahabhir Falls, Assam

moulds. The Photo competition cum exhibition on different aspects of Himalayan Biodiversity was inaugurated by Shri Pradeep Tamta, Member of Parliament. The panel of Judges for the photo competition consisted of Shri T. Kapoor, Shri M. Chandran and Shri M.M. Choudhary. Vote of thank was proposed by Dr. P. P. Dhyani, Senior Scientist of the Institute. Over 300 participants representing diverse section of society participated in the programme.

Wild Life Week Celebrations

Wildlife Week was celebrated at the HQs and its four regional units (6-7 October, 2011). The aim of the celebration was to make aware the youth on issues of Biodiversity Conservation. On this occasion, a Biodiversity exposure and interpretation campaign for students and teachers of Almora District was organized with a particular emphasis on inculcating interest among the children for diversity of life in their immediate surrounding. Exposure visit to the 'Suryakunj' - Nature Interpretation and Learning Centre at Kosi-Katarmal, Almora was the main event followed by various on-spot competitions for the students. Over 100 students and 12 teachers from 11 schools participated in the programme.

Environmental Awareness and Plantation Programme

A one-day programme on environmental awareness was observed along with plantation of elite temperate plant species at Assam-Lingzey area falling under the Taktsom Chu watershed in the east district of Sikkim on 10th Aug, 2011. The programme was organized as a part of the watershed project which includes plantation and monitoring growth performance and adaptation of tissue culture and conventionally raised plants. A total of 40 participants from the different villages of the watershed, teachers, students, local PRI office-bearers and members of NGO of Gairigaon participated in the programme. Dr. K.K. Singh, Scientist Incharge of GBPIHED-Sikkim Unit appraised the gathering on the objective of the programme and also dwelt upon the various mandates and current programmes that are being executed by the Institute in the Indian Himalayan Region. Following this, more discourses on various aspects of conservation continued. After an extensive discussion and consultation with the active Panchayat members of Pastanga village, with the involvement Assistant Livestock Inspector of Animal Husbandry and Veterinary Department (Govt. of Sikkim), Goucharan and villagers, suitable sites for plantation at various locations in and around the village of Gairigaon were identified. The other sites for plantation of saplings was Rajakharka Pokhari and Gufa Dara, at Daragaon.

Species selected for the programme consisted of *Champ* (*Michelia excelsa, M. lanuginosa*), *Buk* or *Bajranth* (*Quercus lamellosa*) and rhododendrons (*Rhododendron ciliatum, R. maddeni* and *R. baileyi*). A good part of the planted species were threatened and vulnerable plants of the region and which were being reintroduced through tissue culture and available propagation technologies at GBPIHED-Sikkim Unit.

Training-cum-Workshop on Earthquake Risk Mitigation and Management

Disaster Management Faculty-Sikkim, G. B. Pant Institute of Himalayan Environment and Development, Sikkim Unit, with National Institute of Disaster Management (Ministry of Home Affairs, Govt. of India) and in collaboration with Land Revenue & Disaster Management Department, Govt. of Sikkim organized a five days training-cum-workshop on Earthquake Risk Mitigation and Management (5-9 September, 2011). This workshop was particularly designed for engineers, architectures, town planner and other concerned departments like Building & Houses, Road & Bridges, Urban Development & Human Resource. The main objective of training was to provide practical skills to engineers, architectures, town planner, and those who are involved in risk reduction in earthquake management planning at different levels. Over 35 participants from different government department participated in the workshop.

Capacity Building and Entrepreneurship Development

Garhwal Unit of the Institute organized two days workshop on Entrepreneurship development through sustainable utilization and management of local bio-resources in Kedar valley during March 24-26, 2011. Scientist In-charge, addressed the participants and made detailed presentation on the potential of natural resource, strategies for sustainable utilization and management of these resources to enhance livelihood through adopting the technologies demonstrated in the centre. A total of 65 stakeholders of different backgrounds such as farmers, students, NGOs, members of line departments of the region participated in the programme. Various issues related to sustainable utilization and management of bioresources and their linkages with livelihood of the stakeholders were discussed among the participants during field demonstration and training.

Workshop on Tourism/Ecotourism

Garhwal Unit of the Institute organised a two days workshop on promoting ecotourism among the youth of the Kedar Valley during March 4–5, 2011. The Scientist-In-charge, Garhwal Unit made a detailed presentation on problem, issues and management of eco-tourism in Kedar Valley. A total of 55 youth of the valley, farmers, NGOs, representatives of line departments, etc.; stakeholders having curiosity for development of entrepreneur in the area of eco-tourism participated in the programme. Different issues related to home stay ecotourism development in the valley by active participation of youth and other stakeholders and role of this activity in income generation through developing capacity and skill were deliberated. Possibilities of adopting activities by way of promoting local food crops through value addition, biodiversity conservation through developing eco-park and local bio-resource utilization etc., were discussed during frontline demonstration and the training part.

Awareness on Biodiversity Conservation and Management and Afforestation

An awareness workshop was organized by Himachal Unit of the Institute on June 1, 2011, to enhance general understanding on Biodiversity Conservation and Management. Scientist In-charge, G.B. Pant Institute of Himalayan Environment and Development, Himachal Unit, apprised the participants about the awareness workshop and made a comprehensive lecture on the subject by way of focusing on definition, levels, values, livelihood options, utilization pattern, factors responsible for the degradation of biodiversity, threatened plants, *in situ* and *ex situ* conservation, education and awareness and people's participation in biodiversity conservation. Mr. B.S. Rana, DFO, delivered a lecture on Bird diversity of the Larji wetland. He highlighted the potential of Larji wetland particularly for the bird diversity and tourism. He emphasized the involvement of all the relevant organizations and Department is urgently required for the management of Larji wetland. Mr. A. Srivastava, Conservator of Forests, Great Himalayan National park, Shamshi addressed the participants. He highlighted the evolutionary account and threats to biodiversity. He said that man is responsible for the loss of biodiversity. Use of proper techniques for the utilization of biodiversity and involvement of inhabitants in the conservation and management of biodiversity are urgently required. Experiences were shared by the participants, Scientists and Research scholars. All the participants desired for frequent organization of such Awareness Workshops. They agreed on the need for mass involvement in conservation and management of biodiversity. Mrs. Subina Thakur Bhardwaj, ACF, Wildlife, Kullu thanked the Institute and participants. She also shared her experience of different wildlife sanctuaries. On June 2, 2011, HP Unit organized awareness programme on of forestation and environmental conservation. Faculty form the unit, deliberated on various issues of afforestation and environmental conservation in the region. Various officers and Jawans of ITBP, Babeli participated in the workshop.

On June 3, 2011 an awareness programme was organized for SSB Shamshi. The Staff of SSB was exposed to various aspects of the Environment and Developed. It was agreed by participates that SSB in collaboration with the GBPIHED can contribute for the conservation and management of Himalayan environment. Scientist In-charge, GBPIHED, Himachal Unit apprised the participants about the Awareness Workshop and Institute. He delivered a comprehensive lecture on Conservation and Management of Himalayan Environment, and tropical, temperate, sub-alpine and alpine environment highlighted the services provided by the Himalaya. Issues pertaining to various sources of pollution i.e., solid waste, tourism, biomass burning, hydro-electric projects, etc were discussed. Experiences were shared by the Scientists, Research Scholars and SSB participants. The participants appreciated the efforts made by the Institute and said that this collaborative Awareness Workshop has helped them in enhancing their knowledge on various aspects of Himalayan Environment and Developed.

Interactive Workshop on Pollination and Crop Production

An Interactive workshop on biodiversity, pollinators, pollination and crop production was inauguration by President Fruit Grower's Association on June 4, 2011, in his welcome address he said that due to climate change the production of horticultural fruits particularly apple has gone down in the valley. This requires a serious thinking on the conservation and management of environment, so that productivity of the crops could be increased. Scientist In-charge, GBPIHED, Himachal Unit apprised the participants about the Interactive Workshop and made a comprehensive presentation on Biodiversity in relation to pollination and environmental conservation. Dr. Kishor Kothari, PSM, GBPIHED, Himachal Unit presented a brief account on Pollinators, pollination and crop production, and shared his working experience with farmers of Upper valley. Experiences were shared by the Scientists, Research Scholars and Farmers. Shri Bhagat Ram, Treasurer, President Fruit Grower's Association thanked the Scientists, staff and farmers. He highly appreciated the collaborative initiative taken by the Institute, and desired the frequent organization of such Workshops in future.

Workshop of Functioning of Biodiversity Management Committees

Interactive Workshop on "Functioning of Biodiversity Management Committees (BMCs)" was organized on 27th April, 2011 at Apatani Plateau, Arunachal Pradesh, jointly with Divisional Forest Office Hapoli (Ziro), Nature Care and Disaster Management Society, Ziro and Arunachal Pradesh Biodiversity Board, Itanagar for a team from NBA, Chennai consisting Dr. G. Ramachandran, IAS (Retd), Chairperson, NBA Expert Committee on BMC; Shri G. Sai Prakash, IFS, Conservator of Forest, Maharastra; Shri K.S. Sugura, IFS, Member Secretary, Karanataka Biodiversity Board; Dr. V. Arivudai Nambi, Principal Scientist- Biodiversity, M.S. Swaminathan Foundation, Chennai; and Dr. K.P. Raghuram, NBA, Chennai.

3. RESEARCH AND DEVELOPMENT PROGRAMMES

Group: Socio Economic Development (SED) & Environmental Assessment and Management (EAM)

The unique environmental setting of the Indian Himalayan Region (IHR) is varied owing to ecological, socio-economic and cultural diversity. Traditionally, the system is strongly rooted upon the concept of recycling of resources within; however, the system is undergoing rapid breakdown because of the population pressure and developmental needs. In view of the above, Socio Economic Development (SED) theme of the Institute focuses on identified activities such as livelihood enhancement, sustainable tourism, entrepreneurship and self employment, indigenous knowledge, and migration and its socio-economic and cultural implications, etc. The development in the IHR so far has also involved conflict between man and nature. The exploitation of the large resource base of the hills by urban industries through mining, large scale timber extraction or hydro-electric power generation from the hill streams and rivers have resulted in both positive and negative side effects. Environmental costs of such developmental interventions, therefore, need to be integrated with traditionally practiced cost-benefit analysis. Identification of strategies for ameliorating environmental threats through scientific assessments and looking at alternate pathways for securing the ecologic and economic security of the IHR are, therefore, the back bone of the Environmental Assessment and Management (EAM) theme of the Institute, which focuses on activities such as hill specific Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA), aerosols and climate change impacts, disaster mitigation and management, and environmental management of urban areas, etc.

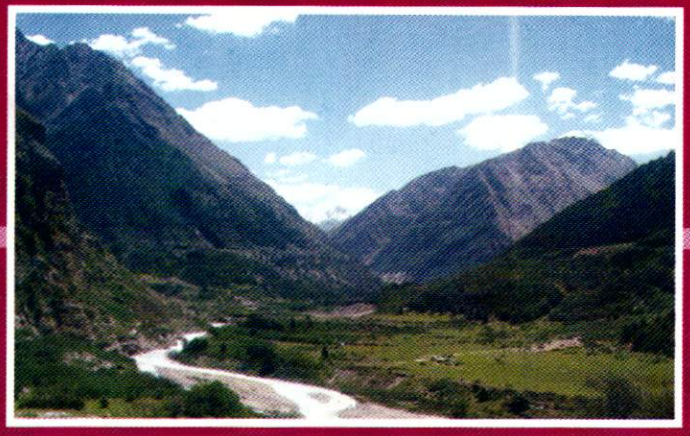
Group: Watershed Processes and Management (WPM) & Knowledge Products and Capacity Building (KCB)

Land and water form the backbone of the resource base on which agriculture, forestry and animal husbandry linkages depend. To meet the Millennium Development Goals for reducing hunger, combating water scarcity and achieving environmental sustainability, it is vital to seek methods for using watershed services more efficiently without compromising with the environment. In the Himalayan context, the challenges are even bigger due to complexity and fragility of the mountain ecosystem. To address some of these challenges in an integrated time bound manner, this group focuses on studies of ecosystem processes operational at watershed level including involvement of user groups and upstream-downstream linkages with a specific target of strengthening mountain specific resource management practices in a systems approach. This group also envisages activities on the enhancement of Institutional outreach based on its research products such as state-of-art methodologies/approaches, models and policy briefs, etc. Besides the above, capacity building through specifically designed modules, trainings programmes, library and IT services, which also help significantly in human resource development, are the other core areas of the R&D activities of the Institute.

Group: Biodiversity Conservation and Management (BCM) & Biotechnological Applications (BTA)

The importance of biological resources for human welfare is tremendous and beyond question since early times. With increasing human population and demand for bioresources, its sustainable and judicious use is essential for the long time survival of the people of the entire world and particularly those in the Indian Himalayan Region, which covers a total geographical

area of approximately 591, 000 km^2 (18% of India) and is inhabited by about 3.7% of the total population of the country. This region harbours a variety of plant, animal and microbial populations, and is considered a "hot-spot" of biodiversity; it also caters and contributes significantly to supporting livelihood and contributing to the economic well being of the people. However, under the changing world scenario stresses the need for increasing food production, pharmaceutical and other products, along with heavy industrialization have compelled biologists to contemplate on serious issues, like conservation of biodiversity, climate change, biotechnological interventions for improved productivity, etc. The group focuses on aspects of biodiversity conservation and management, and on applications of biotechnological methods for improving the rural economy of the Indian Himalayan Region.



WATERSHED PROCESSES AND MANAGEMENT (WPM)

Himalayan watersheds support varieties of managed and natural land use types such as terraced farming, agroforestry and orchards in north west and central to *jhum* farming in north east Himalayan regions. Besides these, natural forests, pastures, degraded lands, glacier and snowbound regions are other important land uses that regulate watershed processes. The recently accepted UN Millennium Development Goal targeted to reduce by half the proportion of people without sustainable access to safe drinking water and reduce hunger. The theme activities include problem identification, assessment and quantification of ecosystem processes through synthesis of research findings and development of practices/packages for implementation with the involvement of beneficiaries. The theme focuses to work on watershed services and management, land and water use policy, consequences of climatic change, improvement of Himalayan farming systems, relevant Indigenous knowledge systems, and domestic energy needs, etc. The main objectives of the theme are: i) Study of dynamics of the watershed processes and evaluation of ecosystem components on watershed scale; ii) Development of ways and means of optimal uses of watershed services for improved economic and ecological viability; and iii) Formulation of strategies for efficient utilization of resource through integrated watershed management.

Optimizing Hydrological Responses in a Functional Land Use Model for Mid-elevation Himalayan Watersheds: An Attempt towards Water Sustainability ***(2007-2012, In-house)***

The study is conducted in the northern part of the Kosi basin (upper Kosi watershed between 29^0 30' and 29^0 55' N Latitudes and 79^0 30' and $79^0$45' E Longitudes covering 480.15 km^2 area) spreading over the Lesser Himalayan domain and administratively within district Almora, Uttarakhand state. The absolute relief of the catchment ranges between 1080 m and 2720 m from the mean sea level. Other study area Taktsom Chu watershed in Sikkim is selected for replicating the output with required modification. The Taktsom chu is a tributary of Rani Khola, lies in Teesta basin. The Taktsom Chu watershed is situated at the south-eastern part of the state in the East district. It extends from $27^0$15' to $27^0$20' N and $88^0$37'30" to $88^0$42'30" E, embracing an area of 35.42 km^2. Optimization and allocation techniques were used last year for water demand forecasting till the year 2030. In the current year an interface between water demand and supply is developed for water supply management. Average daily discharge for last three years is calculated for the watershed. Using the socio-economic scenarios and water demand for functional land use, an integrated

decision support system has been developed for water supply management till the year 2030.

Objectives

- To analyze policies and practices of land use (forest and non-forest land), land transformation (one land use category to other) and related water use in selected watersheds.
- To quantify hydrological processes and establish functional relationship of land use changes and hydrological responses in social and climate change scenario.
- Development and demonstration of functional land use model using optimized hydrological response (water allocations) at sub-watershed level.
- Disseminations of an adaptive land use policy and integrated decision support system for water resource management at watershed level.

Achievements

- Daily discharge in 2009, 2010 and 2011 are given in Fig.3. Maximum average daily discharge was recorded as 40.43 cu m/s on 10th Sep 2009, in 2010 maximum average daily discharge was recorded on 18th Sep (169.23 cu m/s) whereas in 2011 maximum average daily discharge was recorded on 29th June (58.53 cu m/s). The 2011 was a normal rainfall year with average daily discharge levels within the normal range.
- Discharge of different springs in summer season of Pachchisi village is monitored. The discharge of shallow springs shows dependency on rainfall with some time delay. Year 2010 was a high rainfall year, so discharge of springs in summer season of 2011 was greater than year 2010.
- Under present water availability pattern in-stream storage can only satisfy urban water demand of April – June up to 2024. Water demand of June cannot be met fully beyond 2024 (Fig.4) even after small in stream storages as practiced today. Monsoon season storage (using large water retaining structure above 5 m height) may be required for future

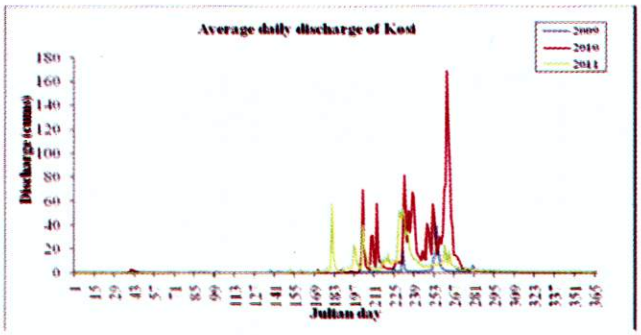


Fig.3. Average Daily Discharge of Kosi

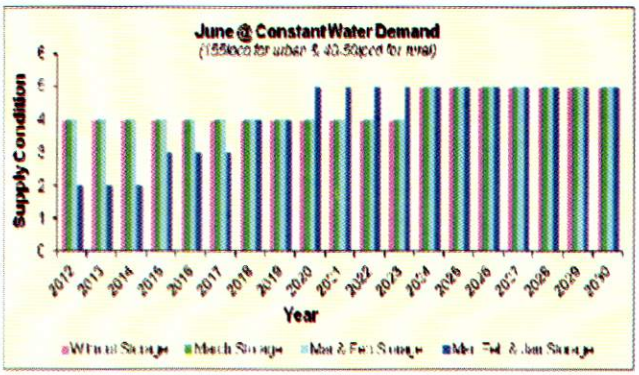


Fig. 4. Projected supply and demand scenario of Kosi watershed

Developing Sacred Landscape Model for Eco-restoration and Biodiversity Conservation in the Central Himalayan Region *(2007-2012, In-house)*

Continued degradation of land and biological diversity in the Indian Himalayan region (IHR) is of serious concern in-spite of a number of R&D interventions. One of the basic reasons for ineffectiveness of the interventions adopted for degraded land rehabilitation and biodiversity conservation could be non-integration of sacred/cultural and scientific values in their approach and strategy. Keeping the above in mind, the Institute (GBPIHED) executed 'Badrivan Restoration Programme' at Badrinath between September 1993 and November 2001 and successfully revived a portion of Badrivan (*the ancient sacred forest of Badrinath shrine*), which is recognised as an inspiring model for rehabilitation of degraded lands and conservation of biodiversity based on utilization of sacred/cultural and

scientific values. As a follow-up of this programme, the Institute executed 'Sacred Forest Programme' at Kolidhaik (Lohaghat) between August 2004 and May 2007 and successfully established a sacred forest of various multipurpose trees with peoples' participation. Both the above-mentioned models clearly demonstrated the value of adopting 'cultural approach' for reforesting degraded lands and biodiversity conservation, and also illustrated the importance of blending science and religion for the protection of environment. Based on the successes of the above-mentioned R&D activities of the Institute, the present project has been executed for the development of a sacred landscape model for eco-restoration and biodiversity conservation in the central Himalayan region.

Objectives

- To create environmental awareness among the local people for eco-restoration and biodiversity conservation.
- To develop a sacred landscape model (consisting of a sacred forest – to value peoples' sentiments, and multipurpose tree model & horticultural tree model – to meet peoples' requirements) for eco-restoration and biodiversity conservation integrating scientific and sacred values.
- To screen/identify/recommend promising plants for rehabilitation of degraded lands based on their eco-physiological health and adaptability potential.
- To make policy recommendations for the development, management and protection of sacred forests/ groves/landscapes in the Indian Himalayan region.

Achievements

- Following R&D interventions for the maintenance and strengthening of the Sacred Landscape Model (SLM) [consisting of a Sacred Forest Model (SFM), Multipurpose Tree Model (MTM) and Horticultural Tree Model (HTM)] in 14.3 ha degraded community land at 1745m elevation in Kolidhaik village (Lohaghat) of Uttarakhand were carried out during the year 2011-2012. The sacred forest, which has been developed at SFM site, has now been dedicated to Mother Goddess *'Kali'* by the villagers of Koli Dhek from where fodder collection is allowed and cutting of trees is totally banned; the farmers/women of 76 families (of 6 villages) collected almost 20 MT green fodder from the project area during the year 2011.
- About 325 m long eco-path (1 m wide) was constructed at 2 project sites (200m at MTM and 125 m at SFM). Construction for the development of umbrella-shaped rain sheds, with platforms, near Kail Bakriya and Kali temples has also been initiated and will be completed before the completion of the project.
- About 1000 well-established saplings of a sacred tree species namely, Deodar (*Cedrus deodara*) were planted at the SFM project site with the involvement of local stakeholders. *Tree plantation was carried out with the active participation of various stakeholders after organizing Plantation Ceremony in July 2011* (Fig.5). At this site (i.e., SFM), the average survival of plants, which were planted earlier, was

Fig.5. Survival of trees at Sacred Forest Model (SFM) at Koli Dhek village in Lohaghat, Uttarakhand.

Fig.6. Collection of fodder from SFM project site.

recorded 82%.

The data obtained on the eco-physiological health and leaf energy exchange characteristics of 20 promising tree species, when planted at the MTM project site in Kolidhaik village, revealed suitability of *under-temperature* plants for afforestation on the exposed slopes of the mountains (Fig.6).

Energy Use Pattern in Rural Domestic Sector of Uttarakhand State – Issues, Options & Challenges *(2007-2012, In-house)*

Use of energy is essential key in the functioning of human society. Nature and availability of energy determine pace of development and magnitude of many global processes (changes in forest cover and habitat alteration, land production and degradation, climate change, and politics of fossil fuel). More than half of the world's population lives in rural areas, nearly 90% of them in the developing countries, dependent on the traditional fuels often using primitive and inefficient technologies. Rural domestic energy requirements are mainly for cooking, lightning, and space heating. Thus, in addition to affluence as a variable, geography also play crucial role in energy use and associated processes. Increasing demands of the growing rural population has put additional pressure on the local resources. Wide variety of energy resources and their highly site-specific and variable nature, coupled with different types and qualities of energy needs, pose a challenging problem in the designing of an integrated planning and management system. This study will build synergy between the local options and governmental efforts, and is expected to highlight socio-economic and environmental benefits of various energy options. Providing mechanism for integration of rural energy requirement and convergence of incentives with other development factors for better implementation of energy management is expected.

Objectives

- To analyze patterns of domestic energy requirements with varying variables in rural settings for projection of future patterns and impact on resources.
- To understand technical, institutional and financial mechanisms in rural energy demand, supply, and alternatives for planning and management.

Achievements

- Total 15,499 watermills were present till the year 2010-11 in the state of Uttarakhand as per record. But most of these installations are defunct (55%), and only 45% were working with an operational efficiency of 10-15%.
- 600 watermills have been upgraded in the state by UREDA with an increasing efficiency of 40-50% which provides additional livelihood opportunities through either mechanical power generation or electro-mechanical operations. Upto 5kW power can be generated through these upgraded watermills instead of 0.5-1.5kW.
- Almora district represents case of rainfed dominated hydrology where most of the

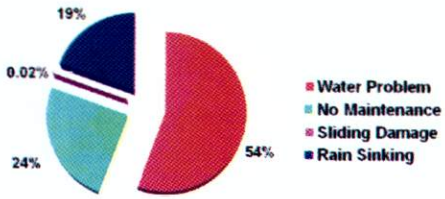


Fig.7. Attributes of non-functioning of watermills in the Uttarakhand State.

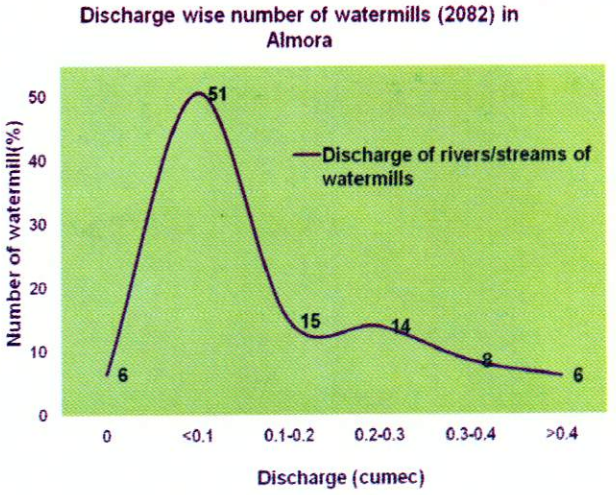


Fig.8. Distribution of watermills on discharge of feeder stream.

originating perennial rivers are rainfed. Out of 2082 watermills of the Almora district 22% have potential for upgradation but 84% of the total watermills are defunct for various reasons.

- Majority of the watermills are non-functional due to no or short availability of the water in the feeder stream (Fig.7). This is well supported argument on the face of depleting water resources and reducing stream flow in the areas where rainfed dominated landscapes prevail. Thus landscape level changes (reducing tree cover, choked infiltration due to non-porus activities in the soil, etc.) are affecting the potential of power generation at local scale.
- Most of the watermills of the state are functioning on a low discharge (Fig.8) from the feeder stream or river thus producing low efficiency..

Exploration, Diversity and Mapping of Vegetation in the Urban Forests of Kumaun Himalayan Towns Using Remote Sensing & GIS *(2008-2011, Ministry of Environment & Forests, Govt. of India, New Delhi)*

It is expected that in the 21st century urban population will share majority of the world's population. Urban centres (Cities and towns) can be defined as ecosystems to explain ecological and social systems and the interaction of these two. Natural vegetation in an urban ecosystem is subject to modification, rearrangement, and conscious or accidental design by humans. Trees and vegetation contribute to the beauty, distinctiveness, and material value of communities by incorporating the natural environment into the built environment. Trees in urban areas occupy a wide variety of habitats, from a single specimen competing in the urban forest to extensive remnant or planted forest stands. Each is shown to produce distinct micro- to local scale climates contributing to the larger urban climate mosaic. Urban ecosystems are need to be managed as local environments: for biodiversity, for human health and well being, and for economic stability. Well-planned cities can also be environmentally friendly is the concept of green cities where people can live in a clean and healthy environment. Information from high-resolution satellite remote sensing can be integrated with a city's vegetation information for a complete inventory and detailed mapping of the urban environment to define boundaries of different components and their role in functioning. This has been observed that land uses take on different functions depending on their location in the urban matrix. Human activities, such as informal management, play a key role in the provision of critical ecosystem services, something that largely is unperceived in official green area management strategies.

Objectives

- To explore diversity and structure of urban forest/vegetation for identification of processes and factors to determine different vegetation types, and to identify positive and negative forces in maintaining the diversity in the towns.
- To map urban forest/vegetation in the urban areas; analyze landscape attributes (e.g., patch and matrix) using high resolution satellite data, and record changes in the urban green areas in the Kumaun Himalayan region along temporal scale.
- To suggest measures for conservation of biodiversity in urban areas for formulation of

Table-1. Landscape attributes of Almora town.

Class	Area		Patch				Landscape Shape Index
	ha	% of Total	Number	Density (Per km^2)	Mean Area (ha)	Range (max-min)	
	25.02	7.06	190	53.26	0.13	4.72	18.60
Deodar	11.99	3.36	139	38.97	0.08	1.78	15.94
Conifers (Mixed)	6.63	1.86	70	19.62	0.09	1.57	13.53
Broad leaf evergreen	1.87	0.52	63	17.66	0.02	0.13	9.75
Broad leaf deciduous	53.82	15.09	647	181.39	0.08	1.07	35.84
Mixed broad leaf	41.57	11.65	151	42.33	0.27	12.27	32.56
Mixed broad leaf and conifers	49.16	13.78	230	64.48	0.21	4.30	35.48
Scrub	5.92	1.66	60	16.82	0.09	0.47	12.62
Agriculture	3.46	0.97	15	4.20	0.23	0.79	9.17
-up area	103.03	28.88	675	189.24	0.15	13.72	37.71
Open area without	47.43	13.29	249	69.80	0.19	2.65	33.57
Playground	6.54	1.83	27	7.56	0.24	1.60	6.92

policies for management of urban green areas.

Achievements

- Various landscape attributes of Almora town are given in the Table-1. Despite of having tree cover in more than half of the town area, Almora urban area is highly heterogeneous as evident by (i) total number of patches in an area of 3.5 km^2 (i.e., 2516 of all the Landuse/landcover classes), (ii) patch density (7.5 patches per km^2), (iii) small size of the patch (mean patch area 0.141 ha), and (iv) a high Shannon Wiener Index (2.02).
- Number of patches between different Landuse/landcover varies from 15 (agriculture) and 675 (built up area). Patch density (per km^2) in the Almora town varies from 4 (agriculture) to 189 (built up; Table- 1).
- Human settlements are sporadically present all over the urban landscape as reflected by highest number of patches and great variation in size among the patches of this class (difference of 13.7 ha between minimum size and maximum size patch).
- The study indicates a higher fragmentation of broadleaf deciduous trees in small size patches but mostly of similar size (variation of 1.07 ha among the smallest and largest patch) while this variation was much greater in case of settlements (~13 ha) indicating greater concentration in some areas but present all over the landscape.

Nematode Diversity in the Traditional Agro-ecosystem of Central Himalaya, their Impact on Soil Health, Crop Growth *(2007-2012, In-house)*

Nematodes are important mineralizers, in systems poor in nitrogen, approximately 40% of total mineralization, in certain ecosystem is due to grazing of microbial populations by nematodes and other soil fauna. Information on soil nematode diversity and their role in the traditional cropping system is fragmentary. The gap needs to be filled for promotion of traditional cropping system for sustainable development. Developing an understanding of fluctuations in nematode diversity and nitrogen mineralization is desirable for exploiting the supply of nutrients that might become available for crop use. Approximately 34 – 44 % of the energy in organic matter from crop

residues is passed through bacteria and fungi and consumed by nematodes within a year. Changes in relative proportions of the nematodes bacterivores and fungivores over time reflect changes in the pathway of decomposition. Nematodes are particularly important in recycling nitrogen which can become immobilized in bacterial populations during decomposition. Since nematodes have a higher C: N ratio (8:1 to 12:1) than their bacterial food sources (3:1 to 4:1) their feeding results in excretion of N mostly as NH_3. Presence of nematodes in soil confirm increase of NH_4^+ and other inorganic N sources in soil and also increased N- level in plant tissues. Nematodes are also important in the enhanced mineralization of P and even S in some systems.

Objectives

- To examine the nematode diversity in the traditional agro ecosystem across the year under different cropping combination.
- To analyse the relationship of the nematodes with soil health (nitrogen dynamics) under different cropping combination.

Achievements

- During the current academic year nematodes were isolated and identified as per standard protocol (the double maximum method) from paddy (*Oryza sativa*) and foxtail millet (*Setaria italica*) sole and intercropped plots of paddy and foxtail millet sown in the ratio 4:2, 3:3 and 2:4. All the five treatments were in triplicate under a completely randomized block design.
- The nematodes were identified up to generic level after careful study of their interior morphology. The identified nematodes belonged to five orders, order *Rhabditida, Tylenchida* and *Aphelenchida* belonged to class *Secernentea* and orders *Dorylaimida* and *Mononchida* belonged to class *Adenophorae.*
- The nematodes were classified in to their trophic groups based in their feeding habits and mouth parts. They were identified as bacterivores, fungivores, herbivores, omnivores and predators.
- The seasonal patterns of nematode showed that fewer genera were present in the soil in the dry summer months (Fig.9). As nematodes are typically moisture loving organisms their diversity increased sharply at the onset of the rainy season and later decreased with drying up of soil.
- A total of approximately fifty major genera have been identified from the experimental soil and a calendar based on their presence and absence at each sampling date corresponding to a month has been prepared.
- Thus altered soil-water availability related to potential changes in climate results in complex changes in the structure of soil food webs. This shift in the nematode composition and abundance is a useful indicator of soil condition.
- The cropping ratios of paddy and foxtail millet in *Kharif* season and wheat and mustard during *Rabi* season had significant effects on the temporal variability and hence stability of the various nematode functional groups across the study period. The variability in the bacterial and fungal feeding groups was the greatest. This suggested that manipulation of the resource base can have important multi-trophic effects.

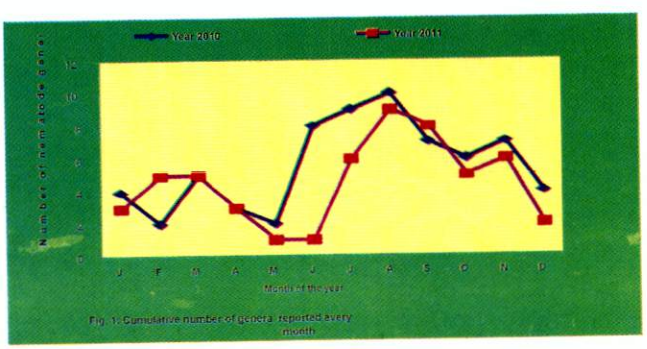


Fig.9. Cumulative number of genera reported every month.

Indigenous Knowledge: Traditional Health Care Practices in Rural Areas of Uttarakhand – Central Himalaya *(2007-2012, In-house)*

Table-2. Herbal formulations used by the village elders in the Upper Alaknanda valley.

S.N.	Ailment	Number of ailments	Nos. of formulations
A: HUMAN			
1.	Indigestion & Gas formation, Leucorrhoea	2	6
2.	Cough and Cold	1	4
3.	Diabetes, Ear pain, Gastritis, Diarrhoea, Stomach pain	5	3
4.	Common fever, Conceiving, Easy delivery, Headache during cold, Pneumonia	5	2
5.	39 Ailments	39	1
B. CATTLE			
1.	*Khurpaka*, Warmness in cattle	2	2
2.	Cattle fever, Feebleness, *Galghotu*, Urinary bleeding	4	1

Table-3. Medicinal plants of proven/reported therapeutic activity used by the vaidyas and village elders in the Upper Alaknanda valley.

	S.No.	Plant name	Therapeutic activity
1.		*Aconitum heterophyllum* Wall. ex Royle	Anti-bacterial, Anti-inflammatory, Anti-oxidant and Synaptic exciter
2.		*Asparagus racemosus* Willd.	Galactogogue, uterine sedation and immunomodulator.
3.		*Boswellia serrata* L.	Antiarthritic & antiinflammatory
4.		*Berberis asiatica* DC	Antidiarrhoeal
5.		*Boerhavia diffusa* L.	Diuretic, anti-inflammatory
6.		*Cannabis sativa* L.	Psychoactive
7.		*Cassia fistula* L.	Cathartic
8.		*Centella asiatica* (L.)	Urban Memory enhancing, wound healing
9.		*Curcuma longa* L. Syn.	Anti-inflammatory, anti-oxidant
10.		*C. domesticata*	anti-bacterial
11.		*Discorea deltoides* Wall.	Steroidal activities
12.		*Hypericum performatum* L.	Antidepresent, antiviral, inhibitd leukaemia virus
13.		*Momordica charantia* L.	Hypoglycemic
14.		*Nardostachys jatamansi* DC.	Neurotonic
15.		*Ocimum sanctum* L. Anti-stress,	Anti-stress, adaptogenic
16.		*Phyllanthus emblica* L. Syn. *E. officinalis* Gaertn.	Anti-oxidant
17.		*Picrorrhiza kurrooa* Royle ex Benth	Antithepatotoxic
18.		*Piper longum* L.	Immunomodulator
19.		*Piper nigrum* L.	Bioavailability enhancer
20.		*Podophyllum hexandrum* Royle.	Against testicular cancer, small cell lung cancer
21.		*Swertia chirayita* (Roxb. ex Flem) Karst.	Adatogenic, Febrifuge
22.		*Taxus wallichiana* Zucc.	Against ovarian cancer, Lung cancer
23.		*Terminalia chebula* Retz.	Antiageing
24.		*Tinospora cordifolia* (Willd.) Miers	Immunoenhancing, adaptogenic

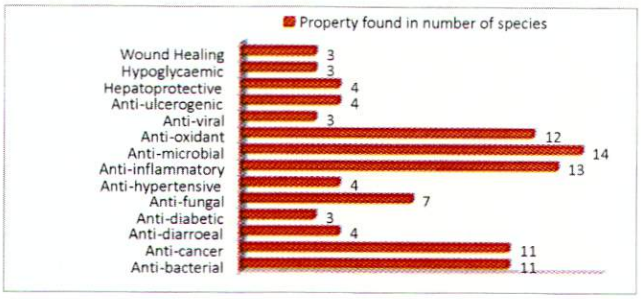


Fig.10. Few important therapeutic properties of medicinal plants used by the traditional vaidyas and village

Fig.11. Paste of tubers of Dactylorhiza hatagirea (D. Don) Soo (local name salam panja) given in kidney pain. Locally it is used as a nervine tonic, aphrodisiac, diarrhea, dysentery, chronic fever and in leucorrhea

Restrengthening of Indigenous Knowledge (IK) and culture base lead towards enhancement of conservation practices. Validation and value addition of IK helps strengthen the practices and create potential for enterprises, which, in turn leads to economic upliftment and growth of the society. In India, traditional health care practices, particularly use of medicinal herbs for healing is a practice since time immemorial. Such practices are still continuing in rural area as they are inexpensive, culturally familiar and readily available. However, excessive removals of herbs from wild for commercial use and forest degradation in recent past have resulted in shortage of quantity of herb species. In Uttarakhand majority of traditional health care practiceners (THCP), locally called *vaidyas*, are providing their services in remote rural areas in absence of modern health services. Village elders also treat few ailments at household level.

Objectives

- Documentation of traditional health care practices.
- Documentation of plant species used in traditional health care practices.
- Documentation of IK of practices, processes, knowledge and resources use in traditional health care practice.
- Identification of possible IPR value.

Achievements

- 78 traditional herbal formulations used by the village elders for treatment of human ailments and 8 formulations for treatment of cattle diseases were documented with information containing ingredients, and use method. For treatment of gas formation in stomach and treatment of leucorrhoea 6 herbal formulations were used, 4 formulations were used for treating cough and cold. For treating diabetes, diarrhea, ear pain, gastritis and stomach pain village elders used 3 formulations for each ailments (Table-2).
- *Vaidyas* and village elders use nearly 140 medicinal herbs out of them about two dozen herbs were with proven/reported therapeutic activities (Table-3).
- Validation results of herbal formulations for dissolving gall stone showed mixed result. In 50% cases stone size reduced slightly, in 33.3% cases on gall stone response was either poor or no response. Nearly similar result was also obtained on dissolving of kidney stone using herbal formulation.

Information of therapeutic properties and associated active principals of medicinal herbs (information including botanical and vernacular names, family, part used and activc principles involved) used by the traditional *vaidyas* and villagers of Upper Alaknanda valley have been updated. Total 101 therapeutic properties have been identified. Antimicrobial therapeutic property was possessed by larger number of medicinal plants (Fig.10&11).

Development of Analytical Models through Establishment of Modeling & Statistical Computing Laboratory: An Attempt towards Capacity Building *(2009-2014, In-house)*

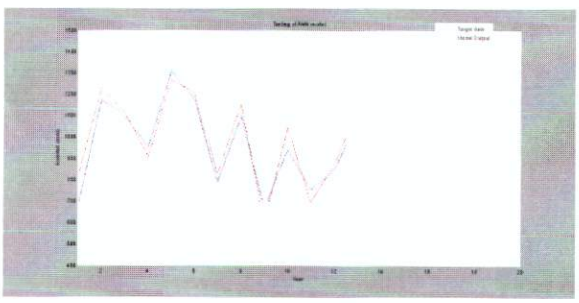
The proliferation of digital technologies and pervasive networks through which data are collected, generated and shared requires comprehensive infrastructure that can be used to capitalize on remarkable advances in IT and thus integrates hardware for data organization, computation, analysis and modeling. Establishment of modeling and computing lab represents the core of WPM-KCB research group and is a part of R&D works and capacity building activities of the Institute. GBPIHED, through its R&D activities, has produced considerable data on different aspects which is scattered and thus needs to be organized and integrated with other research activities. Keeping in view of the interdisciplinary research work in the Institute, a network based resource centre for modeling and capacity building is required which can efficiently be used to access, organize, integrate, and statistically analyze the large datasets on different aspects to provide appropriate mathematical treatment to different research problems. These issues has been raised in the previously held SAC meetings of GBPIHED and in the National brainstorming meeting organized by the Institute on September 8, 2007 and then it was recommended to develop a comprehensive and validated data base on different aspects and their qualitative assessment and analysis using statistical and modeling techniques.

Objectives

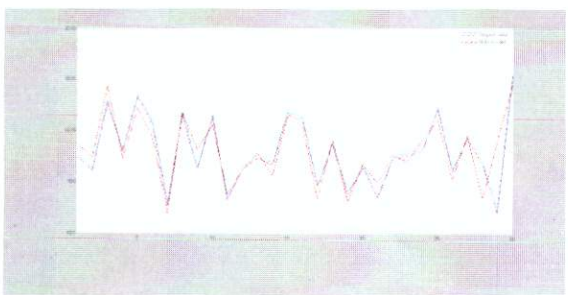
- To develop long term database for available data on different aspects, gap analysis and apply various statistical and mathematical tools for analysis and development of analytical model.

Table-4. Performance statistics for various ANN models developed for Almora station.

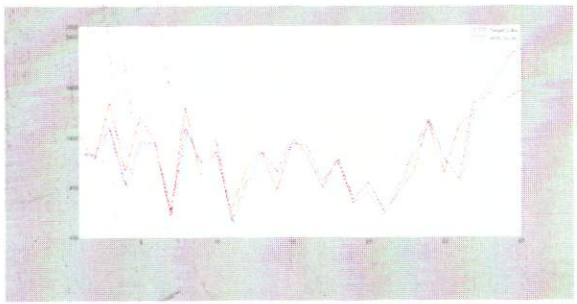
Model	Nodes	Hiddenr		MSE	
		Training	Validation	Training	Validation
ANN-M1	2	0.78	0.09	23097.62	23485.64
ANN-M2 (Best Model)	**3**	**0.83**	**0.53**	**8999.05**	**13996.86**
ANN-M3	4	0.80	0.21	10533.53	16745.13
ANN-M4	5	0.88	0.36	1723.56	18249.41
ANN-M5	6	0.97	0.04	11345.34	18342.43



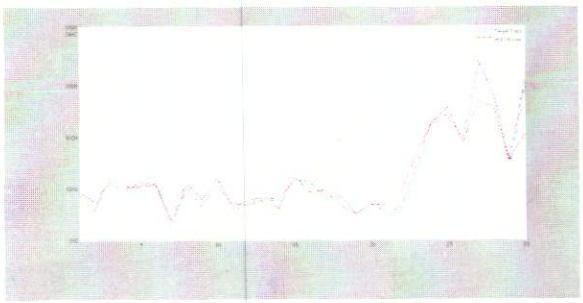
Almora (r=0.98)



Chamoli (r=0.97)



Champawat (r=0.7)



Dehradun (r=0.9)

Fig.12. Testing of developed ANN Model for few districts of Uttarakhand State.

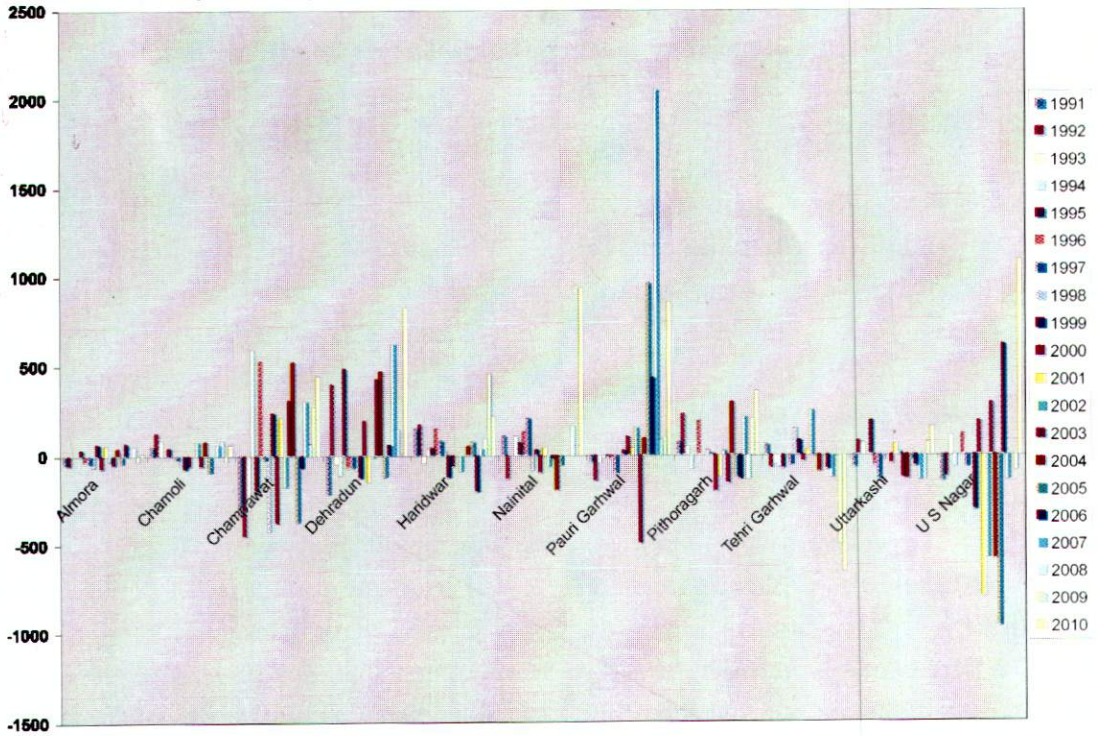


Fig.13. Error estimate curve for the developed ANN model.

- To strengthen the modeling and statistical computing facility with particular emphasis on computer aided mathematical modeling and its application into various interdisciplinary research activities.
- To train fellow researchers on different available softwares/packages by providing regular hands-on-training.

Achievements

- An attempt to investigate the potential for soft computing techniques such as Artificial Neural Networks (ANNs) to downscale the GCM/RCM output at an interior point is made. In this analysis, suitability of Artificial Neural Network (ANN) technique to interpolate rainfall data from a grid structure to interior points with certain accuracy has been tested for eleven districts of Uttarakhand state.
- To develop ANN model for spatial interpolation of rainfall, thc whole evaluation is described as following:

A. Data used:

1. Rainfall data (at 0.5^{0} lat-long grid) of the Climate Research Unit (CRU TS2.1dataset), UK for the period of 1901-2000 is used as input and IMD data (for 2004-2010) are used as desired output

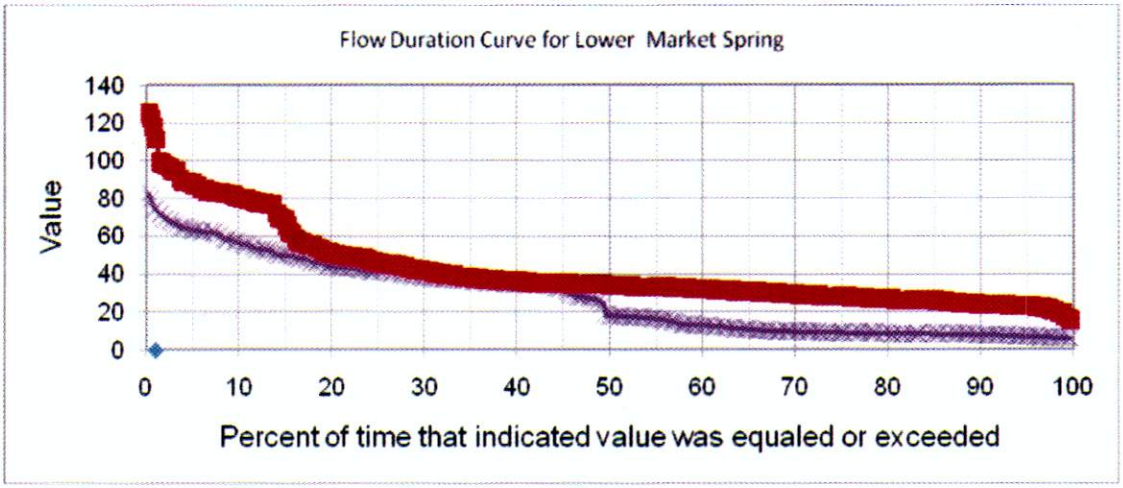


Fig.14. Flow Duration Curve of Lower Market Spring, Pauri showing significant rise in the availability of water due to surplus rainfall in the year 2010 and normal rainfall in the year 2011.

2. Data observed under U-PROBE project is used to fill the gaps in the IMD data and mathematical interpolation techniques is used fill gaps in the U-PROBE met data

B. Training & Testing of the model:

3. 80% of the data (1901-1990) are used for training of model while remaining 20% (1991-2010) are used for testing of the developed model
4. The multilayer Feed-forward Back Propagation Networks (FBPN) ANNs are used to develop the model; five different models were developed by adjusting weights of the transfer function of the neural network

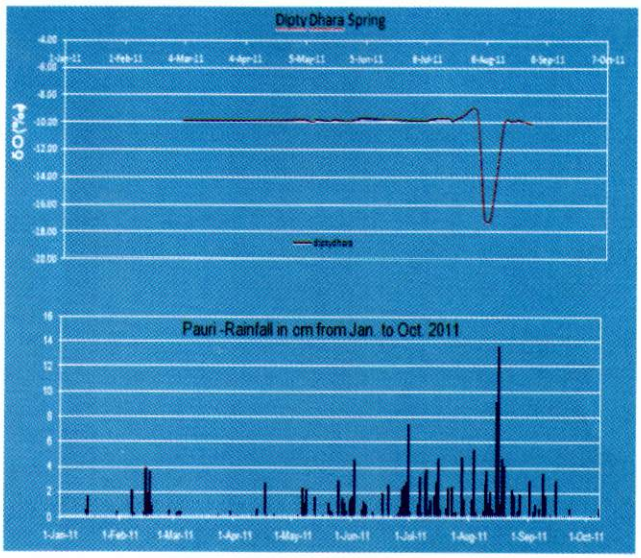


Fig.15. Variability of oxygen isotope with time and rainfall.

5. Number of iterations is performed during training phase of model and performance evaluation of all five ANN models is done using statistical parameters (Table-4) and best model is selected for testing and spatial interpolation purpose
6. Spatial interpolation of rainfall is carried out for various districts of Uttarakhand using best trained model and applied on remaining 20% dataset for testing of the model and (Fig.12)

§ Performance evaluation of the developed model is depicts by error estimate curve (Fig.13) which shows applicability of ANN techniques as an alternate tool for downscaling of RCM/GCM output at point level.

Since the dynamical downscaling techniques require resources and high power computing facility; empirical models can effectively be used for downscaling in the Himalayas.

Recharge Area Identification and Estimation Mean Residence Time for Springs in One Urban and One Rural Microwatershed in Pauri Garhwal Using Isotope Technique, Remote Sensing, and GIS for Implementation of Artificial Recharge Structures *(2009-2014, GBPIHED and NIH, Roorkee)*

Water Resource is becoming the biggest concern in Indian Himalayan Region, especially during the summer. This project is an attempt to quantify the

available spring water resource in two micro watersheds, one urban micro-watershed (Pauri Urban Area) and the other is rural micro watershed (Dugar-gad watershed). This project we will also attempt in finding the probable recharge area of springs falling in the study area by using the state- of- the- art technology and implement the ground water recharge structures to augment the spring discharge.

Objectives

- To decipher the recharge zone and mean residence time for springs falling in the study area using isotope technique.
- To analyse the relationship rainfall, hydrogeology, land use/land cover with the spring discharge.

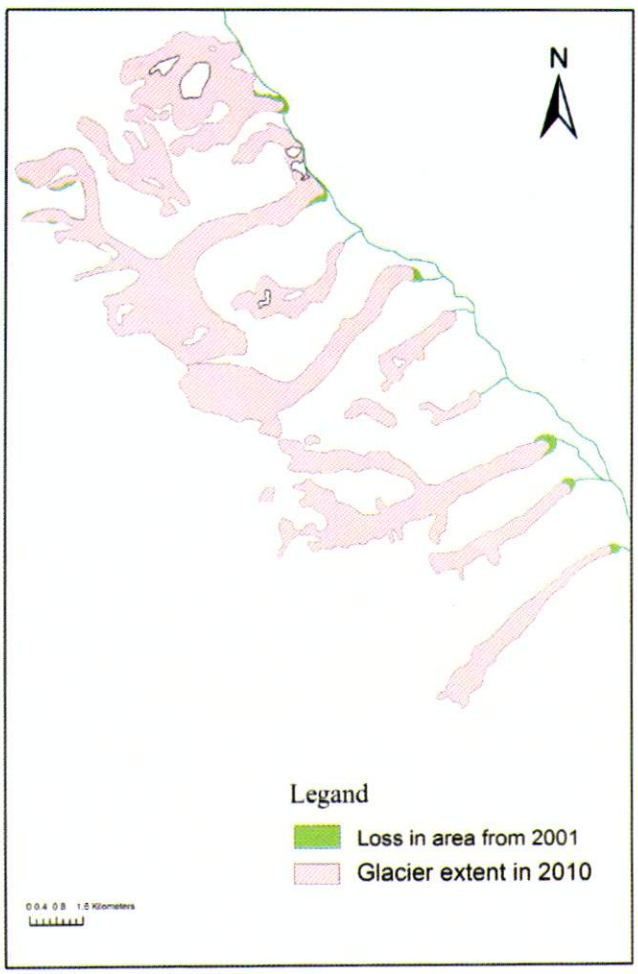


Fig.16. Change in glacier area in Dhauliganga basin (2001-10).

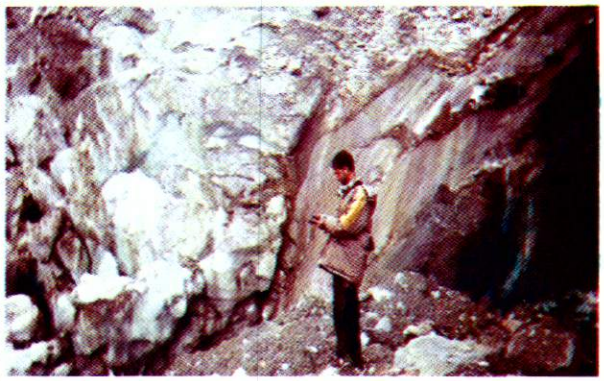


Fig.17. Field Verification using handheld GPS in Dhauliganga basin on September 2011.

- To implement rainwater recharge structure in the catchment area and execute water harvesting structures to enhance the productivity of the fracture hardrock aquifer.

Achievements

- The availability of spring flow for the year 2010 and 2011 is being investigated (Fig.14). Flow Duration Curve of Spring flow show significant rise in the availability of water due to surplus rainfall in the year 2010 and normal rainfall in the year 2011, especially during the lean period also.
- The isotope data of the spring water samples is being investigated. The variability of stable isotope with rainfall is under investigation .This data is useful for planning artificial recharge structure in the catchment of springs (Fig.15). The database generated will be used for selection of springs suitable for artificial recharge.

Monitoring Snow and Glaciers of Himalayan Region. Phase- II *(2010-2014, Space Application Centre, Ahmedabad)*

In field of glaciology, satellite remote sensing has been proven as one of the best tools as most of the Himalayan glaciers are located at very high altitude and in rugged inaccessible terrain which often makes monitoring of these glaciers by conventional field methods a tedious, hazardous and time consuming task.

Considering this, the focus of the present project is on the glacier monitoring using the satellite data supported with field studies to study the advance/retreat in Kumaun Himalayan region. The study area includes Dhauliganga basin, located between 80°14'42.73"E to 80°44'04.49"E and 30°34'29.35"N to 29°56'57.44"N and Goriganga basin, located between 79°58'59.52"E to 82°29'36.96"E and 30°36'02.35"N to 29°44'14.75" and area of 1345.12 km^2 and 2265.12 km^2, respectively. The elevations of the basins vary from 600 meters to 6600 meters above mean sea level. IRS LISS III satellite image of year 2001 and 2010 is used for identification and interpretation of glaciers. Georeferencing and digitization is done for delineation of glacier boundary and database is developed.

Objectives

- To generate data base of glacier extent using moderate to high resolution satellite data of ablation period of 2010-2012 time frame and monitor the change in advance retreat in Dhauliganga,Goriganga and Kaliganga sub basin in Western Himalayan region.
- To carry out field studies of the specific glacier in Dhauliganga basin.

Achievements

- In Gori valley, total number of glaciers in 2001 was 47 as mapped using IRS, LISS-III data (Fig.16). The total area occupied by these 47 glaciers was 328.92 km^2 in 2001, while it reduced to 326.88 km^2 in 2010. This means there is 0.99 % loss of area in 9 Years.
- In Gori valley, Only 75 Glacier could be digitized in 2001 and total area occupied by these 75 glaciers was 199.32 km^2, which was reduced to 196.68 km^2 in 2010. This indicated about 1.32% loss of area in 9 Years. However, total number of glaciers in Dhauliganga basin as mapped using IRS, LISS III data of 2010 are 81(Fig.17).
- Field verification of Neola glacier snout is done using by handheld GPS in Sep-2011 in Dhauliganga basin (Fig.17). The glacier is selected for further field study.

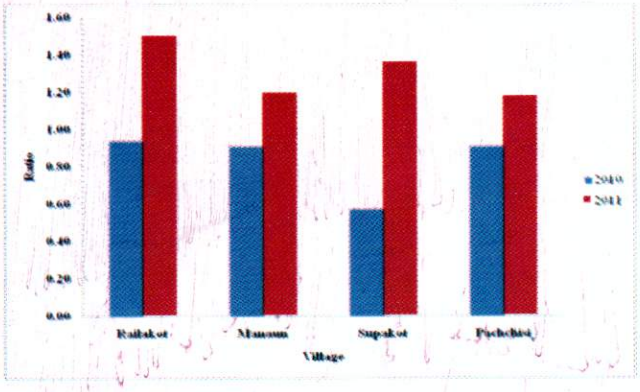


Fig.18. Availability demand ratio of water in different villages.

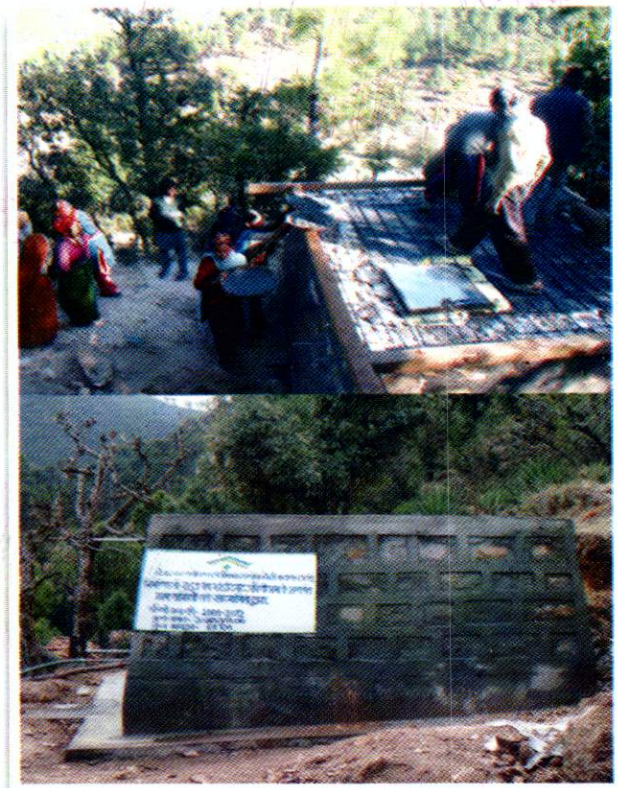


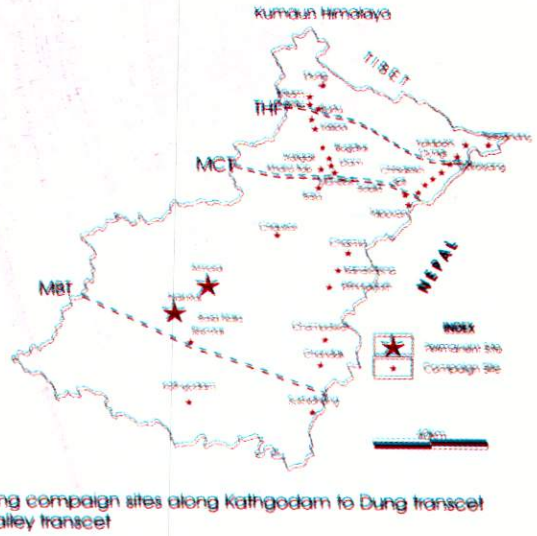
Fig.19. Participation of villagers for augmenting water supply in Chauna.

Participatory Water Management Plan for Mid Altitude Himalayan Villages Using Optimized Water Harvesting Systems *(2009-2012, DST, New Delhi)*

Water and overall environmental security in mid-elevation Himalayan watersheds are highly vulnerable to seasonal changes in the water regime. Understanding the year to year and season to season trend of rainfall, flow of river in past decades provides a major step towards understanding and coping with *changes* in seasonality of sources. *There may be sufficient annual water available in a region to satisfy basic needs, if adequate conservation and storage measures are taken. Thus, water management strategies should focus on building adaptive optimized models on the basis of allocation of hydrological responses to cope with water scarcity and seasonality.* This study is conducted in four villages *i.e.* Railakot, Manan, Supakot and Pachchisi of Upper Kosi watershed. Water availability analysis is done by *measurement* of available water sources in villages in two different season *i.e.* monsoon and summer in year 2010 and 2011. The secondary data of water availability (rainfall) is used for developing three scenarios, *i.e.*, drought year, high rainfall year and normal rainfall year. Based on the above criteria, 2009 was a normal rainfall year (annual rainfall 1100 mm) and 2010 and 2011 were above normal rainfall years (annual rainfall 1340 mm and 1555 mm, respectively). These scenarios are used for further analysis using mathematical formulation of these scenarios using optimization

Objectives

- Quantification of water resources and demand at village level.
- Scenario building on variable water availability and optimization model of water allocation.
- To develop and test the participatory water management plan for optimizing water distribution within a single village system.
- Development of guidelines for integrated water management plan for implementation at village level.



Map showing compaign sites along Kathgodam to Dung transcet and Kali valley transcet

Fig.20. Compaign Sites.

Achievements

- Water availability analysis is done by measurement of available water sources in all villages in two different season i.e. monsoon and summer. Availability demand ratio in summer months is presented in Fig.18. In every village available water is less then demand in summer season in 2010 but results of water availability are different in 2011. Rainfall received in monsoon season of year 2010 was above normal rainfall so available water in summer season of 2011 is greater than demand of the village.
- Based on proposed plan, pilot scale testing is initiated in village Pachchisi. At village level, available water is more than the demand of village, but in two hamlets (Kafari and Chauna) water shortage is recorded in summer months. It is concluded by PRA that decentralized water management of village should be done for each hamlet to ensure better operational arrangements.
- Water source in Chauna was monitored in different seasons to assess water availability. Population of this hamlet is 85 and household demand is estimated as 4250 litre/day. Based on the lowest available discharge (0.07 litre/sec) and optimized demand assessment, identified source was found suitable for harvesting. Construction of

water tank of capacity 5.5 cu m for harvesting of source has been done with the active participation of villagers (Fig.19).

Operation of Permanent and Campaign Mode GPS Stations for Quantification of Tectonic Deformation Field in Himalayan Terrain *(2012-2014, Ministry of Earth Science, New Delhi)*

This project is designed to delineate the deformation field in the Himalayan urban centers, including some notable land slip zones with high resolution, across Himalaya by using 6 continuously operating GPS systems at Almora, Gangtok, Nainital, Kullu, Zero and Srinagar-Garhwal. Study is also planned to constrain the deformation rate (strain) field in the Uttarakhand Himalaya based on GPS measurements to date, by reoccupying several GPS campaign stations along the Gori and Kali valleys from the foothills to the trans-Himalaya (Fig.20) to test whether the Lesser Himalaya and Siwalik Himalaya deform coherently with respect to the main Himalayan thrusts, In tectonically active regions where deformation rates are large, especially in the neighborhood of active faults, hill slopes are subject to steady steepening and tend to be perpetually in a far-from equilibrium state, critically poised to slide down vast amount of their soil cover in response to any triggering mechanism. In Himalaya, the zones along the Main Boundary Thrust (MBT) and Main Central Thrust (MCT) and the trans-Himadri thrust (THT) that delimits the northern boundary of the great Himalaya, are the three highly vulnerable zones prone to recurrent landslips and earthquakes. Several damaging landslides have occurred in the region.

Objectives

- To maintain and operate existing permanent GPS stations at Kullu (HP), Almora (UK), Nainital (UK), Srinagar (Garhwal), Pangthang (Sikkim), Zero (Arunachal Pradesh) and focusing on quantification of tectonic deformation field by experimentally determining the displacements of these fixed sites (urban centres) using GPS Geodesy with high resolution.
- To further refine the strain rate field across the Himalaya, along the Kali and Gori valleys (Kumaun Himalaya) by re-occupying the 31 control points already established in previous DST project

Achievements

- Daily up keeping and data achieving from permanent GPS stations is continued. Providing V-SAT connectivity for data transfer from permanent GPS stations is under progress.
- The preparation for campaign mode study is started and field survey conducted for finding the status of campaign stations.

BIODIVERSITY CONSERVATION AND MANAGEMENT (BCM)

An understanding of the magnitude of biodiversity at gene, species and ecosystem levels is crucial to its utilization, conservation and management. The scale of biodiversity is immense and investment is required to bridge crucial knowledge gaps and synthesizing existing information. The recognition and characterization of biodiversity depends critically on taxonomical, genetic and ecological studies. The attributes such as topographic heterogeneity, habitat productivity and structural complexity allow prediction of biodiversity. The long-term research sites and programmes provide essential information on how biodiversity changes are important in distinguishing anthropogenic and natural changes. Human dependence on biodiversity and assessment of economic value of biodiversity are also critical issues. The human induced activities have been identified as the critical factors for the biodiversity loss and global climate change. This has necessitated the inventory and monitoring of biodiversity at different levels and climatic regimes. Biodiversity conservation measures such as establishment and maintenance of live repositories/Outreach in different agro climatic zones will help in ensuring quality planting material for the promotion of conservation programmes, and enhancement of the capabilities of the stakeholders at local, regional, state and national levels to manage and disseminate information on biodiversity. Such capabilities at different levels are required for the best management of biodiversity that is critical to maintaining the air, water, soil and other conditions essential to human life. The studies conducted in the BCM theme are in tune with above concept. Realizing the importance of biodiversity for sustainable development and environmental conservation, the Biodiversity Conservation and Management (BCM) theme envisages the following objectives: (i) To assess, evaluate, prioritize, map and monitor biodiversity of the protected and unprotected areas at gene, species and ecosystem levels across the IHR for understanding the status, availability, potential and patterns; (ii) To evaluate response of Himalayan biodiversity under changing climatic conditions across the IHR; (iii) To develop packages of practices for maintenance and optimal use of sensitive biodiversity components and improvement of bio-resource based livelihood options for indigenous communities; (iv) To establish and maintain live repositories (Arboreta, Herbal Gardens, Nurseries, etc.) in different agro climatic zones across the IHR for ensuring the availability of quality planting material; (v) To sensitize diverse stakeholders and build partnerships to develop and demonstrate best practices of management and optimal use of biodiversity components.

Response Assessment and Processing of Knowledge Base to Serve Long-term Management and Use of Biodiversity in the Himalaya - Focus on Representative Protected Sites *(2007-2012, In-house)*

Considering that the world's mountain ecosystems are undergoing rapid environmental changes thereby affecting their overall integrity and life support values, the need for better understanding the response patterns and implementation of multidisciplinary approach to address the issues is globally realized. While considering approach for effective implementation of such strategy, the Mountain Protected Areas (MPAs) have emerged as global priority sites and are being used as an 'early warning' system. In this context, this project seeks to define appropriate mid to long term management regimes that maintain the multiple functions of MPAs as a major challenge to the management of integrity and diversity of representative ecosystems. The study has been conducted in Nanda Devi Biosphere Reserve of Western Himalaya; Nargu Wildlife Sanctuary of North Western Himalaya and Kanchendzonga Biosphere Reserve of Central Himalaya and a proposed Tawang Kamang Biosphere Reserve in Eastern Himalaya of the Indian Himalayan Region to explore the comparative biodiversity scenarios in selected sites which can be used for wider generalization in the region.

Objectives

- To synthesize existing information on biodiversity components of the Protected areas in the Indian Himalayan Region.
- To investigate the diversity including recruitment trends and compositional patterns of forest communities of the protected areas.
- To understand use patterns on protected areas resources by the stakeholders.
- To identify and prioritize human wildlife conflicts in the protected areas.
- To study the grazing competition among livestock and wild ungulates.
- To determine the livestock depredation and retaliatory killing of Wild carnivores.
- To identify threat categories of the biodiversity elements.
- To suggest policy interventions with a view of general applicability in other protected areas of the region particularly focusing on issues of conservation and optimal use of biodiversity components.
- To draw comprehensive biodiversity management plans for alternative scenarios, especially building on evidences generated through present study.

Achievements

Nanda Devi Biosphere Reserve, Uttarakhand

- In NDBR West Himalaya – continuing with the revisit studies in Lata region, Garhwal west Himalaya total species richness, nativity and endemism of trees, shrubs and herbs were recorded. Of the total 251, 168 native, 83 non-native, and 83 endemic/near endemic were recorded.
- In herb layer, out of 180 species, 112 native, 68 non-native and 53 endemics were recorded. A total of 48 species were identified in shrub layer out of which 38 were identified as native, 10 non-native and 21 endemics. In tree layer total 23 species were recorded, out of which, 18 were native, 5 were non-native and 9 were endemic or near endemics.
- Soil parameters, estimated in different forest communities, were correlated with altitudes; organic carbon, organic matter, and total nitrogen increased with increasing altitude (Table-5).
- A positive correlation was found between the species richness and number of native and endemic species. Suggesting that richness supports the number of natives and endemic species.

Table-5. Community wise soil parameters in Lata-Tolma-Palni regions.

Forest communities	Altitude	pH	OC	OM	N	C/N
Cedrus deodara	2440	6.32	4.03	6.94	0.39	10.25
Juglans regia-Prunus cornuta mixed	2450	6.11	4.06	7.00	0.5	8.12
Acer caesium-Prunus cornata mixed	2600	6.27	1.21	2.09	0.22	5.50
Pinus wallichiana	2830	6.06	6.30	10.85	0.36	17.39
Abies spectabilis	3050	4.79	3.32	5.73	0.34	9.67
Taxus baccata subsp. *wallichiana-Abies pindrow* mixed	3160	5.12	5.49	9.46	0.85	6.46
Abies pindrow	3200	5.31	5.49	9.46	0.79	6.96
Betula utilis	3590	5.34	6.90	11.89	1.10	6.26

Nargu Wildlife Sanctuary, Himachal Pradesh

- 265 species of vascular plants with the dominance of families, Asteraceae (30 spp.); Rosaceae (22 spp.) and Lamiaceae (16 spp.) were recorded. 150 species were native to the Himalayan Region, four species (i.e., *Pleurospermum brunonis*, *Pleurospermum candollii*, *Corydalis cashmeriana* & *Pimpinella acuminata*) were endemic and 75 species near endemic. Five species (i.e., *Aconitum heterophyllum*, *Arnebia benthamii*, *Dactylorhiza hatagirea*, *Malaxis muscifera* and *Lilium polyphyllum)* were Critically Endangered; eight species Endangered (i.e., *Angelica glauca*, *Betula utilis*, *Jurinea dolomiaea*, *Meconopsis aculeata*, *Picrorhiza kurrooa*, *Podophyllum hexandrum*, *Polygonatum cirrhifolium, Rheum australe*) and 12 species vulnerable.
- 174 species were economically important and used as medicine (128 spp.), wild edible/food (32 spp.), fodder (37 spp.), fuel (28 spp.), timber (04 spp.), religious (15 spp.), fiber (02 spp.), and various other purposes (46 spp.). Among the 23 studied villages, 21 species were used as fodder. Mean collection, PU and RUI were maximum for *Quercus leucotrichophora*, *Quercus semecarpifolia* and *Rhus javanica*, respectively (Fig.21).
- 29 sites falling between 1384-4052m and 31°47'14"-32°02'57"N latitudes and 76°51'04"-77°02'21"E longitudes and representing different aspects and habitats were sampled, 20 communities i.e. 05 forest tree, 09 shrub and 06 herb communities were identified based on Importance Value Index and relative density, respectively. Total tree density, total basal area, 0.16-65.4 m^2ha^{-1}, total shrub density and aspects of the communities. Three tree communities showed highest regeneration of dominant species and 2 tree communities highest regeneration co-dominant species.

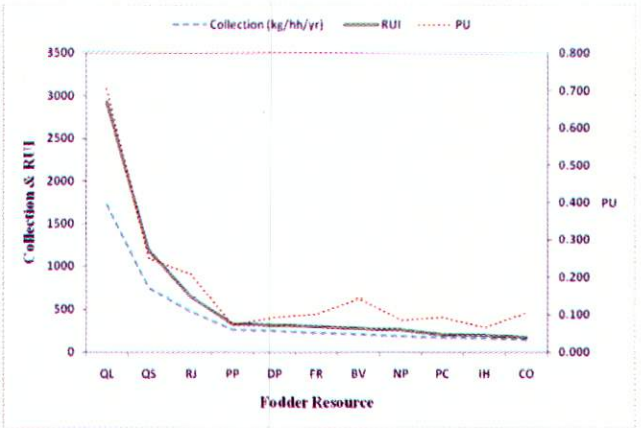


Fig. 21. Total Mean collection, PU and RUI of the preferred fodder resources in NWLS

Abbreviations used: QL= *Quercus leucotrichophora*, QS= *Quercus semecarpifolia*, RJ= *Rhus javanica*, PP= *Pyrus pashia*, DP=*Daphne papyracea*, FR= *Ficus roxburghii*, BV= *Bauhinia variegata*, NP= *Neolitsea pallens*, PC= *Prunus cornuta*, IH= *Indigofera heterantha* and CO= *Cotoneaster obtusus*

- Species richness within communities ranged from 19-105. Species diversity index (H') for trees ranged from 1.16-1.69, saplings, 0.26-1.08, seedlings, 1.16-1.84, shrubs, 0.0-2.05 and herbs, 2.30-3.93. Soils analysis showed pH 5.2-7.40, moisture content, 5.7-41.0 %, nitrogen, 0.10-0.70%, organic matter, 0.8 -8.7% and carbon, 0.5-5.0%.

Khangchendzonga Biosphere Reserve (KBR), Sikkim

- Yemtaar-Sukochuli-Neytham transect (2100-3900m) along Indo-Nepal border (western Sikkim) was investigated. Transect (15 major sites) was divided into 3 major forest systems viz., temperate mixed broad-leaved forest [TBLF, 2100- 3050m], temperate coniferous forest [TCF, 3050 - 3600 m], and sub-alpine forest [SAF, 3350 - 3900m], by identifying 12 forest communities. 61 woody species (69% trees and 31% shrubs) were quantified, Ericaceae (14 spp.) appeared as the most diverse family. 32 species of fuel and 61 species of fodder were used inhabitants of four villages; *Alnus nepalensis, Edgeworthia gardenerii, Symplocos theaefolia* and *Viburnum erubescens* amongst fuel and *Ficus nemarolis, Ficus roxburghii* and *Saurauia nepaulensis* amongst fodder were most preferred species.
- Along altitudinal gradient, cumulatively for trees and shrubs, significant decrease ($p<0.01$) in number of species ($r = -0.716$), number of genera ($r = -0.802$) and number of families ($r = -0.874$) was observed (Fig.22). Tree species richness significantly declined with increasing altitude ($r = -0.818$; $p<0.01$), while shrub species insignificantly increased along the altitude ($r = 0.300$; ns). Cumulatively for each forest type, the density of adult individuals in lowest diameter category (C-class) appeared maximum, which further declined with increasing diameter size categories.
- In TBLF, for adults, *Symplocos theaefolia, Rhododendron falconeri* and *Eurya acuminata* together accounted for 38.34% of total stem density (986 ind/ha); *Quercus glauca* and *Lithocarpus pachyphylla* accounted for 44.46% of total basal area (63.97 m^2/ha); in TCF, *Abies densa* accounted for 28.61% of the total stem density (1118 ind/ha) and 76.64% of the total basal cover (60.77 m^2/ha); in SAF, *Sorbus* sp., and *Betula utilis* together accounted for 57.0% of the total adult individuals (1173 ind/ha); however, maximum total basal area was recorded for *A. densa* (15.45 m^2/ha).

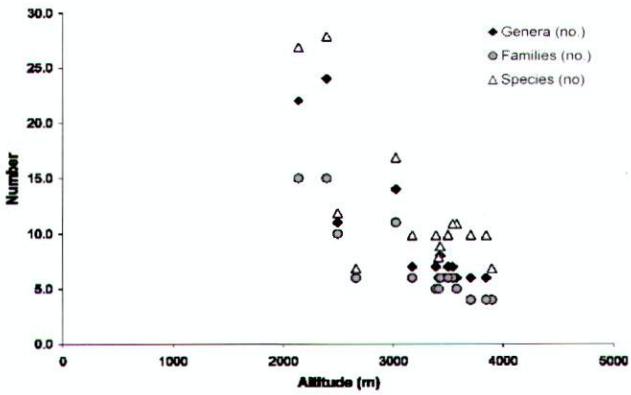


Fig. 22. Number of species, genera and families for different study sites along altitudes in Yemtaar-Sukochuli-Neytham transect in Khangchendzonga Biosphere Reserve (west Sikkim).

- A consultation workshop of stakeholders on 'Biodiversity Conservation and Management in KBR' was organized in collaboration with FEWMD (Govt. of Sikkim) in transition zone of KBR in West Sikkim. Over 70 stakeholders, representing EDCs, Panchayats JFMCs, Jila personnel, villagers, Foresters, teachers, and scientists participated and made intensive interaction on various conservation and livelihood issues in KBR.

Tawang-West Kameng Biosphere Reserve (proposed), Arunachal Pradesh

- The proposed BR area constitutes Tropical semi evergreen, Sub tropical broad leaved, Sub-tropical pine, temperate broad leaved forests, Alpine and Secondary forest. *Phytosociological studies were carried out in Yewang Forest of Circle Dirang.* Total 180 quadrats of 10x10m size

were randomly laid in 6 altitudinal zones and cbh of 3000 individuals of trees were recorded. Species were analyzed for density, frequency, abundance, IVI, etc. At 1800m, *Quercus sp.* (IVI: 94.76), at 2000m *Pinus wallichiana* (IVI: 121.44), at 2200m *Rhodendron sp.* (IVI: 64.96), at 2400m *Lyonia ovalifolia* (IVI: 75.69), at 2600m *Quercus sp.* (IVI: 46.4) and at 2800m *Illicium griffithii* (IVI: 76.75) were dominant.

- The highest density was recorded at 2200m (229 ind/ ha) and lowest at 1800m (81 ind/ ha). The density of trees at 2000m was 146.67 ind/ha; at 2400m, 120.74 ind/ha; at 2600m, 110.37 ind/ha and at 2800m, 133.33ind/ha. Total basal area (TBA) of trees was 14.45 m^2/ha, highest at 1800m; 6.71 m^2/ ha at 2000m; 4.26 m^2/ha (the lowest) at 2200m; 8.71 m^2/ ha at 2400m; 9.21 m^2/ ha at 2600m and 9.95 m^2/ha at 2800m.
- The total numbers of species and individuals i.e., 110 and 2221, respectively were recorded from Yewang forest. The number of species along an altitudinal gradient varied (i.e. at 1800m (29); 2000m (11); 2200m (16); 2400 (8); 2600m (25) & 2800m (21)). The highest number of individuals was 620 (at 2200m) and the lowest was 298 (at 2600m).

Conservation and Sustainable Utilization of Medicinal Plants in Himachal Pradesh, North Western Himalaya *(2007-2012, In-house)*

The Himalayan Region is one of the richest habitats for medicinal plants. Besides its use in modern medicine, majority of them are used in Ayurvedic, Unani, Tibetan and other traditional systems of medicine. With the increasing world also demand and renewed global interest in traditional ethnopharmacy coupled with the increasing preference for natural substances in the health care system, the natural stock of medicinal plants of Indian Himalayan Region (IHR) is under tremendous pressure. Himachal Pradesh is being seen as a herbal state and medicinal plants as a major sources of income generations. The Kullu and Lahaul & Spiti districts of the State being rich in medicinal plants, there is ample scope for the cultivation and conservation of these plants. As such an integrated study on conservation and sustainable utilization of the medicinal plants has not been carried out so far; therefore, the Upper Banjar Valley (1500-3600), Mohal Khad Watershed (1,200-3,000m); Parbati Watershed (1,100- 6,500m) and Upper Beas Valley (2,300- 5,000m) in Kullu district and Chandra Valley (3,300-5,000m) in Lahaul & Spiti district have been selected to conduct such.

Objectives

- To assess, monitor, map and evaluate the medicinal plant diversity.
- To assess the medicinal plant diversity for threat categories.
- To prioritize potential medicinal plants for conservation and socio-economic development of the inhabitants.
- To develop conventional propagation protocols and agrotechniques for the potential medicinal plants.
- To develop strategies and promote ex-situ and in-situ conservation of medicinal plants.
- To impart training to different stakeholders on conservation and sustainable utilization of medicinal plants.

Achievements

- Information on medicinal plants (MPs) updated and inventory of 476 species prepared and species were analyzed for nativity and endemism. In Parbati Watershed 244 species were native, 44 near endemic & 04 endemic; in Chandra Valley 161 species native, 19 near endemic & 02 endemic; in Upper Beas Valley 239 species native, 43 near endemic & 03 endemic; in Mohal Khad watershed 160 species native, 29 near endemic &

03 endemic and in Upper Banjar Valley 226 species native, 43 near endemic & 03 species endemic to the Himalayan region and IHR, respectively. From Parbati Watershed, 13 MPs were categorized as Critically Endangered, 9 Endangered, 27 Vulnerable & 26 Near Threatened; Chandra Valley, 15 MPs as Critically Endangered, 11 Endangered, 25 Vulnerable & 17 Near Threatened; Upper Beas Valley, 7 MPs as Critically Endangered, 10 Endangered, 12 Vulnerable & 17 Near Threatened; and Banjar Valley, 13 MPs as Critically Endangered, 12 Endangered, 20 Vulnerable & 14 Near Threatened.

- Quantitative assessment of *Withania somnifera* population was done twelve sites were sampled between 946-1,259m and latitudes 31° 42.517'N to 31° 56.101'N and longitudes 77° 07.768'E to 77° 13.845'E in the Kullu Valley. These sites represented roadside, dry forest, riverine, dumping site and bouldary habitats and located in SE, SW, E, S, NE and W aspects. The total tree density ranged from 0.1-4.1 Ind ha^{-1}; total basal area, 0.07-7.34m^2 ha^{-1}; total shrub density, 3-14.11 Ind ha^{-1} and total herb density, 6-34.45Ind m^{-2}. Maximum total tree density was recorded for *Toona serrata* (4.1 Ind ha^{-1}), total shrub density for *Withania somnifera* (6.1 Ind ha^{-1}) and total herb density for *Parthenium hysterophorus* (6.8 Ind m^{-2}). pH ranged from 6.68-8.17, moisture content 5.50-14.46%, organic matter 4.57-8.20%, total nitrogen 0.14-0.42%, total carbon -2.65-4.76% and C/N ratio -9.47-16.99.

Fig.23(a&b). Cultivation of Aconitum heterophyllum in Jana Village, Kullu a

- Cultivation of *Withania somnifera* in Tawarafae, Pandoh, Balikchowki, Thachi, Pandoh, Jhiri, Smaila and Sundernagar was initiated and over 4,000 seedlings were planted by a group of 35 farmers in Kullu and Mandi districts. Over 16,000 seedlings/plantlets of 18 MPs were developed in the Herbal Gardens and medicinal plants nurseries and distributed to different stakeholders including the participants of State Children Science Congress at Una.
- Over 1,50,000 seedlings of *Aconitum heterophyllum* were raised by 20 farmers in the fields at Jana village and 60,000 seedlings at Khansar village by a farmer (Fig. 23a&b). One farmer from Jana village developed > 1, 50,000 seedlings of *Aconitum heterophyllum* and generated > Rs. 1, 00,000/- from the seeds and seedlings under the guidance of the Institute.
- Growth performance of plants (i.e., shoot length, basal diameter, number of leaves, number of floral buds and number of fruit initiation) of *Aconitum heterophyllum* populations, namely P-1 (Jana) & P-2 (Lahaul) at Doharanala, at Jana following different treatments to seeds was monitored. It was observed that pre-soaking treatment with GA_3, KNO_3, IAA and $HClo_3$ solution markedly enhanced growth of seedlings/plants.

- One Day Training Workshop on *"Diversity Conservation and Utilization of Medicinal Plants"* was organized on March 14, 2012 for the farmers of Mandi and Kullu districts. The farmers were trained on assessment, monitoring, valuation, prioritization, conservation and agrotechniques for mass scale cultivation of MPs. Also, Exposures Visits (10 Nos.) of the Institute demonstration sites for over 1,000 stakeholders representing GOs and NGOs and local Institutions were organized.

Up-scaling Applicability of *Ex-situ* Mechanisms for Conservation and Utilization of High Value Plant Species – Focusing on Promotion of Conservation Education & Capacity Buildings *(2007-2012, In-house)*

Conservation and optimal use of high value species has emerged as one of the priority agenda of research and development realizing the fact that it can serve the basic needs of human being together with maintaining the biodiversity. Indian Himalayan Region (IHR) occupies a significant position in the world as far as biodiversity is concerned. The propagation protocols need to be further put to test for their efficacy and up-scaling the applicability in the field condition through promotion of conservation education and capacity building in the IHR. In the Himalayan context, this activity assumes greater significance in view of the rapid loss of biodiversity. The work therefore integrates the Conservation Education and promotion of ex-situ mechanisms of conservation and use to up-scale the applicability for effective utilization of high value species.

Objectives

- To apply the ex-situ conservation techniques for developing appropriate technologies of mass multiplication and storage of germplasm for conservation an effective utilization
- To demonstrate and upscale the applicability of existing protocols in selected sites and meet the demand of planting material by different stakeholders
- To ensure the quality planting material through phytochemical and genetic investigation of target species
- To understand the growth responses of the target species in wild as well as the cultivated land
- To develop a centre for on-site training and extension programmes for various stakeholder groups and also as a place for nature interpretation
- To inculcate among students excitement of understanding and working on different aspects of biodiversity conservation and encourage them to pursue higher studies in the biodiversity conservation

Achievements

Himachal Pradesh-Himachal Unit

- In the Arboretum sites over 37 seedlings/plantlets of 07 species of ecological, economical and ornamental importance were planted. Maximum survival was shown by *Platanus orientalis* and *Toona ciliata* (100%), followed by *Pittosporum eriocarpum* (91%), *Quercus leucotrichophora*, *Q. glauca* and *Fraxinus micrantha* (80%, each) and *Quercus floribunda* (60%), respectively. 101 seedlings of 11 tree species were planted in the 3rd class forest land at Mohal. Maximum survival was

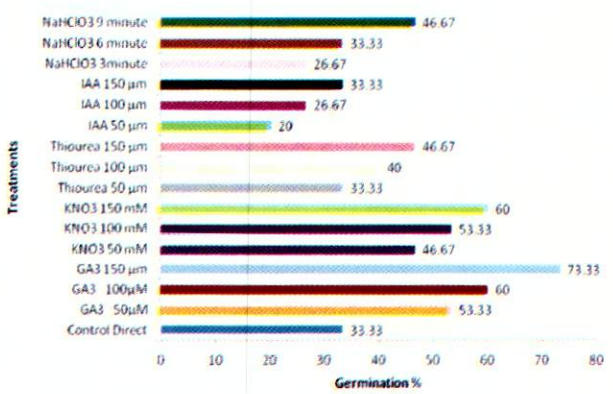


Fig. 24. Seed germination performance of Corylus jacquemontii (with seed coat) in different treatments.

shown by *Quercus leucotrichophora, Q. glauca, Toona ciliata* and *T. serrata* (80%, each), *Grevillea robusta* (76%) and *Platanus orientalis* (75%).

- Seed germination protocols for *Corylus jacquemontii, Acer caesium, Buxus wallichiana* and *Pittosporum eriocarpum were standardiged.* In *Corylus jacquemontii*, among various presoaking treatments (GA_3, KNO_3, IAA, $NaHCLo_3$) to seeds, maximum germination (73.33%) was observed following treatment with 150µM GA_3 (Fig.24); KNO_3 100mM showed maximum germination (72.50%) in *Acer caesium*; GA_3 100µM showed maximum germination (86.67%) in *Buxus wallichiana* and GA_3 500µM showed maximum germination (90.00%) in *Pittosporum eriocarpum*.
- Vegetative propagation protocols for *Platanus orientalis, Ulmus wallichiana* and *Tilia europea* were developed. The treatment with IBA at different concentrations gave maximum rooting in all the species i.e., *Platanus orientalis, Ulmus wallichiana* and *Tilia europea* (IBA 150µm (78%) at Doharanala nursery and 76% at Mohal nursery and IBA 300µm (76%), respectively.
- Over 1200 seedlings of different multipurpose trees, medicinal plants and ornamental species were planted for development of campuses of GSSS, Raison, GSSS, Manali and GSSS, Goshal of Kullu district.
- One Day Training Programme on "Weather Monitoring, Climate Change and Biodiversity Conservation and Management" was organized at GSSS, Raison, Distt Kullu (March 24, 2012) for the teachers and students for their capacity building on weather monitoring, climate change and biodiversity conservation and management in biodiversity assessment and PRA exercise. The pre and post feedbacks showed tremendous improvement in their subject knowledge. Exposure visits for over 1000 participants representing diverse stakeholders from the state and outside organized . They were trained on the propagation, cultivation and plantation techniques.

Table-6. Comparison of total phenol, phenolic compounds and antioxidant activity of in vitro callus culture and wild tuber of H. edgeworthii. Values are mean ± standard error; Means values followed by the same letter(s) in a column are not significantly different (p <0.05) based on DMRT

	Total Phenol (mg/g DW)	Phenolic compound (mg/100 g)		
		Gallic acid	Catechin	Hydroxy benzoic acid
B (3.0 µM)	14.30±0.03[a]	143.63±0.93[a]	2.98±0.05	5.50±0.15[b]
MeJA (10 µM)	14.70±0.72[a]	113.69±3.69[b]	2.44±0.06	5.66±0.79[b]
Wild Tuber	5.28±0.06[b]	5.51±0.07[c]	0	7.56±0.02[a]

Table-7. Effect of drying conditions on plant parts on antioxidant phytochemicals of Valeriana jatamansi.

Antioxidant phytochemicals (mg/g dry weight)	Growing sources	Oven dry		Mean	Shade dry		Mean	LSD (<0.05
		Aerial Part	Root		Aerial Part	Root		
Phenol	Wild	10.99	12.79	11.89	7.44	6.21	6.82	2.33
	Planted	18.44	7.66	13.05	10.13	7.56	8.84	
Flavonoid	Wild	4.34	4.19	4.26	5.51	4.66	5.08	4.11
	Planted	4.40	4.45	4.43	6.89	4.60	5.75	
Tannin	Wild	3.13	2.94	3.03	2.96	2.74	2.85	3.26
	Planted	3.09	2.65	2.87	2.90	2.53	2.71	

Uttarakhand –Headquarters

- *In vitro* production protocol for phenolic contents in *Habenaria edgeworthii* was standardized. Among the different BA and MeJA concentrations, the total phenolic content increased with increasing BA concentration and ranged from 10.33- 14.30 mg per g DW (compared to 10.17 mg in control) reaching a maximum (14.30 mg per g DW) at 3.0 µM BA. Although MeJA was not very effective in improving the callus biomass but, at 10 µM it resulted in maximum total phenol (14.70 mg per g DW compared to 10.17 mg in control), followed by significantly ($p<0.05$) lower values (11.86 mg per g DW) at 100 µM. However, further increase in MeJA concentration (200-1000 µM) resulted in significant ($p<0.05$) reduction in total phenol content.
- HPLC analysis revealed the presence of gallic acid to be a major phenolic compound that accumulated with increasing concentration of BA and ranged between 58.41 - 143.63 mg per 100 g DW; maximum value was found in callus cultured on medium supplemented with 3.0 µM BA. While comparing the *in vitro* produced callus (best culture of BA and MeJA) with wild tuber exhibited a three fold higher total phenol content in *in vitro* callus as compared to the wild tuber (Table-6). Moreover, about 28 times higher gallic acid content was detected in callus as compared to the wild tuber.
- Suitable method for drying of *Valeriana jatamansi* was optimized. Among the two different conditions (shade and hot air oven at 45 °C), higher phytochemicals and more antioxidant activity in plant parts (leaves and rhizomes) dried at hot air oven at 45 °C was found (Table-7). While comparing the wild and planted individuals, total phenols and flavonoids were found significantly ($P<0.05$) higher in the planted individuals and dried at hot air oven, however, the tannin content was higher in wild individuals.

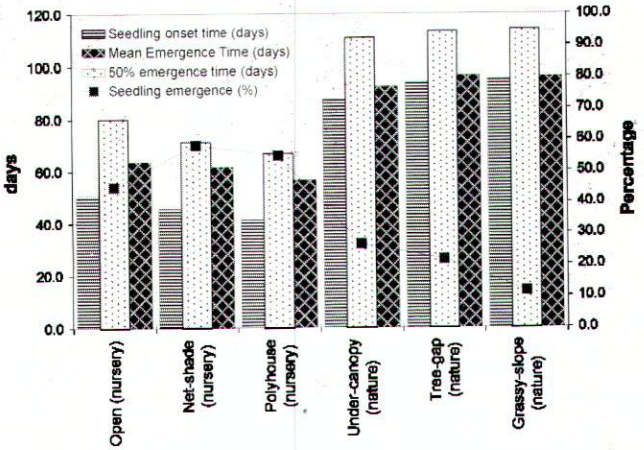


Fig. 25. Effect of different growing conditions (nursery and natural) on seedling emergence in Juglans regia in Sikkim

- A Three-Day onsite Training Workshop was organized at Govt. Intermediate College, Gangolihat, Pithoragarh from November 3-5, 2011 for sensitizing the young school children about biodiversity conservation. The teachers and students were exposed to different aspects of biodiversity i.e., introduction, assessment, value and value addition, conservation and linking biodiversity with other environmental issues, (i.e., climate change, water and land). Besides, a hand out on training on information generation on wild, agricultural and domesticated biodiversity were given to the students and teachers. Over 40 teachers and 94 students from 44 Schools of district Pithoragarh participated.

Sikkim - Sikkim Unit

- Over 40 new accessions were collected and 150 seedlings each of *Machilus edulis, Pandanus nepalensis, Michelia doltsopa, Juglans regia* were transplanted in open slope and under canopy in the arboretum. Innovative use of local bamboo stems to check soil/manure loss due to rains standardized. In arboretum, phenology of >2 dozen tree species recorded. On Over 2000 nursery raised MPTs saplings were distributed to over a dozen villagers, with technical guidance. *Michelia doltsopa, Juglans regia, Michelia velutina, Spondias axillaris, Acer campbelli,*

Symingtonia populnea Eriobotrya petiolata and Ficus nemoralis were the top preferred. *Spondias axillaris* could not survive. *Symingtonia populnea* (80%) and *Michelia doltsopa* (*61%*) showed better survival. *M. doltsopa* substantially improved in plant height, while, maximum collar diameter (16.6 mm) achieved in *S. populnea*.

- *In Juglans regia,* seedling emergence (54%) took 90.6 days average. Plant height significantly (negatively) correlated with days taken to FSE after 10 days of FSE. *In another experiment* all nursery conditions proved very favourable to significantly greater seedling emergence with lesser emergence timing, over nature (Fig.25).
- Seedling onset time (days), MET (days) and 50% ET (days) were significantly ($P<0.05$) lowest under poly house among all growing conditions. Seedling emergence was significantly ($P<0.05$) highest (58%) in net shade. Over 500 seedlings maintained in nursery for transplantation/distribution.
- In *Heracleum wallichii*, 12 substrate combinations were tested on seedling emergence and growth; significantly ($P<0.05$) maximum (94%) final seedling emergence and MET (15 days), maximum emergence rate (0.067), minimum 50% seedling emergence days (14 days) and minimum onset time (9 days) were observed in substrate using *Sand +FYM+ Humus (1:1:1)* over control (sand, and sandy loam soil).

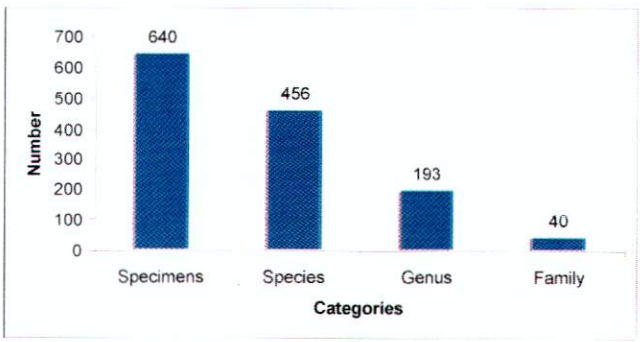


Fig.26. Digitalized and prepared data sets of species information as per GBIF format.

- *Swertia chirayita showed* highest plant survival (92 %; $p<0.05$) in green house. In open, plant biomass/individual was highest (42.60 g/plant), against green house (37.79 g/plant) and poly house (31.52 g/plant; $p<0.05$).
- Capacity building workshop on *Biodiversity Conservation and Livelihood Options,* for different stakeholders organized in west Sikkim. Over 60 stakeholders representing farmers, villagers, BDO officials, researchers, home-stay owners, retired officials, educators, and NGOs participated. Livelihood issues were prioritized.

Development of Database of Vascular Plants of Western Himalaya *(2009-2014, In-house)*

Application of bioinformatics in biodiversity data management and its impact on biological research are now well demonstrated. Biodiversity informatics developed using computational tools represents the collective research efforts and products of the life sciences community throughout the world. At present, some information is accessible through the web, and more is being added regularly. However, currently scientists do not find it easy to exploit the information because of a variety of semantics, interfaces, and data formats used by the underlying data sources. To harness the information resources, their authentication and integration are the main tasks currently faced by the biologists. A wealth of information exists on India's biological resources and associated knowledge may be in form of specimens, gray literature such as unpublished reports of District Floras project or Forest Working Plans, and books, monographs and scientific papers. A good beginning has been made in organizing a part of this information in the form of electronic databases. Keeping in view the importance of digitized electronic database, the present study have been initiated to develop digitized electronic database for the vascular plants of Western Himalaya

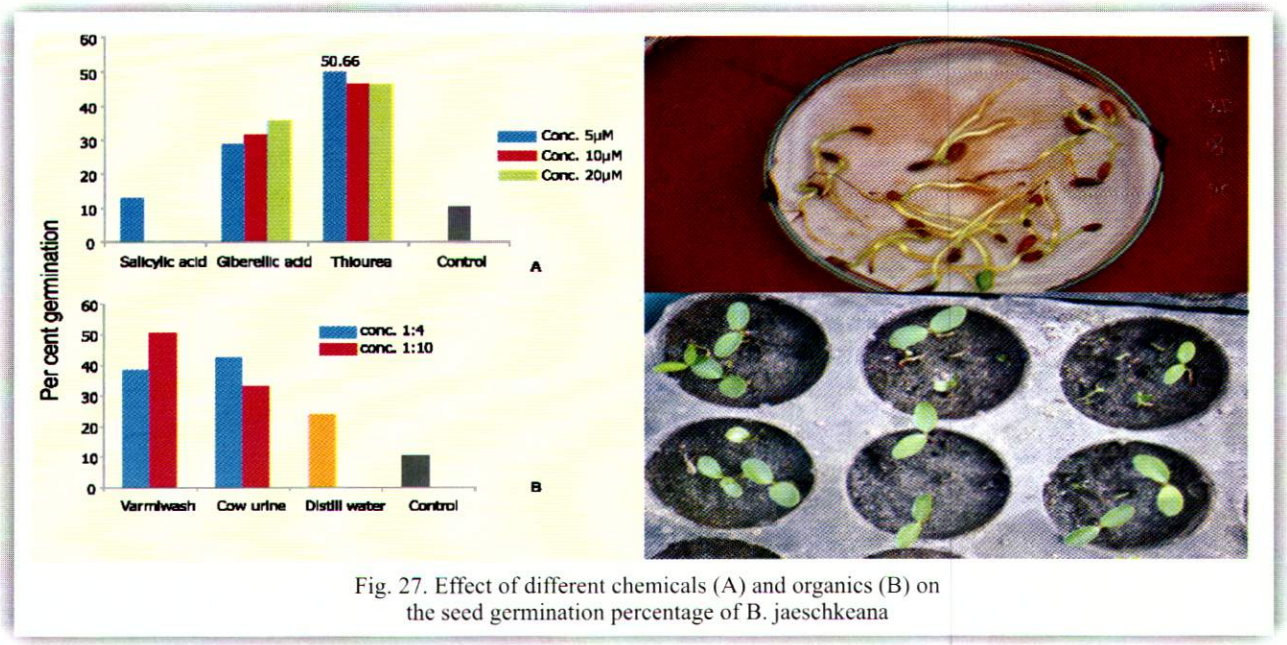


Fig. 27. Effect of different chemicals (A) and organics (B) on the seed germination percentage of B. jaeschkeana

Objectives

- To develop digital plant database of Western Himalaya through secondary information available in the herbarium and literature.
- To establish web-based inter-linkages with Global Biodiversity Information.

Achievements

- Total 640 specimens belonging to 456 species, 193 genera and 40 families were digitalized and edited. These specimens were housed in the herbarium of GBPIHED (GBP) (Fig.26). Good quality photographs of 20 plants were added. The binomials were carefully checked with help of relevant floras and monographs. The valid names are incorporated in the data sheet.
- Total 13 unidentified specimens housed in the GBP were identified and entered in the GBIF format. The complete data sets of the 640 specimens were entered as per the GBIF format and the digitalized images were incorporated along with the data sets. The data include, unique identification number, institutional code, collection id, collection code, catalog number, kingdom, class, order, family, genus, species, scientific name, author, date identified, identified by, country, state province, locality, elevation, basis of record (preserved/live), date of collection, recorded by, date last modified and photo details. The completed data sheets are now ready for attachment to the GBIF through nodal centre.

Assessment of Ecological and Phytochemical Features and Development of Propagation Packages for Production of Elite Planting Material of Selected Himalayan *Berberis* Species: A Potential Source for 'Berberine' Alkaloid *(2011-2013, Uttarakhand State Biotechnology Programme)*

Himalaya is well known for richness and uniqueness of medicinal plants. A great number of these are in use of various systems of medicine, like Ayurveda, Siddha and Unani, etc. Of the total 1748 species reported from the region, 700 species are being used by pharmaceutical companies in India in which the Himalayan medicinal plants contribute almost 50%. However, the gap between demand and supply is widening due to decreasing population size of many valuable plant species in nature. Further, indiscriminate collection and destructive harvesting of the medicinal plants from the wild have put many valuable plant

Table-8. Community wise changes in soil parameters in Pindari-Sunderdhunga-Kafni regions.

Community types	Soil parameters									
	pH		OC		OM		N		C/N	
	1990	2010	1990	2010	1990	2010	1990	2010	1990	2010
Alnus nepalensis	6.75	6.62	4.00	3.38	6.90	5.83	0.50	0.63	8.08	5.39
Mixed Oak Deciduous	6.87	6.60	4.80	4.14	8.28	7.15	0.53	0.68	9.06	6.12
Hippophae salicifolia	6.80	6.54	3.37	3.47	5.80	4.85	0.51	0.40	6.64	8.73
Quercus floribunda	6.85	6.54	4.68	4.06	8.06	6.99	0.59	0.62	7.99	6.55
Q. semecarpifolia	6.80	6.58	4.65	3.90	8.02	6.74	0.63	0.72	7.35	5.45
Mixed Deciduous	6.83	6.64	4.67	4.22	8.05	7.25	0.67	0.74	7.00	5.73
Mixed Silver fir-Oak	6.93	6.67	4.77	4.23	8.22	7.29	0.65	0.76	7.33	5.54
Mixed Silver fir-Rhododendron-Maple	6.80	6.63	4.70	4.25	8.10	7.32	0.71	0.86	6.67	4.94
Abies pindrow	6.75	6.55	4.80	4.35	8.28	7.51	0.73	0.84	6.62	5.17
Mixed Birch-Silver fir	6.75	6.52	5.05	4.63	8.71	7.97	0.83	0.86	6.12	5.41
Betula utilis	6.70	6.48	5.10	4.69	8.79	8.08	0.84	0.98	6.11	4.81

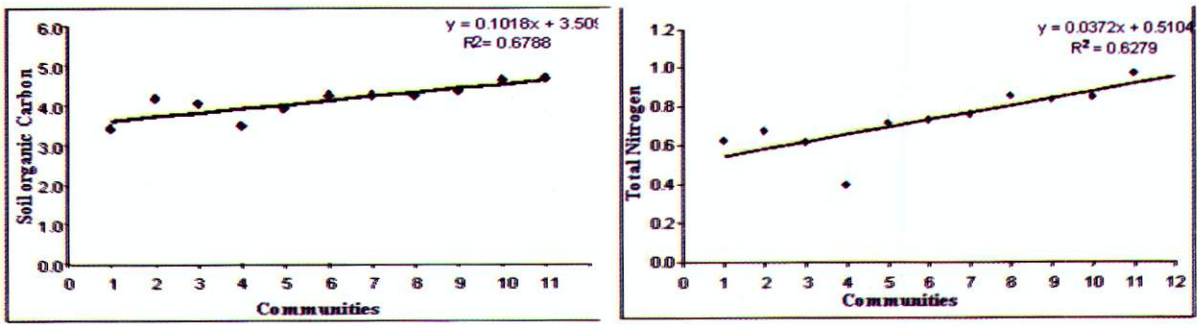


Fig.28(a&b). Relationship of soil parameter with altitude; a) Soil organic carbon; b) Total nitrogen: 1 -Alnus nepalensis; 2 -Mixed Oak Deciduous; 3 - Hippophae salicifolia; 4 - Quercus floribunda; 5 - Q. semecarpifolia; 6 -Mixed Deciduous; 7 - Mixed Silver fir-Oak; 8-Mixed Silver fir-Rhododendron-Maple; 9 -Abies pindrow; 10 -Mixed Birch-Silver fir; & 11-Betula utilis

species in the category of endangered, vulnerable and even extinct. In this context, development of suitable protocols for mass production of planting materials, packages of cultivation, assurance of quality through phytochemical investigations and understanding growth responses in wild and cultivation are some of the areas which may contribute in achieving the goal of conservation as well as sustainable development of medicinal plants. In addition, ecological assessment in natural habitat for quantifying the available wild stock and their regeneration potential will be helpful in developing management strategies for *in situ* conservation of the target species

Objectives

- To ascertain the diversity in populations (performance of species – abundance, biomass, regeneration and phenology, etc.) of selected *Berberis* species across different habitat ranges
- To explore variations in edibility and medicinal properties (i.e. diversity of active compounds) of selected species across populations in different habitats

- To establish relationship of value attributes (i.e., edibility and medicinal value) with plant age, phenophases and part of the plants)
- To develop conventional as well as *in vitro* propagation protocols of target species (*Berberis jaeschkeana* and *Berberis pseudoumbellata*)
- To plant and establish seedlings in the demonstration plots at different Himalayan locations

Achievements

- Vegetative propagation protocol of *B. jaeschkeana* was developed for the purpose of mass multiplication. In this context, stem cuttings were collected from the Kedarnath area (Altitude – 3300 m asl; Lat. 79° 4' E; Long. 30°44' N) and exposed to different plant growth regulators treatment. The maximum sprouting percentage was observed in IBA (2000 M). Only 20% sprouting was achieved in the cuttings without plant growth regulators.Similarly, 60% cutting showed rooting in IBA (2000 M), however, no rooting was observed in the cuttings of control condition.
- Seed germination protocol was developed for *B. jaeschkeana*. Seeds were exposed to different concentration of salicylic acids, thiourea, gibberelic acid and some organic treatments such as cow urine, vermiwash (1:4 and 1:10 ratio), and distilled water. A set of seeds was sown without giving any treatment represented control. Results revealed that maximum seed germination was found in thiourea and vermiwash (Fig.27 A & B), which was 5 times higher as compared to control.

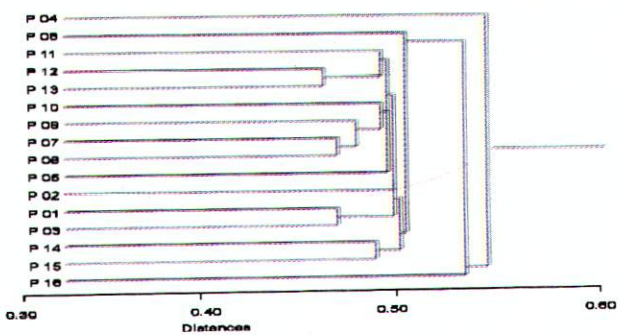


Fig. 29. Dendrogram constructed for 16 populations of Hedychium spicatum based on genetic distances using ISSR markers primers.

Assessment of Plant Responses and Changes in Vegetation Diversity in Nanda Devi Biosphere Reserve over the Last Two Decades *(2011-2012, CSIR, New Delhi)*

The Himalayan Biosphere Reserves with their unique biophysical settings and life support values have attracted great attention. Among them, the Nanda Devi Biosphere Reserve (NDBR) has been identified as potential site for detailed investigation from Asia-Pacific region. NDBR has a wide altitudinal range, unique topography, climate and soil which support diverse ecosystems, habitats, communities and species. Prevailing representativeness, naturalness and uniqueness of biodiversity elements in the reserve highlights its conservation value. In spite of the availability of extensive information on different aspects of the reserve i.e., structure and composition, resource use patterns, identification and conservation priorities of rare and endangered plants, conservation and management of biosphere reserve, etc. the information has not been properly processed to make it accessible to different stakeholders who are involved in decision making and formulation of management plan. As a result, the appropriate mid to long term management regimes, that maintain the multiple functions of NDBR, remain unattended even under rapidly changing climatic and socio-economic scenarios. This justifies not only the strong need to process the existing information, especially the one available on patterns and processes of vegetation in the reserve to ensure optimal use by managers and policy makers but also to generate strong scientific evidences to signal potential changes in vegetation attributes in future

Objectives

- To assess diversity in vegetation and other land use patterns in NDBR using standard phytosociological approaches and application of RS/GIS

- To detect changes (temporal/spatial) of vegetation at community and species level (dominant/co-dominant)
- To identify sensitive/vulnerable areas and communities considering patterns of natural recruitment
- To develop future scenarios and predict maps to propose long term alternative management plan for NDBR

Achievements

- Analysis of soil samples collected from the Pindari region revealed that pH ranged from 6.48 - 6.67, total nitrogen, 0.40 - 0.98%, organic carbon, 3.38 - 4.69%, organic matter, 4.85 - 8.08% and C/N ratio, 4.81 - 8.73. A significant ($r<=0.01$) increase in total nitrogen and soil organic carbon along the altitudinal gradient was found (Fig. 28 a&b). A slight decrease in the value of pH, soil organic carbon, and organic matter in each community as well as along altitudinal gradient was observed. However, a gradual increase was observed in total nitrogen (Table-8). A good correlation between the soil parameters and recruitment density was observed.

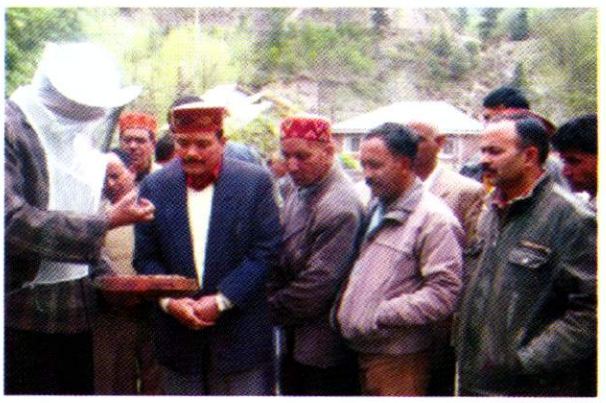


Fig. 30. Training of Trainers Meeting on 5th April, 2011.

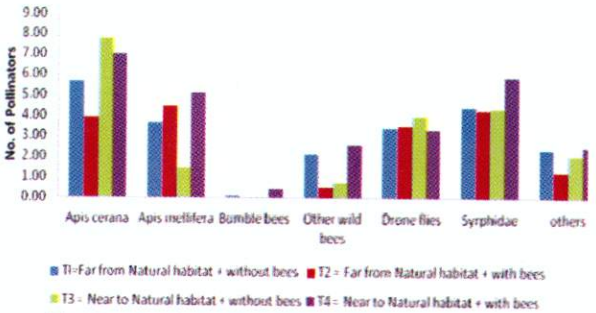


Fig.31. Density of insect pollinators on apple bloom

Distribution of native and endemic species in identified forest communities revealed a total of 37 native and 17 endemic tree species. In shrub layer, out of 54 species, 42 native and 14 endemic and in herb layer, out of 235 species, 147 native and 49 endemic were recorded.

a. *Apis cerana*

b. *Apis mellifera*

c. *Eupeodes frequens*

Fig.32(a,b&c). Potential Apple Pollinator Species

Genetic and phytochemical diversity in *Hedychium spicatum* and *Roscoea procera* in west Himalaya *(2011-2012, CSIR, New Delhi)*

Diverse attributes (genetic, phytochemical and ecological) affect accumulation of secondary metabolites in plant species, thus affecting their medicinal properties. Variations in active constituents among the populations to ascertain the suitable chemotypes are not known in many species. Moreover, characterization of genetic diversity of these species is necessary for determining interrelationship and development of conservation strategies. Detailed studies on phytochemical constituents and genetic variation in many species have not been carried out. Therefore, knowledge on the seasonal changes in phytochemical content would be useful for the standardization and optimization of best harvesting time.

Objectives

- To investigate the phytochemical variation and antioxidant activity among plants from different populations in west Himalaya
- To examine the seasonal changes of different phytochemical constituents
- To assess genetic diversity using DNA based molecular markers

Achievements

- Genetic diversity analysis of *Hedychium spicatum* collected from 16 populations of Indian west Himalaya showed high percentage of polymorphism which is an indicator of high level of genetic diversity. Analysis of Molecular Variance (AMOVA) revealed higher within population variation (94%).
- The UPGMA clustering exhibited grouping of most populations from the same or adjacent regions (Fig.29). Study revealed that variation in phenolic content and antioxidant activity may be related to genetic factors along with environmental conditions. The results exhibited that the high genetic diversity of this species can be attributed to its wider adaptation.

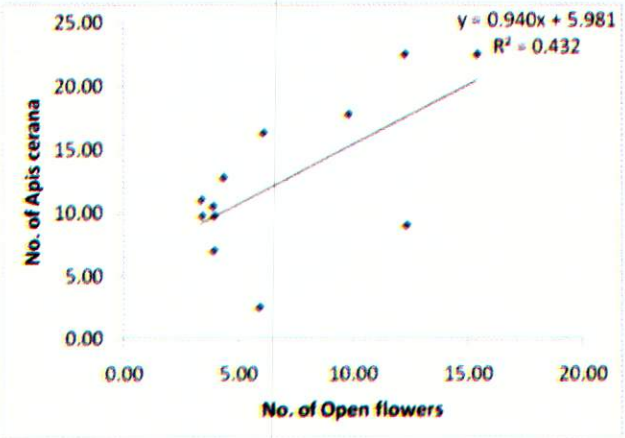


Fig.33. Corelation between Apis cerana and no. of open flowers.

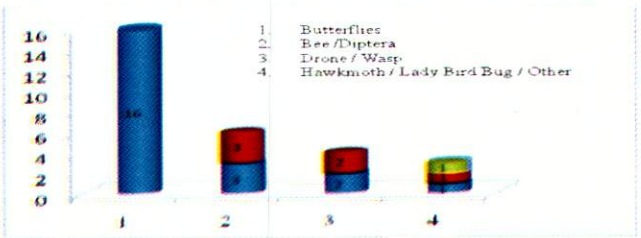


Fig. 34. Pollinator density in mustard field.

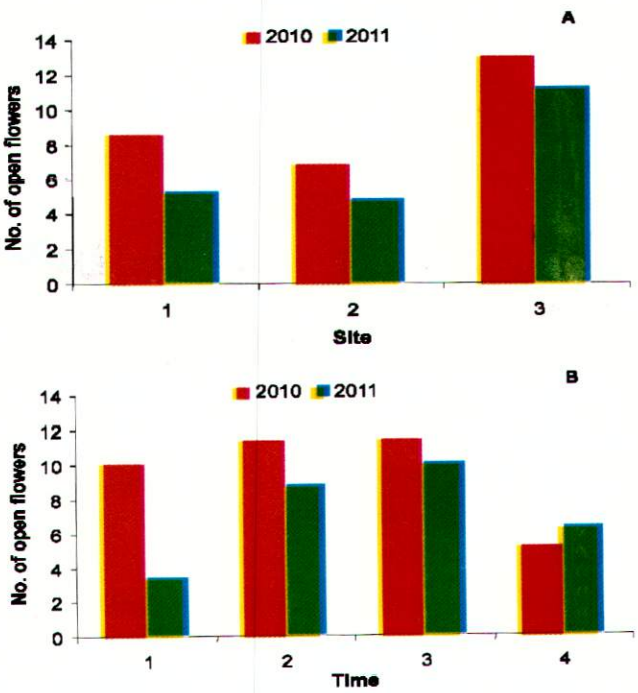


Fig. 35(A& B). Phenological variation of large cardamom between site and time.

Table-9. Variation in density of pollinators per 100 opened flowers of Large Cardamom in two different years.

Source of variation	DF	2010		2011	
		Honey bee	Bumble bee	Honey bee	Bumble bee
		MSS	MSS	MSS	MSS
Block	3	20.33	33.27	13.90	18.21
Site	2	64.70*	0.27ns	29.91*	161.56*
Time	3	86.04**	119.09**	148.21**	30.36ns
Site x Time	6	20.32ns	27.33**	21.96*	19.32ns
Error	33	11.90	6.53	6.58	24.25

MSS- Mean Sum of Square, *significant (P<0.05), ** significant (P<0.01), ns- non significant

Table-10. Correlation matrix between phenology, pollinators and crop yield of large cardamom.

		No. of open flowers/plant	Pollinators/100 flowers			Yield (Kg/ha)
			Honey bee	Bumble bee	Total bees	
No. of open flowers		1				
Pollinators/100 flowers	Honey bee	-0.078	1			
	Bumble bee	0.464	0.584*	1		
	Total bees	0.387	0.710**	0.986**	1	
Yield (Kg/ha)		0.824**	0.336	0.621*	0.608*	1

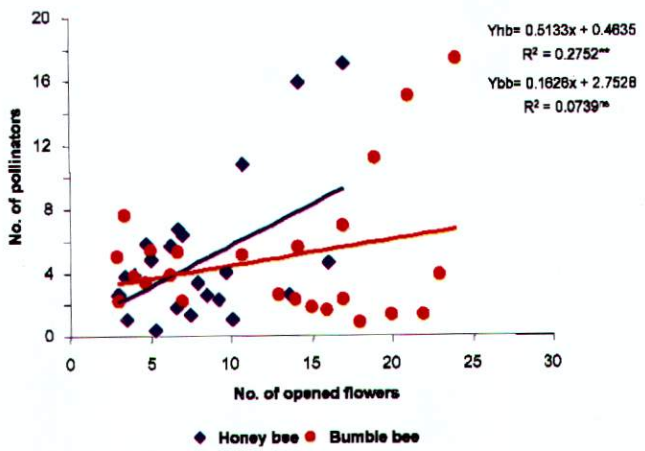


Fig. 36. Relationship between number of flowering in large cardamom and number of pollinators.

Conservation and Management of Pollinators for Sustainable Agriculture through an Ecosystem Approach *(2009-2014, GEF, UNEP, FAO)*

Pollination is a keystone process in both human managed and natural terrestrial ecosystems. It is critical for food production and human livelihoods, and directly links wild ecosystems with agricultural production systems. The vast majority of flowering plants only produce seeds if animal pollinators move pollen from the anthers to the stigmas of their flowers. Without this service, many interconnected species and processes functioning within an ecosystem would collapse. Recognizing the dimensions of a "pollination crisis" and its links to biodiversity and human livelihoods, the Convention on Biological Diversity has made the conservation and sustainable use of pollinators a priority. At the Fifth Conference of Parties (COP V) in 2000, an International Initiative for the Conservation and Sustainable Use of Pollinators (also known as the International Pollinator Initiative - IPI) was established (COP decision V/5, section II).

Objectives

- To improve food security, nutrition, livelihoods through enhanced conservation and sustainable use of pollinators
- To identify ecological practices in multiple agro-ecosystems for preventing the loss of pollination services
- To harness benefits of wild diversity

- To enhance conservation and sustainable use of pollinators

Achievements

Himachal STEP Site

- Training of Trainers (TOT) on Pollination and Pollinators (April 05, 2011) in collaboration with Dr. YSPUHF, Nauni, Solan and Interactive Workshop on Biodiversity Conservation, Pollinators, Pollination and Crop Production in collaboration with Fruit Grower's Association, Mahili, Patlikuhl (June 04, 2011) at Fruit Grower's Association, Mahili, Patlikuhl and Village Level Meetings (02) at Kais Village Panchayat Hall, Kais (November 04, 2011) and Naggar Panchayat Hall, Naggar (November o5, 2011) in collaboration with Dr. YSPUHF, Nauni, Solan were organized. The meetings were attended by 100 participants (50 each meeting) representing Village Panchayat Pradhans, President and Members of Fruit Grower's Association, Orchardist/Farmers of upper Kullu Valley (Fig. 30)
- Under the Pollination Deficit Protocol Pan Trap, Flower Phenology, Scan Sampling, Sweep Sampling and Total fruit yield were implemented. Orchards near natural habitat had highest number of solitary bees/trap as compared to orchards far from natural habitat (Fig.31). Blooms of apple orchards under different treatments revealed a high population of indigenous honey bee (*Apis cerana*) (varied between 3.9 -7.75 bees per 250 apple flowers), followed by *Apis mellifera* and Syrphid flies (Fig.32 a,b&c)..
- The study conducted in 20 selected apple orchards revealed maximum fruit yield both in terms of quality and quantity from the orchards near to natural habitat with bee hives. Orchards having less number of apple fruits were better both in terms of weight and size in comparison to the orchards with higher number of fruits.
- The crop specific best practices for the effective apple pollination management and crop production were keeping bouquet of pollinizer on the blooming branches of production trees of Apple, grafting of polliniser variety on branches of the production variety of apple, conservation of natural bee flora, adoption of diversified horticultural crops, use of traditional Indian bees *(Apis cerana)* for apple pollination as well as honey production and hiring of bee colonies on rental basis for apple pollination. Total 175 farmers/orchardists of seven different locations in the STEP Site were interviewed to know the status of basic knowledge on pollination and its services. Survey revealed the sound knowledge on different aspects of pollination and its services.

Kosi STEP Site

- Pollination Deficit Protocol has been applied in target crops of mustard and cucurbits for the year 2011. Significant correlation has been observed between the visits of *Apis cerana* and no. of open flowers, suggesting the availability of foraging resources attracts high density of *Apis cerana*, and declares it as the main pollinating insect of the Mustard in the region (Fig.33).
- Diversity of pollinators visiting Mustard has been recorded and results showed a total of 29 species, visiting to the Mustard in the region. Of which 18 species have been identified so far (Fig.34).

Sikkim STEP Site

- Pollination bibliography (16) was prepared, only 6 articles indicated pollination activities in large cardamom and rest 10 articles were indicated management and practices of large cardamom.
- A total of four village panchayats (Upper Jaubari, Lower Jaubari, Damthang and Tingrithang) of Mamlay-watershed were surveyed with total 182 questionnaires (i.e. Farmers-120, Students-30 and Teachers-32). The findings revealed that 22.5% of

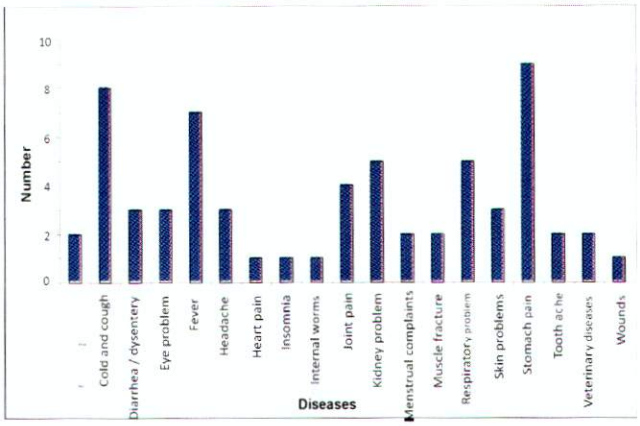


Fig. 37. Number of ethnomedicinal plants used by the tribal communities against different diseases in Lahaul - Spiti

farmers of the region are aware of the fact that pollination has some role in crop yield whereas in remaining the target groups of students and teachers the level of understanding was 20 % and 65.62 %, respectively.

- The research experiment was carried out during the peak flowering time of large cardamom in the 3 distinct areas of the STEP site. Opened flowering frequency observed maximum in site 3 i.e., close to protected (i.e. 13 flowers/plant for 2010 and 11/flowers/plant for 2011) (Fig.35A) and maximum during 7-15 June (i.e., 11 flowers/plant for 2010 and 10 flowers/plant for 2011) significantly ($p<0.01$) (Fig.35B).
- Density of honey bee per 100 flowers showed significant difference between sites ($P<0.05$) for the both year 2010 and 2011, while bumble bee showed significant difference between sites for the year 1011 (Table-9). Density of honey bee per 100 flowers showed significant difference between time ($P<0.01$) for the both year 2010 and 2011 and bumble bee showed for 2011 year. Density of honey bee showed between interaction of sites and time for the year 2011 significantly ($P<0.05$) and bumble bee for the year 2010 ($P<0.01$). Higher number of open flowered responded the higher density of the honey bee ($P<0.01$) (Fig.36). Correlation matrix showed that the maximum number of open flowers correlated with higher yield of crop. Also, bumble bee positively responded the yield of crop significantly ($P<0.05$) (Table-10).
- A Meeting of farmers (49) was organized and the knowledge base on introduction of pollination and pollinators and pollination process in large cardamom shared. Draft of farmers teaching manual was prepared for printing.

Ecological Evaluation Mapping and Conservation Prioritization of Floristic Diversity of the Spiti Valley in a Proposed Cold Desert Biosphere Reserve in Trans Himalaya *(2011-2014, MoEF, New Delhi)*

Biosphere Reserves (BRs) have been established throughout the globe to conserve the representative ecosystems. In India, The Ministry of Environment and Forests has taken initiative to establish representative BRs in different biogeographic zones. The Indian Himalayan Region represents seven BRs. The Cold Desert Biosphere Reserve (CDBR) covering whole Spiti Valley and a few parts of Lahaul Valley is a recently designated BR with core, buffer and transition zones. It represents the Trans Himalayan Ecosystem and supports a representative, natural, unique, ecologically and economically important species of Trans Himalaya. The Spiti valley of the CDBR is inhabited by a number of tribal villages. This rich biodiversity is used by the tribal communities in various forms for their sustenance. Pin Valley National Park, Kibber and Chandertal Wildlife Sanctuaries form the core zones. The review of literature indicated that the available studies are restricted to the flora and ethnobotany. Studies integrating different components of biodiversity and prioritizing habitats, species and communities for conservation and economically important species for the socio-economic development of the Tribal Communities have not been carried out so far. Therefore, present study has been initiated on these lines.

Objectives

- To assess the floristic diversity of the Spiti Valley in a proposed Cold Desert Biosphere Reserve
- To study the status and distribution pattern of the native and endemic species
- To assess the utilization pattern of floristic diversity and document indigenous knowledge and traditional practices by the tribal communities
- To assess the floristic diversity for threat categories
- To prioritize habitats, species and communities for conservation, and economically important species for the socio-economic development of the Tribal Communities

Achievements

- 57 sites representing 10 habitats and 06 aspects between 2,620-4,559m amsl and 31° 54'41" N to 32°28'23" N Lat. and 77°36'49"E to 78°35'20"E Long. were sampled. Maximum sites (17) were represented by Dry slope habitat, followed by Bouldary and Riverine (09 sites, each), Rocky (07 sites), Dry pasture (06 sites) and Moist slope (04 sites). The remaining habitats represented < 2 sites. Ten (10) sites were represented in North West aspect, 09 sites each in North and North East, 07 sites each in East and West, 05 sites in South and 03 sites in South East aspects. The slope varied from 3-55.
- Total 121 species belonging to 35 families and 98 genera were identified. Among the identified species, 5 species were trees, 8 shrubs and 108 herbs. *Astragalus* (4 spp.), *Allium, Artemisia, Hippophae, Rheum,* and *Salix* (3 spp., each) were among the dominant genera. Further identification of the species is in progress.
- Soil samples were analyzed for various chemical properties. The soil moisture content ranged from 0.10%-35.13%, pH, 6.58-8.30, total nitrogen, 0.021-0.098% and organic carbon, 8.03-27.69%.

Promoting bioresource based livelihood opportunities for the tribal community in Lahaul-Spiti, cold desert area of Trans Himalaya *(2011-2012, Central Arid Zone Research Institute-ICAR, Jodhpur)*

'The tribal population is recognized as socially and economically vulnerable. Their lifestyles and food habits are different from that of their rural neighbours. They depend on minor forest produce and manual labour for livelihood. Their food consumption pattern is dependent on the vagaries of nature and varies from extreme deprivation (in the lean seasons) to high intakes (in the post-harvest period). Several focused interventions for tribal development and improvement in health and nutritional status of tribal population have been initiated in the last three decades in different hill states of Indian Himalayan Region (IHR). Lahaul & Spiti is scarcely populated and located in the northeastern part of Himachal Pradesh. The schedule cast population is 2,605 (7.34 %) and the schedule tribe population, 24,238 (72.95 %). On the basis of situational analysis and detailed discussion with the tribal peoples, major problems in the district are lack of knowledge about the bioresources, mal-nutrition and lack of improved knowledge of agricultural practices.

Objectives

- To investigate the existing potential of wild edibles and medicinally important plants in the landscape
- To explore possibilities for value addition, through processing and product development, of potential wild edibles and plants of medicinal value
- To enable target groups, through awareness and capacity building programmes, to harness the economic potential of bio-resources, including wild edibles and medicinal plants

Achievements

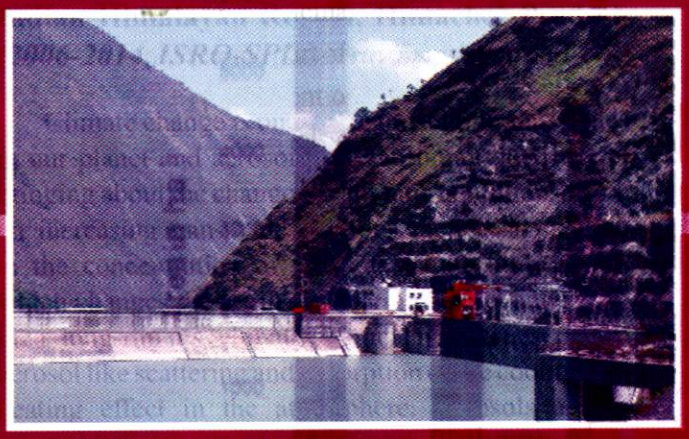
- Total 35 wild edibles belonging to 17 families and 22 genera were documented from Lahaul – Spiti. 65 ethnomedicinal plants belonging to 30 families and 53 genera were listed through interviews of the tribal people from Lahaul – Spiti. Medicinal plants used against different diseases are presented in Fig. 37.
- Three plant species namely, *Aconitum heterophyllum, Inula racemosa* and *Saussurea costus* were found under cultivation. The market value of the dried roots of *Aconitum heterophyllum, Inula racemosa* and *Saussurea costus* are Rs. 3200, 100, 120 per kg, respectively. The information obtained from the tribal communities revealed >80% population interested in apple cultivation.

Summary of Completed Project / Activity

Assessment of Plant Diversity and Dependency in West Kameng District of Arunachal Pradesh *(2009-2011, DST, New Delhi)*

The project was focused on; assessment of plant diversity in the selected watershed; identification; identification of conservation priorities; preparation of database of the assessed plant diversity; and establishment of herbarium for dissemination and further study. The major achievements of the project are summarized below

- Surveys and samplings were carried out in seven grids. Total 202 species were found in seven grids. Only 33 species were identified. The identification of rest of the specimens is in progress.
- Total seven RMU (Resource mapping unit) were surveyed. All seven sites were represented by moist habitat in the altitudinal range of 381-811m. Three sites were North-West facing, two North-East and one each South-East and South-West. Slope percentage was 30% for all sites.
- 6 forest communities were delineated in Pinjoli watershed. The community types were 121-126, 138-128, 235, Rudraksh-196-190, 333 and *Ficus* sp. Species richness ranged from 17-50. It was highest in RMU II, followed by RMU III and RMU IV. Total tree density ranged from 725-1900 Ind ha^{-1}, it was maximum (1900 Ind ha^{-1}) in RMU II. Species diversity ranged from 2.39-3.69 and recorded highest in RMU II.
- Species richness ranged from 26-50. Richness was maximum in 138-128 community while minimum in 333 community. Total tree density Ind ha^{-1} ranged from 8.63-1900. It was recorded maximum in 138-128 and minimum 8.63 in *Ficus* sp. Species diversity ranged from 3.03-3.69. Species diversity was recorded maximum in 138-128 community and minimum in *Ficus* sp. community. Concentration of dominance ranged from 0.03-0.08. The maximum was recorded in *Ficus* sp. community and minimum in 235 community.



ENVIRONMENTAL ASSESSMENT AND MANAGEMENT (EAM)

The growing populations and their continuously increasing demands together have led over-exploitation of natural resources. As a result, these resources are now scarce and degrading. Low availability but high demands of the resources have posed high anthropogenic pressure beyond their carrying capacity. Consequently, a variety of environmental disorders and pollutions arise. The day-by-day upcoming developmental activities need a fresh re-look in an integrated manner with a view to sustainable development. The theme– Environmental Assessment and Management (EAM) therefore addresses, monitors, assesses and analyzes physical, biological and cultural components of environment, concerned with the developmental activities/ interventions/ projects/ policies/ plans in the Indian Himalayan Region (IHR). The theme aims to assess and analyse impacts, set priorities, identify gaps, develop early mitigating approach and find new technology to achieve the goal of sustainable development. Forests, ecosystem services and conservation have always been among the core issues in the mountain agenda. IHR is likely to be adversely affected due to land use/land cover change for practicing a variety of economic activities for livelihood options and upcoming threats of climate change, its adaptation, resilience and mitigation. The shrinking of forest resources, it's functioning and ecosystem services (ES) are of utmost importance to address. The conversion of forest land into developmental activities like alternative land uses, infrastructural development, hydropower, etc. and loss in ES need to be assessed for compensation / rehabilitation packages based on net present value of forests. Mitigating and minimizing adverse impacts due to developmental activities and maximizing their positive impacts would improve ecosystem services and would help becoming stakeholders self reliant. The environmental issues like land use/land cover change, forest conservation and ES, strategic environmental assessment of hydropower projects and ecotourism have been the primary focus to improve better livelihood options. While adverse impacts due to developmental activities and sprawling urban environment such as acrosols (particulate, gaseous, liquid) and its impact on temperature rise, and solid waste problem, have been covered under the R&D activities of the theme. The EAM theme therefore envisages planning and management options for the sustainable ecological and economic developmental of the IHR. The objectives of the theme are: (i) Assessment and monitoring of physical, biological and socio-economic environmental attributes related to various developmental interventions/policies/plans in the Indian Himalayan Region (IHR), and (ii)

Development/formulation/ suggestion of appropriate management plans ensuring ecological and economic sustainability

Small Holder Farming Systems: Strategies for Economic and Environmental Viability in the Western Himalaya *(2007-2012, In-house)*

Agriculture is the mainstay of people in the western Himalayan region. Most of the agriculture in this region is dominated by small farms as 60-80% families hold <1 ha agricultural land. Moreover, most of the agricultural land in the region is rainfed and is characterized by tiny and sloping terraces poor in soil fertility, which in return produce very low yield. The farm yield is far less than adequate to meet the dietary demand of the small holder farmers. Working with smallholders, therefore, form an important priority area for the Indian Himalayan Region (IHR). Handling the issues like degradation of arable land, diversification of rural income and rehabilitation of common property resources seeking farmers' participation would help in improving the living status of these farmers and would also contribute to environmental conservation and sustainable development. Increasing community access, participation in natural resource management and diversifying livelihood options at village level would be the primary steps in this regard. In this regard, background studies were undertaken in the region and a village (Patharkotc; District Almora) inhabited by smallholders was taken into account for demonstrations.

Objectives

- To undertake in-depth assessment of farming systems and its economic growth in the western Himalayan region.
- To identify issues and options for rural income diversification (on-farm and off-farm).
- To restore the village commons and degraded areas.
- To strengthen village energy and fodder requirements, and plantation of commercial species.
- To strengthen village institutions for natural resource management.
- To develop pathways and policies for rural livelihood.

Achievements

- Five promising farming practices i.e. floriculture, mixed multi-layer vegetable cultivation, dairy farming, horticulture and integrated farming practices of the region were studied. Input:output ratio of these improved farming practices viz., floriculture (1:5), horticulture (1:65) and mixed multilayer vegetable cultivation (1:7) were found greater than the cereal based traditional farming practice of the region.
- In the Makraun village (District Almora), an innovative practice of vegetable cultivation was found where farmers sow seeds/rootstocks of 3-5 different vegetables at different soil depths on a same piece of land. For example, they sow early germinating and fast growing leafy vegetables (coriander, spinach, fenugreek, etc.) in the top soil (0-10 cm), while next soil depth (10-20 cm) is sown with potato and the deeper soil layer (20-30 cm) is planted with root stock of *Colocasia*- a tuberous crop. A crop sown at the top soil layer (e.g., spinach and brassica in January) grows first and harvested. Again, the top soil layer is sown with leafy vegetables (e.g., coriander, spinach and brassica) subsequently. Simultaneously, potato sown at deeper soil depths cover the surface layer in March and harvested in May. Subsequent to the harvest of potato, *Colocasia* occupies the surface and is harvested in October (Fig.38). Through this technique, farmers get a simultaneous and uninterrupted production of vegetables within a

Table-11. Survival, biomass and carbon stock of planted saplings (after 2 years) in village Patharkote.

Planted species	No. of planted saplings (monsoon 2009 & 2010)	% Survival (March 2012)	Biomass (kg) March 2012	Carbon stock (kg) March 2012
Q. leucotrichophora	900	69.17	8590.87	4295.44
Q. glauca	910	51.15	6124.65	3062.33
Cedrus deodara	520	37.50	120.06	60.03
Grewia optiva	660	38.39	130.56	65.28
Alnus nepalensis	950	44.46	198.52	99.26
Bauhinia racemosa	550	46.28	172.15	86.08
Morus alba	25	48.00	160.09	80.05
	4515	47.85	15497.0 (3.10 t/ha)	7749.0 (1.6 t/ha)

small piece of land that accounts for about 20 t/ha/yr with an income about Rs.1.39 lakh/ha/yr. The input: output ratio of this system stands to be 1:7. This practice also lessens the time required for land preparation and soil nutrients and water is utilized efficiently.

- The on-farm activity for rural income, diversification of polyhouses were done in the Patharkot village. In addition to their own consumption, vegetables were also sold in the nearby markets. Vegetables grown under two of these polyhouses studied in detail showed that average income through sale of vegetables (including self consumption) ranged from Rs. 572.50 ± 245.17 to Rs. 944.00 ± 689.38 per month.
- In the Patharkote village, a community wasteland (5.6 ha) was taken up for orchard development. Species such as *Citrus sinensis, Prunus amygdalus* and *Citrus reticulata* have started bearing fruits in 2011. As a part of strategy for horticultural extension in the Patharkote village, 510 fruit plants of 11 species were distributed to village people for plantation around their home gardens. Survival of these plants was recorded 60%; out of which *Citrus lemon* recorded the maximum (90%) and *Pyrus malus* recorded the minimum (37.5%) in December 2011. The survival around home gardens is notably just double than the survival of fruit plants in the community land and species such as *C. reticulata, C. grandis, P. amygdalus* and *C. aurantifolia have* started bearing fruits in 2011.
- 6115 fuel/fodder saplings of 7 species were planted in the degraded areas of village during monsoon 2009-2012 in view of a larger gap between fuelwood/fodder requirement and availability in the Patharkote. In March 2012, survival of these planted saplings was 42.8± 8.25%. Standing biomass and carbon stock of the saplings surviving in the above plantation was estimated as 15.5 t and 7.5 t, respectively (Table-11). Maximum survival (i.e., 69.2%) was

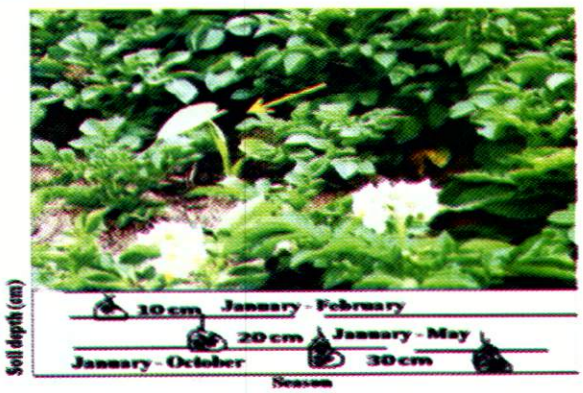


Fig. 38. Pattern of mixed-multilayer vegetable cultivation in the Makraun village.

recorded for *Quercus leucotrichophora,* whereas the minimum survival was recorded for *Cedrus deodara* (37.5%).

- Total carbon stock of Patharkote village community managed by Van Panchayat forest was assessed and found 338.51 t C ha^{-1}. Of the total carbon stock, 53% was stored in tree biomass, whereas 47% in the soil

Forest Ecosystem Services in the Central Himalayan Mountains: Quantification and Valuation *(2007-2012, In-house)*

Goods and services provided by natural and modified ecosystems are essential for human survival. Ecosystem goods and services (ES) provide the benefits to the human populations being produced directly or indirectly from ecosystem functions. In other words, ES are the conditions and processes through which natural ecosystems and the species make them up and fulfill supply of goods and services to sustain human life. Conservation and sustainable utilization of forests has always been the core issues of sustainable mountain development. As elsewhere, the IHR is mostly affected due to anthropogenic pressure and sensitive to climate change (including land use/land cover change). The increasing pressure on squeezing forest resources in the IHR and its consequent environmental implications (both within and outside the region) have led to the fundamental need of better understanding of the functioning of the forest ecosystems and a range of ES the people derive from them. Further, these services are valued in monetary terms and the stakeholders are paid for the maintenance and flow of these services which are essential to affect any conservation approach. The conversion of forested landscapes into other purposes for developmental needs (e.g., hydropower, infrastructure development, alternative land uses) and loss in ES also need to be assessed for compensation / rehabilitation packages to those who are so far based on the net present value of forests and land. This project aims at quantification and valuation of ES of selected major forest types (Oak and Pine) of the Central Himalaya with an aim to produce state-of-art methodology having policy implications for conservation and management of these vital natural resources. It is expected that valuation of ES would sensitize the stakeholders to better conserve and manage the natural resources to improve quality of life.

Objectives

- To quantify and evaluate various ecosystem goods and services accrued from major forest types of Central Himalayan region.
- To investigate soil formation, soil fertility, soil and water conservation, and carbon sequestration value of these forest ecosystems.
- To investigate the impact of these forests on crop field fertility, pollinators, crop yield and crop diversity.
- To develop methodologies and approaches for quantification and valuation of forest ES.
- To find suitable mechanism and incorporate the findings in the EIA framework for taking informed decision on compensation to the stakeholder groups.

Achievements

- Based on the household surveys (27 villages; 1549 households; > 60% females in the region), the quantity of different goods collected from the Oak and Pine forests and their monetary values based on local market price are given in Table-12. People obtain green fodder (lopped from trees and harvested from the forest floor), minor timber and wood for house construction and agricultural implements, wild edibles and medicines from the Oak forests in larger quantities as compared to the Pine forests. Total monetary value of goods thus obtained from Oak forests was markedly higher as compared to Pine forests (Rs. 5742 vs. 4256/capita/yr).

- Oak forests were also found rich in tree layer diversity (Shannon Wiener index) (1.6 vs. 0.23) as compared to Pine forests. Density of tree layer of Oak forests was high (1160 ind. /ha) as compared to the Pine forests (1090 ind./ha). The total basal area of tree layer of Oak forests (60.75 m^2/ha) was also found more than the Pine forests (54.11 m^2/ha).

Table-12. Quantity and monetary value of different ecosystem goods obtained from Oak and Pine forests across the studied villages (AU= Animal Unit).

Ecosystem goods	Oak forests		Pine forests	
	Quantity (Kg/capita/yr) n= 790	Monetary value (Rs./capita/yr)	Quantity (Kg/capita/yr) n= 759	Monetary value (Rs./capita/yr)
Green fodder (trees)/AU	169 ± 12	1130 ±141	-	-
Green fodder (ground)/AU	95 ± 10	456 ±81	242 ± 23	1981 ±262
Bedding leaves/AU	171 ± 17	825 ±102	181 ± 22	480 ±42
Fuel wood	611 ± 42	2123 ±279	741 ± 73	1582 ±162
Wood for agricultural implements	5 ± 0.35	34 ±2	3 ± 0.21	18 ±1
Fencing wood	11 ± 1	24 ±4	7 ± 0.92	18 ±3
Minor timber for houses	11 ± 1	33 ±6	6 ± 0.65	19 ±2
M. esculenta fruits	4 ± 1	227 ±73	2 ± 0.71	138 ±45
Rhododendron flowers	1 ± 0.08	9 ±1	0.5 ± 0.17	7 ±2
Lichens	2 ± 0.20	56 ±6	0.4 ± 0.18	13 ±5

Table-13. Biomass and Carbon in tree layer in Oak and Pine forest of District Champawat

Forest	Biomass (t/ha)		Carbon (t/ha)		Carbon sequestration (t/ha/yr) $\Delta B = B_2 - B_1$
	First year (2010)	Second year (2011)	First year (B_1)	Second year (B_2)	
Oak	581 (79%)*	595 (78.8%)	291(79.0%)	298 (78.9%)	6.79 (69.2%)
Pine	208 (94%)	223 (93.7%)	104 (94.2%)	111 (94.6%)	7.46 (95.8%)

*Values in parentheses are the contribution of Oak and Pine trees among other tree species

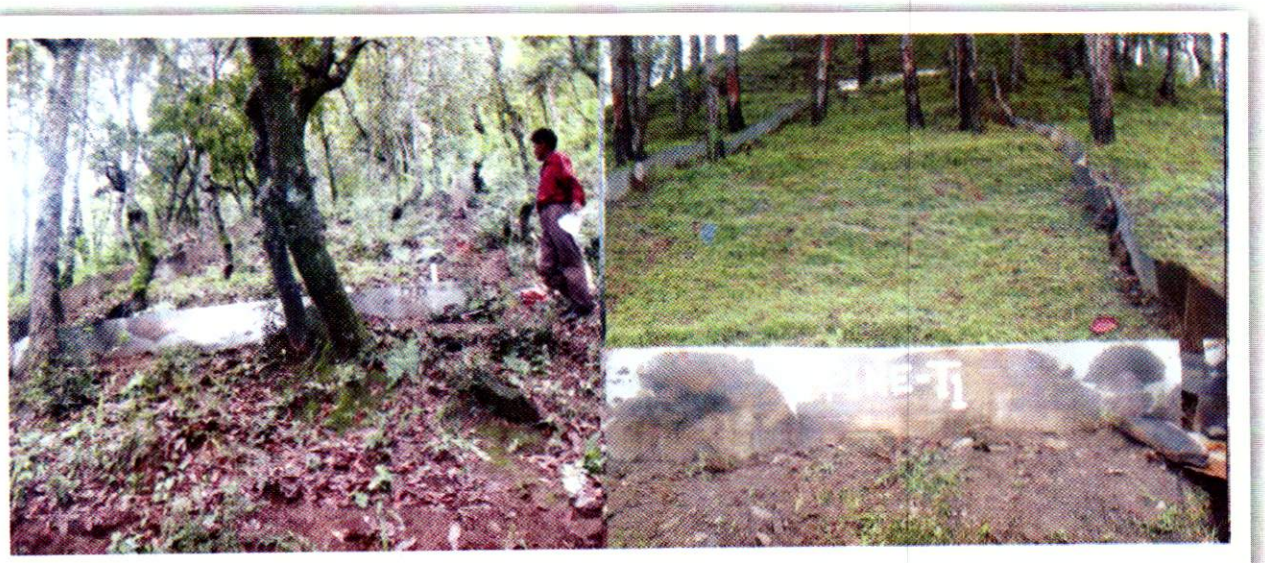


Fig. 39. Runoff plots maintained for hydrological studies under Oak (left) and Pine (right) forests

- Tree layer biomass (595 vs. 223 t/ha) and carbon (298 vs. 111 t/ha) stored in Oak forests was recorded higher as compared to Pine forests (Table-13). Carbon sequestration rate was recorded slightly higher in Pine forests as compared to Oak forests (7.46 vs. 6.79 t/ha/yr).The total monetary value of carbon stock (@ Rs. 4160 / t C) in standing above ground biomass was computed Rs.1239680/ha for Oak forests and Rs. 461760/ha for Pine forests. Monetary value of the Carbon sequestration was thus recorded high for the Oak forests as compared to Pine forests (Rs. 31034 vs. 28246 /ha/yr).
- Hydrological experiments were conducted to study the effect of soil and water conservation (SWC) of the Oak and Pine forests (Fig.39) during August – September, 2011 for 17 out of 20 rainfall events (total rainfall = 251 mm; average rainfall intensity = 2.25 mm/hr). Total runoff and soil loss in Pine forests (runoff = 2465 L/ha and soil loss = 1006 kg/ha) was recorded higher as compared to Oak forests (runoff= 1810 L/ha and soil loss = 349 kg/ha), and the rainfall- runoff, runoff-sediment loss and rainfall- sediment loss were positively correlated ($P< 0.01$). Total nitrogen loss in Pine forest through soil loss was about twice as compared to Oak forests (5.33 vs. 2.86 kg/ha). Monetary value of N lost in soil loss was computed (using cost of Urea @ Rs. 5.6/kg) Rs. 34/ha for Oak forests and Rs. 64 for Pine forests during the study period

Strategic Environmental Assessment (SEA) and Environmental Impact Analysis (EIA) of Hydropower Projects in Western Himalayan Region *(2007-2012, In-house)*

The site selection for the development of hydroelectric projects in the Himalayan Region has always been experienced a difficult task. It is due to undulating terrain, harsh climate and huge construction costs. Still, numerous hydroelectric projects are under developing stage to fulfill the national energy demand. Hydroelectric projects are causing frequent environmental as well as socio-economic problems. Since a large number of hydroelectric projects in the Satluj River Basin in Himachal Pradesh are under operation phase. These projects are causing social as well as economic problems. But in the Alaknanda River basin the situation is different. In this river basin, maximum hydroelectric projects are in construction phase which are not facing any social problem. To overcome social as well as economic problems, there is a need to put forward a suitable policy for sustainable development of hydroelectric projects. It is therefore a need of Environmental Impact Assessment (EIA) for the individual project at its initial stages for environmental clearance. Whereas, Strategic Environmental Assessment (SEA) approach carefully assess and evaluate the hydroelectric project activities and examine inter-relationship between two or more hydroelectric projects.

Objectives

- To overcome the challenges associated with project level EIA process and try to conduct cumulative impact assessment (-ve/+ve) of various hydropower projects (existing/ proposed) on social, biological, and physical environment initially for a river basin in the western Himalaya and subsequently for entire the western Himalayan region as a whole.
- To develop a GIS based database that can be used by project proponents / consultants apart from assisting policy planners to reach to strategic decisions regarding individual projects.
- To suggest the optimal number and types of hydropower projects in such a way that the development should be environmentally viable.
- To incorporate ecological-economic based prospecting for compensation of ecosystem services.
- To make recommendations for the MoEF / state government or other similar agencies for modifications or formulations of separate policy / plan.

Achievements

Satluj Basin

- With the help of Global Positioning System (GPS), the locations of 37 hydroelectric projects (HEPs) from mini to large were identified. Out of 37 HEPs, 11 were examined for land use and land cover (LULC) study. Among these projects, 1 project was identified under mini (<2 MW), 8 under small (>2 to < 25 MW) and 2 under large (>25 MW). The study shows highest influence zone of HEPs in the upper Satluj basin (Fig.40).

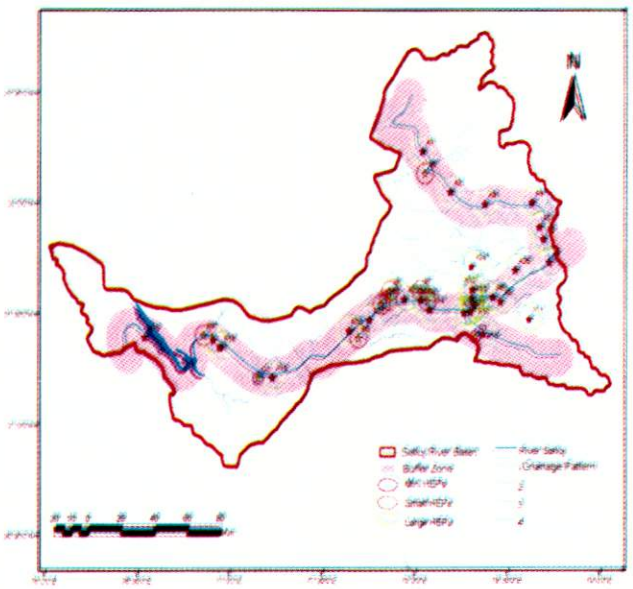


Fig. 40. Influence zone of the hydroelectric projects in the Satluj Basin.

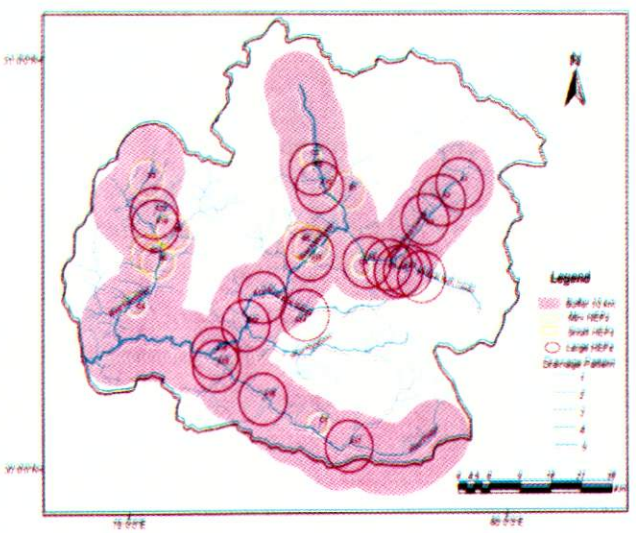


Fig. 41. Influence zone of the hydroelectric projects in the Alaknanda Basin.

- The elevations of the study area were examined by Digital Elevation Model (DEM) and ***Triangulated Irregular Network*** (TIN) modeling. The elevation of study area was identified with a range from 233 m to 6751 m. In the different districts like Kinnaur, the elevation ranged from 1000 m to 4000 m, in Shimla 300 m to 6000 m, and in Kullu 1300 m to 3500 m. Based on DEM modeling at small scale, maximum HEPs locations were identified between 2600 m to 3200 m.
- Morphometric analysis of the lower Satluj catchment was done on the basis of DEM and TIN modeling. Under the linear aspects of the drainage system, 1st to 5th stream orders (N_u) and total 1654 number of streams (N_u) were identified. The calculated total length of streams (L_u) were 1857 km, whereas mean Bifurcation Ratio (R_b) was 5.213, Stream Length Ratio (R_l) was 0.478 and the mean stream length ratio was 1.29.
- The Areal Aspect of Drainage (A) catchment was 2945 km^2, whereas stream length (N) was 165 km. While Drainage Density (D) obtained as 0.56 km/km^2 indicating proneness to erosion. The stream frequency was calculated 0.29 streams/km^2.

Alaknanda Basin

- In the Alaknanda basin, geographical locations of 38 HEPs were identified. Out of 38 HEPs, 6 projects were identified under operation phase. In these 6 HEPs, 5 projects were identified under mini (<2 MW) and 1 project under large (>25 MW). However, 8 HEPs were identified under construction phase. Out of these HEPs, 3 were under small (>2 to < 25 MW), and 5 were under large (>25 MW). The proposed HEPs were 24. Out of 24 HEPs, 6 projects were identified under small, and 18 were under large (Fig. 41).

Table-14. Air pollution concentrations at Hamirpur, Kangra and Chamba towns in Himachal Pradesh

Study towns	Season/duration	Concentration of different pollutants (in $\mu g\ m^{-3}$)				
		TSP	PM_{10}	SO_2	NO_2	NH_3
Hamirpur	Pre-monsoon	159.8±18.7	55.0±3.3	0.51±0.1	7.23±0.8	9.08±1.1
	Post-monsoon	196.0±18.8	111.7±4.6	0.98±0.2	17.40±1.9	20.30±3.6
Kangra	Pre-monsoon	73.5±7.3	49.2±6.0	0.39±0.1	6.34±0.4	12.32±1.1
	Post-monsoon	153.3±9.8	113.5±7.5	2.02±0.4	11.20±1.0	15.50±2.5
Chamba	Pre-monsoon	143.5±19.3	39.6±2.8	0.47±0.1	6.28±0.4	6.52±1.0
	Post-monsoon	151.4±15.0	58.2±4.4	1.22±0.1	16.00±1.4	12.60±1.9

Number of streams (N_u) and length of streams were estimated under the Linear Aspects. According to estimation of stream orders, 203 streams were identified under 1st to 5th stream orders (N_u) and total length of streams (L_u) were 677 km.

Urbanization vis-à-vis Solid Waste Management and Air Pollution in Sprawling Urban Cities of Himachal Himalaya *(2007-2012, In-house)*

The migration of population from the villages to urban towns as well as ever growing urban population within these towns and their activities have collectively caused high load of pollutions. This pollution situation becomes more aggravated when infrastructural facilities remain improper and inadequate. Some of the Himalayan towns have been facing certain human induced pollutions such as solid waste and air pollution. Indiscriminate waste throwing and open dumping create unhygienic conditions building up of a home to breed flies, cockroaches, insects, worms and rats which later become a cause of many health risks and diseases. Solid waste, if dumped openly, deteriorates water quality in streams and rivers. Sometimes, the practice of burning waste emits hazardous gases into the atmosphere; as a result ambient air quality (AAQ) also degrades. In addition, biomass burning in the form of fuel wood, coal, etc. also causes AAQ degradation in the sprawling towns. Keeping in mind alike environmental problems, the study under the present project was initiated on solid waste management (SWM) and ambient air quality in six hill towns, namely, Bilaspur, Kangra, Mandi, Hamirpur, Chamba and Keylong. The sites were selected in a manner so as to represent different altitudinal gradients from Siwalik to Trans Himalayan ranges in Himachal Pradesh. For the present reporting period (April 2011 to March 2012), ambient air quality monitoring (AAQM) study was carried out, simultaneously in a campaign mode, during pre-monsoon and post-monsoon period of 2011 as background values for three towns; Hamirpur, Kangra and Chamba.

Objectives

- To identify solid waste status and compositions.
- To assess the existing waste treatment and disposal facilities available including their adequacy.
- To monitor particulate and gaseous pollutants in ambient air to establish background values.
- To suggest solid waste management and air pollution mitigating plans for policy implications.

Achievements

- During the present reporting period, ambient air quality (AAQ) at Hamirpur (790 m), Kangra (776 m) and Chamba (936 m) towns of Himachal Pradesh state was monitored in 2011 during pre-monsoon and post-monsoon periods.

Within ambient air, particulate pollutants like TSP (particles <100 μ), PM_{10} (particles <10 μ) and gaseous pollutants like SO_2, NO_2 and NH_3 were monitored on diurnal basis starting from midnight (0 hr) up to morning 8 hr, then 8 to 16 hr in a day and finally 16 hr to again midnight (24 hr IST). Many times the concentration of particulate pollutants was found to be above their permissible limits (i.e. TSP 200; PM_{10} 100 μg/m^3) at the present three sites. However, the gaseous pollutants were found to be much below their permissible limits (i.e., SO_2 80; NO_2 80; NH_3 400 μg/m^3).

- During pre-monsoon period, PM_{10} was 55±3.3 μg m^{-3} as highest at Hamirpur and 39.6±2.8 μg m^{-3} as lowest at Chamba. While during post monsoon, it was 111.7±4.6 μg m^{-3} as highest at Kangra and 58.2±4.4 μg m^{-3} as lowest at Chamba. In case of TSP, it was recorded highest at Hamirpur during both the sampling periods and lowest at Kangra (during pre-monsoon) and Chamba (during post-monsoon). This means that Hamirpur and Kangra were considered to be significantly polluted compared to Chamba (Table-14). On diurnal basis, most of the times TSP and PM_{10} were found to be highest between 8-16 hr IST followed by 16-0 hr (evening) and lowest in 0-8 hr (morning) during both the monitoring periods at all the sites.
- During pre-monsoon, SO_2 was recorded highest as 0.51± 0.07 μg m^{-3} at Hamirpur and lowest with 0.39±0.07 μg m^{-3} at Kangra. The opposite levels of SO_2 status were found during post-monsoon and it was recorded highest at Kangra (2.0±0.1 μg m^{-3}) and lowest at Hamirpur (0.98±0.24 μg m^{-3}) (see Table-14). In case of NO_2 and NH_3, these pollutants were found much higher in post-monsoon compared to pre-monsoon. During both the monitoring periods, NO_2 was recorded to be highest at Hamirpur (7.2±0.8 & 17.4±1.86 μg m^{-3}) and lowest at Chamba (6.28±0.36 μg m^{-3}; during pre-monsoon) and Kangra (11.2±1 μg m^{-3}; during post-monsoon). However, NH_3, during pre-monsoon was recorded to be highest at Kangra (12.32±1.12 μg m^{-3}), while during post-monsoon, it was high at Hamirpur (20.3±3.6 μg m^{-3}). It was Chamba where NH_3 was recorded to be lowest (6.5±1 &12.6±2 μg m^{-3}) during both the sampling periods (see Table-14). At all the three towns, the concentration of gaseous pollutants were found to be very low, but on diurnal and daily basis fluctuation was observed very high during both seasons.

Assessment of Status and Impacts of Tourism for Sustainability– Case Studies from Himachal Pradesh *(2011-2015, In-house)*

Today, tourism is being viewed as an important activity of economic development in the mountains. If managed properly, it may come out as most amenable to sustainable development. It has wide ranging multiplier spin-off impacts transcending across sectors and beyond local and regional domains. In most of the destinations, the growth is usually spontaneous; in addition it provides ample opportunities for low cost small enterprises and development at community level. But the recent experiences with tourism in the world suggest that the industry – its growth and promotion is not without diseconomies. At many places, tourism has been found to be damaging to the base resource, environment, and culture on which it subsists, affecting its sustainability in the long run. The Himalayas which are rich in terms of natural endowments, cultural diversity and heritage value cater a great potential for tourism. This is being promoted in all the Himalayan states as an important sector for economic development. The exquisite natural beauty of Himachal Pradesh, the religious shrines, cultural and landscape diversity, the inherent adventure of environment, climate and well developed hill resorts are some of the driving factors that helped in spectacular growth of tourism in the state. The policy directives of the government and the enterprising community are also

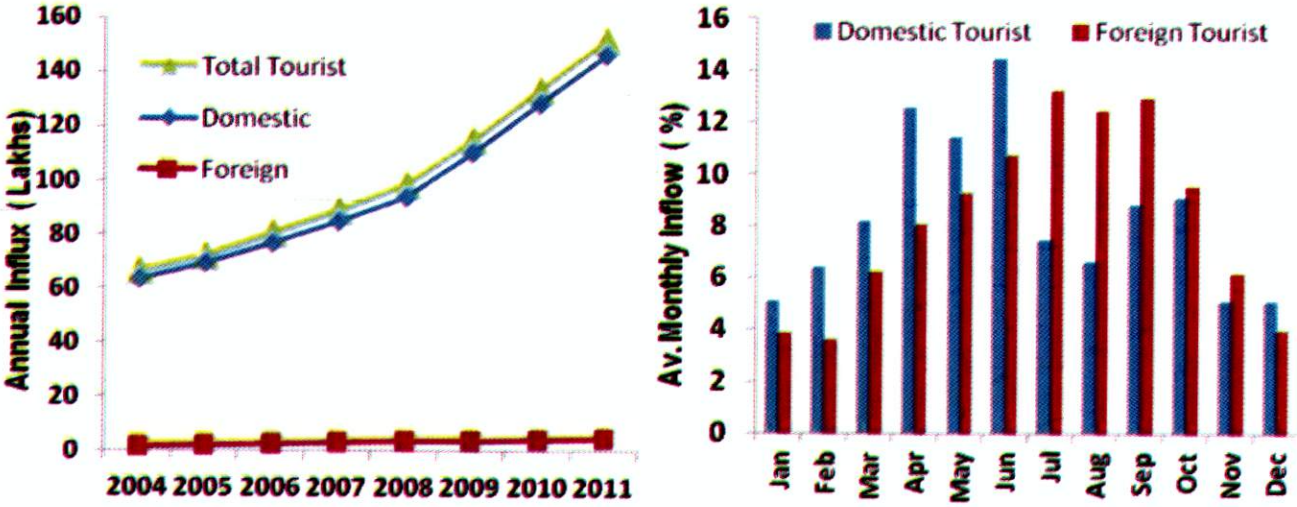


Fig. 42. Monthly and annual inflow patterns of tourists in Himachal.

Table-15. Summary of tourist inflow to Himachal Pradesh (2004 -11)

Month	Domestic Tourists		Foreign Tourists		Domestic + Foreign Tourists		Per cent of annual flow
	Mean (sd)	Max (min)	Mean (sd)	Max (min)	Mean (sd)	Max (min)	
Jan	489856 (176112)	757377 (278473)	13322 (5899)	18931 (3532)	503178 (181346)	776308 (282005)	5.03
Feb	615351 (268265)	1035789 (329227)	12389 (5985)	18846 (3051)	627740 (273164)	1053881 (333144)	6.28
Mar	789818 (350698)	1428569 (424220)	21332 (10738)	34827 (7244)	811151 (360454)	1463396 (432696)	8.11
Apr	1210879 (433712)	1903137 (745484)	27758 (12935)	42575 (10270)	1238637 (446007)	**1945712** (755754)	12.39
May	1100451 (310325)	1592719 (704419)	31751 (9770)	48055 (19436)	1132202 (319773)	1640774 (723855)	11.32
Jun	**1391545** (267904)	**1808553** (992403)	36839 (10819)	52110 (22496)	**1428384** (278401)	1860663 (1017057)	**14.28**
Jul	717073 (210996)	1088438 (481826)	**45525** (13790)	**62492** (26656)	762598 (224082)	1149500 (508482)	7.63
Aug	638231 (233942)	1087424 (399873)	42779 (11455)	60098 (28471)	681011 (244845)	1147522 (432182)	6.81
Sep	848044 (168760)	1196179 (684317)	44395 (11788)	57122 (27713)	892439 (177988)	1253301 (712030)	8.93
Oct	871618 (322555)	1484130 (578527)	32648 (6934)	43834 (24147)	904266 (329179)	1527964 (602875)	9.04
Nov	493237 (135398)	686067 (346381)	21164 (4396)	26316 (14860)	514402 (137596)	710250 (361241)	5.14
Dec	490501 (130356)	702911 (379919)	13670 (5724)	22875 (7197)	504171 (135317)	725786 (388092)	5.04

helping in its growth. But some problems in terms of cluttered growth in tourist towns, traffic congestion, solid waste, deforestation and degradation are coming up; cultural impacts is another area which needs to be looked into. Since tourism is important for the economy, therefore its sustenance is a must. This needs

a holistic assessment of its growth, changes in trend patterns, impacts, economy and management issues. This activity has been initiated to explore these points through case studies.

Objectives

- To study and document status of tourism in terms of its nature, process, trends-patterns, and seasonality, etc.
- To assess economic significance of tourism in terms of its impact on income of local business community
- To identify critical tourism resources, impending threats, and impacts, and
- To analyze issues and make appraisal of management options and policy alternatives for sustainability.

Achievements

- The tourist inflow statistics for the Himachal Pradesh state was compiled and analyzed for a broader understanding of its nature and trend-patterns. The inflow profile for period 2004 -11 (Fig.42) suggests nearly 2.5 times increase in tourist inflow from 6.55 million in 2004 to 15.09 million in 2011. Linear mapping of Tourist Inflow (Y) for subscripted period against time (X) - $Y_{2004\text{-}11}$ = 1212017 (X-2003) + 4546102; R-sq=0.958, t_{coff} = 11.74, p=.00002, suggest an average growth of 1212017 tourists per year. The figure also reveals that tourism in Himachal Pradesh is mainly domestic type, since foreign tourists are contributing only 3-4% of the total annual tourists-rush.
- Data for tourists inflow statistics for the state is synthesized in Table-15. The scrutiny of monthly profile suggests April (12.59%), May (11.40%), June (14.41%), September (8.78%) and October (9.03%) are the main rush months; the period November-January with around 5% influx per month and February 6.37% and August 6.61% rush characterize the lean period. While the monthly distribution of foreign tourist inflow reveals maximum rush in July – 13.25%, followed by September – 12.92%, August – 12.45%, June – 10.72%, October – 9.50% and May – 9.50%. The period December to February with 3-4% of annual rush of foreign tourist, and November and March with around 6% of rush are the lean months. The period April-June accounts for 39% of the total (domestic + foreign) tourist inflow. \
- The preliminary results of survey and reconnaissance in Dharamshala reveals the western influence in lifestyle, cuisines, upcoming café, restaurants and building designs, and other touristic development around Mcleodganj. It has also brought about a substantial economic transformation of villages of Gaddi tribe around Mcleodganj. The Gaddi, the transhumant pastoral communities, who during their hunt for pastures used to stay at these villages and worked as a labourer in agricultural fields and nearby slate mines, now mostly have owned the hotels, tourist lodges, and travel agencies around Mcleodganj and command substantial share in local tourism business. Conversion of agricultural land for touristic development, and abandoning of agriculture are the other noticeable impacts of tourism in Bagsunag, Naddi, Dharamkot, *etc.*, and Gaddi villages around Mcleodganj.
- Preliminary results of survey show a positive impact of summer season on the income of local business community. These impacts are highly localized and have very poor spatial distribution. Such impacts are maximum in the Mcleodganj area which is the main tourist hub, decreases significantly in the lower Dharamshala where there is less developed tourist infrastructure. Similarly there are no impacts in the Sauli Khad area i.e. the place with negligible tourist infrastructure. There is high demand of Tibetan handicraft items amongst the foreign tourists. As a

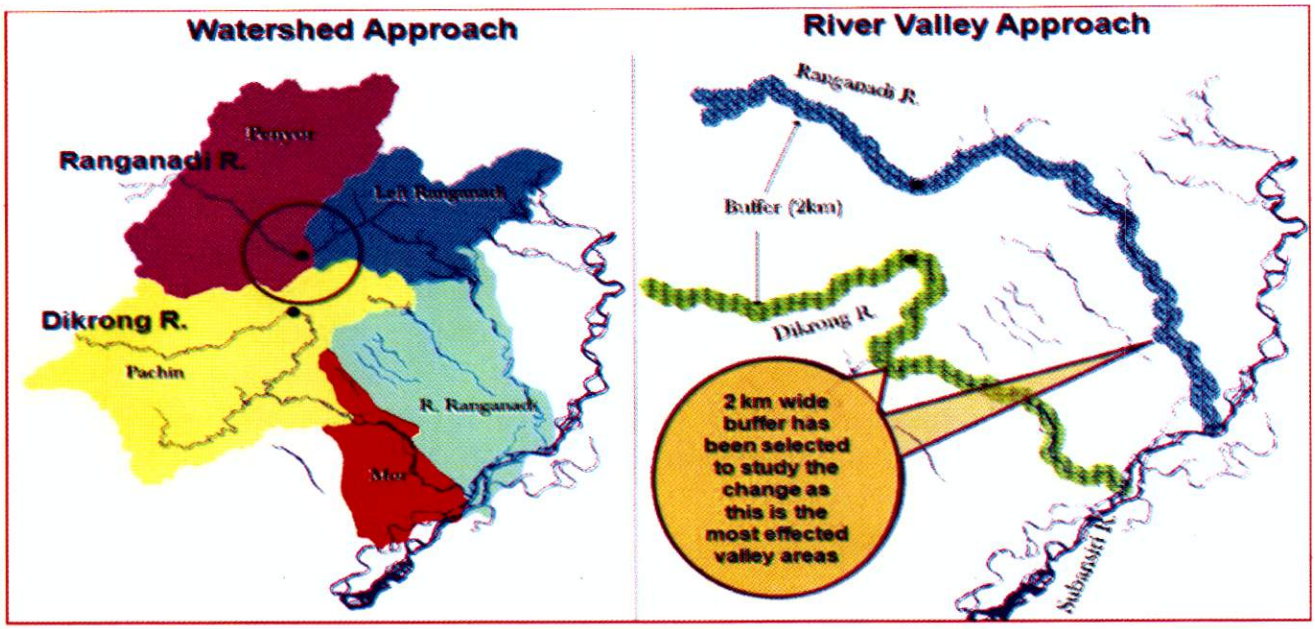


Fig. 29. Dendrogram constructed for 16 populations of Hedychium spicatum based on genetic distances using ISSR markers primers.

Table-16. Water quality monitoring results in River Ranganadi hydropower project.

Sampling Location	Parameters								
	Alkalinity (mg/l)	Hardness (mg/l)	Ammonia (mg/l)	DO (mg/l)	BOD (mg/l)	TDS (mg/l)	TSS (mg/l)	Na (mg/l)	K (mg/l)
R1	25	36	3.64	16.83	360	0.47	2.25	1.08	0.09
R2	34	50	3.22	16.63	370	0.44	0.98	1.27	0.08
R3	26	49	4.2	14.65	195	0.44	1.01	1.08	0.06
R4	45	55	3.64	17.62	410	0.45	0.70	1.06	0.06
R5	48	89	3.92	14.85	305	0.42	0.58	1.55	0.07
R6	65	68	4.20	8.12	185	0.10	0.53	1.54	0.06
R7	91	78	3.22	8.31	80	0.04	0.66	1.61	0.09

Note: 'R' indicates 'Ranganadi' while numbers 1 to 7 are sampling sites in the upstream (R1-R4) and downstream (R5-R7) locations of the dam

result of increased market prospects and remunerative returns, this industry is heading/edging towards excellence in development.

Assessment of Downstream Impacts of Hydroelectric Projects in Arunachal Pradesh: A Case of Ranganadi Hydroelectric Project *(2011-2014, In-house)*

The upcoming development of hydroelectric projects in the Himalayan region needs ideally to be

Fig. 29. Dendrogram constructed for 16 populations of Hedychium spicatum based on genetic distances using ISSR markers primers.fect

progressed in relation to scientific findings based on the qualitative and quantified database. The unpredicted or underestimated impacts in earlier studies can be recognized, integrated and managed for sustainable development. Looking at the likely repercussions of hydropower development, it is indeed an urgency to take up research oriented action so that the overlooked detrimental downstream impacts of hydropower projects can be assessed and identified in a precise manner. The hydropower-dams affect the environment and society in a two different spatial dimensions; one in upstream and other in downstream regions. The upstream impacts fall within the area of study under EIA studies. While the downstream impacts are mostly spread beyond the legal boundary of impact study zone (i.e. an area of 10 km radius) and most importantly they are discrete to the working zone of the project activities where these impacts are negligible. Keeping in view the above issues and scope of the work, the present study is focused to assess and address the actual downstream impacts of hydropower projects so as to bridge the knowledge gap between actual and envisaged impacts.

Objectives

- To evaluate the actual post project downstream impacts of the existing hydropower project under study on ecology and environment, soil erosion and sedimentation, water quality, agriculture and other alike natural resources based livelihood options, floods, etc.
- To review and address the distribution of downstream impacts in space and time, and to address knowledge gap between foreseen and actual impacts of the hydropower development in the fragile Himalaya.
- To formulate the recommendations for incorporating identified potential downstream impacts of hydropower projects and respective guidelines for management of downstream impacts, followed by review of the present existing policies and legislations.

Achievements

- Rangnadi HEP (405 MW) is taken into account which is in operation since 2002 in Arunachal Pradesh. Ranganadi HEP is utilizing water of River Ranganadi to generate electricity and this used water is diverted into adjacent River Dikrong. These two river streams and areas adjoining or dependent on these streams are under the influence of the hydroelectric project.
- Two different approaches were followed to study the impacts in the project area. These are at watershed and river valley levels. Here, 2 km wide buffer area including river bed was selected as the study area (Fig.43). General water use pattern and related social and environmental problems of the rivers were identified.
- The present work is focused on the study of various aspects, *viz.*, water quality, land cover changes, livelihood issues, etc. primarily in the downstream areas of the two rivers of the project. In the beginning, general reconnaissance surveys were made in the project areas.
- Water quality parameters analyzed at 12 sites showed within permissible limit. However, negative change was slightly found in downstream regions. Once one time physical and chemical analysis of water quality completed for 12 permanent sites on both the river is given in Table-16 for River Ranganadi.
- The change detection shows significant changes in the land cover of the study area, especially within the river valleys. Land use land cover change study of the project area shows that around 85% of the area had no change in it. However, there was found significant increase in the area of Jhum cultivation (2750 ha) under study. No significant change was found in dense forest area but moderate dense forest was changed into open forest area.

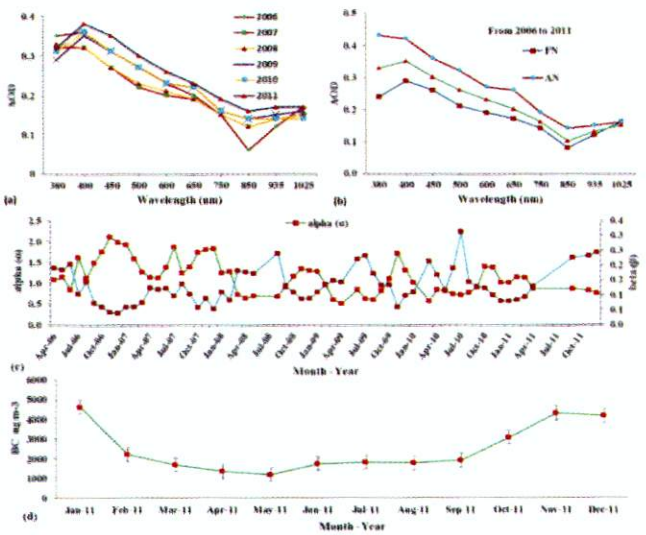


Fig.45. Aerosols at Mohal: (a) AOD, (b) FN and AN AOD, (c) monthly mean values of alpha (α), beta (β) and (d) monthly mean BCA concentration.

- The major issues relating to hydropower development in the project area came out to be flash floods, erratic river discharge, drying up of river bed or fragmented flow at places, water quality problems, damage to fish population, sand and stone mining: destabilized river bed and increased sedimentation (Fig.44).

Aerosol Climatology Over Northwestern Indian Himalayan Region, Himachal Pradesh *(2006-2012, ISRO, Thiruvananthapuram)*

The aerosols mainly absorb and scatter solar radiation thereby attenuating the solar radiation reaching the ground. The aerosols having more scattering efficiency produce cooling effect while aerosols having absorption efficiency produce warming effects. Aerosols optical depth (AOD) is considered to be one of the most important optical properties of aerosols which is directly related to the magnitude of attenuation of direct solar radiation by scattering and absorption process in the atmosphere. These aerosols from natural and anthropogenic sources are the important factors to cause disturbances in existing weather, human health and climatic conditions.The processes which change the radiation budget and balance of a climatic system is called radiative forcing. High radiative forcing is shown in the surface as compared to the top of atmosphere because of rarefication of the air. Cooling effect is shown if radiative forcing is negative and *vice versa*. Fine particles, generated through anthropogenic activities are highly responsible for respiratory problems in human beings. Moreover, study of aerosols in the Himalayan region is also important because it will have long run effect in temperature rise, shifting of vegetation and crops from low altitude to higher altitude, glacier melting, etc. Aerosols optical depth (AOD) represents columnar aerosols obtained through Multi-wavelength Radiometer (MWR), while black carbon aerosol (BCA) through Aethalometer

Objectives

- To obtain aerosol optical depth (AOD) at ultra-violet, visible and near infrared spectrums (380-1025 nm) using Multi-wavelength Radiometer (MWR).
- To obtain black carbon (BC) aerosol concentrations using Aethalometer.
- To determine the impact of aerosols on climate change in the Himalayan region.

Achievements

- Average of the full day mean AODs at ten wavelengths for the clear sky days of the year 2006 to 2011 was taken. It was found that AOD values were noticed maximum for the year 2011 and minimum for the year 2007 which showed 36.36% increase at 500 nm during these years

Fig. 46. Environmental observatory for monitoring gaseous and other aerosols at Mohal in the Kullu valley.

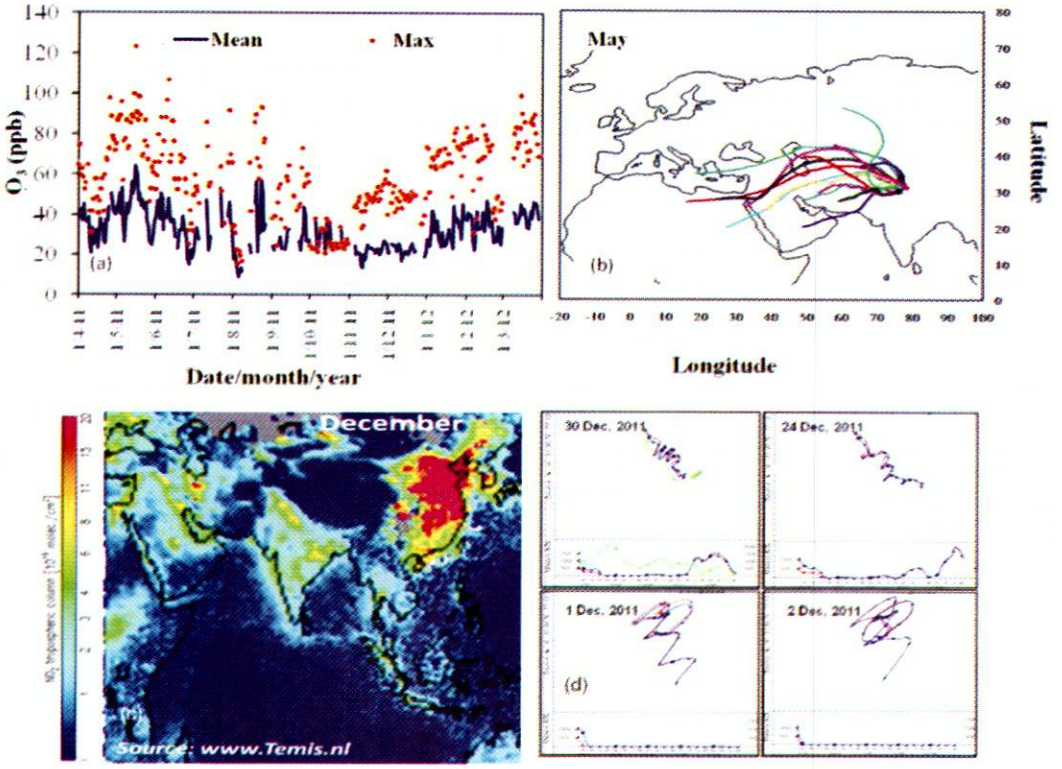


Fig.47. (a) Hourly maximum and daily mean concentration of O_3 at Mohal, (b) five days back trajectories in May, (c) tropospheric columnar NO_2 in December, and (d) five days back trajectories for NO_2 episode days.

(Fig. 45a). Similarly, the average values of AODs for forenoon (FN) and afternoon (AN) at ten wavelengths for the same period was also calculated. The increase in AODs values from FN to AN at 500 nm was found to be 52.38% and overall increase at ten wavelengths from FN to AN was 45.16% (Fig 45b).

- The highest ever maximum FN AOD for the clear sky days at 500 nm was 0.59, 0.45, 0.43, 0.37, 0.33, and 0.61 on May 30, 2006, November 5, 2007, September 14, 2008, September 2, 2009, December 21, 2010 and December 21, 2011 respectively. While the minimum FN AOD at the same wavelength was 0.04, 0.05, 0.03, 0.08, 0.08 and 0.03 on November 26, 2006, October 29, 2007, November 23, 2008, November 25, 2009, November 24, 2010 and November 15, 2011 respectively.
- The maximum AN AOD for the clear sky days at 500 nm was found to be 0.59, 0.48, 0.48, 0.81, 0.76 and 0.86 on May 8, 2006, April 22, 2007, January 31, 2008, October 19, 2009, March 19, 2010 and April 24, 2011 respectively. However, minimum AN AOD at 500 nm was 0.06, 0.08, 0.07, 0.10, 0.08 and 0.04 on December 27, 2006, January 2, 2007, February 26, 2008, April 10, 2009, January 10, 2010 and February 8, 2011 respectively.
- For the year 2011, the monthly mean value of α and β under the clear sky days was calculated and showed maximum α as 1.12 in February. Its minimum value stood to be 0.76 in December. On the other hand, the maximum value of the turbidity coefficient β was obtained as 0.24 in December and minimum as 0.08 in February. It is found that α and β were inversely proportional (Fig. 45c).
- The monthly mean Black Carbon Aerosol concentrations at Mohal was maximum as 4592 ngm^{-3} in January, 2011 and minimum 1161 ngm^{-3} in May, 2011 (Fig. 45d). The BCA concentration generally increases with the increase in activities

like biomass burning, forest fire and vehicular emission.

Gaseous Air Pollution in the Background Site of Sprawling Urban Environment of Himachal Pradesh *(2008-2013, ISRO)*

Photochemical smog is a major secondary pollutant in urban and downwind locations. The key pollutants of this smog are gaseous pollutants such as surface ozone (O_3), nitrogen dioxide (NO_2), nitrous acid (HNO_2), nitric acid (HNO_3), peroxy acetyl nitrate (PAN) and polycyclic aromatic hydrocarbons (PAHs). Once emitted into the atmosphere, primary pollutants are transported downwind with the air masses, providing more reaction time to generate secondary pollutants. The reaction mechanism includes gas phase reactions and heterogeneous reactions. For example, NO_x produces O_3 through photochemical reactions, and SO_2 and NO_x produce sub-micron aerosols via photochemical reactions. NO plays a critical role in O_3 production, even in rural regions, where NO concentration is higher than10 parts per trillion (ppt). Meteorology also plays an important role in the formation, dispersion, transport and dilution of O_3 in the atmosphere. Type of air mass is another important factor in assessing the ozone concentration on a regional scale. Through the absorption of infrared radiation at 9.6 μm, O_3 also acts as a greenhouse gas, which has implications on the global climate change. Even though the warming effect of O_3 is lower compared to other gases such as CO_2, methane (NH_4) and water vapor, but it is still significant. The emission of SO_2 from coal and other biomass burning has led to the formation of acid deposition. The large emission of air pollutants has not only adversely affected air quality in major cities but has also caused pollution to occur on regional scales. Some of the gaseous pollutants like O_3, NO_x and SO_2 were continuously monitored using the respective online Analyzers at Mohal in the Kullu valley (Fig. 46).

Objectives

- To measure important concentration of gaseous pollutants such as surface ozone (O_3), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) in ambient air to establish background values in the Himalayan region.
- To observe local meteorological parameters and relate these with gaseous pollutants, and analyze in the background of long range transport sources.
- To suggest some feasible mitigating measures implementable at policy level.

Achievements

- Surface ozone (O_3) concentrations were observed at Mohal (Kullu) from April 2011 to March 2012. The highest hourly value of O_3 was observed to be 123 ppb on 16 May 2011, followed by 107 ppb on 11 June 2011 and 100 ppb on 15 May 2011 **(Fig. 47a)**. Back trajectory analysis showed that during May, O_3 is also transported through air masses from the north western regions to Mohal (Fig. 47b).
- The O_3 formation and amplitude of ozone cycle is strongly influenced by meteorological conditions and prevailing levels of precursors (NO_x). The diurnal cycles of O_3 and solar flux were similar, which with the O_3 showed maximum at 1500-1600 h IST. This is about 2–3 hours after the solar flux was found to be maximum. Statistical analysis reveals that the correlation between O_3 and solar flux is significant with a correlation coefficient of 0.65. The daily mean concentration of O_3 decreased with the increase in NO.
- The maximum hourly concentrations of NO_2 were observed as 32.9 ppb on 5 December 2011, followed by 31.8 ppb on 30 December 2011 and 31.6 ppb on 19 December 2011. Maximum hourly concentration of SO_2 was observed up to 13.79 ppb on 30 December 2011, followed by 11.40 ppb on 28 January 2011 and 10.95 ppb on 26 October 2011.

- The mixing layer height is generally lower in winter than in summer. The shallower mixing layer is the principal contributor to the higher concentrations of primary emitted gaseous pollutants in winter. As the domestic heating starts in the region from November onwards, it ends upto March. During this period, more combustion of wood and coal (in houses and restaurants) leads to higher emissions of SO_2 and NO_2. During episodes days, four days back trajectories showed wind direction from nearby region to the present study sites. Tropospheric columnar NO_2 concentrations through OMI/MLS satellite imageries showed the high monthly mean concentration of NO_2 (11-15 mole cm^{-2}) in the study region (Fig. 47c & d).
- At Mohal, the average annual ratio of SO_2/NO_X was 0.26 indicating mobile sources of pollution like vehicular emission which is dominant in the present region.

Ambient Air Pollution and Its Sources in the Background Sites of Different Hill Spots in the Northwestern Himalaya, Himachal Pradesh *(2009-2012, DST, New Delhi)*

The study on ambient air pollution and its sources investigates primarily the physical characteristics of aerosols such as PM_{10}, $PM_{2.5}$ and trace gases like SO_2 and NO_2 in two different altitudinal locations close to two important hill spots, Kullu and Manali in the Kullu valley. Mohal (1154 m), 5 km south to Kullu, and Kothi (2478 m), 12 km north to Manali, have been taken into account as two important experimental locations to monitor particulate as well as gaseous pollutants in ambient air. Respirable Dust Samplers (460 NL; make Envirotech) and Fine Particulate Sampler (APM-550; make Envirotech) for PM_{10} and $PM_{2.5}$ were used to expose 8 to 24 hourly samples on an alternate day basis at both the locations. The Whatman Glass Microfiber Filter paper GF/A (20.3×25.4 cm) and GF/A (47 mm) were used to expose PM_{10} and $PM_{2.5}$, respectively. In the present report, **particulate pollutants (PM_{10} and $PM_{2.5}$) were monitored** from January 2011 to December 2011.The ionic components in particulate pollution were analyzed through Ion Chromatography. The meteorological data such as wind direction, wind speed, temperature and humidity were obtained with the help of Automatic Weather Station (AWS) at Mohal and Wind Monitor (WM-251) at Kothi. This rainfall collection gadget combines a system of its funnel, bottle and stand having 2 m height from the ground. To test the same, the census of plying vehicles on a National Highway (NH)-21 from 6 a.m. to 6 p.m. on an alternate day basis was carried out from January 2011 to December 2011 at Mohal and Kothi. Besides, the Hybrid Single Particle Lagrangian Integrated Trajectory Model (HYSPLIT) model was also used to identify the long range sources.

Objectives

- To analyse physico-chemical characteristics of aerosols, gaseous concentration of trace gases and rainwater chemistry in relation to vehicular influx to establish background values in the Himalayan region.
- To observe local meteorological conditions, back trajectories and to relate these with the pollution episodes.
- To identify pollution sources from a viewpoint to outline an environment management plan and mitigation strategies needed to protect the sensitive Himalayan region.

Achievement

- At Mohal, the highest average daily PM_{10} concentration was 138.3 $\mu g\ m^{-3}$ on January 7, 2011 while at Kothi it was 96.9 $\mu g\ m^{-3}$ in June 30, 2011 (Fig. 48a). Winter season found polluted due to haze events at Mohal shown in Fig. 48b. On monthly basis, maximum mean PM_{10} (62.4±6.6 $\mu g\ m^{-3}$) was at Mohal in May 2011, while at Kothi this value was 68.1±4.6 $\mu g\ m^{-3}$ in December 2011.

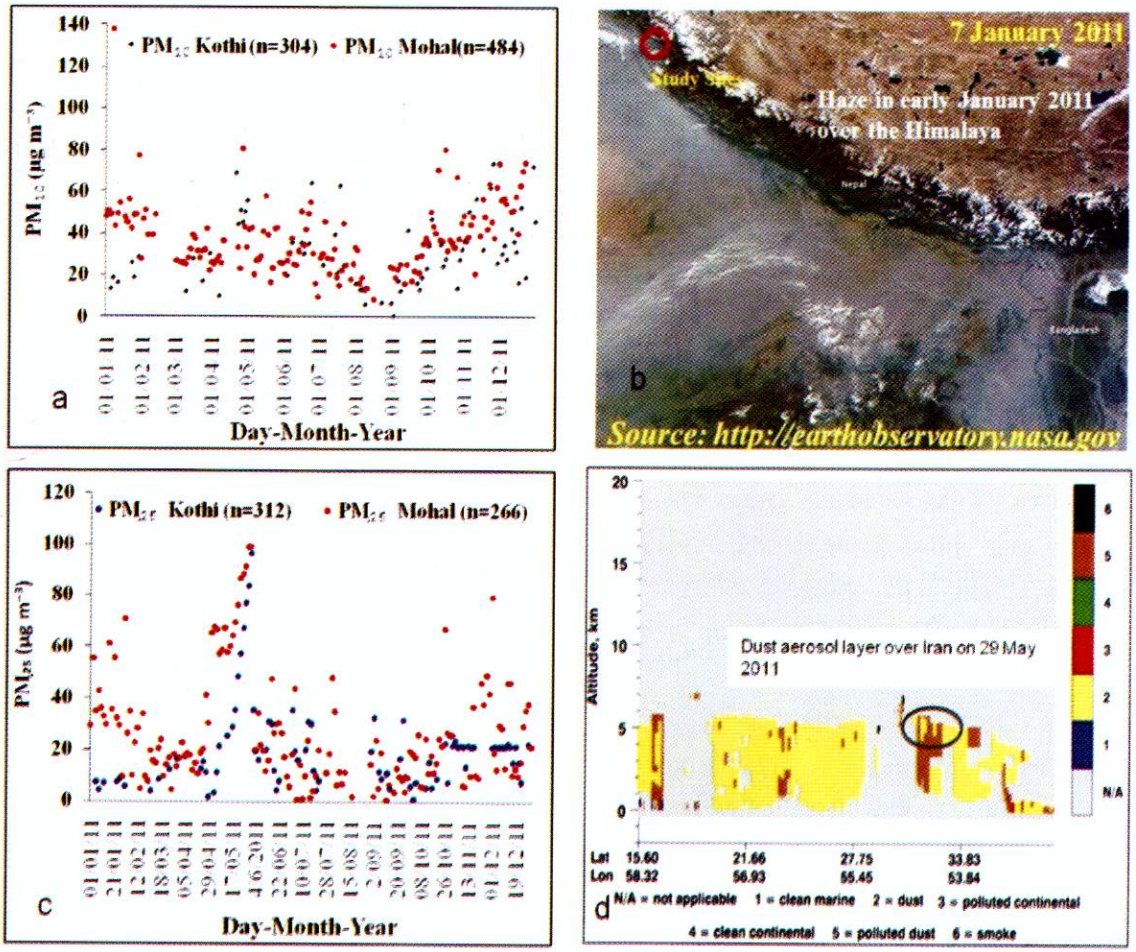
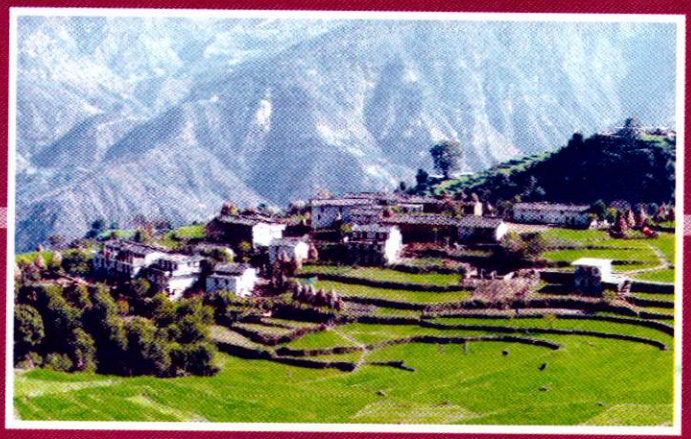


Fig. 48. External sources of PM_{10} and $PM_{2.5}$: (a) PM_{10} concentration during January 2011-December 2011, (b) PM_{10} episode day (January 7, 2011) at Mohal, (c) $PM_{2.5}$ concentration during January 2011-December 2011 and (d) CALIPSO drawn for $PM_{2.5}$ episode day (May 29, 2011) at Mohal

- The daily highest $PM_{2.5}$ was 96.4 µg m^{-3} on May 31, 2011 at Kothi, however this value at Mohal was 99.3 µg m^{-3} on May 29, 2011 (Fig.48c). Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) also show that the columnar aerosols at Mohal were maximum during these episode days. CALIPSO analysis and dirccction of back trajectories (24 h) support this pollution event due to external sources from Iran (Fig. 48d).
- Monthly maximum $PM_{2.5}$ concentration was 28±2.7 µg m^{-3} in May 2011, while at Mohal it was 46.8±10.9 µg m^{-3} in May 2011. Summer season had the maximum concentration due to both sources; local sources such as vehicular emission and external sources through polluted air mass trajectories. Vehicular influx is high 239^{-1} in summer seasons.
- At Mohal, among anion NO_3^- contributed 23% followed by CL^- (19%), while cations included Mg^{2+} (18%) and Ca^{+} (13%). At Kothi, among anions, Cl^- (32%) was observed maximum followed by $SO_4 2^-$ (26%), but among cation s, Na^+ (14%) was highest followed by K^+ (3%).



SOCIO-ECONOMIC DEVELOPMENT (SED)

The Indian Himalayan region (IHR) is a unique zone of convergence of diverse cultures and plethora of ethnic communities. Bio-physically, this ecosystem is also rich and unique. However, the ability of this mountain ecosystem is fast approaching many of its limits and the ecosystem is gradually becoming unable to provide a minimum standard of living to its continually growing population. The continued population growth and consequential poverty are fast depleting the finite natural resource base and breaking down the indigenously evolved resource use patterns that were socially sanctioned and culturally patterned. Therefore, reduction in poverty in this ecosystem through ecologically appropriate and socio-culturally acceptable interventions, promotion of innovative livelihoods and skill enhancement of the local communities for rational and judicious use of local resources for their social and economic development is crucial as decrease in poverty can increase in environmental protection. With this in view, the Socio Economic Development Theme has focused on identified and prioritized activities such as improved and sustainable farming systems, innovative livelihood options, bio-conservation through community, sustainable tourism, entrepreneurship and self employment, indigenous knowledge, and migration and its socio-economic and cultural implications, which have potential to benefit the economically disadvantaged communities of the IHR reversing the trend of poverty. In the process, the Theme has also emphasized on identification and implementation of region specific sub-activities such as strategy for economic development of small holders farming systems, scaling of innovative resources management practices by communities themselves, assessment of ecotourism potential, documentation of local health traditions, capacity building for entrepreneurship development, technology development, dissemination and backstopping, managing shifting agriculture focusing on enhancement of fallow period, participatory assessment of sustainable scenarios for Himalayan pastoralism, and culture in conservation and sustainable development and many others. The main objectives of the theme are: (i) Sustainable tourism; (ii) Entrepreneurship and self employment in the Himalaya; (iii) Indigenous knowledge: traditional lifestyle, architecture and healthcare practices; and (iv) Migration: socio-economic and cultural implications.

Shifting Agriculture: Issues and Options with Focus on Adaptive Interventions to Make it Ecologically, Economically and Socially Viable ***(2007-2012, In-house)***

In north east India, Shifting agriculture is practiced in rampart covering about 19.82 lakh ha of land and 4.43 lakh households (Table-17). However in NE India, the ecological and economic efficiency and viability of this agro-ecosystem is gradually becoming untenable under pressure from a number of factors and it is besieged with conflicting views with regard to degradation/conservation of ecosystem. Irrespective of the conflicts, shifting agriculture, which is a well knitted assemblage of socio-cultural and economic traits, continues to be the predominant land use system and primary livelihood option of the majority of the communities of NE India. In managing the shifting agriculture, the tribal communities of the NE region, over the period, have accumulated a rich and time tested traditional ecological knowledge (TEK). Documentation of this TEK, which is fast disappearing adversely impacting the unique resource ownership and utilization pattern of shifting agriculture, has assumed high priority. Further, the lack of baseline information on biological data prevents reliable evaluation of biodiversity values of shifting agriculture, seriously hindering effective approaches for conservation of faunal diversity. Keeping these in view, the project aims to review both customary laws and state policies on shifting agriculture for their possible synchronization, introduce potential low cost technologies for improving shifting agriculture, validate indigenous soil and water conservation practices and analyze the impact of shifting agriculture on faunal diversity in Arunachal Pradesh with recommendations to make the system ecologically, socially and economically viable. The project also aims to investigate the possible reasons for adoption of the practice by certain tribal communities and non-adoption by some other tribal communities.

Objectives

- To review the state and central policies and laws in the forest and agriculture sectors dealing with shifting cultivation and ongoing schemes and programmes of state and central Government for control and regulation of shifting cultivation.
- To study the land tenure and customary laws of selected ethnic communities relating to shifting cultivation.
- Documentation of TEK on soil conservation, water & forest resource management and validation of indigenous soil & water conservation practices.
- Impact of shifting agriculture on faunal diversity with special reference to avifauna and mammals.
- Need based assessment and identification of potential interventions and their application.

Achievements

- The project site, initially, covered five districts of State of Arunachal Pradesh – East Siang, West Siang, Upper Siang, Papumpare and West Kameng. Three major tribal communities, i.e., Adis, Nyshis and Akkas are studied. However, keeping in view the suggestions of the SAC (17th Meeting held on April 20-21, 2010), two more districts (Tawang and Lower Subansiri) and two more tribal communities, Monpas and Apatanis) are added in the study.
- During the reporting period, the major activities carried out included: 1. Analyses of policies and acts, 2. Field interventions and introduction of the "Integrated Agro-Horti-Silvicultural Cultivation Model" developed under this project to address fallow management, 3. Status and variations in the practices of shifting agriculture in north eastern states, and study of local people's wisdom in managing shifting agriculture.
- The various policies, acts and programmes analyzed during the year are North East Forest Policy, 2001, Wildlife (protection) Amendment Act, 2002, Watershed Development in Shifting Cultivation Area, 1976-77, Balipara/Sadiya/Tirap Frontier Tract Jhum Regulation Act, 1947, Arunachal Pradesh Anchal Forest Reserve Act, 1975, Arunachal Pradesh Forest (Removal of Timber) Regulation Act, 1983, Assam Forest

Table–17. State wise status and trends of shifting cultivation in NE India

State	Area under S.C. (lakh ha)	Families practicing shifting cultivation	Fallow period (yr)	No. of districts	Shifting cultivation prevalent in districts
Arunachal	2.61	54,000	3-10	16	10
Assam	3.10	58,000	2-7	26	3
Manipur	3.60	70,000	4-7	9	5
Meghalaya	2.65	52,290	5-7	7	5
Mizoram	0.45	50,000	3-4	8	3
Nagaland	6.33	1,16046	5-8	8	7
Tripura	1.08	43,000	5-9	4	3
Total	**19.82**	**4,43,336**	-	**78**	**36**

Table–18. State wise status and trends of shifting cultivation in NE India

State	Geographical area in km^2	Forest cover (2007) in km^2				% of Geographical area	Change w.r.t. 2005 in km^2
		Very Dense Forest	Moderately Dense Forest	Open Forest	Total		
Arunachal	83,743	20,858	31,556	14,939	67,353	80.43	-119
Assam	78,438	1,461	11,558	14,673	27,692	35.30	-66
Manipur	22,327	701	5,474	11,105	17,280	77.40	328
Meghalaya	22,429	410	9,501	7,410	17,321	77.23	116
Mizoram	21,081	134	6,251	12,855	19,240	91.27	640
Nagaland	16,579	1,274	4,897	7,293	13,464	81.21	-201
Tripura	10,486	111	4,770	3,192	8,073	76.95	-100
Total	255,083	24,949	74,007	71,467	170,423	66.81	598

Regulation Act, 1891, and Forest (conservation) Act, 1980, etc.

- For example, analysis of North East Forest Policy, 2001 revealed many positive aspects; it acknowledged the need for increasing food production and stressed up on mandatory requirement of 33% and 66% forest cover for nation and hill areas, respectively. Negatively, the policy failed to recognize shifting cultivation as a system of food production and forestry system, encouraged to utilize jhum land for development activities and replace with other practices leading to marginalization of cultivable land increase in social tension.
- The model on 'Integrated Agro-Horti-Silvicultural Cultivation' developed under the project has been adopted by Govt. of Arunachal Pradesh to address various issues in shifting agriculture. The model has been put in to practice in three districts of Arunachal under the CAMPA programme.
- The status and variations in the practices of shifting agriculture in north eastern states during the period 2005-2007 revealed that shifting cultivation, though responsible for deforestation, is not the singular factor of deforestation (Table-18).
- Further investigations were made to understand the reasons behind the non-practice of shifting agriculture by the Monpa and Apatani communities. In case of Apatani community in Ziro valley in Lower Subansiri district, temperate forests type, moderate nature of slope, valley land abundant with water for irrigation appeared to be a determining factor for practice of settled

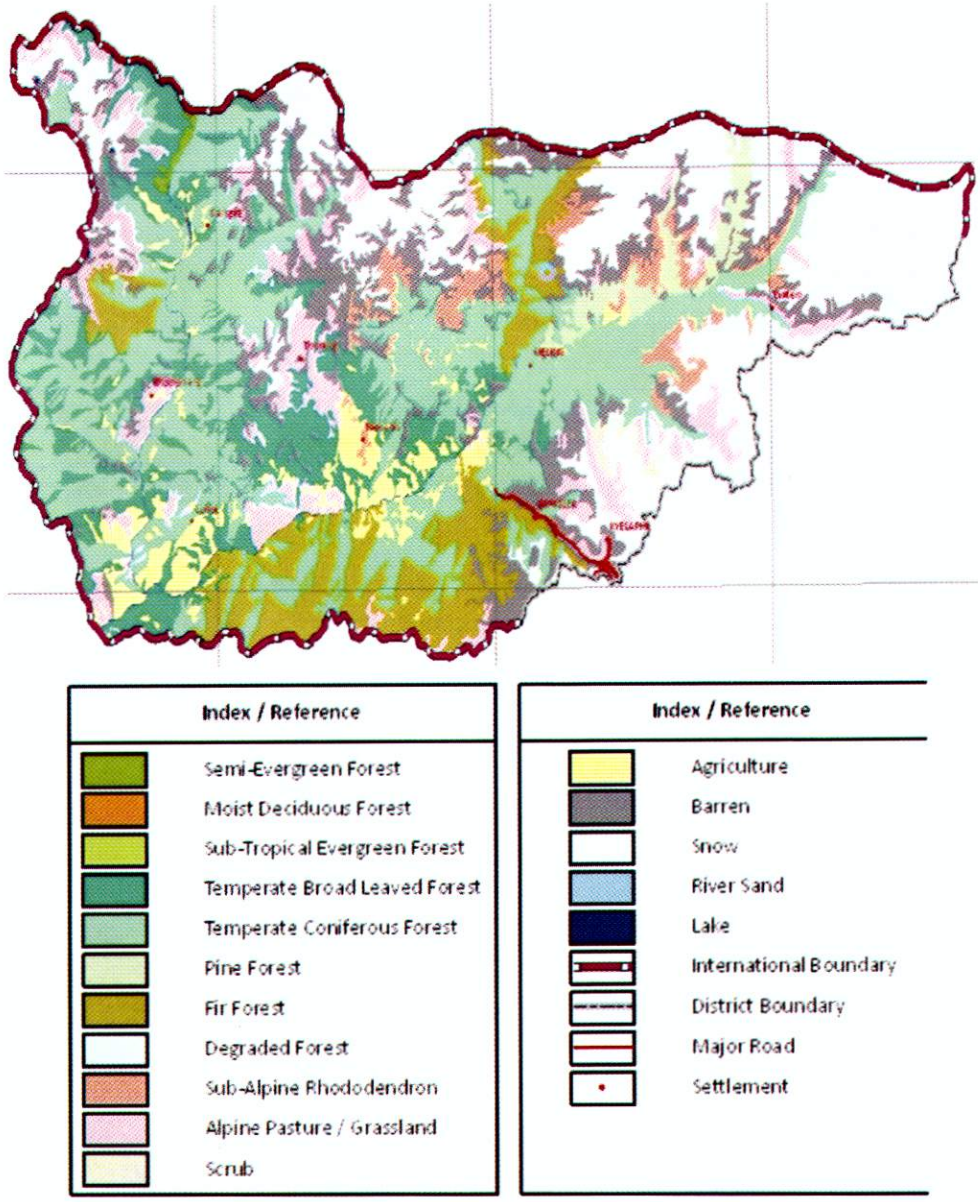


Fig.49. Forests types in Tawang district, Arunachal Pradesh

agriculture and non-practice of shifting agriculture. The cultural determinations also could not be ruled out, as the community, it appears, did not practise shifting agriculture since they migrated from South Tibet to Arunachal Pradesh. Some of the old people of the community profess that the community also did not practise shifting cultivation in South Tibet. However, this is being investigated.

In case of Monpas, associated pastoralism and temperate type of forests in Tawang (Fig.49) and West Kameng district are some of the factors for non-practice of shifting agriculture. In Tawang district pasture land constitutes about 7.3% of the total geographical area that facilitates pastoralism. Shifting agriculture across the globe is confined to tropical forests. However, Kalaktang sect of Monpa practise shifting agriculture. The cultural factors and their possible influences in non-practice of shifting cultivation in case of Monpas are being investigated.

Scaling Up Innovative Resource Management Practices for Improved Livelihoods in the Mid Hills of the Central Himalaya *(2007-2012, In-house)*

Strong evidences from different regions of the world show that there is a large potential to improve the livelihoods of the inhabitants by increasing the agricultural productivity in rain fed areas, like Himalayan mid hills where water poses a key challenge. Knowledge exists generally in mix of indigenous practices and novel innovations tested by various workers under different locations of this region exemplifies that integration of available peoples' knowledge on recently developed approaches could be effective methods for conservation and management that could be the best approach for improved economic and ecological viability of this region. The follow up of the efforts made under different activities aiming to address these problems, were probably not well planned and as a result such efforts were not able to halt the process of degradation of the resources. Building on the lessons learned the technical back stopping and material support is needed to be provided to the villagers, particularly to the marginal farmers in the adoption/ adaptation process. The present study aims to follow the adoption/ adaptation process and scenario of the tested options and facilitate for improved management of the natural resources through up scaling farm based interventions, strengthening market linkages, soil and water conservation, rehabilitation of community degraded lands, strengthening of weakened farming system concept, etc. in Garurganga watershed of Bageshwar district

Objectives

- To analyze adoption/adaptation scenario of tested/innovative resource management practices.
- To develop strategies for adoption/adaptation of innovations for improved economic and ecological viability in the region.
- Scaling up of the viable practices through participatory action research involving community institutions, local stakeholders and resource farmers.
- Sharing of knowledge and information through improved networking of the stakeholders by organizing regular meetings/workshops and exchange visits.

Achievements

- Detailed study on adoption/adaptation of different options of improved livelihoods and management of natural resources during last 15 years revealed that the farming system, as a whole, is under stress. Access to natural resources has been reduced, which has negatively impacted on overall farming system in the study area.

Table-19. A comparative account of agricultural practices and yield during last 50- 60 years in the study area

Attributes		Year/ Decades					
		1960	1960-70	1970-80*	1980-90	1990-2000	2000-2010
Crop varieties sown	Rabi	6-8	6-8	4-6	4-5	3-4	3-4
	Kharief	9-12	9-12	7-9	6-7	5-6	5-6
Av. use of inorganic fertilizers**	Rabi	0.0	0.0	0.0	0.0	0.05	0.05
	Kharief	0.0	0.05	0.1	0.2	0.25	0.25
Av. production (t/ ha)	Food grains	2.0	3.5	4.0	3.6	2.9	2.0
	Pulses	0.6	0.8	0.6	0.58	0.43	0.4

* Mr Jeevan Lal Verma was awarded as Krishi Pandit for 9.5 t/ha production of paddy

** Mostly in irrigated conditions

- The major problems identified are shrinking water sources and bases, sectoral approach of the developmental projects, weak backstopping, poor access to the science & technology know how, weak project withdrawal strategies and absence of structured monitoring and evaluation system.
- The traditional agriculture in the area is either in a process of transformation to the cash crop and/or vegetable crop cultivation (if water is available) or 'no agriculture' due to out migration, scarcity of water, small and fragmented land holdings, and crop grazing by wild animals, etc.
- A comparative account of agricultural practices and yield during last 50- 60 years in the study area shows a sharp decline both in the number of crop varieties sown and the production.
- Adoption scenario clearly indicates that the farmer is a selective taker and adopt a very few, out of the available options. Water storage under different projects was not accepted by the farmer but option of fish culture, as a value addition under the present project, has easily been adopted. Soil conservation options (engineering structures) were adopted for the irrigated land but such adoption has not been observed for unproductive upland and community waste/ degraded land.
- Community waste land rehabilitation is not priority of the villagers due to the ownership issues and weakening of village institutions, especially Van Panchayat Institution. Adoption of options ensuring short term benefits to the rural house holds indicated towards changing scenario of the farming system approach in the study villages.
- Marketing aspect, which was a major huddle of the farming system, has been addressed trough establishment of 'Sunday Market'. The State Mandi Parishad has started construction of permanent shades which will be provided to the progressive farmers.

Migration: Its Socio-Economic and Cultural Implication in Indian Central Himalaya *(2009-2012, In-house)*

Migration is an important livelihood option for both the poor and rich in the Himalayas region. Nepal tops the list with maximum labor force migration in the world. Though population migration to affluent areas is a common phenomenon, it is rampant in hill regions like Uttarakhand. The quality and direction of migration as well as its economic, social and cultural impacts on the life of communities have changed along with the increase number of migrants in the state. Migration is a complex and dynamic process and plays a significant role in establishing the socio-economic structure of particular region as well as defining the mode of development with the region specific economy. While migration may be considered as a positive indicator of regional development, out migration of particular age group from the state like Uttarakhand creates regional imbalance adversely impacting agricultural productivity, therefore, the economy of the region as out migration results in loss of larger proportion of able, educated and active work force. Out migration could because of factors like inadequate production from agriculture, food security, secured earning, better education and non-availability of work in native villages.

Objectives

- To assess the impact of out-migration on natural resources and ecology.

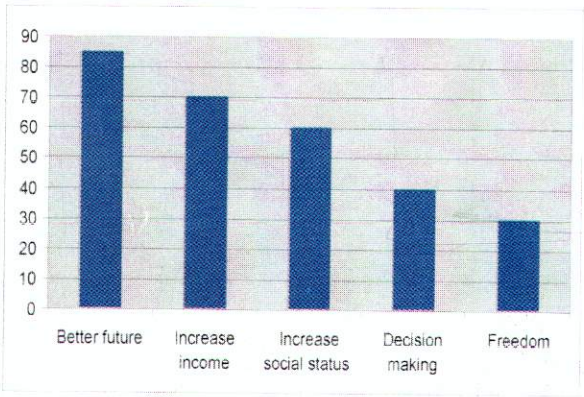


Fig.50. Factors of satisfaction

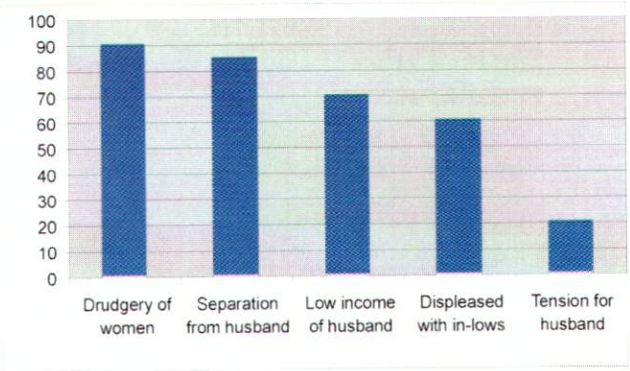


Fig.51. Factors of dissatisfaction

- To understand the linkages between social infrastructure and resource scarcity with migration.
- To analyze economic characteristics of migration for possible development of entrepreneurship.
- To evaluate implications of migration on economic and socio-cultural issues like gender.

Achievements

- Surveys conducted, so far, revealed that lack of basic amenities like education, health, Job Avenue and unequal growth in agricultural sector are major factors for out migration of people from Uttarakhand to other states or migration of youth from the villages to the developed areas of the state itself. The economically sound people, particularly the higher castes show the tendency of moving from villages with all family members for better education and health, where as in case of the lower sections of the society like the schedule caste, in particular, only the male members migrates, which is mostly seasonal.
- Survey of 236 respondents during the reporting year revealed that lack of basic infrastructure (90% of the respondents) followed by job avenue (75 % of the respondents) elsewhere are dominant factors for migration.
- During the reporting year a two-day meeting was conducted in village Dallakote, which was also attended by Dist. Development Maneger, NABARD, ALMORA and office bearer of *Dallakoti Jan Kalyan gramdyog siskhya tatha paryavaran sasthan.*
- Two *Kissan* Clubs were formed and each club opened bank account in SBI, Barechhina, Almora with the contribution from farmers.
- A water natural source was renovated with *Sramadan* of villagers.
- Out of the 32 persons trained on agro-based technologies, 12.5% of the trained farmers adopted poly house cultivation for income generation.
- Factors of satisfaction and dissatisfaction were analysed (Fig. 50 & 51)

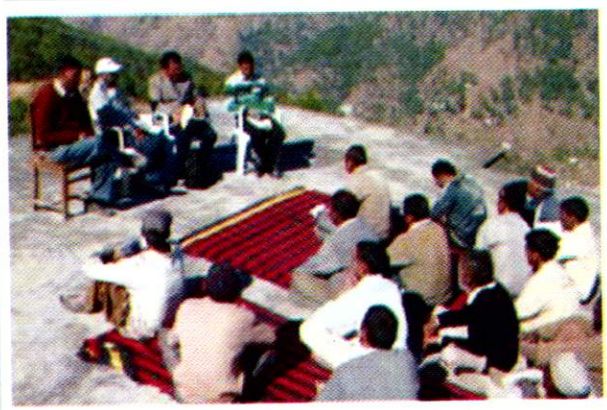


Fig.52. Meeting with farmers to convince them

Fig.53. Renovation of natural water sources to form for Kissan club

Pesticide Residue Contamination of Food Chain: Appropriate Monitoring and Control Measures from Field Studies in Himachal Pradesh *(2009-2012, In-house)*

The contamination of environment with toxic chemicals is one of the growing concerns throughout the world, particularly in the developing countries like India. Applications of pesticides in agriculture have increased the crops productivity; however, on the other hand indiscriminate use of pesticides can contaminate water and soil resources and food chain and consequently affects human health. The elevated levels of pesticide residues in soil have negatively affected the soil microbial communities and soil fertility. Management of these pesticide residues in soil is essential for the sustainable agriculture as well as socio-economic upliftment of farmers. Since very rare data on pesticide residues levels in environmental samples are available from the hilly regions of India, therefore the monitoring of pesticide residues in soil, water and food chain, assessment their risks to human health and nitrate in water has become an essential issue in Himalaya. This project has focused mainly on the monitoring of commonly used pesticide residues (endosulfan, chlorpyrifos, cypermethrin and malathion) in the food chain and nitrate in water of Kullu Himalaya. The project has also developed low cost effective techniques to reduce the negative effects of these pesticide residues on agriculture crops and human health.

Objectives

- To quantify pesticide residue levels in soils, water and in edible parts of crops grown locally and sold in markets.
- To assess dietary exposure of local consumers to pesticide residues through contaminated crops and their health risk by comparing generated database with their maximum residue limits (MRLs) set by national and international agencies.
- To assess effect of household practices on removal of pesticide residues from the surface of edible parts of crops commonly sold in markets.
- To assess the effect of organic matters amendments and poly-house techniques on accumulation of pesticide residues in edible part/s of crops grown in local environment.

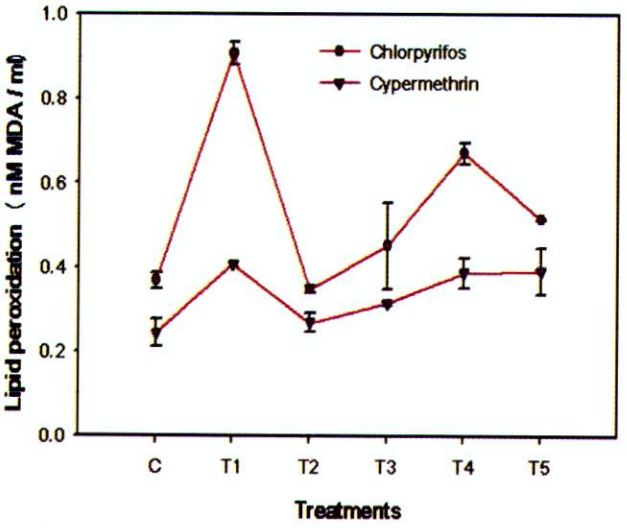


Fig.54. Effects organic matter amendments on chlorpyrifos and cypermethrin induced oxidative damage in cauliflower foliage

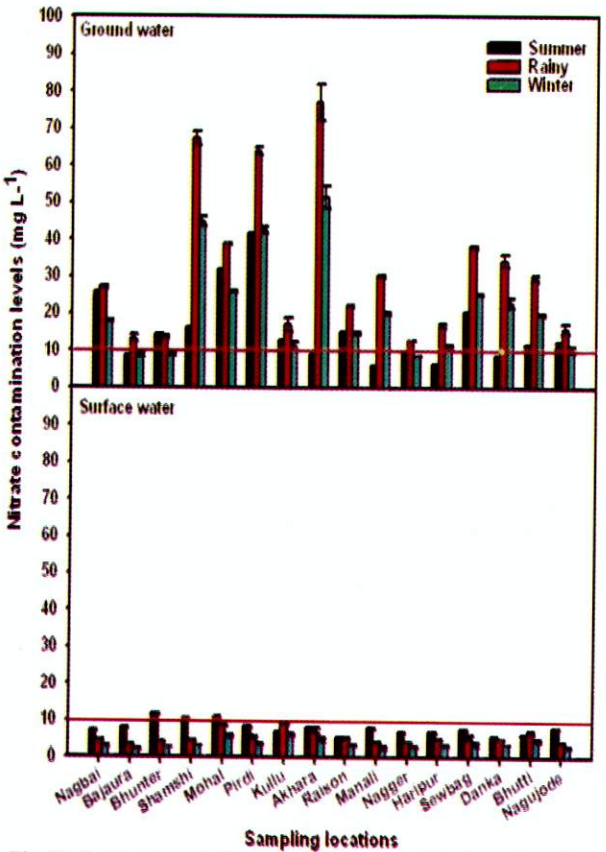


Fig.55. Seasonal variations in nitrate contamination of surface and ground water of selected urban and rural areas of Kullu district of Himachal Pradesh

Fig.56. Participants of training programme organized at GBPIHED, Kullu (H.P.)

Achievements

- Samples of apples (N=25), cauliflowers (N= 15) and tomatoes (N = 14) were collected from field and market sites in triplicates and were analyzed for endosulfan sulphate, cypermethrin, chlorpyrifos and malathion using gas chromatograph. The concentration of tested pesticides were found below the maximum residue limits in samples of apples, cauliflowers and tomatoes collected from both field and market sites. The contamination levels of tested pesticides residues in tested samples of fruits and vegetables were, however, found higher at field sites as compared to those from market sites.
- Daily intake of tested pesticide residues through consumption of apples, cauliflowers and tomatoes was recorded higher for male than the female population. The daily intake of pesticide residues via consumption of apples, tomatoes and cauliflowers by local population was, however, within the accepted daily intake value.
- Oxidative damage caused by cypermethrin and chlorpyrifos contaminated soil in foliage cauliflower was measured in term of lipid peroxidation and the effects of different organic carbon sources (e.g. farm yard manures, vermin-composts, municipal solid waste composts) on recovery of cypermethrin and chlorpyrifos induced oxidative damage was studied. The results revealed that farm yard manure, a source of organic carbon, can be used to reduce the adverse effects of cypermethrin and chlorpyrifos induced oxidative damage in cauliflower (Fig.54).
- Seasonal variation in nitrate contamination levels of surface (N=53) & ground water (N=53) from different urban and rural areas of Kullu district of Himachal Pradesh were monitored. Nitrate contamination level in surface water was found many folds lower than the ground water. The levels of nitrate concentration in ground water was found above the safe limit of WHO (10mg L^{-1}) and not suitable for the drinking purposes. The nitrate contamination of surface and ground water varied and found in order from maximum to minimum as summer > rainy > winter for surface water and rainy > winter > summer for ground water (Fig.55).

One day training programme on "Impacts of pesticides and heavy metals on plants and human health" was organized to aware 83 local participants of Kullu district from various health affects of these chemicals and route of exposure. They were made aware about the strategies needed to reduce the risks of heavy metals and pesticide residues (Fig.56).

Enhancement of Livelihood Security Through Sustainable Farming Systems and Related Farm Enterprises in North-West Himalaya *(2007-2012, World Bank- ICAR)*

The challenge of long-term sustenance of growth has been highlighted by several recent studies that found the total factor productivity (TFP) in agriculture declining between the 1980s and 1990s. The green revolution in wheat and rice, white revolution in milk, yellow revolution in oilseed and the blue revolution in fisheries have augmented the food basket of the country. But many technological challenges remain. To address these challenges and to generate additional income and employment for the poor, the role of agricultural research and development is critical. Given the limited scope for area expansion, increases in

Table–20. Cost-benefit analysis of MAPs cultivation in selected clusters of Champawat.

Name of plant species	Production (Kg /ha/dry)	Expenditure (Rs/ha)	Income (Rs/ha)	Net Profit (Rs/ha)	Expenditure/ income ratio
Rosmarinus officinalis **Linn.**	1250 ±7.2	42500±23.2	168750±18.3	126250±21.3	3.98±3.5
Asparagus racemosus **Willd.**	700±3.5	40000±13.5	140000±22.5	100000±16.8	3.5±1.7
Ocimum basilicum **L.**	1100±1.7	37500±15.3	121000±12.9	83500±12.7	3.23±7.2
Valeriana jatamansi **Jones.**	1300±5.3	31500±11.2	91000±15.6	59500±10.9	2.89±5.3
Origanum vulgare **L.**	900±2.5	41000±15.7	148500±17.1	107500±13.8	3.63±2.8
Hedychium spicatum **Buch. Hum. Ex J.E. Smith**	2000±4.6	30500±12.1	60000±20.7	29500±22.1	1.97±1.6
Withania somnifera **L. Dunal**	1000±2.3	30000±18.4	65000±15.8	35000±15.2	2.17±4.2
Cymbopogon flexuosus **Nees ex Steudel**	200±5.7	30000±16.5	70000±11.7	40000±18.3	2.34±8.1
Matricaria chamomilla **Linn.**	500±1.8	20000±10.6	39000±13.6	19000±19.4	1.95±3.9

Note: 1 Hectare = 50 Nali

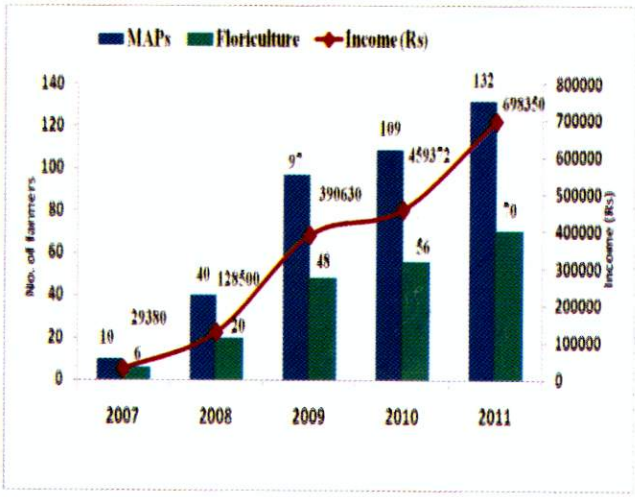


Fig.57. Adoption and monetary benefit to the flower & MAPs cultivators in Champawat district

productivity, profitability and competitiveness will have to be the main parameters of the agricultural growth in the future and this should be led or triggered by advances and innovations in, and applications of science in agriculture. In other words, Indian agriculture will have to shift from resource or input-based growth to knowledge or science-based growth. Integrated farming system approach for improved livelihood through community based natural resources management has been identified for execution of the present project. Strengthening of interrelationship between different components of the hill farming system and dependency of the villagers on the natural resources have been taken in to consideration. The main emphasis in this component is given to improving the sustainability of the farming systems and natural resource management in less favorable environments. Particular attention has been given to rain-fed agriculture, common lands and waste lands of the Champawat and Tehri districts of Uttarakhand

Objectives

- Enhancement in the agricultural productivity and profitability through proven technological interventions.
- Up-gradation and management of natural resource base.
- Agro-processing, value addition and improved marketing for enhancing profitability and employment opportunities.
- Empowerment through capacity building and skill development in core and allied agricultural sectors along with employment generation.

Achievements

- Five different prototypes have been established in all the six identified village clusters of Champawat and Tehri districts, based on the eco-physiological conditions and villagers need. Over

9 ha of community land under different clusters has been rehabilitated through establishment of well tested prototypes during the period adopting CBNRM approach.

- Five (5) mother nurseries are established for germ plasma distribution and cultivation of 11 MAPs (9.0 ha) and 2 varieties of cut-flowers (7.9 ha) are promoted for ensuring short term benefits to the farming community through participatory approach.
- Facilitation was provided for legal status to the 132 MAPs growers for marketing and to avail facilities/ schemes through their registration with State Herbal Research and Development Institute (HRDI), Chamoli, Uttarakhand
- Processing of raw material of MAPs has been started after establishing of oil distillation unit and training the local farmers.
- A total of 18.22 quintals raw materials of selected MAPs and 147000 spikes of cut-flowers were harvested by farmers in all three clusters after fourth year of cultivation. This has provided a sum of Rs. 6, 98,350/- net monetary benefit after marketing to the traders in local market (Fig.57, Table 20).
- Emphasis has been given to the harvesting and storage of water, soil/ water conservation practices and mass scale cultivation of improved grasses on degraded /waste lands as well as terrace bunds and risers of agricultural land. Six such structures for storing rain water have been constructed and stored water is being used for life saving irrigation during summer and winters.
- The horticultural models started to produce fruits and a collection centre has been developed at village level under the management committee of the villagers. In future when the fruits are ripen, these will be harvested and stored in collection centre and sold in the market by the selected village management committee.

Biodiversity Conservation through Community Based Natural Resource Management in Arunachal Pradesh *(2008-2012, GOI-UNDP CCF-II)*

Arunachal Pradesh is India's biological frontier; arguably the biologically richest region in the country. Located in the Eastern Himalayan biodiversity hotspot, it is one among the 200 globally important eco-regions. It has also been designated as a globally important Endemic Bird Area as out of the 1200 bird species in India, nearly 600 have been recorded from Arunachal. Culturally, it is also quite rich being home to 26 major and 110 minor indigenous communities. However, the rich bioresource of the state, particularly its fauna, is being seriously threatened in the recent time under various forces. Therefore, an effort has been made with this project to conserve the rich biodiversity of the state, through community participation and adopting an integrated approach embracing to the acknowledged fact that biodiversity conservation approaches do not work in isolation of traditional communities inhabiting along the forest fringes. The project focuses on local human resource development and a mechanism to institutionalize the process of environmental sustainability through formation of community based institutions and their involvement in the entire process of interventions for biodiversity conservation and livelihood development. The project basically aims at developing viable, replicable and effective community based natural resource management initiative in the proposed Tawang-West Kameng Biosphere Reserve (TWKBR) and Apatani Plateau in Lower Subansiri District of Arunachal Pradesh by providing incentives to the local communities to effectively conserve and enhance biodiversity.

Objectives

- To promote participation of local communities in biodiversity conservation measures and resource management.
- To promote alternative livelihood schemes like ecotourism, agro forestry, and micro enterprise in the project areas to provide incentives and reduce natural resource dependence.
- To improve upon shifting cultivation and promote of livelihoods through technological interventions.

- To enhance community well being (Primary health care and education).
- To carry out studies and inventories about the lack of information for improving policies, knowledge base and monitoring.

Achievements

- All the 15 BMCs constituted under this project in Apatani plateau are adopted by Arunachal Pradesh Biodiversity Board (APBB). This has largely strengthened to the continuity and better functioning of the BMCs, with a defined pathway for the existence of the BMCs after the exit of the project. Also, the BMCs were re-constituted by selecting women representatives as per the guidelines of NBA and APBB. The APBB has already started strengthening the activities of BMCs by financially assisting about Rs. 25,000.00 (Rupees Twenty five thousand only) to BMC of Hong Niti Village for furthering awareness campaigns towards bio-conservation.
- During the reporting year, about 57 ha and 20 ha have been brought under *Taxus wallichiana* and *Michelia champaca* plantation, respectively, in project villages. In addition, 500 number of *Castanopsis* sp. were also planted at *'Siikhe-Bo'* CCA in Apatani plateau. Considering the benefit of tree-crop farming system in climatically suitable regions of the area, cultivation of large cardamom is promoted in 29.5 ha of land.
- In an effort to popularise the ecologically efficient integrated pisciculture farming system for optimised production per unit available land, 1,00,000 fingerlings have been distributed to 190 beneficiaries of 15 villages in Apatani Plateau.
- A total of seven (7) women led SHGs were constituted in the project villages. Efforts for empowerment of SHGs has been vigorously carried out through activities like distribution of 150 kgs of yarn to the SHGs. One of the SHGs, i.e., *Yarke* SHG supported under the project for weaving traditional bags earned about Rupees 15,000 during the reporting year. Tailoring, a gender focused activity is also promoted by providing sewing machines to the *Hong Tailoring SHG* of Hong Nichii and Hong Nitii villages in Apatani plateau and providing six month training on tailoring at KVIC centre, Midpu, Doimukh to six members of Tailoring SHGs. Five (5) SHGs were also encouraged to carry out income generation activities by rearing pigs. These SHGs were provided 45 piglets as well as feeds. In order to enhance the capacity and skill of the SHGs on beekeeping, 18 members of beekeeping SHGs were trained in a workshop on 28th September 2011. The trainees were elaborately trained by experts on various components of beekeeping such as bee-rearing, activities relating to tools and techniques of beekeeping, handing and caring of bees, identifying queen, drones and workers, etc. *Also, a training workshop on beekeeping was also held at TWKBR project site on 27th January, 2012.*
- A medical camp was organized on eye on December 06, 2011 at Abotani Hall, Hapoli (Ziro) jointly with Arun Dristi, Naharlagun and Nature Care and Disaster Management Society, Ziro. A team of Doctors treated about 300 eye patients in the camp. The diagnosis of about 300 patients revealed that major eye problems prevalent in Ziro are Refractive error, Pterygium, Cataract, colour blindness, and infection, etc. More than 210 patients suffering from refractive errors and other infections were treated in the Camp, while about 20 patients suffering from Cataract were advised to undergo operation at Arunachal Sate Hopital Naharlagun or at RK Mission Hospital, Itanagar.
- A team from NBA, Chennai lead by Dr. G. Ramachandran, IAS (Retd), Chairperson, NBA Expert Committee on BMC visited the Apatani plateau project site on 27th April, 2011. The visiting team members, apart from interacting

with BMCs also visited the project plantation sites. During the interactive meeting with the BMC members, the NBA officials distributed about 1500 saplings each of *Taxus wallichiana* and *Michelia champaca* to the BMC beneficiaries.

- As a part of the biodiversity conservation awareness of the project, telecasting in local TV channels regarding biodiversity conservation and other activities of the project were carried out during 27th April, 2011; 22nd May, 2011; 3th to 5th June, 2011 and 2nd to 8th October, 2011.
- Towards policy contribution, draft guidelines on Homestay and CCA are developed during the reporting year.

Cultural Landscape: The Basis for Linking Biodiversity Conservation with Sustainable Development of Arunachal Pradesh, India *(2008-2012, UNESCO-McArthur Foundation, New Delhi)*

Cultural landscapes are complex socioeconomic expressions of ecosystems that have co-evolved under the influence of biophysical factors as well as of human societies at different levels of their cultural, social, and technological development. Human cultures have always been influenced and shaped by the nature of the ecosystem. At the same time, humankind has always influenced and shaped its environment to enhance the availability of certain valued services. Unless ecosystem management is firmly rooted in the local cultural ethos, it can affect the livelihood concerns of large numbers of people, particularly marginalized societies living in the fringe of the forests, causing social disruptions and ecological degradation. Precisely, cultural manifestation in an ecosystem could simply be understood from the very definition of culture that it is that complex, which include art, belief, knowledge, morals of any other things acquired by the man as the member of the society. Therefore, the way of life, i.e., culture, of the traditional communities living near to bioresources must be comprehensively understood and be integrated in biodiversity

Table-21. Ranking of plants as per their cultural/religious value.

Local Name	Botanical name	Family	Cultural/religious value
Tatool	*Orozylum indicum*	Bignoniaceae	+++++
Sulu bulu	*Rhododendron sp*	Ericaceae	+++++
-	*Aconitum sp*	Ranunculaceae	+++++
Urling shing	*Cryptomeria japonica*	Cupressaceae	+++++
Wangsing	*Cupressus torulosa*	Cupressaceae	+++++
Poss sing	*Cupressus cashmeriana*	Cupressaceae	+++++
Wangmu	*Thuja orientalis*	Cupressaceae	+++++
Posi	*Santalum album*		+++++
Khandak	*Rhododendron arboretum*	Ericaceae	++++
Forchi	*Canarium sp*	Burseraceae	++++
-	*Eleocarpus sphaericus*	Eleocarpaceae	++++
Bechi hing	*Pinus roxburghii*	Pinaceae	+++
Lenchong hing	*Pinus wallichiana*	Pinaceae	+++
Bukku	*Triticum aestivum*	Poaceae	+++
Nge	*Artimesia sp*	Asteraceae	+++
Mong	*Capsicum sp*	Solanaceae	++
Eucalyptus	*Eucalyptus sp.*	Myrtaceae	++
-	*Zea Mays*	Poaceae	+
Suyuk	*Glycine max*		+
Hing	*Phaseolus sp*	Legume	+

+++++= Very high; ++++= High; +++= Medium; ++= low; += lowest

Table–22. Various animal parts traditionally used by the Monpas.

Species	Scientific name	Uses
Asiatic black bear	*Urasus thibetanus*	This species is hunted extensively for the gall bladder. They believe that this has plenty of medicinal value and used for curing malaria, T.B. etc. Meat is also consumed by Monpas. Skin is also used by the Monpas.
Tiger (Locally called *Vartak/ Bartak*)	*Panthera tigris*	Bones are dried, powdered and applied as paste for curing rheumatic and other body pain.
Musk deer	*Moschus moschiferus*	Musk gland is highly priced item in national and international market. Meat is also consumed by the locals.
Leopard	*Panthera paradus*	Meat is used as food as well as medicine for typhoid, malaria and rheumatic pain.
Assamese macaque (Locally called *Pungzala*)	*Macaca assamensis*	The Monpa people uses the macaque meat for the treatment of various ailments like malaria, etc.
Arunachal Macaque (Locally called *Munzala*)	*Macaca munzala*	Hunted and killed as crop raider in fields. In some pockets of Tawang district the locals kill it for meat.
Capped langur	*Trachypithecus pileatus*	Monpas of Wes Kameng district are utilizing meat as food and as medicine for malaria, typhoid dysentery and small pox. They also use the skin particularly the tail for covering their weapon (dao).
Rhesus monkey	*Macaca mulatta*	Local Monpas use it as food and therapeutic purposes. Flesh is used for treating malaria, typhoid and small pox.
Yak	*Bos grunniens*	It is of high utility to Monpas in terms of food; hair and skin are used for making a variety of household items.
Himalayan Goral	*Naemorhedus goral*	The skin is used to make the sack for storing the flour and other kitchen items. Skin is also used for making jackets. Meat is also consumed by the locals.

conservation strategies for effective conservation and sustainable development; however, the relationships between culture and biodiversity are complex, which need extensive investigation. Keeping this in view, the study aims to address biodiversity conservation with concern for sustainable development of traditional communities living in the mega cultural landscape along an altitudinal transect of the Tawang and West Kameng districts in Arunachal Pradesh, inhabited by Monpa and Sherdukpen tribal communities alongwith others like Mijis (Sajolang), Bugun and Aka. Two minor tribal communities Lishpa and Chugpa also inhabit the region.

Objective

- Landscape system analysis, figuring out the linkages between natural and human-managed ecosystems in the landscape and the manner in which they are linked to the village ecosystem functioning.
- Trying to evaluate the manner in which traditional societies perceive management of biomass, soil fertility and water resources within the landscape and the kind of eco-cultural drivers that ensure effective management of natural resources, and it's sharing on an equitable basis.
- A detail analysis of the culture-based non-codified institutional arrangements, such as the organisation of cultural calendar linked to the biophysical dimensions of the ecosystems that they are concern with.
- Issues related to competition vs coexistence of different ethnic groups within and outside the identified boundaries of a given cultural landscape and their implications for sustainable

use of natural resources within and between societies, and

- The role of institutional arrangements for effective management of natural resources with emphasis upon the traditional institutional arrangements.

Achievement

- During the reporting year, the clan system and detailed analysis of the interactions among the various clans of Monpa and Sherdukpen tribes inhabiting in the study area (Tawang and West Kameng districts of Arunachal Pradesh) were studied. Various rituals practices, deities worshipped, *observance of festivals and ceremonies, settlement and housing pattern,* food and beverages, *etc., were also documented.* Principal Monpa festivals include Choskart, Losar, Ajilamu and Torgya. Various deities that exist in the traditional Monpa and Sherdukpens society were documented. So far, eight and seven deities that are being worshiped or believed by Monpa and Sherdukpen society, respectively, have been documented. Though ostensibly Buddhist, the religion of the Sherdukpen is a flexible one, being a curious blend of Buddhism and local beliefs.
- It was observed that floral diversity of the area leads to the high dependency of these people on the natural resources in terms of food supplement, for fodder, fiber, construction, handicrafts, beverages, colouring agents (dyes) and more importantly, in health care practices. Based on their utility and importance, different plants have got different cultural values and hierarchy. Documentation of a total of 20 plant species (among them 8 with have high cultural value) preferred by Sherdukpen tribe were analyzed for the different values attached with them and ranked them accordingly (Table-21). Further, 12 different plants were identified, which are at the height of religious importance (7 are having high religious value).
- Culturally, hunting has been one of the traditional ways of life for the local tribes. However, considering the utility value of the faunal species, the Monpa community has evolved mechanisms in the form of totems, taboos, etc., to conserve them. With increase in population and developmental activities the traditional values have become diluted as communities are becoming part of illegal wildlife trade, which can be recognized as one of the serious threats to wildlife of the state. Sometimes over-population of wild and domestic animals often results in man-animal conflicts, which manifests itself in form of crop raiding and livestock depredation.
- The various animal body parts that are being traditionally used by Monpas in various aspects e.g. food, therapeutic purposes, traditional medicine and for storing various food grains and products were documented (Table-22). A total of 10 species were recorded out of which species like

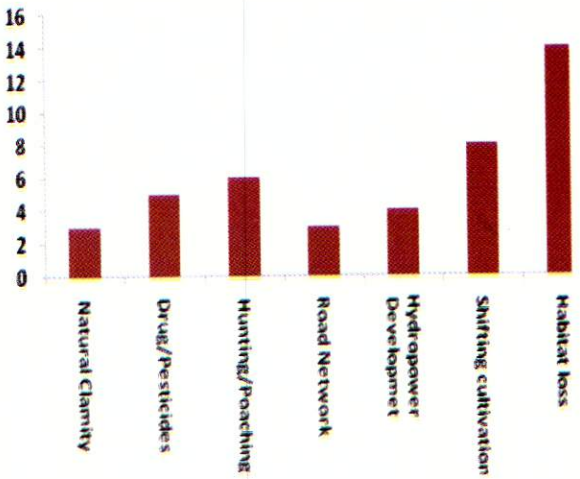


Fig. 58. Quantification of major threats to avian population decline.

Musk deer (*Moschus moschiferus)*, Common Leopard (*Panthera parades), Tiger (Panthera tigris), Asiatic Black Bear (Urasus thibetanus),* Arunachal Macaque *(Macaca munzala), Capped langur (Trachypithecus pileatus) and* Himalayan Goral *(Naemorhedus goral) were the endangered species.*

- There are several lakes, most of which are high altitude water bodies in the studied area and many of them are playing significant role in maintaining ecological balance and are productive systems. Most of these wetlands are considered as sacred and there are strict taboos associated, which are followed with strict norms by the local Monpa people. These wetlands provide a good space for flourishing high altitude rich biodiversity of this part of eastern Himalaya. Some of the endangered high altitude rare mammals like Musk Deer, Snow Leopard, Chinese Goral, Himalayan Goral, Red Goral, Blue sheep, Pika and avifauna like marmot are found in the area water bodies while the catchment area of the lake complexes are mostly occupied by the Rhododendron and Junipers bushes along with Primula sp., Gentiana sp., Frageria sp., Aconitum sp., Artimesia sp., Anaphalis sp., Aster sp., Anemon sp., Aconitum sp., Leontopodium sp., Rheum species,etc. The taboos and religious restrictions associated with these wetlands helped in preserving these vast faunal and floral resources along with preventing the degradation of the lake by siltation. Ecologically, these lakes have also played vital role in maintaining the normal hydrology of the high altitude areas of western Arunachal Pradesh.
- Various intangible cultural practices, which are directly and indirectly associated with biodiversity conservation were also documented. Documentation of various painting, folklore and folktales, which depict conservation of flora and fauna has also been done. Various traditional institutions and their role in management of agricultural system among Monpas and Sherdukpen were also documented.

Summary of Completed Project / Activity

Development of Baseline Information and Identification of Potential Corridors for Namdapha National Park (Tiger Reserve) and Mouling National Park ***(2010-2011, ICIMOD, Nepal)***

The Eastern Himalaya, encompassing parts of the three global biodiversity hotspots, namely the Himalaya, Indo-Burma, and the mountains of south-western China, is among the world's ten most critical centres for biodiversity and endemism. The region is also recognized as a global significance as it provides various goods and services, which are lifelines for millions of people downstream in the Gangetic, Brahmaputra, and Salween river basins. The region, however, faces numerous environmental and socio-economic challenges manifested by poorest people from diverse culture and social backgrounds, who largely depend upon the bioresources for their sustenance. Fifteen percent of the land areas in the Eastern Himalayas are under formal protected area network and many of these protected areas are yet to be explored and lack the basic data of species list and their status. With this in background, the aforesaid project was implemented in order to fill the knowledge gap and have a better understanding on biodiversity conservation and management challenges for Namdapha National Park (tiger reserve) and Mouling National Park, and areas (corridors) in between both the NPs.

Compilation and analysis of information on faunal diversity of Namdapha National Park showed representation of 1278 species belonging to 47 orders, 196 families and 588 genera while that of Mouling showed representation of 779 species belonging to 31 orders, 127 families and 462 genera. The Namdapha National Park represented 187 species of Mammals belonging to 10 orders,

Table–23. CITES protected birds of Mouling National Park.

Species	Common name	CITES Appendix I	CITES Appendix II
Aquila clanga	Greater spotted eagle	✓	
Aquila heliaca	Imperial Eagle	✓	✓
Circus macrourus	Pallid Harrier		✓
Icthyophaga humilis	Lesser fishing eagle		✓
Gyps indicus	Long billed vulture		✓
Haliaeetus leucoryphus	Pallas's fishing Eagle		✓
Falco naumanni	Lesser Kestrel		✓
Lophophorus sclateri	Sclater's monal		✓
Aceros nipalensis	Rufous-necked Hornbill	✓	✓
Buceros bicornis	Great hornbill	✓	

34 families and 102 genera while the Mouling National Park represented 143 species of mammals belonging to 10 orders, 28 families and 87 genera. With respect to avifauna 490 species of bird belonging to 17 orders, 52 families and 217 genera were documented in Namdapha NP against 332 species belonging to 17 orders, 57 families and 187 genera in Mouling NP. With respect to possible wildlife corridor between Mouling and Namdapha national Parks it was found that there are some major rivers (tributaries of river Brahmaputra) flowing between both the national parks at relatively lower elevations. The river flowing between the national parks are significantly wide and deep and with extremely high current water with a large percentage of sediment, wildlife corridor between Mouling and Namdapha national Parks may not be possible. Alternatively also, a 10 km redial peripheri in case of both the NPs are not suitable and poential areas to be developed as additional buffer zone or can serve as a connecting corridor with the nearby protected area, since there are roads, settlements, etc., within the area. However, additional forest area within 1 km radious from the prsent boundary of both the NPs privdes adequate scope to be developed as additional buffer which are also good-quality forests.

Major threat types were quantified for the avian species of both the NPs. For example in Mouling National it was observed that habitat loss poses as major threat to the avian population decline followed by shifting agriculture, housing and hunting (Fig. 58) Out of 332 species of birds, 10 species of Mouling NP were found protected under the appendix I, II of International Convention on Trade of Endangerend Species (CITES, Table-23).

In brief, the project succeeded in bringing out comprehensive review report on floral and faunal diversity including status, distribution, threats and their use by local communities from the two protected areas providing separate lists of species that are endemic or threatened and traded or exported from the area. The project contributed towards preparation of baseline information on floral and faunal species of the potential corridor between Mouling and Namdapha NPs based on Rapid Biodiversity Assessment, identification of human induced threats and conservation challenges (both local and transboundary) in the said protected areas, documentation of local level traditional knowledge/practices practiced by people to enhance conservation. Further, landuse and cover change map of the area with dominant forest types was prepared, and potential area for developing buffer or connectivity between said protected areas was identified.

BIOTECHNOLOGY APPLICATIONS (BTA)

Three major groups of bioresources, viz. plants, animals and microorganisms are being addressed under this Theme. Plants being the primary producers, hence a thorough understanding of the factors that govern their productivity and functioning is of paramount importance especially in the light of harsh environmental conditions prevailing in the Himalaya, and current concern about the global climatic change. An understanding of the mechanism of plant adaptation is necessary as it helps in increasing productivity of the plants. Plant propagation packages, addressing the need of local people, are being developed using conventional and biotechnological tools; moreover, studies on phytochemical and molecular profiling of medicinal and aromatic plants are underway.

Documentation of animal and microbial diversity is equally important. A study on diversity and locally useful species of fish is underway in Arunachal Pradesh. Exploration on microbial diversity with special reference to rhizosphere microorganisms has been carried out; this has led to the formulation of carrier based bioinoculants for mountains. The microorganisms that thrive under extreme environments, from polar deserts to geothermal springs, are referred as extremophiles. Psychrophiles and thermophiles, in particular, have received special attention and are being explored for their diversity, biotechnological applications and the strategies adapted for survival under extreme climatic conditions of IHR. The theme envisages to: i) identify and document bioresources of applied value, ii) generate technological know-how of the process development, and iii) build capacity of the human resource.

Assessment of Microbial Diversity in Himalayan Soil and Determination of Potential Applications ***(2007-2012, In-house)***

Research projects related to microbial diversity and potential applications have been initiated in the Institute since 1993. The focus of these projects has been on isolation, identification and characterization of microbial communities. While the temperate and alpine locations have been explored for enumerating the diversity of free-living bacterial actinomycetes and fungal communities, the symbiotic associations between selected trees and the arbuscular mycorrhizal fungi have been investigated. Investigations have also been carried out on microbial diversity of the hot spring sites, located in the Garhwal Himalaya. Microbial inoculants suitable for colder regions of mountains have been developed. The present proposal has been formulated on the basis of the leads obtained from the earlier work done in the area of microbial diversity of

IHR with an emphasis on: (1) rhizosphere microbial communities, and, (2) extremophiles. In addition, studies on water microbes in river *Jataganga* and microbial diversity in agriculture plots under shifting cultivation in north east India have also been initiated.

Objectives

- Assessment of diversity of microorganisms growing in extreme conditions (thermophiles and psychrophiles) of Indian Himalayan Region.
- Determination of potential applications of selected microorganisms with an emphasis on production of secondary metabolites and enzymes.
- Preservation of pure cultures in the Institute's laboratory and accessioning of selected cultures in National and International Culture Collections and Gene Banks.
- Initiation of a HQ and NE unit collaborative study with an objective "influence of fire process during shifting cultivation on soil microflora and nutrients".

Achievements

- *Study on rhizosphere and antimicrobial activity of Ginkgo biloba:* The trend of using natural products has been increasing in recent times, and the "active" plant extracts are frequently used for the discovery of new drugs, which are also known as a source of antimicrobials. *Ginkgo biloba*, growing in hilly tracts of IHR has got attention mainly for its (1) propagation, and (2) chemical constituents. While rhizosphere studies have been established with a view to understand the rhizosphere communities and their role in propagation of the species, the evaluation of medicinal properties including antimicrobials has also been initiated.
- The antimicrobial activity in leaf extracts of *G. biloba* has been investigated in respect of various groups of microorganisms. Out of three groups, bacteria were found to be most sensitive to the antimicrobial substances, followed by actinomycetes and fungi. Methanolic extracts exhibited maximum activity, followed by extracts done with ethyl acetate and n-buatnol. Inhibition of microorganisms was also observed where reference substances, Ginkgolide A (GA), Ginkgolide B (GB), and Bilobalide (BB) were used. No inhibition of microorganisms was observed in aqueous leaf extracts and in control experiments where only solvents were used. The results obtained in minimal inhibitory concentration (MIC) experiments were found to be in line with those obtained from antimicrobial activity plate assays.
- ***Accessioning of microbial cultures:*** Pure cultures of bacteria, actinomycetes and fungi are being maintained in the Microbiology Laboratory of the Institute and regularly being accessioned by MTCC, IMTECH, Chandigarh; ITCC, IARI, New Delhi, and Agarkar Institute, Pune, and NCBI (gene sequences).
- *Characterization of actinomycetes isolated from fired plots in north east India:* Thirty five isolates of actinomycetes were isolated from the soil samples, collected after fire operations, at agricultural sites under shifting cultivation in northeast India. More than half of these isolates were observed in viable but nonculturable (VBNC) state. Eleven morphological distinct and cultivable isolates were subjected to characterization and identification. The isolates varied in cell morphology, utilization of carbon sources, sensitivity to antibiotics, and salt tolerance. Based on 16S rRNA sequencing, the isolates revealed maximum similarity to the genus *Streptomyces* (9), and to *Kitasatospora* and *Nocardia* (1 each). Several isolates were found to be positive for production of lytic (chitinase and glucanase), and industrially important enzymes (amylase, lipase, and protease). Occurrence of actinomycetes in VBNC state was attributed

towards the cope up mechanisms associated with these organisms under stress (high temperature) conditions. The cultivable cultures extend opportunity for further investigations on ecological resilience, during fire operations.

Development of Propagation Protocols, Multiplication and Field Evaluation of Selected Economically Important Plants in Indian Himalayan Region *(2007-2012, In-house)*

The ever increasing human population has placed tremendous pressure on plants, the primary producers. There has always been a growing demand for plants and plant based products. Reduction in the forest cover from the Indian Himalayan region, due to over exploitation, has also resulted in decreasing the availability of non-timber forest products including several medicinal plants of high value. Since the Indian Himalayan region is a home to a large number of economically and ecologically important plants, including non-timber forest products, to cope with such challenges, large scale plantations need to be taken up. Therefore, large scale multiplication of quality planting material would be required. Besides conventional methods of propagation, in vitro propagation techniques have the recognized potential for rapid multiplication of elite clones not only to provide the much needed planting material for cultivation to derive economic benefits but also for restoration of degraded land and conservation. Keeping these goals in mind, investigations have been undertaken on various target species based on local demand, and results of different studies taken up during this year has been reported.

Target species: *Zanthoxylum armatum* DC [syn Z. *alatum* Roxb. (Rutaceae)], *Amomum subulatum* Roxb. (Zingiberaceae) - HQs; *Quercus* spp. (Fagaceae), *Rhododendron* spp. (Ericaceae) - Sikkim unit; *Olea ferruginea* Royle (syn. *O. cuspidata* Wall. ex G. Don. (Oleaceae)] - Himachal unit, Kullu. All are economically important species.

Objectives

- Comprehensive base line information, germplasm collection and maintenance in nursery.
- Development of propagation protocols by conventional (by cuttings and seeds) and *in vitro* methods.
- Large scale propagation of *R. maddeni* and *R. dalhousiae* plants for conservation using existing protocols
- Large scale multiplication and field performance of transferred plants.
- Analysis of chemical constituents.
- Training of students, farmers and villagers.

Achievements

- Stem cuttings (15-20cm) of *Olea ferruginea* from Suind, Kolibehar, Sapangi, Thalaut and Kais population treated with different concentrations of IAA, NAA, IBA, GA_3 and thiourea were planted in nursery. Initial sprouting was observed in 90% cases and data on rooting is awaited.
- Cultures of *Olea ferruginea* were re-established using nodal explants from mature tree of Kolibehar population. Murshige and Skoog's (MS) medium containing half strength salts and combination of BAP and NAA were found more suitable when compared with either NAA or BAP alone, in inducing bud breaks and shoot proliferation.
- Antioxidant potential of stem barks, leaves and fruits of *Olea spp.* were evaluated using three *in-vitro* models, i.e., DPPH, ABTS and FRAP assays. Indian olive (*Olea ferruginea*) was identified as one of the potential and rich sources of natural antioxidants, and can be exploited for pharmaceutical purposes.
- Seed of *R. griffithianum* (local name: *'Seto chimal')* were collected from different parts of Barsey Rhododendron Sanctuary, West Sikkim. To select a suitable treatment for *in vitro* multiple

Fig.59. Organogenesis through callus culture on solid medium: (a) prolific callus formation at the base of R. griffithianum seedling grown in vitro, (b) formation of shoots from callus, (c) closer view of the shoot organogenesis.

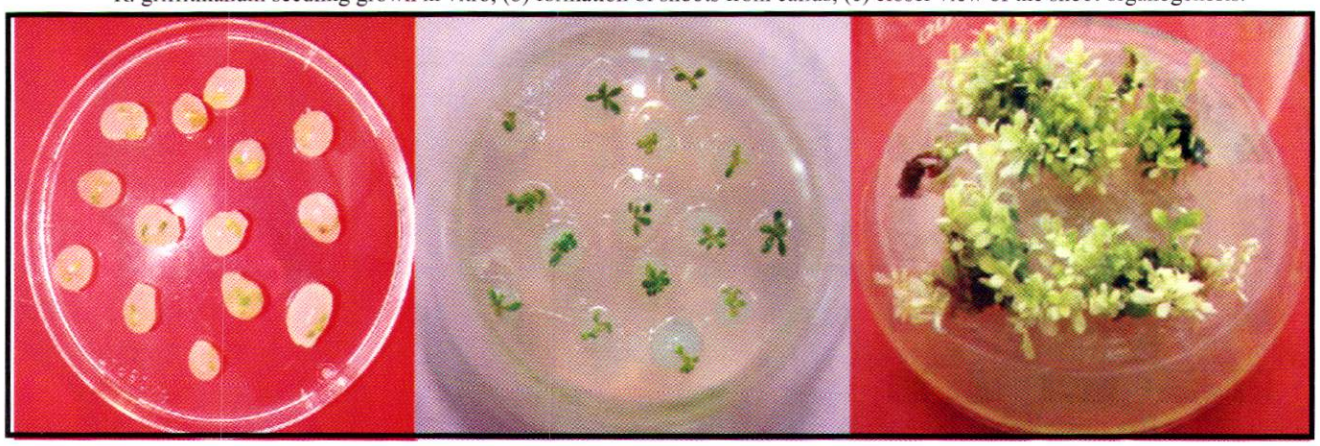


Fig. 60. In vitro plant regeneration from encapsulated shoot tips of R. dalhousiae Hook. f. a. 'bead' formed following encapsulation of shoot tips using 3% sodium alginate and 60 mM $CaCl_2.H_2O$. b. Ruptured 'beads' showing sprouting shoots on MS medium after 8 weeks of culture. c. Regenerated plantlets from encapsulated nodal segment on MS medium supplemented with 0.3% phytagel after 12 weeks of culture.

Fig. 61. Propagation of *Z. armatum* and *A. subulatum*. (a) Seedlings obtained following acid treatment to *Z. armatum* seeds, (b) saplings of the same in pots under green house conditions, (c) multiple shoot formation in *Z. armatum* following culture on MS medium supplemented with growth regulators, and various stages during in vitro propagation of *A. subulatum* (d-f).

shoot induction in *R. griffithianum*, different combinations auxins and cytokinins were used in Anderson's medium (AM); addition of 15µM isopentenyladenine (2iP) along with 1.5 µM IBA gave best results with maximum mean number of shoots (10.9).

- *Few of the shoots (as in above) also formed prolific callus at the base (Fig. 59a-c). When these calli were sub-cultured they produced shoots showing direct organogenesis. Extensive organogenesis was seen in these cultures using AM medium* along with additives like 100 mg/L polyvinyl pyrrolidone (PVP), 100 mg/L ascorbic acid, 10 mg/L citric acid *supplemented with 2iP (5µM) and IBA (1 µM)*.
- *R. maddeni* and *R. dalhousiae* are being micropropagated routinely using the protocol developed by the institute. Growth parameters of tissue culture raised (TCR) plants of *R. maddeni* planted at Himalayan Zoological Park, Bulbulay, Gangtok and in the Institute arboretum were assessed and their performance was found satisfactory.
- Plant regeneration from alginate-encapsulated nodal segments of *R. dalhousiae* was developed. Encapsulated nodal segments stored at 4°C for 25 days also showed successful conversion, followed by development into complete plantlets when returned to regeneration medium (Fig. 60a-c).
- Plantlets with developed shoot and roots were hardened and successfully established in greenhouse. Possibility of direct sowing of synthetic seeds in the soil was also examined.
- Large number of *Q. lamellosa* saplings raised from seeds is currently being maintained at net house and nursery beds, and are ready for field plantation.
- The calli of *Q. lamellosa* grown on Woody Plant medium with 25 µM BAP and 2.94 µM GA_3 showed somatic embryogenesis; the various stages, i.e. globular, heart and torpedo shapes were clearly visible to the naked eye at end of fourth week. However, the cultures failed to produce shoots subsequently.
- Seeds of *Z. armatum* possess hard coat and thus were scarified to break coat imposed dormancy, and treated with different concentrations of sulphuric acid (2-20 min). Among various treatments, 50% sulphuric acid (15 min, washing & sowing in soil) resulted in about 85% germination (compared to 0% in control) after 140 days. Plants are being raised using this method (Fig. 61a&b).
- Nodal explants taken from branches of *Z.armatum* trees were used to develop *in vitro* cultures. The sprouted shoots were multiplied in MS medium supplemented with auxins and cytokinins; following shoot proliferation and further multiplication, different treatments were provided to induce root formation in these shoots (Fig. 61c).
- Multiple shoots of *A. subulatum* were cultured on the MS medium supplemented with different concentrations of cytokinins. Effective and maximum shoot proliferation was obtained on MS medium supplemented with 0.5 µM BAP and 1.0 µM kinetin; the shoots were multiplied, rooted, hardened and planted in soil; over 1000 plants are ready for field transfer (Fig.61d-f); assessment of genetic fidelity of these *in vitro* raised plants are being done.

Molecular Characterization of Selected Medicinal Plants of Himalayan Region *(2009-2014, In-house)*

Indian Himalayan region (IHR) is a rich reservoir of valuable resource of medicinal and aromatic plants along with the other economically important plants. One hundred and seventy five out of 280 medicinal plants which are mostly used by pharmaceutical industries are from the IHR. Most of the plant derived medicines are obtained from plants either in simple plants-part form, or crude extract or mixture forms. Some of the well known medicinal plants of this region

include *Aconitum heterophyllum, A. balfourii, Podophyllum hexandrum, Picrorhiza kurooa, Valeriana wallichi, Taxus baccata, Pinus roxburghii, P. gerardiana, Zanthoxyllum armatum, Swertia angustifolia, Angelica glauca, Heracleum candicans, Ginkgo biloba,* etc. A number of biologically active compounds and secondary metabolites have been identified and purified from these plants. In order to identify genetically high yielder (based on the active component, e.g. anticancer drug podophyllotoxin, ginkogolites used in memory loss, and antimalarial drug artemisinin) the relevant medicinal plants have been selected for the study

Objectives

- Collection and maintenance of germplasm
- Development of morphological, chemical and molecular profile
- Establishment of relationship among morphological, chemical and molecular profiles
- Molecular tagging of high yielding genotypes

Achievements

- Inter and intra specific molecular diversity through RAPD, ISSR and AFLP was estimated in *Podophyllum* species. Using 20 AFLP markers, 88.01% polymorphism was observed amongst the species and the paired relationship of intercontinental species in the *Podophyllum* group [*P. hexandrum,* and *P. sikkimensis* (Indian May apple) vs. *P. pelatum* (American May apple)] appears to be paraphyletic (Fig. 71).
- Sixty RAPD markers were used to develop species specific markers. Out of the 60 only 4 markers were able to clearly differentiate the species. These markers were eluted and cloned in *Eco* RI site.
- Two and three leaved plants were observed in *P. hexandrum*. These plants were to developed molecular profile specific profile was observed with Operon primers.
- *Podophyllum hexandrum* germplasm collected from Kullu, showed high amount of podophyllotoxin (1.5%) as compared to *P. sikkimensis* (0.336%).
- Based on morphological and molecular dendogram, *P. hexandrum* (Kullu) and *P. sikkimensis* belonged to same group. These species appeared to be paraphylectic.
- Some podophylotoxin pathway specific genes were identified and their expression is in progress.
- Male and female trees of *G. biloba* from Kumaun region were identified using sex specific primers. Cloning has been completed and sequencing is in progress.
- Poly cross mating in *Artemisia annua* was carried out for gene pool exploitation. Total 220 plants were planted in polycross design (50x20 cm row to row distance). A wide variation in artemisinin content (0.01-0.7%) was observed following analysis by HPTLC.

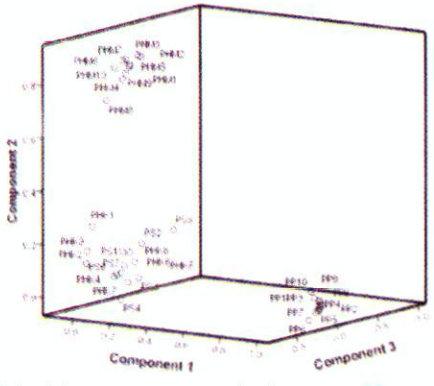


Fig. 71. Principles component analysis among 35 genotypes of three species of *Podophyllum.* Note: PP1-10 (*P. peltatum*), PHM1-10 (*P. hexandrum*-Munsyari genotypes, Uttarakhand), PHK1-8 (*P. hexandrum*-Kullu genotypes, Himachal Pradesh), PS1-7 (*P. sikkimensis*).

Phosphate Solubilizing Fungi in Himalayan Soil: Diversity and Applications *(2010-2013, DST, New Delhi - Young Scientist Scheme)*

Microorganisms play a fundamental role in the biogeochemical cycling of phosphorus in natural ecosystems. Since phosphate solubilization is a prime

process for plant growth, the importance of phosphate solubilizing microorganisms is well recognized. Temperature, pH and biomass are vital factors for various activities of microorganisms. The major microbiological process by which insoluble phosphorus compounds are mobilized is by the production of organic acids. Literature on microbial diversity of colder regions is scanty. The aim of the present project is to determine the phosphate solubilization and litter decomposition potential of the dominant fungi, isolated from Himalayan soil.

Objectives

- Phenotypic and genotypic characterization of fungal cultures isolated from temperate Himalayan soil.
- Screening and selection of efficient phosphate solubilizing fungi, with special reference to litter decomposition and plant growth promotion.
- Demonstration of the preparation and usage of carrier based formulations of efficient fungi to the target people of Indian Himalayan Region (IHR) (participatory technology development).
- Dissemination of the technique to the local people through booklets and people's participation.

Achievements

- Three species of *Aspergillus, viz. A. niger, A. glaucus* and *A. sydowii,* isolated from soil samples collected from Indian Himalayan Region (IHR), have been investigated for solubilization of aluminium phosphate and iron phosphate in presence of different carbon and nitrogen sources. Preferencc of each fungal species varied for nitrogen and carbon sources, in terms of phosphate solubilization. Among three species, *Aspergillus niger* gave the best results; it solubilized 32 and 8 % of the supplemented aluminium phosphate and iron phosphate, respectively.
- The results exhibited that the effect of carbon and nitrogen sources can influence the phosphate solubilizing efficiency of all the three *Aspergillus* spp. tested. All the three species were found to be plant growth promoters in bioassays conducted under greenhouse conditions. The Al and Fe phosphate solubilization efficiency investigated in the present study has been recorded lower as compared to their previously reported tricalcium phosphate solubilization efficiency. The cultures are likely to have better applications due to their potential towards solubilization of Al and Fe phosphates, which are known for lesser solubility through microbial activity.

Characterization of Pyschrotolerant Fungi with Particular Reference to Lignin Degradation under Mountain Ecosystem *(2010-2015, ICMR, New Delhi)*

Lignocelluloses are mainly present in the wood cell wall where lignin acts as a barrier against microbes. Lignin is a natural biopolymer which is abundant in nature. Biodegradation of lignin is a crucial step in the global carbon cycle. There are three categories of fungi which can degrade lignin: white rot, brown rot and soft rot. Brown rot fungi are basically Basidiomycetes which can modify lignin by demethylation and they have preference for coniferous substrates. Biodegradation is a slow process under low temperature environments. The present project is based on isolation and characterization of cold tolerant lignolytic fungi with reference to their biodegradable abilities under low temperature environments of IHR

Objectives

- Characterization and screening of fungal isolates for lignolytic activity
- Characterization of enzymes involved in lignin degradation.
- Study of molccular diversity of laccase gene in the positive isolates.

Achievements

- One hundred and sixty psychrotolerant fungal isolates, isolated from soil samples collected from temperate locations in the Indian Himalayan Region (IHR), have been screened for laccase activity at 25°C. The isolates (nos. 48) with positive results were rescreened for the laccase activity at different temperatures (5-45°C). *Aspergillus niger* exhibited best activity at a wide range of temperature, henceforth, selected for detailed studies. In quantitative estimations, *A. niger* gave maximum laccase activity (10.53 U/L) at 15°C on day 21 of incubation. Almost similar activity (9.08 U/L) was recorded on day 12 of incubation, at 25°C.
- The correlation among biomass, protein concentration, and enzyme activity varied at different temperatures that can be attributed to the stability of enzyme with respect to different growth conditions. Native gel study showed a band of size 27 kDa after reacting with the substrate ABTS supplemented to agarose gel. PCR based study confirmed the presence of laccase specific gene of approximate size of 300 bp.

Role of Mycorrhizae on Gas Exchange Characteristics, Particularly Photosynthesis and on Water Relations in Three Central Himalayan Oak Species: Implications with Reference to Climate Change *(2010-2013, DST, New Delhi)*

Oaks (*Quercus* spp.) are the climax species of the central Hiamalyan region. They are well known to protect the fragile ecosystem and help in soil and water conservation and soil fertility. The leaves are used widely in the hills for fodder. Regeneration of oaks is very low and oak forests are deteriorating at an alarming rate due to tremendous anthropogenic pressure. Oaks are known to form mycorrhizal associations which help in absorption of nutrients, especially phosphate, help in disease resistance and drought tolerance. Therefore, three oak species (*Q. glauca*, *Q.leucotrichophora* and *Q. semecarpifolia) of* this region based on their occurrence in different altitudes, were selected for this study

Objectives

- To observe the effect of mycorrhizal inoculation on overall growth.
- To investigate the effect of climate change with reference to elevated temperature and CO_2 on inoculated and mycorrhizal oaks over uninoculated controls.
- Do mycorrhizae protect oaks from drought stress?
- To develop a simple nursery level protocol for raising seedlings for forestry

Achievements

- Physiological studies were carried out on the photosynthetic performance and water relations of 3 oak species using seedlings and trees.
- Gas exchange studies showed that *Q. leucotrichophora* showed the highest net photosynthesis rate and transpiration, and the water potential of 1.5 MPa; these values were highest as compared to other species. Preliminary study reveals that this species must have adapted a strategy for survival, occupying a wider altitudinal range from 1000 to 2500 m asl, i.e. 1500 m, in terms of area.
- Climate change altitude gradient (m asl) base line studies have been done on abovementioned 3 oak species. High CO_2 concentration (550 ppm) and increase in temperature (1 ^{0}C above ambient) were provided to the plants kept at 3 altitudes 2000 m at Shyahidevi, 1600 m at Salla Retella and at 1200 m at Katarmal.
- A significant difference in results was observed in *Q .glauca* and *Q. semecarpifolia* at the 2000 m; *Q. leucotrichophora* was not affected at all the three sites for both the treatments.
- Due to elevated CO_2, *Q. glauca* showed a decline in net photosynthesis and in water use efficiency

over control (at p= 0.01 and 0.1) whereas *Q. semecarpifolia* showed a decline only in WUE over control (at p=0.01). In *Q. glauca* high temperature resulted in decline in net photosynthesis and in water use efficiency over control (at p=0.01). On the other hand *Q. semecarpifolia* showed an increase in net photosynthesis, stomatal conductance, internal CO_2 concentration and transpiration, however, water use efficiency showed a decline over control at p=0.01.

- The above study suggests that since *Q.glauca* and *Q. semecarpifolia* were planted at 2000 m, i.e. 200 m above its normal growing range of 900-1800 m for *Q.glauca*, and *Q. semecarpifolia* planted at 300 m below its normal growing range of 2300-3200 m, the environmental conditions may not be suitable and the plants may have undergone stress at the new altitude.

Saprolegniasis in Mid-altitude Fish Ponds of Central Himalaya: Iteology, Pathology and Management Strategies *(2011-2014, CSIR, New Delhi)*

Fisheries constitute a significant sector of the Indian economy not only from the view point of food supplies and foreign exchange earnings but also for potential employment generation. Out of the total inland fish production of over 3.6 million metric tons, more than 60% is contributed by fish culture in ponds and reservoirs. The average productivity from pond is around 2500 kg/ha/yr, though in Andhra Pradesh and Haryana, it is more than 5000 kg/ha/yr, and even higher yields to the tune of 6000-8000 kg/ha/yr is being realized by farmers in several parts of the country. Endowed with water resources, Uttarakhand has a great potential for fish culture in ponds. However, unavailability of good quality of fish seed and feed coupled with outbreak of diseases often cause economic loss, which has hampered development of fishery in the state.

Fig. 72. The fungus Saprolegnia parasitica showing aseptate hyphae, mature and empty zoospoangia with internal proliferation.

Saprolegniasis is the most problematic fungal infection of fish in lakes and ponds. The disease is caused by any of the several species of the family Saprolegniaceae that are ubiquitous component of aquatic environment. Previous exposer to stress, physical injuries, pre-existing illness and inadequate nutrition appear to predispose fish to the disease. Under congenial conditions, these fungi often cause epizootic infection resulting in grave loss. The mid altitude exotic carp farming has shown promise and only a fraction of the suitable areas has been brought under fish culture. Thus, there is a potential for many fold increase in fish production. However, fungal diseases along with several other factors have been limiting factors for the development of fishery. The objective of this study is to identify causal agents, environmental factors influencing appearance and development of disease and to develop strategies for reducing loss from disease in fish ponds

Objectives

- Survey of fish ponds in mid hills of Kumaun region for fish diseases and selection of sites for detail investigations based on disease prevalence and loss due to disease outbreak.
- To explore fungal infection in fingerlings and adult fish and to isolate, culture, characterize and identify associated fungal species.

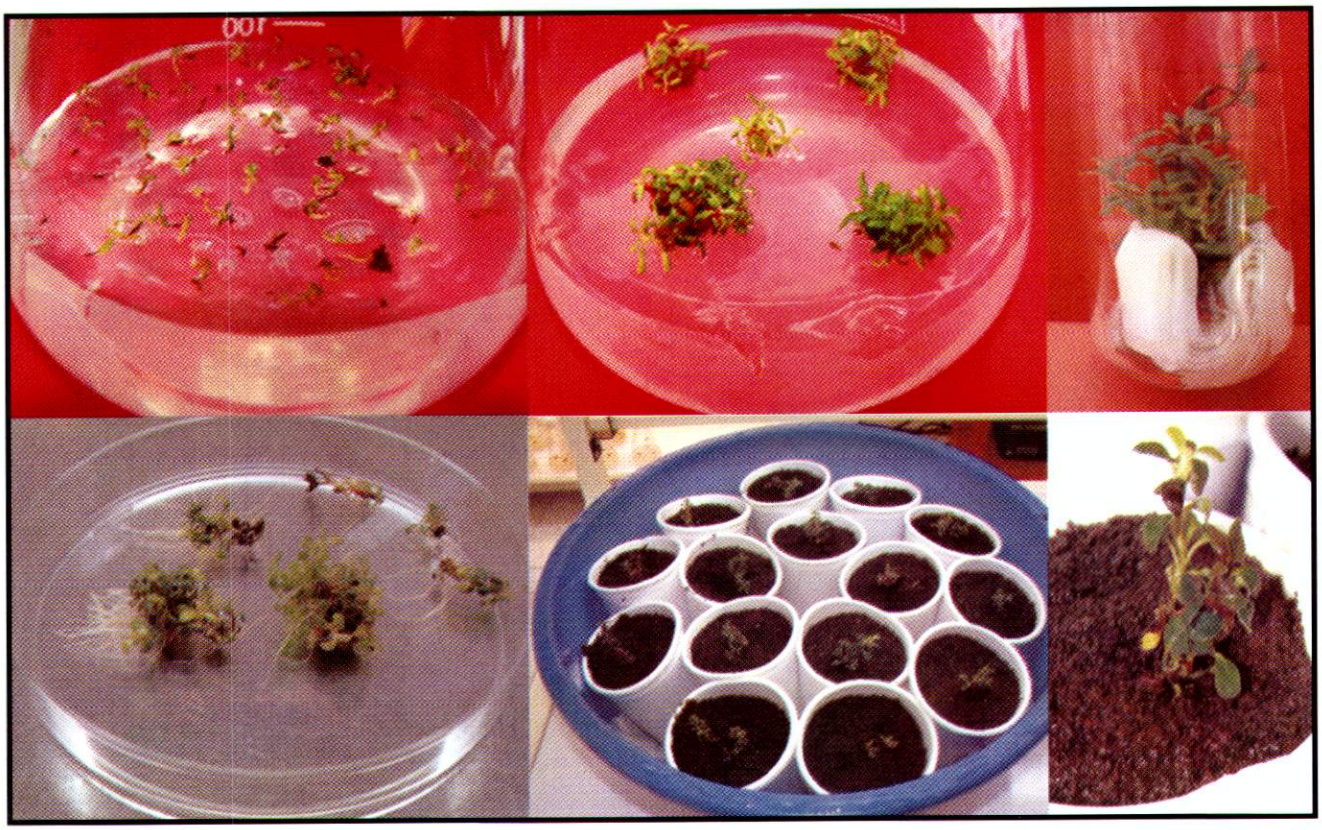


Fig. 73. *In vitro* propagation of *R. niveum*: **(a)** Germinating seeds in AM medium, **(b)** multiplication of shoots on AM medium with 2iP, **(c, d)** Rooted microshoots, **(e)** Hardened *in vitro* raised plants after transfer to fresh peat moss and soil in green house. **(f)** Hardened plants in the greenhouse..

- To determine seasonal changes in physico-chemical and microbiological parameters of water and variables that influences fungal growth and intensity of infections.
- To determine pathogenic potential of isolates under laboratory conditions and mode of infection through investigations on clinical signs and histopathology.
- To explore therapeutic and prophylactic measures for mycoses in fish.
- To create awareness and provide comprehensive understanding to the farmers in fish diseases and their integrated management.

Achievements

- A survey was conducted in mid hills of Kumaun region to ascertain the pond fishery resources and disease problem therein. Based on disease prevalence and farmer's response, three sites, namely, Kosi (1100 m), Sunola (1250 m) and Basoli (1500 m) were selected for investigations.
- Fingerlings (5.5-10.0 cm) of exotic carp species viz., Silver carp (*Hypophthalmichthys molitrix*), Grass carp (*Ctenopharyngodon idellus*) and Common carp (*Cyprinus carpio*) at a density of 3/m^2 were stocked into the ponds at selected sites.
- Significant variations in values of physicochemical variables were observed at different sites. Water temperature ranged between 9.7 and 30.7°C; pH range of water in the ponds was 6.6-8.4, lower values being during summer. Dissolved oxygen ranged from 4.9-8.8 mg/L and BOD 4.8-8.8 mg/L. Conductivity and total dissolved solids were in the range of 88.3-204.2 mg/L and 42.2-98.2 mg/L, respectively.
- In all, 20 species of zoosporic fungi including virulent pathogens of fish, such as, species of *Achlya*, *Aphanomyces* and *Saprolegnia* and plants *Pythium* species were isolated.
- Spring and autumn favoured infection of water

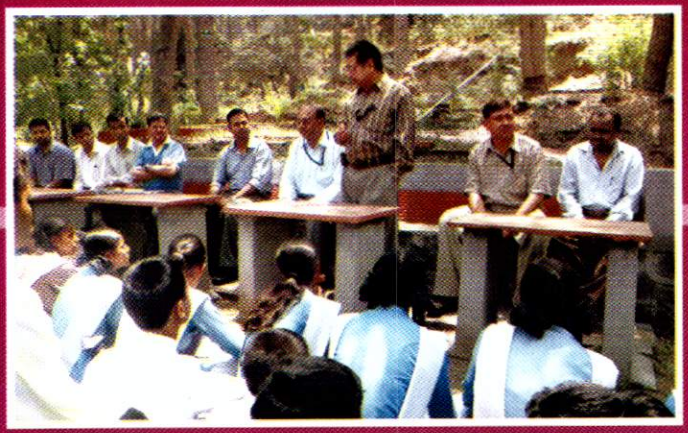
molds and development of mycoses in fish. Such conditions are also congenial for asexual reproduction in water molds. High zoospore density during the period increased possibility of attachment of zoospores and initiation of infection on fish.

- High temperature of summer-rainy season suppressed the growth and pathogenic ability of fungal species.

Summary of Completed Project/Activity

***In vitro* Propagation and Conservation of Some Rare and Endangered Rhododendrons species of Sikkim Himalaya** *(2009-2012, CSIR, New Delhi)*

Rhododendron nevium **Hook f.** is a beautiful and endangered species that has limited distribution in the Sikkim Himalaya. Conservation initiatives were made through *in vitro* and *ex situ* mass propagation and restoration of rhododendron population in the wild. In an effort to improve and promote the propagation of this over-exploited plant, the effect of temperature and light on the germination of seeds was investigated with various presoaking treatments of plant growth substances (GA_3, Kinetin and BAP) and nitrogenous compound (KNO_3). The combined effect of GA_3 with Kinetin or BAP (25 µM) was also examined. Seeds were given a presoaking treatment with GA_3, BAP or a combination of both to influence germination. A temperature of 21°C was found optimum and showed 34.33% germination, with 21 days for onset and 50 days for final germination under 16 hr light condition. The seeds of *R. niveum* need light to trigger the germination and no germination was observed in darkness. Though the seed viability was 86% as determined by tetrazolium staining, maximum germination of 63.67% was obtained only when the seed was soaked in GA_3 + BAP (25 µM each) solution for 24 h and incubated for germination at 21°C, constant temperatures in 16 hr photoperiod. The other treatments were far less effective in promoting the germination of this endangered species. The present study indicates that constant 21°C, temperature incubation and 16 hr photoperiod have a positive relationship with seed germination of *R. niveum* even under no pre-treatments. Seeds stored at low temperature (4 °C) could remain viable for about six months. This is the first report on seed germination requirements of *R. niveum*.



KNOWLEDGE PRODUCTS & CAPACITY BUILDING (KCB)

There are hundreds of different culture in the Indian Himalayan region, each with its unique practices and way of looking at life. Through their reliance on and interaction with nature and natural resources, communities have acquired an immense knowledge of their natural environment. Yet this accumulated knowledge is rapidly disappearing as the traditional communities steadily becoming culturally and biologically uniform. Unlike modern human societies who impact upon ecosystem from outside, traditional societies influence the functioning of ecosystem from within as they are integrated within the ecosystem boundary and derive a variety of benefits and services. While there is a diversity of cultures and local knowledge systems, certain characteristics are common to many knowledge systems. In particular, the way in which knowledge, cultural expressions, cultural values, customary laws, biological resources and landscapes are inextricably linked, together maintain the integrity of knowledge systems. Knowledge and resources are used and transmitted together. Biological resources cannot be separated from knowledge for a number of reasons. Besides, landscapes provide the physical space for interaction with natural and biological resources and for sharing of knowledge and resources between individuals and communities. Knowledge is often acquired from particular site in the landscape of spiritual significance such as sacred lakes, rivers, forests or mountains. All these elements play a critical role in maintaining traditional knowledge, innovations and practices. This broader focus recognizes the holistic view of traditional Himalayan communities, where tangible and intangible elements cannot be separated. Knowledge, innovations and practices of rural indigenous and local communities, are collectively held and inextricably linked to traditional resources and territories, local economies, diversity of genes, varieties of species and ecosystems, cultural and spiritual values, and customary laws shaped within the socio-ecological context of communities. We are using this concept to provide both a common framework for the research and as the basis for policy engagement. As a mixed group of indigenous and non-indigenous researchers (including natural and scientists), using an indigenous vision to guide the research has led to significant internal capacity building within the group.

The theme emphasizes the need to protect rights not only to traditional knowledge itself, but to all the inter-linked components of traditional knowledge systems including bio-genetic resources, eco-technologies, landscapes, cultural and spiritual values, and customary laws and institutions. It therefore sets out a framework to develop mechanisms to protect

traditional and modern knowledge which are holistic and based on human rights, including rights to land and natural resources, and the rights to self determination. The knowledge accumulated, documented, produced or developed over a period of time in any field related to human well being and natural resource management, environmental conservation required to be transmitted or exchanged through capacity building efforts provide unique paradigms designed to empower all the stakeholders and enhance their institutional and human capacities for integrating environmental considerations and related issues into development planning and decision making. Transfer of knowledge and capacity building requires high levels of planning, management and evaluation skills to ensure clarity of purpose, focused partnerships and assessment of effective progress. The level of understanding, skills, enthusiasm and values of the user groups are considered key factors in stimulating the learner's interest and appreciation of implementation of knowledge produce. In addition, one must consider a number of other factors including policy and regulation environment, nature of resource base, local capacities, external support, and prevailing natural resource management practices that considerably influence the effectiveness of the integrated knowledge base and its implementation. Knowledge base of the different traditional societies and knowledge developed through science and technology interventions, if successfully adopted/implemented through capacity building would certainly generate ecologically sound, economically viable, socially acceptable and institutionally enforceable outputs. With greater realization of the value of this knowledge base, for looking at issues linked to social process and natural resource management there is increasing realization that in many ecological/ social situations, knowledge should be an integral part of a holistic and cost-effective approach to sustainable development

The objectives of the theme are: (a) to undertake in-depth studies on documentation and validation of knowledge (traditional/indigenous/rural or developed through science & technological interventions) system of traditional/modern societies including their cultural, biological, material, spatial, landscape as well as intellectual components and their on-going interaction, as the basis for protecting and safeguarding the modern knowledge base; (b) to utilize natural resources for income generation using local knowledge and capacities through science and technology interventions; (c) to translate existing knowledge related to Bio and natural resources etc into products; (d) to enhance capacities and skill of human being in harnessing the potential of knowledge systems for environmental conservation and management and socio-economic development; (e) to provide opportunity for stakeholders to interact with each other and with institutions working on knowledge building/upgrading/updating system together to address research, action and policy needs of this complex subject and help to develop appropriate strategies, guidelines, and policy brief for development

Sustainable Tourism: Assessing the Eco-Tourism Potential of Garhwal Himalaya *(2007-2012, In-house)*

Tourism has been identified as an important thrust area to create employment and other income generating activities in mountain areas. Mountains attract tourists for their unique landscapes, clean cool air, recreational opportunities, bio-and cultural diversity and sacred sites. Yet tourism industry has a tendency to destroy its own foundations. Tourism relies on natural and cultural capital which highlights the fact that it is important to protect the environment and resources on which the industry depends. However, inappropriate mass tourism cause severe negative impacts on the natural and cultural environment including biodiversity. There are adverse impacts mainly on soil, air and water resources, vegetation, animal life, sanitation, cultural environment and aesthetic impacts on the landscape. Conventional mass tourism is still the mainstream of the tourism industry and it is quite likely to prevail for

some more time. Therefore, the need to develop tourism in a sustainable manner which requires an appropriate balance of the positive aspects of cultural encounters with enough income generated, and a consensus about the use and distribution of the income to the people involved in and affected by tourism.

Objectives

- To assess eco-tourism potential of selected sites such as *Panchkedar* (Kedarnath, Mudmaheshwar, Tungnath, Rudranath and Kalpeshwar) and Triyjginarayan.
- To undertake analysis of environmental, social and cultural impacts of eco-tourism.
- To select a model of eco-trekking/eco-expedition routes of few potential sites.
- To create awareness, develop capacities and empower all the stakeholders at different levels in eco-tourism chain such that it results in a clean, green environment.
- To empower local communities to manage eco-tourism while linking it with local production system, development of eco-tourism products and other income generating activities.\
- To develop a variety of advocacy and awareness, education and training materials, guidelines, policy recommendations and strategies and action plan for sustainable tourism/eco-tourism.

Achievements

- Detail information on various aspects (primary and secondary survey – that includes assessment of potential and need (i.e, tourist resources and new destinations infrastructural requirements, training needs etc.) were collected, compiled and processed for developing guidelines/action plan/management plan for tourism/eco-tourism in the valley.
- The impact of tourism on various sectors/areas/aspects i.e. agriculture, livestock, forestry, infrastructure, land use pattern, human population, socio-cultural traditions, etc. and option for maximizing benefits/opportunities and mitigation of the problems encountered was carried out.
- Popularized lesser-known tourism spots (e.g. Panch Kedar, Tungnath, Rudranath, Madmaheshwar and Kalpeshwar – Ansuya, Triyuginarayan, Kalimath, Pawalin Kantha, etc.) and highlighted their tourism value for promoting tourism in these areas, which will reduce pressure on well-known tourist places and provide opportunities to local people to participate in managing tourism and deriving benefits from it.
- Documented traditional food systems of local community which contain treasures of knowledge from long evolved cultures and patterns of living in local ecosystems. However, these food systems which are intricately related to the complexities of social and economic circumstances are becoming increasingly more affected by the forces of globalization. The main objective in this context is to promote tourism and health through traditional food products having nutraceutical potential (Table-24).
- Initiated a dialogue with Sirsi, Budasu, Rampur and Triyuginarayan village institutions for demarcating community conserved area from existing Van Panchayats area (about 5-10 ha forest land) for wild bioresource management.

Table-24. Nutraceutical potential of locally useful bioresources used as eco-tourism products.

Ingredients	Wild fruit	Medicinal Spices	
	Viburnum mullaha	*Allium humile*	*Angelica gluaca*
Vitamin B2 (mcg/gm)	14.39	23.73	33.74
Vitamin C (mg/g)	122.27	141.95	66.89
Vitamin E (mg/g)	13.47	46.21	38.73
Carbohydrate (mg/g)	183.56	92.16	29.8
Proteins (mg/g)	112.69	151.354	106.34
Lipids (mg/g)	183.56	92.16	29.8
MACRO-NUTRIENTS			
Phosphorus (mg/gm)	5.619	12.57	.81
Patassium (meq/L)	0.392	0.324	0.272
Calcium (meq/L)	0.392	0.324	0.272
MICRO-NUTRIENTS			
Iron (ppm/g)	0.68	0.17	0.88
Zinc (ppb/g)	48.8	36.0	42.0

- Organized two days training programme on "Promoting eco-tourism for local stakeholders involved in various tourism related activities" on 4th – 5th March, 2012 at tourism interpretation centre, Triyuginarayan. About more than 70 participants actively participated in the training workshop. Besides, 40 students of Govt. intermediate collage, Lawara, Rudraprayag were also imparted knowledge on tourism/eco-tourism and its environmental, economic and socio-cultural implications.
- In-depth study on local people perception and attitude towards helicopter services and its impact on local economy and environment has been carried out.
- Developed and expanded tourism/eco-tourism knowledge network with various R & D institutions (HNB Garhwal University, Tourism Department, GMVN, District Adventure Tourism Office, Health Department, Forest Department etc.), line departments (Zila Panchayat, Badri Kedar Mandir Samiti, Chardham Yatra Samiti etc.), village institutions (Triyuginarayan, Toshi, Majoshi, Joshi, Sitapur, Rampur, Sarsi, etc.) and NGOs i.e. Kedarghati Eco-tourism Development Action and Research and Swarajay Bahudeshya Sanstha etc.
- Tourism/eco-tourism interpretation centre has been established through participatory approaches at Triyuginarayan for imparting training and capacity building programme to the stakeholders.

Table-25. Training organized for different users (April, 2011 – March, 2012)

Users	Total	Male	Female
Farmers selected by Govt. organizations	319	272	47
Farmers selected by NGOs	144	72	72
Institute programme	352	225	127
Students	119	79	39
Total	**924**	**649**	**285**
Districts covered		11	
Villages covered		170	

Capacity Building for Entrepreneurship Development and Self Employment in the Himalayan Region *(2007-2012, In-house)*

The Himalayan region shows vast diversity, in respect of topography, natural and cultural landscape, climate, water availability etc., therefore, a generalized and uniform development plan cannot be of much use in such a diverse area. People living in this natural resources-rich Himalayan region happen to be quite poor. Because of limited opportunities of economic development within the region, youth are migrating in large numbers to the urban and industrial regions in the plains in search of employment. Environmental degradation and poverty are threats to the livelihoods of not only mountain people, but also of a much larger population inhabiting the adjoining Indo-Gangetic plains.

In Himalaya, central and state governments have realized the urgency of harnessing the potential of science and technology to overcome the constraints to sustainable development in the fragile Himalayan environment. In this regard, the Rural Technology Complex (RTC) has been perceived as a means of developing and disseminating improveed technologies enabling improvement in the yield potential of farms, income generation from off-farm activities, and conservation and efficient use of natural resources of remote, rural hill areas. With this rationale a centre which can act as a nodal point to collect information from various agencies/institutions/individual experts and to disseminate this knowledge to target groups spread all over the Himalayan region was established in the Institute's old campus at Kosi. The centre is involved in testing, developing, upgrading, validating and demonstrating appropriate technologies through action and participatory research for entrepreneurship development and self-employment generation. It was found that this is a very important and successful step towards taking benefits of science to end users.

Objectives

- To provide basket of hill specific technological intervention based on rural resource availability.
- Capacity building through trainings/live demonstration/ field exercises of stake holders and training of trainers (TOTs) on a regular basis.
- Guidance and support for field implementation of technology packages to the stakeholders and subsequent monitoring.
- To present a case study of peoples empowerment by adopting diverse options.
- To reduce out-migration by providing self-sufficiency within the system in the long run.

Achievements

- Maintenance of participatory action research and training centres at the RTC (HQs), Maletha and Triyuginarayan (Garhwal Unit) with a view to replicate and/or disseminate the simple technologies to users. All the centres have got wide popularity and played a catalytic role in the capacity building and skill development of the user groups on various technologies introduced, developed and modified as per the local condition and climate. The overall goals of these centres are to train and build capacity of local farmers and other stakeholders/user groups and motivate them to adopt promising, low cost, hill specific rural technologies in participatory mode.
- Developed appropriate approaches & framework for capacity building & skill development in the area of natural resource based simple rural technologies. Strong linkage and network where developed with various institutions, NGOs and line departments and listed the names and address and contact number of resource persons for directory preparation for future use.
- During this year (April, 2011 to March, 2012) at total of 30 on-site training, capacity building and awareness programme were conducted for various stakeholders at HQs and Triyuginarayan through which 53% training/awareness programme were for farmers/officials selected by Govt. organizations, 21% NOGs, 15% students, 11% institute programme. A total of 924 persons (285 female, 639 male farmers) covered 11 districts and 161 villages were trained and benefited (Table-24).
- At the end of each training programme feedback and suggestions were requested from trainees regarding the training/demonstration programme and necessary improvements were made and found that every trainee feel that each activity is very important to them.
- Based on the participatory discussion, 5 needs based training manuals on various technology packages were prepared, and distributed to the farmers and user groups.
- About total of 2.5 lakhs seedlings of *Picrorrahiza kurrooa* and *Sassurea costus* were raised with the support of HRDI (Gopeshwar) and about 5000 seedlings were distributed to 10 progressive farmers of the region for large scale nursery development of these two species and request from 30 farmers has been received for these planting materials

Table-26. Observations during qualitative analysis of extracts.

	Soxhlet extraction		Room temperature extraction	Remarks
Plant	***Hedychium spicatume***			
Solvent used for extarction	**Duration**			
	3 hours	6 hours	48 hrs	
Hexane	-	Flavalnoids Terpenes Cardiacglycosides glycosides		1. Terpenes are showing their presence only in room temperature extraction. 2. For extracting phenol only methanol is required. 3. For soxhlet extraction of the plant, 3hrs are not sufficient, 6 hrs are essential.
Methanol	Phenol	Phenol	Phenol Flavanoids Tannins	
Diethyl ether	-	Flavanoids glycosides	Terpenes glycosides	
Dichloromethane	-	Glycosides	Terpenes	
Ethyl acetate	-	Glycosides	Glycosides Terpenes	
Chloroform		Glycosides	Glycosides Terpenes	
Plant	***Picrorhiza kurroa***			
Solvent used for extarction	**Duration**			
	3 hours	6 hours	48 hrs	
Hexane	Glycosides	Flavalnoids	Terpenes	1. Terpenes are showing their presence only in room temperature extraction. 2. For extracting phenol only methanol is required. 3. Alkaloids can soxhlet extracted using methanol at more than 3hrs and with diethyl ether 3 hr is suufficient.
Methanol	Phenol Tannin	Phenol Alkaloid	Phenol Flavanoids	
Diethyl ether	Alkaloid Glycosides	Not done	Terpenes	
Dichloromethane	Flavanoids Glycosides	Not done	Terpenes	
Ethyl acetate	Flavanoids	Flavanoids	Terpenes	
Chloroform	Glycosides	Not done	Terpenes	

- The RTC has provided employment of the nine (9) persons at RTC and 3 persons for supported activities).
- The capacity building programme at Triyuginarayan has made significant contribution in the field of off-season vegetable cultivation and bioprospecting of wild bioresources. More than 170 progressive farmers of 15 villages have started off-seasonal vegetable cultivation using low cost polyhouse technique. The economic benefits by selling vegetables during 2009-12 has increased many folds. Similarly more than 96 youth/people of about 7 villages have adopted value addition of wild bioresources and their income has also been increased significantly while selling the eco-tourism products in local market.
- During period (April, 2011 to till date, 2011) an amount of Rs. 2.60 was generated by the RTC (HQs).

Establishment of Quality Assurance Laboratory for Medicinal Plants *(2009-2012, In-house)*

All over the world, plants play an important role in health care of majority of people. India has one of the richest and most diverse cultural traditions associated with the cultivation and use of medicinal plant. As per the traditional medicines programme of the World Health Organization (WHO) nearly 80% of the world population use phyto-products, phytoconstituents produced by wild plants which play very important role in the livelihood of the rural communities (Dubey et al, 2004). The task force report (2000) on "Conservation and Sustainable Uses of Medicinal Plants", Planning Commission Govt. of India, has clearly indicated that in recent years the interest on medicinal plants in the country has increased many folds. This realization has resulted into phenomenal increase of R&D in medicinal plant sector. The Indian Himalayan Region (IHR) due to its vastness and diverse climatic zones harbors a large number of plants of medicinal value (Samant et al, 1998, Dhar et al, 2000).

Natural products mainly secondary metabolites, present in these medicinal plants, have always received a great deal of attention of chemists, enzymologists, biotechnologists as well as industrialist in recent times. These are the organic compounds that are formed by living systems. The elucidation of their structures and chemistry, synthesis and biosynthesis are major areas of organic chemistry. Our institute is already working on the ecological, biochemical and biotechnological aspects of these medicinal plants, e.g. *Aconitum balfourii, Podophyllum hexandrum, Picrorhiza kurrooa, Berberis* spp. etc. Except these *Taxus baccata, Ginkgo biloba, Rosa damascene* had also been studied.

Now there is need to develop full-fledged laboratory dedicated to phytochemical analysis. The main aim of establishing this facility is to centralize this in the institute so that it would be accessible to every researcher of institute. In the initial stage emphasis would be on development of basic chromatographic facility for chemical finger printing purpose.

Objectives

- To establish quality assurance laboratory for medicinal plant analysis.
- To develop Chemical profile of selected Medicinal Plants initially from prioritized list of Uttarakhand.
- To provide hands-on-training and support in the Institute as well as outside agencies.

Achievements

- Extraction of *Picrorrhiza kurroa* and *Hedychium spicatum* have been carried out using different solvents under room temperature and also using soxhlet extraction method. Selection of solvent has been done following eluotropic series of the solvent. Different types of solvents extracts have been tested for types of secondary metabolites present in the extract (qualitative analysis). Extraction kinetics has also been carried out (Table-26).
- Work on standardization of solvent system for column chromatographic separation of crude

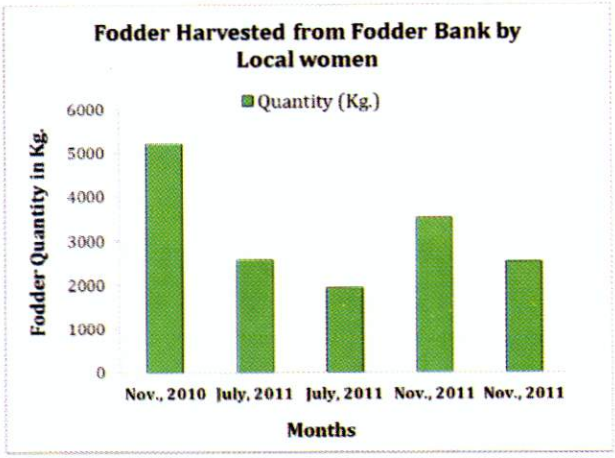
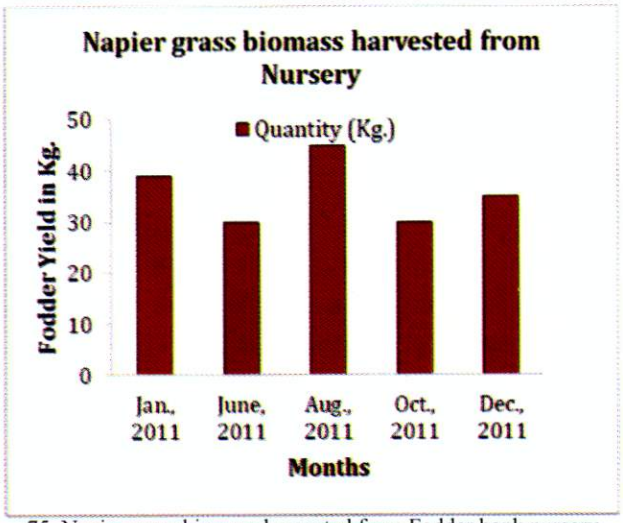


Fig.74. Fodder quantity harvested from fodder bank by locals



75. Napier grass biomass harvested from Fodder bank nursery

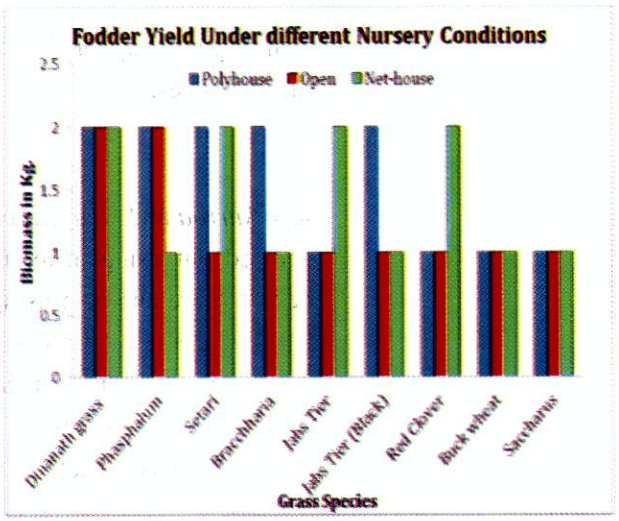


Fig.76. Fodder yield under different nursery conditions from different fast growing grass species.

extract has been carried out using thin layer chromatography (TLC). Various solvents and combinations of two solvents have been tried. As pure solvent chloroform has shown comparatively better separation using thin layer chromatography and combinations of solvent in different ratios are performing better, work is still going on.

Strengthening Fodder Resources and Developing a Pilot Model for Reducing Drudgery of Rural Women in Kedarnath Valley, Uttarakhand *(2009-2012, DST, New Delhi)*

Fodder obtained from arable land is not sufficient to maintain the livestock in sound health in mountain areas of Central Himalaya. Therefore, the hill farmers largely depend upon the forest based fodder resource of the upper Kedar valley. Raising fast growing and high yielding nutritious fodder species on farm lands can reduce the drudgery of women in collecting fodder from distant forests and also protect the degrading forests. The objective of the initiative was to relieve the pressure and improve their life style on women by reducing their fodder collection time as well as the distance they travel. It was also meant to create awareness among them regarding reducing pressure from forests and on better methods of livestock feeding, and better health improved milk and meat yield by improved quality of fodder. This project was designed to develop a fodder bank model using fast growing and high biomass yielding nutritious species (both indigenous as well as introduced). The indigenous species were selected by people based on their need, their indigenous knowledge about species, with regard to enhanced lactation, better nutrition etc.

Objectives

- To screen and propagate promising fodder species on community lands.
- To rehabilitate village commons with people's participation and develop a fodder based pilot model for replication.

- To build capacity of the women for strengthening fodder resources within village ecosystem.
- To suggest a workable strategy for replication of fodder-based approach for reducing drudgery of hill women.

Achievements

- A cost effective Rain water harvesting tank was also constructed using locally available material and Resources to store the rain water for irrigating seedlings and planted cuttings as the area faces shortage of water during summers. This tank was 12X5 ft. dimensions while the depth was 4ft. The storage capacity of the constructed tank is approximately 12,500 litres of rain water.
- Project has established a fodder bank model of more than 5 ha. Area on a community wasteland on a hillock that has reduced pressure from nearby forests for almost 10 days/month that includes for almost a week fodder is collected from fodder bank site whereas, fast growing fodder species planted on crop land bunds have reduced women's pressure for about 3-5 days in a month (Fig. 74 & 75).
- The supply of superior seed and seedlings is an important part of this fodder bank site (Fig.76). Farmers have access to seed and seedlings through a small-scale nursery that enables farmers and local women to learn and produce vegetative and mass propagation of indigenous and fast growing trees, shrub species of fodder for self use. Currently plants raised in project are distributed free of cost to locals.

Demonstration, Value Addition and Up-gradation of Traditional Wild Edible Products for Sustainable Livelihood in Kedarnath Valley of Uttarakhand *(2008-2011, DST, New Delhi)*

The wild edible bioresources are recognized and valued not only for their short term economic benefits but also for their cultural richness and the sustenance

Table-27. Cost–benefit analysis of wild herbal spices.

Plant species	Input (Rs/kg)		Output (Rs/kg)	
	Cost of raw materials	Other expenditure (grinding/ packing & labour)	Cost of local value added spices	Net return after local value addition
Allium stracheyi	210±5.7	30±2.2	470±11.6	230±6.1
Allium humile	230±7.7	40±2.9	500±13.2	230±8.3
Allium rubellium	230±6.4	40±1.8	500±15.3	230±8.3
Angelica glauca	300±16.1	40±3.2	550±22.6	210±5.1
Pleurospermum angelicoides	300±14.6	40±2.1	560±23.7	210±7.2
Rheum emodi	300±14.6	50±3.8	560±23.7	210±7.2
Carum carvi	250±14.6	40±4.7	500±23.7	210±7.2
Cinnamomum tamala	35±0.9	30±1.2	150±10.6	85±2.2

that they offer to large number of rural and tribal households. For centuries, these wild bioresources have played vital role in meeting subsistence need of the hills and mountains people of the Himalaya. A variety of wild edibles with huge economic potential, also provide important source of family income for those with few other choices, as well as for those with access to capital or land and the initiative to further market or commercialize a particular bioresources product. Wild edibles are still a relatively new area of applied research and practice. In general, the biological and ecological uncertainties associated with wild edible exploitation are greater than the economic uncertainties, but socio-cultural and economic practices can vary a great deal. Majority of wild edible plant species are quite widespread and traditionally known. However, it is less well known that majority of these species were formerly consumed by rural people particularly in the Himalaya. Most of the traditional ecological knowledge and documentary evidence for use of these wild edibles relates to the Himalayan region, where some of these are still consumed in smaller quantities and have continued to be neglected and their collection and consumption has declined to the maximum extent. This neglect and decline are likely to continue unless efforts are made through value addition and create awareness about their high nutritive, medicinal value as a healthy food and other uses and potential among rural, urban and semi-urban

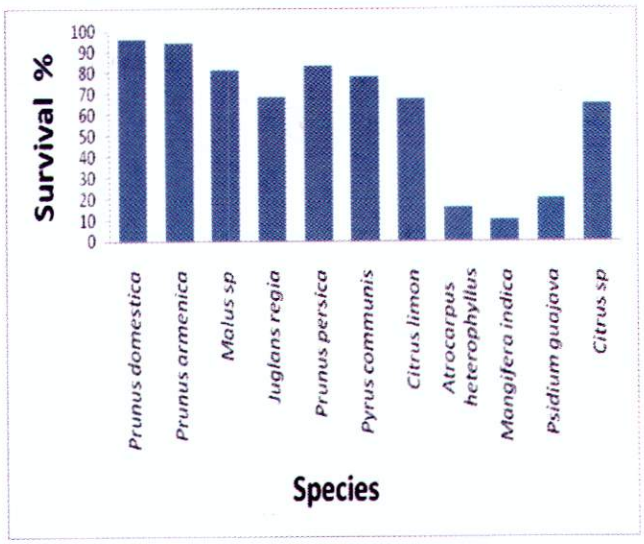


Fig.77. Survival % of Horticulture

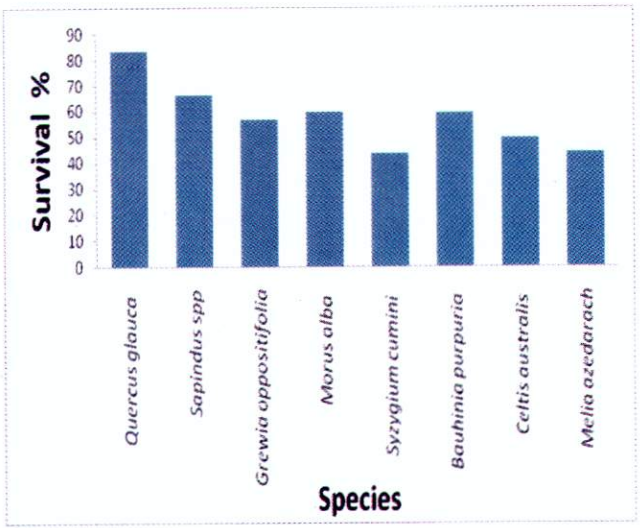


Fig.78. Survival % of MPTs

consumers for solving malnutrition on one hand and economic development on the other

Objectives

- To undertake in-depth survey to assess the extent of area under some potential wild edibles species, MAPs and wild oil species across an altitudinal gradient of the Kedarnath valley, document indigenous knowledge and evaluate their contribution in local diet and traditional health care system.
- To undertake fruit yield assessment and phenological studies so as to provide appropriate time for fruit harvesting.
- To select the wild edible species, MAPs and wild edible oil yielding plant species depending upon the dominance and availability for local value addition and undertake cost benefit analysis of edible products developed from them.
- To develop skill and capacity building while providing timely and regular training to the target population and demonstrate the enterprise while preparing a variety of local value added edible products from selected wild edibles species, MAPs and wild oil yielding species which may be easily marketed.
- To explore the possibilities for establishing linkages between farmers/users and small scale industries for marketing and up gradation of the product made from different wild bioresources.

Achievements

- In-depth survey and documentation of indigenous knowledge and ethnobotanical information available with the people inhabited in the upper Kedar valley reveals that majority of the wild edible plant is utilized in multidimensional aspects such as food, fuel, medicine, veterinary, agricultural tools, bio-fencing etc.
- Preliminary phytochemical screening of the extract of *Viburnum mullaha* revealed that the fruit berries contain vitamins, essential dietary mineral, manganese, as well as a balanced profile of other essential micronutrients. Vitamin analysis confirmed that the fruit contains high amount of vitamin C (122.27 mg/100g), Vitamin B2 (0.14 mg/g) and Vitamin E (13.47 mg/g). Macronutrient profile revealed that the *Viburnum mullaha* is rich sources of carbohydrates (18.4 g/100g), proteins (11.3 g/100g) and lipids (18.4 g/100g). On the basis of the proximate analysis, it can be calculated that an edible portion of 100 g of fruit berries provides, on average, 284.4 kcal (1185.7kJ).

- The determination of various micro and macro mineral nutrients confirmed that the fruit berries of *Viburnum mullaha* can be potential source to combat the hidden hunger of micro and macro nutrient deficiencies. The good composition of carbohydrate, protein and lipids (184 mg/g) make it a very nutritional fruit can be processed to develop various health products.
- In 30 villages of upper Kedar valley about 210 households have adopted the local value addition of variety of wild edible plants as small household activity for income generation. The various local value added products i.e. squash, juice and sauce etc prepared by the people for their household consumption and also for marketing.
- Cost benefit analysis of value addition revealed that various spice products made from about 7 plant species provide higher economic return and could be a good source of economic generation in rural areas at higher altitude (Table-27).

Enhancement of Livelihood Security through Sustainable Farming Systems and Related Farm Enterprises in North-West Himalaya *(2007-2014, NAIP/ICAR)*

The Himalayan Mountains have always played a crucial role in determining the ecology of the large ecosystem, but during recent past it has faced serious threats of environmental degradation. Increase in population pressure from within as well as outside of the mountain region has contributed to major changes in the land use cover change patterns in these mountain ranges and the associated rapid depletion of natural resources. In view of this it was realized that people participation in an ecological restoration of village common degraded land or wasteland is important for sustainable development at a local, national and global level. Although numerous land restoration projects have been implemented in the Himalayan Mountains but their impacts have been modest due to lack of appropriate technologies, policies and implementation mechanisms. The development of rehabilitation models in terms of prototypes (silvi-pasture, silvi-medicinal and horticulture) on village common degraded land is one way to achieve the goal of natural resource management.

Objectives

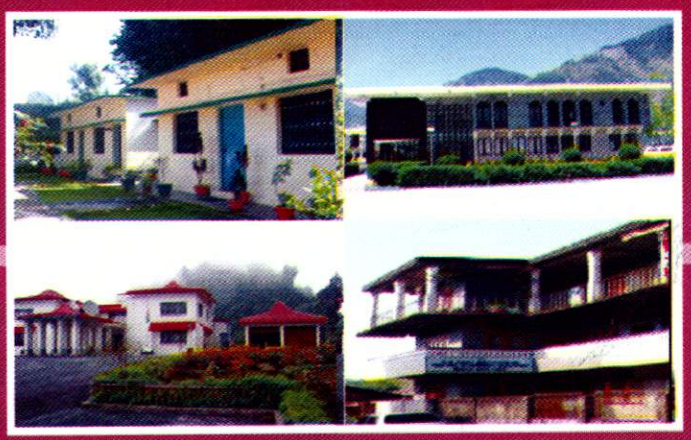
- To develop selected prototypes (models) for increasing community livelihood on village commons (i.e. Van- panchayat and other community lands) and improve natural resource status in the identified village micro-watersheds.
- To document indigenous knowledge, develop local capacity and strengthen village institution for sustained people's participation and development of natural resource management.
- To develop village information system for decision support.
- To identify indicators of sustainability for the perceived success and failure of farming systems in target districts in terms of equity (including gender), production and environmental stability, and standardize a methodology of such indicators.

Achievements

- A total of 1200 seedlings of MPTs (400 *Morus alba*, 300 *Bauhinia purpuria*, 200 *Quercus glauca; 300 Grewia oppositifolia*) in July 2011 and 300 seedlings (200 Citrus sp, 30 *Juglans regia; 30 Prunus armenica; 40 Prunus domestica*) were planted in February 2012.
- Under horticulture model (plate 1) the collective results illustrated that the *Prunus domestica* showed the maximum survival of 96% followed by *Prunus armenica* (94.2%), *Malus sp* (81.5%), *Juglans regia* (68.71%), *Prunus persica* (83.33%), *Pyrus communis* (78.3%), *Citrus limon* (67.37%) followed by *Atrocarpus heterophyllus* (15.9%), *Mangifera indica* (10%), *Psidium guajava* (20%) and *Citrus sp* (65%) in horticulture models (Fig. 77).

- Under MPTs model (plate 2) results revealed that the *Quercus glauca showed maximum survival (83.5%) in Jaminikhal village cluster followed by Sapindus spp (66.6%), Morus alba (59.9%), Bauhinia purpuria (59.3%), Grewia oppositifolia (56.7%), Celtis australis (49.7%), Melia azedarach (44%)*, *Syzygium cumini* (43.6%) (Fig. 78).

After three year, a total of 2134 kg/ha green fodder (grass) harvested which was assessed monetary equivalent of Rs. 4268/ha as per the prevailing rate of the local market. Whereas, a total 1257 Kg of fruits particularly of *Prunus persica*, *P. armanica* and *P. domestica* was estimated monetary equivalent of Rs. 83,464.00 for horticulture models.



R&D HIGHLIGHT OF THE REGIONAL UNITS

GARHWAL UNIT

- Developed appropriate approaches & framework for capacity building & skill development in the area of eco-friendly simple rural technologies. Strong linkage and network were developed with various institutions, NGOs and line departments and listed the names and address and contact number of resource persons for directory preparation for future use.
- The capacity building and outreach programme in the area of value addition of wild bioresources have made a significant impact in the study area and has stimulated local youth and village institutions to adopt the value addition practices based on wild bioresources. Exhibition of wild edible products, regional and village level business workshops were organized bi-annually and annually. Awareness generation through print as well as electronic media was also popularized. About 210 households of 30 village in upper Kedar valley have adopted the local value addition of variety of wild edible plants as small household activity for income generation. The various local value added products i.e. squash, juice and sauce etc prepared by the people for their household consumption and also for marketing.
- Establishment of small bioprospecting unit through financial support of DST, eco-tourism knowledge network and tourism interpretation centre through participatory and action research approaches for imparting training and capacity building to user groups for self-employment generation.
- Around 2.5 lakhs seedlings of Picrorrahiza kurrooa and Sassurea costus were raised with the support of HRDI (Gopeshwar) and about 5000 seedlings were distributed to 10 prograssive farmers of the region for large scale nursery development of these two species and request from 30 farmers has been received for these planting materials
- Constant efforts were made regarding sustainable harvesting, cost-benefit analysis (Rs/kg) of value addition as well as for large scale domestication of potential wild spice yielding herbal species (i.e., *Allium*

strecheyii, *A. rubellium*, *A. humile*, *Angelica glauca*, *Carum carvi*, *Pleurospermum angelicoides* and *Cinnamomum tamala*), besides raising awareness amongst the key stakeholders. Efforts were also made to enhance the yield of these wild herbal species through the application of simple science & technological interventions.

- Developed 23 ha of village common degraded land under 7 prototypes (2 MPTs and 5 Horticulture models) in three village clusters of Tehri Garhwal districts. In addition, Fodder Bank model has been developed on 5 ha degraded waste land of Maikhanda village in Rudraprayag district
- Initiated a dialogue with Sirsi, Budasu, Rampur and Triyuginarayan village institutions for demarcating community conserved areas from existing Van Panchayats area (about 5-10 ha. forest land) for wild bioresource management.
- Promoting and linking tourism/eco-tourism with agro-production base and wild resource collection base and enhanced the capacities and skill of local people of the region. Empowered local people/youth in the field of simple and eco-friendly technologies for improving the yield particularly vegetables (off-season) and traditional crops. This linkages of local production and consumption systems helped people to involve themselves in tourism and make good profit from this venture.
- The detail ecological and socio-economic study of Dhaulchina – Binsar eco-camp (DBEC) and eco-tourism for community based natural resource management at Dhanolti has been carried out.
- Enhanced capacities and skill of local stakeholders in CBT i.e. homestay accommodation, agro-production system, bioprospecting of wild bioresources and production development for livelihood improvement.
- Popularized lesser-known tourism spots (e.g. Panch Kedar, Tungnath, Rudranath, Madmaheshwar and Kalpeshwar – Ansuya, Triyuginarayan, Kalimath, Pawalin Kantha etc.) and highlighted their tourism value for promoting tourism in these areas, which will reduce pressure on well-known tourist places and provide opportunities to local people to participate in managing tourism and deriving benefits from it.
- Promoted traditional foods, wild edibles and wild herbal species having nutraceutical potentials through community based tourism.
- In-depth study on local people perception and attitude towards helicopter services and its impact on local economy and environment has been carried out.
- The impact of tourism on various sectors/areas/aspects i.e. agriculture, livestock, forestry, infrastructure, land use pattern, human population, socio-cultural traditions, etc. and option for maximizing benefits/opportunities and mitigation of the problems encountered was carried out.
- Developed strategies, action and management plan, policy brief for sustainable tourism in Uttarakhand.
- The determination of various micro and macro mineral nutrients confirmed that the fruit berries of Viburnum mullaha can be potential source to combat the hidden hunger of micro and macro nutrient deficiencies. The

good composition of carbohydrate, protein and lipids (184 mg/g) make it a very nutritional fruit can be processed to develop various health products.

- In 30 villages of upper Kedar valley about 210 households have adopted the local value addition of variety of wild edible plants as small household activity for income generation. The various local value added products, i.e. squash, juice and sauce etc prepared by the people for their household consumption and also for marketing.
- Fodder Bank model has been developed on the5 ha degraded waste land of Maikhanda village in Rudraprayag district. In 2011 a total of 3750 fodder species (*Chimnobambusa falcata, Thamnocalamus spathiflorus, Arundinaria* spp, *Quercus leucotricophora, Ficus nemoralis, Ficus auriculata, Debregeasia salicifolia, Ficus subincisa, Celtis australis, Morus alba, Bauhinia varigata*) were planted in fodder bank model.
- Capacity building of women folk of Talla Maikhanda, Malla Maikhanda, Phata and Jamu for sustainable harvesting of fodder, raising fodder in their own lands, fast growing, high biomass yielding fodder species and scientific feeding methods for improved milk and other products.

HIMACHAL UNIT

- 265 species of vascular plants, 04 endemic, 75 near endemic, 05 species Critically Endangered; 08 Endangered, 12 vulnerable and 174 economically important species were recorded from the Nargu Wildlife sanctuary. Extraction trends of fodder species (21 spp.) in 23 villages showed mean collection, PU and RUI maximum for *Quercus leucotrichophora, Quercus semecarpifolia* and *Rhus javanica*, respectively. In CDBR, 57 sites representing 10 habitats and 06 aspects were sampled and total 121 species identified. Soil samples were analyzed for soil moisture (0.10%-35.13%), pH (6.58-8.30), total nitrogen (0.021-0.098%) and organic carbon (8.03-27.69%).
- Database for 476 species of medicinal plants recorded from Parbati Watershed, Chandra Valley, Upper Beas Valley, Mohal Khad watershed and Upper Banjar Valley of Himachal Pradesh, prepared. For all the five sites, nativity, endemism and threat categories of the species identified. From Parbati Watershed, 13 MPs were categorized as Critically Endangered and 9 Endangered; Chandra Valley, 15 MPs as Critically Endangered and 11 Endangered; Upper Beas Valley, 7 MPs as Critically Endangered and 10 Endangered; and Banjar Valley, 13 MPs as Critically Endangered and 12 Endangered. Population of Withania somnifera in 12 sites was assessed using quardrat method. Soil samples from all the sites analyzed for physical and chemical properties.
- Seed germination protocols for the *Corylus jacquemontii, Acer caesium, Buxus wallichiana and Pittosporum eriocarpum* and vegetative propagation protocols for *Platanus orientalis, Ulmus wallichiana* and *Tilia europea* were developed at Himachal Unit, Mohal-Kullu. Growth performance (i.e., shoot length, basal diameter, number of leaves, number of floral buds and number of fruit initiation) of *Aconitum heterophyllum*

populations under different treatments was monitored.

- Cultures of *Olea ferruginea* using nodal explants from mature tree of Kolibehar population were re-established. Murshige and Skoog's (MS) medium containing half strength salts and combination of BAP and NAA were found more suitable than either NAA or BAP alone in inducing bud breaks and shoot proliferation. Antioxidant potential of stem barks, leaves and fruits of Olea spp. were evaluated using three in-vitro models i.e., DPPH, ABTS and FRAP assays. Indian olive (Olea ferruginea) was identified as one of the potential and rich sources of natural antioxidants.
- Pollination Deficit Protocol for the apple (Himachal STEP Site) was tested. Responses of the farmers obtained and analysis revealed high level of awareness on pollination and pollinators amongst farmers.
- At Arboretum sites over 37 seedlings/plantlets of 07 species of ecological, economical and ornamental importance were planted. 101 seedlings of 11 tree species were planted in the 3rd class forest land at Mohal. Cultivation of Withania somnifera was initiated and over 4,000 seedlings were planted by a group of 35 farmers in Kullu and Mandi districts. Over 16,000 seedlings/plantlets of 18 MPs were developed in the Herbal Gardens and medicinal plants nurseries and distributed to different stakeholders including the participants of State Children Science Congress at Una. Over 1, 50,000 seedlings of Aconitum heterophyllum were raised by 20 farmers in the fields at Jana village and 60,000 seedlings at Khansar village by a farmer. One farmer from Jana village developed > 1, 50,000 seedlings of Aconitum heterophyllum and generated > Rs. 1, 00,000/- from the seeds and seedlings. Over 1200 seedlings of different multipurpose trees, medicinal plants and ornamental species were planted for development of campuses of three Govt. Senior Secondary Schools of Kullu Valley.
- Digital Elevation Model (DEM) and Triangulated Irregular Network (TIN) modeling with the help of RS & GIS within the Strategic Environmental Assessment (SEA) of hydropower project study showed the elevation of study area under the Sutlej Basin between 233-6751 m. Based on DEM modeling at small scale, maximum HEPs locations were identified between 2600-3200 m. While morphometric analysis of the lower Satluj catchment was done on the basis of DEM and TIN modeling.
- Aerosols were monitored with the help of Multi Wave Length Radiometer. AODs for the clear sky days at 500 nm was measured, it was found 0.59 on May 30, 2006, followed by 0.45 on November 5, 2007, 0.43 on September 14, 2008, 0.37 on September 2, 2009, 0.33 on November 24, 2010 and 0.61 on December 21, 2011. Due to these aerosols, the atmospheric heating rate in 2011 during pre-monsoon, monsoon, post-monsoon and winter came out to be 0.25 - 1.37 K day–1, 0.29 - 1.16 K day–1, 0.22 - 0.90 K day–1 and 0.22 - 0.97 K day–1.
- Ambient Air Quality (AAQ) at Hamirpur (790 m), Kangra (776 m) and Chamba (936 m) towns of Himachal Pradesh state was monitored in 2011 during pre-monsoon and

post-monsoon periods. Within ambient air, particulate pollutants like TSP (particles <100 μ), PM10 (particles <10 μ) and gaseous pollutants (SO2, NO2 and NH3) were monitored on diurnal basis starting from midnight (0 hr) up to morning 8 hr, then 8 to 16 hr in a day and finally16 hr to again midnight (24 hr IST). Many times the concentration of particulate pollutants was found to be above their permissible limits (i.e., TSP 200; PM10 100 μg/m3) in the study sites. However, the gaseous pollutants were found much below their permissible limits (i.e., SO2 80; NO2 80; NH3 400 μg/m3).

- The tourist inflow statistics for the state was compiled and analyzed for a broader understanding of its nature and trend-patterns. The inflow profile for period 2004 -11 suggest nearly 2.5 times increase in tourist inflow from 6.55 million in 2004 to 15.09 million in 2011. Linear mapping of Tourist Inflow (Y) for subscripted period against time (X) - Y2004-11 = 1212017 (X-2003) + 4546102; R-sq=.958, tcoff = 11.74, p=.00002, suggest an average growth of 1212017 tourists per year. The preliminary results of survey and reconnaissance in Dharamshala reveals western influence in lifestyle, cuisines, upcoming café, restaurants and building designs, and other touristic developments around Mcleodganj. It has also brought about a substantial economic transformation of villages of Gaddi tribe around Mcleodganj.
- Samples of apples (N=25), cauliflowers (N= 15) and tomatoes (N = 14) were analyzed for endosulfan sulphate, cypermethrin, chlorpyrifos and malathion using gas chromatograph. The concentration of tested pesticides were found below the maximum residue limits in samples of apples, cauliflowers and tomatoes collected from both field and market sites.
- One Day Training Workshop (March 14, 2012) on "Diversity Conservation and Utilization of Medicinal Plants" for the farmers of Mandi and Kullu districts.
- One Day Training Programme on "Weather Monitoring, Climate Change and Biodiversity Conservation and Management" for the teachers and students at GSSS, Raison, Distt Kullu (March 24, 2012); Training of Trainers (TOT) on Pollination and Pollinators (April 05, 2011) in collaboration with Dr. YSPUHF, Nauni, Solan and Interactive Workshop on Biodiversity Conservation, Pollinators, Pollination and Crop Production in collaboration with Fruit Grower's Association, Mahili, Patlikuhl (June 04, 2011) at Fruit Grower's Association, Mahili, Patlikuhl and Village Level Meetings (02) at Kais Village Panchayat Hall, Kais (November 04, 2011) and Naggar Panchayat Hall, Naggar (November o5, 2011) in collaboration with Dr. YSPUHF, Nauni, Solan for the Village Panchayat Pradhans, President and Members of Fruit Grower's Association and Orchardist/Farmers.
- One day training programme (March 26, 2012) on "Impacts of pesticides and heavy metals on plants and human health" for the farmers of Kullu district; and One Day Training Programme (March 27, 2012) on "Conservation and sustainable use of Kahu (Indian olive)" for the farmers of Kullu and Mandi districts; Consultative Meeting (march 28, 2012) on Tourism Sustainability in

Himachal Pradesh: Options and concerns for the GOs, NGOs and local inhabitants; two Interactive Workshops, one on SEA of hydropower projects (March 29, 2011, forenoon) and another on training workshop on solid waste management technology (March 29, 2011, afternoon) at GBPIHED, Himachal Unit, Mohal-Kullu, Himachal Pradesh; and Exposures Visits (10 Nos.) of the Institute demonstration sites for over 1,000 stakeholders representing GOs and NGOs and local Institutions were organized.

SIKKIM UNIT

- First time, a bench mark exploration along India-Nepal border in Yemtaar-Sukochuli-Neytham transect in Khangchendzonga Biosphere Reserve (west Sikkim) identified 12 forest communities.
- UNESCO nomin. doc, KBR applauded by MAB (ICC), UNESCO & MoEF, N. Delhi (as per MoEF communi. to Dir., GBPIHED & FEWMD, Sikkim).
- For Swertia chirayita, standardized cultivation in Sikkim [Zeit. für Arznei- & Gewürz. 16:118-124; 2011], and first time assessed the influence of microhabitats, light and temperature on seed germination.
- In-vitro Propagation protocol of critically endangered Rhododendron niveum (State tree) of Sikkim Himalaya has been achieved.
- Functional Gene Bank demonstration maintained/modified; innovative sue of local bamboo stems to check the soil/manure loss due to rains standardized.
- Conventional and in-vitro propagation protocols for selected Sikkim Himalayan Rhododendrons were developed.
- The spatial and attribute information of the landslides in the Sikkim Himalaya have been collected with the help of Global Positioning System (GPS) and they were transferred and integrated in the GIS milieu of Arc GIS software 9.3.
- Monitored and analyzed the status and trends of pollinators of Large cardamom in the STEP (Study, Training, Evaluation and Promotion) sites.
- One state level workshop organized by faculty with National Institute of Disaster Management (NIDM) and Land Revenue & Disaster Management (LR & DMD), Government of Sikkim.
- Environmental awareness and plantation programme was observed at Assam-Lingzey area falling under the Taktsom Chu watershed in the east district of Sikkim along with plantation of threatened and vulnerable plants. which were being reintroduced through tissue culture and available propagation technologies at GBPIHED-Sikkim Unit

NORTH EAST UNIT

- Conservation of rich biodiversity of selected proposed heritage sites in Arunachal Pradesh through stronger community/local institutions like Biodiversity Management Committees (BMCs) and community participation addressing critical issues such as hunting, shifting agriculture, community welfare and alternative livelihood. Twenty-two (22) BMCs formed under GOI-UNDP CCF-II Project, so far, have been adopted by Arunachal Pradesh Biodiversity Board

(APBB) strengthening the continuity and functionality of the BMCs.

- Promotion of gender focused enterprises and livelihood options such as agroforestry, pisciculture, piggery, home gardening, weaving, tailoring, bamboo crafting, beekeeping, etc., fund flow from which has empowered women economically.
- Creation/strengthening of Community Conserved Areas (CCAs) focusing on conservation of ecologically and socially valued wild flora and fauna, sustainable extraction of timbers and NTFPs, prohibition of hunting, revival of threatened wild flora and fauna through in-situ or ex-situ conservation, etc., in Arunachal Pradesh where the tribal communities are wary of using the existing Protected Area legislation and are not willing to create more PAs in the forest land owned by them as the present legislation does not adequately recognize their customary rights and ownership.
- Promotion of livelihood through large scale plantation of horticultural crops though bringing more than 60 ha of land under plantation of large cardamom (*Amomum subulatum*) and another 15 ha of land under orange (*Citrus reticulata*) and kiwi (*Actinidia deliciosa*) by the communities themselves.
- Strong and empirically sound data base on tourism potential all across the IHR.
- Analyses of adoption/adaptation scenario of tested/innovative resource management practices.
- Development of baseline information and identification of potential corridors for Namdapha National Park (Tiger Reserve) and Mouling National Park and documentation of 64 avifauna species are that are threatened because of hunting in TWKBR in Arunachal Pradesh.
- Evolving of strategies for management of critical flora/fauna and ecosystems through policy interventions including identification and prioritization of human-wildlife conflicts.
- Strengthened data on biodiversity, its management and policy through inventorization, prioritization, documentation of community practiced best practices of bioconservation and natural resource management.
- Ex-situ conservation initiative is furthered by bringing about 57 ha and 20 ha under *Taxus wallichiana* and *Michelia champaca* plantation, respectively, in project villages of GOI-UNDP CCF-II project in Arunachal Pradesh. In addition, 500 number of Castanopsis sp. were also planted at 'Siikhe-Bo' CCA in Apatani plateau. Considering the benefit of tree-crop farming system in climatically suitable regions of the area, cultivation of large cardamom is promoted in 29.5 ha of land. Also In an effort to popularise the ecologically efficient integrated pisciculture farming system for optimised production per unit available land, 1,00,000 fingerlings have been distributed to 190 beneficiaries of 15 villages in Apatani Plateau.
- Seven (7) women led SHGs were constituted in the project villages of GOI-UNDP CCF-II project in Arunachal Pradesh. Efforts for empowerment of SHGs has been vigorously carried out through activities like distribution of 150 kgs of yarn to the SHGs. One of the

SHGs, i.e., Yarke SHG supported under the project for weaving traditional bags earned about Rupees 15,000 during the reporting year. Tailoring, a gender focused activity is also promoted by providing sewing machines to the Hong Tailoring SHG of ong HHong Nichii and Hong Nitii villages in Apatani plateau and providing six month training on tailoring at KVIC centre, Midpu, Doimukh to six members of Tailoring SHGs. Five (5) SHGs were also encouraged to carry out income generation activities by rearing pigs. These SHGs were provided 45 piglets as well as feeds. In order to enhance the capacity and skill of the SHGs on beekeeping, 18 members of beekeeping SHGs were trained in a workshop on 28th September 2011.

- A medical camp was organized on eye on December 06, 2011 at Abotani Hall, Hapoli (Ziro) jointly with Arun Dristi, Naharlagun and Nature Care and Disaster Management Society, Ziro under GOI-UNDP CCF-II project in Arunachal Pradesh. A team of Doctors treated about 300 eye patients in the camp. The diagnosis of about 300 patients revealed that major eye problems prevalent in Ziro are Refractive error, Pterygium, Cataract, colour blindness, and infection, etc.
- The "Integrated Agro-Horti-Silvicultural Cultivation Model" developed under this project to address fallow management in shifting cultivation is adopted by Govt. of Arunachal Praedsh under its CAMPA programme and put in to practice in three districts of Arunachal.
- Analysis of the status and variations in the practices of shifting agriculture in north eastern states during the period 2005-2007 revealed that shifting cultivation, though responsible for deforestation, is not the singular factor of deforestation.
- Investigations made to understand the reasons behind the non-practice of shifting agriculture by the Monpa and Apatani communities revealed that in case of Apatani community in Ziro valley in Lower Subansiri district, temperate forests type, moderate nature of slope, valley land abundant with water for irrigation appeared to be a determining factor for practice of settled agriculture and non-practice of shifting agriculture. The cultural determinations also could not be ruled out, as the community, it appears, did not practise shifting agriculture since they migrated from South Tibet to Arunachal Pradesh. Some of the old people of the community profess that the community also did not practise shifting cultivation in South Tibet. However, this is being investigated. In case of Monpas, associated pastoralism and temperate type of forests in Tawang and West Kameng district are some of the factors for non-practice of shifting agriculture. In Tawang district pasture land constitutes about 7.3% of the total geographical area that facilitates pastoralism. Shifting agriculture across the globe is confined to tropical forests. However, Kalaktang sect of Monpa practise shifting agriculture. The cultural factors and their possible influences in non-practice of shifting cultivation in case of Monpas are being investigated.
- In an effort to understand the downstream impacts of hydroelectric projects in Himalayan region, water quality monitoring work has been started for Ranganadi Hydro Electric Project in Arunachal Pradesh in 12 permanent sites.

- Compilation and analysis of information on faunal diversity of Namdapha National Park showed representation of 1278 species belonging to 47 orders, 196 families and 588 genera while that of Mouling showed representation of 779 species belonging to 31 orders, 127 families and 462 genera. The Namdapha National Park represented 187 species of Mammals belonging to 10 orders, 34 families and 102 genera while the Mouling National Park represented 143 species of mammals belonging to 10 orders, 28 families and 87 genera. With respect to avifauna 490 species of bird belonging to 17 orders, 52 families and 217 genera were documented in Namdapha NP against 332 species belonging to 17 orders, 57 families and 187 genera in Mouling NP.
- With respect to possible wildlife corridor between Mouling and Namdapha national Parks it was found that there are some major rivers (tributaries of river Brahmaputra) flowing between both the national parks at relatively lower elevations. The river flowing between the national parks are significantly wide and deep and with extremely high current water with a large percentage of sediment, wildlife corridor between Mouling and Namdapha national Parks may not be possible.
- Major threat types were quantified for the avian species of both Mouling and Namdapha NPs. For example, in Mouling National it was observed that habitat loss poses as major threat to the avian population decline followed by shifting agriculture, housing and hunting.
- Investigations on culture in conservation revealed that different plants have got different cultural values and hierarchy among Monpa and Sherdukpen tribal communities in Arunachal Pradesh. Documentation of a total of 20 plant species (among them 8 with have high cultural value) preferred by Sherdukpen tribe were analyzed for the different values attached with them and ranked them accordingly. Further, 12 different plants were identified, which are at the height of religious importance (7 are having high religious value).
- The various animal body parts that are being traditionally used by Monpa community in Arunachal Pradesh in various aspects e.g. food, therapeutic purposes, traditional medicine and for storing various food grains and products were documented. A total of 10 species were recorded out of which species like Musk deer (*Moschus moschiferus*), Common Leopard (*Panthera parades*), Tiger (Panthera tigris), Asiatic Black Bear (*Urasus thibetanus*), Arunachal Macaque (*Macaca munzala*), Capped langur (*Trachypithecus pileatus*) and Himalayan Goral (*Naemorhedus goral*) were the endangered species.
- There are several lakes, most of which are high altitude water bodies in Western Arunachal Pradesh and studies revealed that many of them are playing significant role in maintaining ecological balance and are productive systems. Most of these wetlands are considered as sacred and there are strict taboos associated, which are followed with strict norms by the local Monpa people. These wetlands provide a good space for flourishing

high altitude rich biodiversity of this part of eastern Himalaya. Some of the endangered high altitude rare mammals like Musk Deer, Snow Leopard, Chinese Goral, Himalayan Goral, Red Goral, Blue sheep, Pika and avifauna like marmot are found in water bodies.

- Towards policy contribution, draft guidelines on Homestay (relating to tourism) and Community Conserved Area (CCA) are developed during the reporting year.

APPLICATION OF R&D OUTPUTS IN DEMONSTRATION AND DISSEMINATION

Integrated Eco-development Research Programme (IERP) in the Indian Himalayan Region

Ministry of Environment and Forests (MoEF), Government of India entrusted the responsibility of Integrated Action Oriented Research, Development and Extension Programme (termed as Integrated Eco-development Research Programme - IERP) in the Indian Himalayan region (IHR) to the Institute in 1992. The Institute funded R&D projects under two broad thrust areas [namely, Technology Development and Research (TDR) for Integrated Eco-development, and Technology Demonstration and Extension (TDE)] up to 2006-2007. Since then, location-specific/action-oriented IERP projects are being funded under 6 identified themes [namely, Watershed Processes and Management (WPM), Biodiversity Conservation and Management (BCM), Environmental Assessment and Management (EAM), Socio Economic Development (SED), Biotechnological Applications (BTA), and Knowledge Products and Capacity Building (KCB)] of the Institute.

Objectives

- To provide extra mural funds to different Universities/Institutions/NGOs/Voluntary agencies for the support of location-specific R&D activities in the Indian Himalayan region (IHR).
- To develop scientific capabilities in the IHR and strengthen infrastructure for environmental research.
- To develop and execute coordinated programmes as per R&D needs of the IHR or on the recommendations of the completed projects with the help of identified network partners.

Achievements

- Based on the recommendations of the 15th Project Evaluation Committee (PEC), 9 new projects (3 under BCM theme, 4 under SED theme and 2 under WPM theme) were sanctioned for execution in the 2 States (namely, Himachal Pradesh and Uttarakhand) of the Indian Himalayan region.
- Funds for 25 ongoing/completed projects were released to different organizations after careful examination of Utilization Certificates (UCs) and Statement of Expenditures (SEs).
- Annual Progress Reports (APRs) of 25 on-going projects were processed and referred to the subject experts for evaluation. Subsequently, the comments of the subject experts on the APRs were sent to the concerned PIs for follow-up action.
- Final Technical Reports (FTRs) of 17 completed

projects were sent to various govt./user agencies for follow-up action on the recommendations of the project and also to the subject experts for their comments/suggestions.

- Coordinated programme entitled "*Sacred values, eco-restoration and conservation initiatives in the Indian Himalayan region*" was continued and strengthened in the two States (namely, Uttarakhand and Meghalaya) of the IHR.
- Forty one IERP projects were on-going in 5 States (namely, Himachal Pradesh, J&K, Meghalaya, Nagaland and Uttarakhand) of the Indian Himalayan region.
- Follow-up action on 110 project files (old/fresh/on-going/miscellaneous, etc.), excluding routine correspondences of about 568, was initiated/completed during the year 2011-12.

Strengthening and Management of ENVIS Centre in the Institute *(1992 – Long Term Scheme, **MoEF**, 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 and Forests (MoEF), Govt. of India; the nodal agency in the country for collecting and collating all available information from all the ENVIS Centres to provide national scenarios to the international set up, INFOTERRA Programme, of the UNEP.

Objectives

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

Achievements

- Information on various aspects of Himalayan Ecology from various District Information Centres, Universities/University Campuses, Research Centers, Government Institutions, NGOs and experts/individuals working in the Indian Himalayan region (IHR) were collected and compiled during the year 2011-12.
- Research abstracts/articles/technical reports and news-clippings on Himalayan environment related issues were collected from various sources. The abstracts and news-clippings (bi-lingual) were published in the 'Selected Abstracts' and 'News and Views' section of the ENVIS Bulletin (Vol. 19, pp. 1-80, 2011).
- About 15 research abstracts, related to the various aspects of Himalayan Ecology, were added on the Abstract Database of the ENVIS Centre. At present, this database contains 1995 abstracts.
- State-wise and district-wise resource profile (related to demography as per Census 2011, educational infrastructure, health, agricultural and forest cover, etc.) of all the Indian Himalayan states has been compiled for uploading in the website of the ENVIS Centre.
- Information on medicinal plants; rare, endangered and threatened (RET) species; and most traded plants of the Indian Himalayan region has been collected and compiled for uploading in the website of the ENVIS Centre.
- Information on the books available at the library in the headquarters of the Institute has been collected and compiled for uploading in the website of the ENVIS Centre.
- Information on the subject experts, working on different aspects of Himalayan Ecology, has been collected, compiled and updated for uploading in the website of the ENVIS Centre.
- Information on the Ph.D. theses awarded by the

HNB Garhwal University, Srinagar, Garhwal, Uttarakhand w.e.f. 1976-2011 and Kumaun University, Nainital, Uttarakhand w.e.f. 1978-2005 has been collected and compiled for uploading in the website of the ENVIS Centre.

- About 40 queries, related to Himalayan environment and development, were responded to the individuals/institutions during the year 2011.
- All available information on various aspects of Himalayan Ecology, which were collected and compiled during the year, were disseminated to 481 stakeholders through electronic and print media.
- Electronic versions of all the ENVIS publications in CD formats were prepared and distributed to various stakeholders.
- ENVIS Book entitled "*Glimpses of Forestry Research in Indian Himalayan Region*" was prepared and published on the occasion of International year of Forests – 2011.
- ENVIS Bulletin (Volume 19) and ENVIS Newsletter (Volume 8) on Himalayan Ecology were prepared, published and made online through the website of the ENVIS Centre.\
- All the publications of the ENVIS Centre, such as - ENVIS Bulletins, ENVIS Monographs and ENVIS Newsletters, which were published so far, were uploaded (in PDF format) in the website of the ENVIS Centre.
- Website of the ENVIS Centre on Himalayan Ecology <**http://gbpihedenvis.nic.in**> was re-designed, maintained and upgraded at the headquarters of the Institute (GBPIHED); efforts for the conversion of ENVIS website from its STATIC mode to DYNAMIC mode were also carried out.

Central Library Facility

The Central Library of the Institute at its headquarters, at the end of financial year 2011-2012, had 15,031 books. The library is subscribing a total of 95 periodicals (57 Foreign and 38 Indian). For management of Library and Information Centre, a network version of the software PALMS developed by the Scientist of this Institute is being used. As a result, the Library is providing a number of services such as Article Alert, Current Awareness, Selective Dissemination of Information, Reprography, Reference, Indexing, Bibliography, Web Services (Online Journals) etc., for the development of the human resources. The Library of the Institute is accessible through the Institute's web site (http://gbpihed.gov.in). During the reporting year, 457 new book titles were added to the Library. R & D achievements of the Institute were disseminated through its regular in-house publications, namely Hima-Paryavaran – a biannual newsletter and Institute Annual Report to various academic and scientific institutions, Government departments, NGOs, policymakers, planners and individuals working on various aspects of mountain environment and development.

Central Laboratory Facility

Institute has strengthened the facilities of physico-chemical, biological, heavy metal analysis of drinking, raw and waste water and quantification of volatile compounds of soil and plant samples. The heavy metals in the water and soil samples are detected through Atomic Absorption Spectrophotometer (Make- Varian AA280Z, equipped with graphite tube atomizer). For the quantification of aromatic and volatile compounds institute have Gas Chromatograph (Make- Chemito, Ceres 800^{+}). Institute is also having the facility of detection of C, H, N & S through CHNS-O analyzer (Make- Elementar, Vario EL-*III*) and UV-Vis spectrophotometer (Make- UV 5704, Electronics corporation of India Ltd.) for soil, water & plant analysis. The Institute has extended these services for other organizations (NGOs and other Government Organization) on payment basis. In the financial year

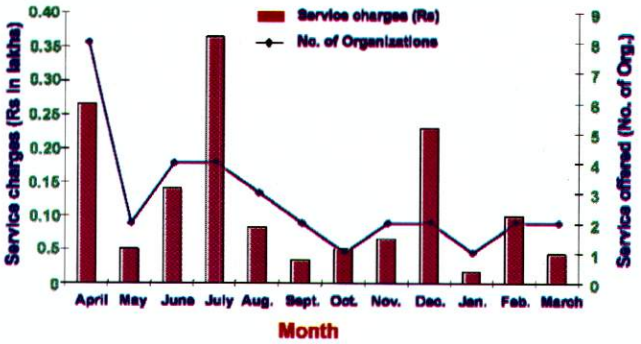
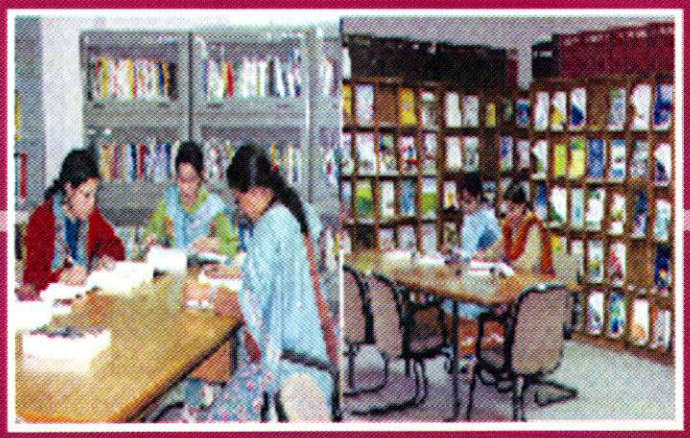


Fig.79. Total charge fee collected from Central Laboratory Services in 2011-12.

2011-12, Institute has collected 1.40 lakh rupees as a central laboratory service charge from 33 organizations (8 - Govt. organization & 25 - NGOs). Fig.79 shows month wise collection of testing charges and service offered to different organizations.



MISCELLANEOUS ITEMS

1. SCIENTIFIC PUBLICATIONS

(I) Scientific Journals

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(III) Authored/ Edited Books/ Booklets/ Bulletins/ Monographs

- **Dhyani, P.P. (2011). ENVIS Bulletin on Himalayan Ecology 19.**
- **Dhyani, P.P. (2011). ENVIS Newsletter on Himalayan Ecology 8, (2012).**
- **Farooquee, N.A., Pernille Gooch, R.K. Maikhuri and D.K. Agarwal (2011).** *Sustainable Pastoralism in the Himalayas* (eds.), Indus Publishing Company, New Delhi. 263p.
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(IV) Popular Articles

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- **Sharma, R.K., S. Devi and P.P. Dhyani** (2010). Comparative assessment of the toxic effects of copper and cypermethrin using seeds of *Spinacea oleracea* l. plants. *ENVIS Bulletin on Himalayan Ecology,* 18: 10-13.
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2. AWARDS AND HONOURS

- Bharat Jyoti Award 2012, for meritorious services, outstanding performance and a remarkable role conferred by India International Friendship Society, New Delhi.**(Ghosh, Paromita).**
- Best Citizens Award by International Publishing House, New Delhi and Bharat Jyoti Award by India International Friendship Society, New Delhi in the Year 2012 **(Dr. G.C.S. Negi).**
- Elected Fellow of the Society of Ethnobotanists by the Society of Ethnobotanists in the year 2010 **(S.S. Samant).**

Participation of Institute Faculty/Project Staff in Different Events:

Events	HQs	Units				*Total*
		NE	Sikkim	Garhwal	HP	
National						
• Conferences / Workshops	56	26	33	28	71	**212**
• Training Courses	25	04	34	12	14	**88**
• Meetings	33	10	37	17	37	**139**

ANSUL AGRAWAL & CO.
Chartered Accountants
Sela Khola, Chaughan Pata, Near P.W.D. Office, Almora-263601 (Uttarakhand)
Tel. : 05962-230158, 232158 Fax : 05962-231030 Mobile : 94101-83805, 098101-53504
E-mail : ansulagrawal@rediffmail.com

To Members
G.B.PANT INSTITUTE OF HIMALAYAN
ENVIRONMENT & DEVELOPMENT,
NEW DELHI

We have audited the attached Balance Sheet of **G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT (A Institute of Govind Ballabh Pant Himalaya Paryavaran Evam Vikas Sansthan)** which are in agreement with the books of accounts, maintained by the Institute as on 31st MARCH,2012 We have obtained all the information & explanations, which to the best of our knowledge and belief were necessary for the purpose of audit. In our opinion, proper books of accounts, as required by the law have been kept by the Head Office and the Units of the above named Institute, so far as appears from our examination of the books. Proper returns adequate for the purpose of audit have been received from Units not visited by us, subject to the Notes on Accounts and comments given below:-

The Institute has provided depreciation on fixed assets as per straight line method at the rates provided in Companies Act, 1956 in place of Income Tax Act & rules.

In our opinion, and to the best of our information and according to the explanations given to us and subject to the notes forming part of accounts the said accounts give the true and fair view :-

I) In the case of Balance Sheet of the State of Affairs of the above named Institute as on 31st MARCH, 2012 and

ii) In the case of Income & Expenditure accounts of the INCOME of its accounting year ending 31st MARCH, 2012

FOR ANSUL AGRAWAL & Company
CHARTERED ACCOUNTANTS

(C.A.ANSUL AGRAWAL)
PARTNER

DATED : 04/09/2012
PLACE : ALMORA

ANSUL AGRAWAL & CO. Chartered Accountants ALMORA

G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT
KATARMAL, KOSI (ALMORA) UTTARAKHAND
BALANCE SHEET AS ON 31ST MARCH 2012

PARTICULARS	SCHEDULE	CURRENT YEAR (₹)	PREVIOUS YEAR (₹)
LIABILITIES			
CORPUS / CAPITAL FUND	1	69536388.81	61481057.71
RESERVE AND SURPLUS	2	405890482.46	404028310.17
EARMARKED / ENDOWMENT FUNDS	3	0	0
SECURED LOANS & BORROWINGS	4	0	0.00
UNSECURED LOANS & BORROWINGS	5	0	0.00
DEFERRED CREDIT LIABILITIES	6	0	0.00
CURRENT LIABILITIES AND PROVISIONS	7	61115506.59	73850837.23
TOTAL		**536542377.86**	**539360205.11**
ASSETS			
FIXED ASSETS	8	405890482.46	404028310.17
INVEST. FROM EARMARKED/ENDOWMENT FUND	9	66206455.71	52622055.92
INVEST. OTHERS	10	0	0.00
CURRENT ASSETS , LOANS, ADVANCES ETC.	11	64445439.69	82709839.02
MISCELLANEOUS EXPENDITURE			
TOTAL		**536542377.86**	**539360205.11**
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES & NOTES ON ACCOUNTS	25		

AUDITOR'S REPORT
As per our separate report of even date annexed.
FOR: ANSUL AGRAWAL & CO.
CHARTERED ACCOUNTANTS

(CA. ANSUL AGRAWAL)
PARTNER
M No. 092048

ANSUL AGRAWAL & CO. Chartered Accountants ALMORA

DATED : 04/09/2012
PLACE :ALMORA

(DR.L.M.S. PALNI)
DIRECTOR

(Dr. S.C.R. Vishvakarma)
D.D.O

(SURYA KANT)
ACCOUNTS OFFICER

G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT
KATARMAL, KOSI (ALMORA) UTTARAKHAND
INCOME & EXPENDITURE A/C FOR THE YEAR ENDED 31ST MARCH 2012.

PARTICULARS	SCHEDULE	CURRENT YEAR (₹)	PREVIOUS YEAR (₹)
INCOME			
Income from Sales/Services	12	59755.00	254466.50
Grants/Subsidies(net off exp)	13	128803394.00	120067716.9
Fees/Subscriptions	14	0.00	0.00
Income tfr from Fixed Assets fund	-	21079559.71	20101215.14
(to the extent of depreciation & WDV of asset sold)			0.00
Income from Royalty, Income from Inv. Publication etc.	16	0.00	0.00
Interest Earned	17	1605085.10	2129872.41
Other Income	18	1665093.00	2324585.88
Increase (decrease) in stock of Finished goods and work in progress)	19	0.00	0.00
TOTAL (A)		**153212886.81**	**144877856.87**
EXPENDITURE			
Establishment Expenses: a) Institute	20	52368082.00	46600236.00
b) Projects		7061433.00	8602695.00
c) F.C (Projects)		1141144.00	1687892.00
Administrative Expenses :a) Institute	21	40391726.00	35065277.94
b) Projects (As per Annexure)		17321694.00	16366781.00
c) F.C (Projects)(As per Annexure)		3511760.00	4989405.00
Expenditure on Grants, Subsidies etc.	22	7007555.00	6755430.00
Interest			0.00
Depreciation (Net Total at the year-end-as per Sch. 8)		21079559.71	20101215.14
TOTAL (B)		**149882953.71**	**140168932.08**
Balance being excess of Income over Expenditure (A - B)			0.00
Transfer to special Reserve			**0.00**
Transfer to/ from General Reserve			**0.00**
BAL.BEING SURPLUS TRF.TO CORPUS/CAPITAL FUND		**3329933.10**	**4708924.79**
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	25		

AUDITOR'S REPORT
As per our separate report of even date annexed.
FOR:ANSUL AGRAWAL & CO.
CHARTERED ACCOUNTANTS

(C.A.ANSUL AGRAWAL)
PARTNER
M No. 092048

ANSUL AGRAWAL & CO. Chartered Accountants ALMORA

DATED : 04/09/2012
PLACE :ALMORA

(DR. L.M.S. PALNI)
DIRECTOR

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D.D.O

(SURYA KANT)
ACCOUNTS OFFICER

G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT

KATARMAL, KOSI (ALMORA) UTTARAKHAND

RECEIPTS & PAYMENTS A/C FOR THE YEAR ENDED 31ST MARCH 2012

RECEIPTS	CURRENT YEAR	PREVIOUS YEAR	PAYMENTS	CURRENT YEAR	PREVIOUS YEAR
I. Opening Balances			**I. EXPENSES**		
a) Cash in hand	128345.13	35553.49	**a) Establishment Expenses**	43256063.53	44152200.91
			I) Institute		
b) Bank Balances			**b) Administrative expenses**		
			a) Institute	23984593.00	22303625.94
i) In current accounts	7273271.40	11502199.80	b)R&D(Rev) expenses	15728053.00	12606240.00
ii) In deposit accounts (Corpus Fund)	20931307.92	29396720.48	c) Payments for current liabilities(gratuity/leave)	1096659.00	795216.00
iii) Savings accounts	34235962.93	37756130.41	**C. Capital expenditure**		
c) Advances & Others	88853165.03	56292508.77	a) Purchase of Fixed Assets	12493376.00	10992538.00
(As per annexure Attached)			b)Expenditure on Capital Work in Progress	965000.00	0.00
			c) Acquirement of land (Lease money)	0.00	0.00
F.C. ACCOUNT			**II Payments made against funds for various proj.**		
A) Cash in hand	27798.33	10321.33	**Expenditure State govt. projects**		
b) Cash at bank	339951.72	3299753.07	a) Capital	1758056.00	5677168.00
c)FC Advances	0.00	0.00	b) Revenue;		
II. Grants Received			Establishment exp	6472262.23	7774916.00
a) From Government of India			Administration exp	17310458.00	16355751.00
i) Institute	99717650.00	110000000.00	**Expenditure FC projects**		
ii) IERP Projects	0.00	0.00	**a) Capital**	2173027.00	1794432.00
b) From Other agencies	21608818.00	3439812.00	**b) Revenue:**		
c) From other sources [from FC]	7697323.55	6230998.47	Establishment exp	1019276.00	1684940.00
III. Income on Investments from			Administration exp	3551419.00	4989405.00
a) Corpus Fund	4725398.00	2617256.00		7007555.00	6755430.00
IV. Interest Received			**IERP grant released**		
a) On Bank deposits savings a/c	1461771.10	1851593.41	**III Investments and deposits made**		
b)On term deposits a/c	0.00	25767.00	Corpus Fund	29759000.00	2617250.00
c) Loans, Advances etc.	143314.00	252512.00	**IV Refund of Surplus money/Loans**		
			a) To the Government of India	1361457.00	1128864.00
			b)To Others/ security/ caution money)	2500.00	1000.00
V. Other Income					
(As per annexure Attached)	1724848.00	2579952.38	**V Other payments**		
VI. Amount Borrowed		0.00	Other Payment to Instt. FC Proj.	111422.00	
VII. Any other receipts.	0.00	0.00	Current liabilities	4568880.74	6412952.97
b) Other Receipt FC a/c	111422.00	2036605.17	**VI Closing balances**		
c) receipts current liabilities	0.00	0.00	**a) Cash in hand**	177496.63	128345.13
d) IERP grants refunded by grantee Org.	262585.00	223125.50	**b) Bank Balance**		
e)Construction Fund	0.00	0.00	i) In Current account	0.00	7273271.40
f) Corpus Fund FDR'S	0.00	0.00	ii) In deposit accounts (Corpus Fund)	498215.71	20931307.92
g) Caution Money	6500.00	1000.00	iii) In savings accounts	25260003.44	34235962.93
h) Security Deposit	0.00	100000.00	**Cheque in transit:**	0.00	769171.00
i) EMD	155000.00	0.00	**C) Advances and others**	89823209.43	88853165.03
			FC Project	0.00	
			a) Cash in hand	18975.33	27798.33
			b) Bank Balance	1007474.07	339951.72
TOTAL	**289404432.11**	**298601903.28**	**TOTAL**	**289404432.11**	**298601903.28**

AUDITOR'S REPORT

As per our separate report of even date annexed.

FOR: ANSUL AGRAWAL & CO.

CHARTERED ACCOUNTANT

(CA.ANSUL AGRAWAL)
PARTNER
M No. 092048
DATED : 04/09/2012
PLACE :ALMORA

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G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT
KATARMAL, KOSI (ALMORA) UTTARAKHAND

STATEMENT OF OPENING & CLOSING BALANCES

PARTICULARS	OPENING AMOUNT	CLOSING AMOUNT
Cash & Bank Balances		
Cash In Hand :		
Srinagar	4632.85	278.85
Sikkim	6078.00	7439.00
Kullu	12061.40	74771.40
Itanagar	24658.16	41907.66
Grant in aid in transit (Biotech-XIII)	184000.00	184000.00
Cheque in transit: (NE Unit)	769171.00	316605.20
Cash at Bank Balances		
SBI Almora A/c No.10861378091 (Corpus)	20931307.92	498215.71
SBI Tadong A/c No 11226047758	416122.84	240626.84
SBI Kullu A/c NO. 10792147561	920181.78	1880141.78
SBI Itanagar A/c No 10940060114	3487038.78	3357712.28
SBI Srinagar A/c No 10972182864	1015119.53	679636.53
Advances		
House Building Advance	2082467.00	1779768.00
Motor cycle/Car Advance	182575.00	134047.00
Festival Advance	31500.00	33000.00
Computer Advance	0.00	27000.00
C.P.F	71.00	0.00
Income tax deducted at source	191498.00	191498.00
Units of Institute:		
Sikkim Unit	-74894.23	-51387.82
HP Unit	-221110.00	-73110.00
Garhwal Unit	25000.00	0.00
NE Unit	14300.00	0.00
FC Advances:		
Elcom Technology Pvt. New Delhi	0.00	1084101.00
ICIMOD RSR (LOA-I)Director, Wild Life Dehradun	729000.00	729000.00
ICIMOD RSR (LOA-III)Director, Wild Life Dehradun	270250.00	270250.00
ICIMOD RSR (LOA-I)M/S TATA Motars N. Delhi	941990.00	177.00
ICIMOD India Day Workshop Habitat World N.Delhi	0.00	70000.00
ICIMOD India Day Workshop The Energy Resources instt.	0.00	75000.00
E.T.& T.N.DELHI(INDO-CANADIAN SUMMER)	2880.00	2880.00
NRSA HYDERABAD(PARDYP)	32274.00	32274.00
Fixed Deposit		
Corpus Fund FDR'S	26051545.00	62028378.00
Interest Accrued on Corpus fund FDR	5639203.00	3679862.00
FDR (Margin Money/LC A/C)		
Institute	6364.00	6364.00
BIOTECH -XI	577.00	577.00
ISRO-JCK-EO (HP Unit)	625000.00	580582.00
TOTAL:	**64300862.03**	**77881595.43**

G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT
KATARMAL, KOSI (ALMORA) UTTARAKHAND

Brought forward	**64300862.03**	**77881595.43**
Due Staff/ other IC A/c		
Dr. L.M.S. Palni	120000.00	120000.00
Ms. Sarita Bagdwal	50000.00	50000.00
Receivable from Sikkim Unit	0.00	800.00
STUP Consultant	(7435.00)	(7435.00)
LICOR INC USA	54460.00	54460.00
Tuder Rose UK (Instt.)	0.00	88535.00
S.K. Diesel Sales (Instt.)	0.00	66538.00
Wipro GE Health Care (Instt.)	0.00	296534.00
Elemonter Analyser (Instt.)	0.00	165000.00
VPKAS Almora (Instt.)	0.00	26560.00
Saveer Biotech New Delhi	0.00	156334.00
Adv. to NIH Roorkee	100000.00	100000.00
Post Master G.P.O Almora	40566.00	40566.00
Employment News	48287.00	48287.00
Sigma Aldrich Chemicals	10590.00	10590.00
Siltap Chemicals Ltd (Biotech -III)	408.00	408.00
Adv.to Indraprasth Medical Cor. N. Delhi	243702.00	0.00
DST (LMS) ILTP NRSA Hyderabad	48000.00	48000.00
NRSA Hyderabad	35300.00	35300.00
R.K.Nanda & Sons	28517.00	28517.00
NICSI New Delhi	35106.00	35106.00
B S N L Banglore	2912596.00	0.00
Security Deposit CET Sikkim Unit	11000.00	11000.00
Uttranchal Renewal (UREDA) LDA Project	50386.00	0.00
NRSA Hyderabad (NNRMS Proj.)	0.00	1970000.00
NRSA Hyderabad (ISRO GBP SSS)	350000.00	350000.00
NRSA Hydrabad (DST-KK-I)	7400.00	7400.00
F.C.Inter A/C	2500.00	0.00
M/s CCU New Delhi	11291753.00	1646753.00
Security Deposit NE Unit	1750.00	1750.00
NCADMS, Itanagar (MOE&F CC-II)	756098.00	160288.00
N.E. Regional Institute, Itanagar (MOE&F UNDP CCF)	1449779.00	815060.00
EE R.E.S. Almora (MOE&F (BG) RSR	3402000.00	3402000.00
EE R.E.S. Almora Insitute	1571000.00	1571000.00
WWF New Delhi (UNDP-CEF-GOL) NE Unit	1210829.00	418070.00
Director State Forest Research Institute (UNDP-CEF-GOL) NE U	656711.00	193.00
Dr. Hari Ballabh MoE&F Hydropower Project	12000.00	0.00
M/S Kasar Jungle Resort (ICTS RSR Wks.)	0.00	60000.00
M/S Mohan's Café (ICTS RSR Wks.)	0.00	25000.00
M/S Imperial Heights (ICTS RSR Wks.)	0.00	30000.00
M/S Paramount Pathfinders (ICTS RSR Wks.)	0.00	50000.00
E E R.E.S. Almora (HRDI I.D.B Project)	59000.00	59000.00
TOTAL	**88853165.03**	**89823209.43**

G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT
KATARMAL, KOSI (ALMORA) UTTARAKHAND
SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2012.

SCHEDULE 8 - FIXED ASSETS
(DETAILS AS PER ANNEXURE ATTACHED)

(In Rupees)

S NO.	DESCRIPTION	GROSS BLOCK				DEPRECIATION				NET BLOCK	
		Cost as at beginning of the year	Additions during the year	adj/deduction during the year	Cost at the end of the year	depreciation for prior periods	depreciation for current year	adj/deduction for previous years	Total up to the end of the year	As at the current Year end	As at the previous year-end
	A. FIXED ASSETS:										
1	**LAND:**										
	a) Freehold	75639.23	0.00	0.00	75639.23	0.00	0.00	0.00	0.00	75639.23	75639.23
	b) Leasehold	40690826.00	0.00	0.00	40690826.00	135634.00	135634.00	0.00	271268.00	3797758.00	3933392.00
2	**BUILDING:**										
	a) On Freehold Land	214751988.00	0.00	0.00	214751988.00	29684716.81	3500457.40	0.00	33185174.21	181566813.79	185067271.19
3	**PLANT MACHINERY & EQUIPMENT**										
	a) Scientific Equipments	163881311.11	5932973.00	0.00	169814284.11	73586903.66	8066178.50	0.00	81653082.16	88161201.95	90294407.42
4	**VEHICLES**	8267959.25	760825.00	523964.95	8504819.30	5959824.64	848199.70	523964.95	6284059.39	2220759.91	2308134.61
5	**FURNITURE FIXTURES**	23665547.40	970833.00	0.00	24636380.40	14254056.15	1559482.88	0.00	15813539.03	8822841.37	9411491.25
6	**OFFICE EQUIPMENT**	21807068.35	2969277.00	0.00	24776345.35	9714093.84	2353752.81	0.00	12067846.65	12708498.70	12092974.52
7	**ELECTRICAL INSTALLATION**	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	**FIRE FIGHTING EQUIPMENTS**	60962.00	0.00	0.00	60962.00	43435.45	2895.70	0.00	46331.15	14630.86	17525.56
9	**LIBRARY BOOKS**	86130847.50	7072524.00	0.00	93203371.50	34992050.85	4427160.15	0.00	39419211.00	53784160.50	51138796.66
10	**TUBE WELLS & W. SUPPLY**										
11	**OTHER FIXED ASSETS**										
	GLASS / NET HOUSE	3911549.00	0.00	0.00	3911549.00	2722998.27	185798.58	0.00	2908796.85	1002752.15	1188550.73
	TOTAL OF CURRENT YEAR	**526621897.84**	**17706432.00**	**523964.95**	**543804364.89**	**171093713.67**	**21079559.71**	**523964.95**	**191649308.43**	**352155056.46**	**355528184.17**
	PREVIOUS YEAR	**508838537.84**	**18467138.00**	**683778.00**	**526621897.84**	**151673419.03**	**20101215.14**	**680920.50**	**171093713.67**	**355528184.17**	**357165118.81**
	B CAPITAL W I P										
	Acquirement of land (Lease money)	0	0.00	0	0.00	0.00	0	0	0	0.00	0.00
	CCU Delhi	48500126.00	9295000.00	4059700.00	53735426.00	0.00	0.00	0.00	0.00	53735426.00	48500126.00
	ASSET UNDER INSTAL/TRANSIT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	**575122023.84**	**27001432.00**	**4583664.95**	**597539790.89**	**171093713.67**	**21079559.71**	**523964.95**	**191649308.43**	**405890482.46**	**404028310.17**

ANSUL AGRAWAL & CO. Chartered Accountants ALMORA

INSTITUTE SUPPORTING STAFF

HEAD QUARTERS

K.K. Pande	Finance Officer (Retd. on 31.12.2011)
Surya Kant Langayan	Accounts Officer
L.M.S. Negi	Office Superintendent (Admn.)
Sanjeev Higgins	Technical Gr. – III(2)
Preeti Tiwari	Technical Gr. – IV(1)
Sarita Bagdwal	Stenographer
Jagdish Kumar	Stenographer
Mamta Higgins	U.D.C.
Heera Singh	U.D.C.
K.K. Pant	U.D.C.
Hema Pandey	U.D.C.
S.K.Gurani	L.D.C.
Suraj Lal	L.D.C.
Jagdish Singh Bisht	Technical Gr. – II(1)
R.C.Bhatt	Driver
Chandra Lal	Driver
K.N.Pathak	Technical Gr. – I(3)
Pan Singh	Peon
G.D.Kandpal	Peon/Mali
Nathu Ram	Peon/Mali
Ganga Joshi	Peon
Kanshi Ram	Peon/Mali

GARHWAL UNIT

D.P. Kumeri	L.D.C.
M.P. Nautiyal	Driver
J.M.S. Rawat	Driver
R.C. Nainwal	Field Assistant
R.P. Sati	Peon

HIMACHAL UNIT

S.P. Maikhuri	Office Superintendent
Daulat Ram	Peon

SIKKIM UNIT

R.K. Das	L.D.C
Jagnnath Dhakal	Technical Gr. – I(3)
P.K. Tamang	Technical Gr. – I(3)
Musafir Rai	Peon
Shyambir	Peon

INSTITUTE FACULTY

HEAD QUARTERS		
L.M.S Palni	Director	Plant Physiology; Biochemistry; Biotechnology
P.P.Dhyani	Scientist-G	Plant Physiology; Restoration Ecology
Kireet Kumar	Scientist-F	Environmental Engineering; Hydrology
S.K. Nandi	Scientist-F	Plant Physiology;
Biochemistry		
R.C. Sundriyal	Scientist-F	Plant Ecology; Rural Ecosystems (On Deputation)
Anita Pandey	Scientist-E	Microbiology
S.C.R. Vishvakarma	Scientist-E	Plant Ecology; Rural Ecosystems
B.P. Kothyari	Scientist-E	Plant Pathology; Restoration Ecology
D.S. Rawat	Scientist-E	Settlement Geography; Rural Ecosystems
R.S. Rawal	Scientist-E	High Altitude Ecology; Conservation Biology
G.C.S. Negi	Scientist-D	Forest Ecology; Watershed Management; EIA
R.C. Prasad	Scientist-D	Library & Information Science; Documentation
Subrat Sharma	Scientist-C	Agroecology; Remote Sensing / GIS
I.D. Bhatt	Scientist-C	Plant Physiology; Phytochemistry
R.K. Singh	Scientist-C	Information Technology
A.K. Sahani	Scientist-C	Social Science; Anthropology
Rajesh Joshi	Scientist-C	Mathematical Modeling
K.C. Sekar	Scientist-C	Plant Taxonomy; Animal Taxonomy
Shilpi Paul	Scientist-C	Molecular Biology; Plant Biotechnology
Vasudha Agnihotri	Scientist-B	Soil Science; Plant Analysis; Instrumentation
R.G. Singh	Tech. Grade IV (3)	Applied Arts; Photography, Social Science
B.S.Majila	Tech. Grade IV (3)	Forest Ecology; Restoration Ecology
Subodh Airi	Tech. Grade IV (2)	Forest Ecology; Biotechnology
HIMACHAL UNIT		
S.S. Samant	Scientist-E & In-charge	Plant Taxonomy; Conservation Biology
J.C. Kuniyal	Scientist-D	Development Geography; Waste Management
Ranjan Joshi	Scientist-C	Ecology Economics; Resource Valuation
R.K. Sharma	Scientist-C	Policy Analysis; Environmental Management
SIKKIM UNIT		
H.K. Badola	Scientist-E	Morphoanatomy; Conservation Biology
K.K. Singh	Scientist-D & In-charge	Plant Physiology; Stress Physiology
L.K. Rai	Tech. Grade IV (3)	Plant Taxonomy
Y.K. Rai	Tech. Grade IV (3)	Rural Ecosystems
GARHWAL UNIT		
R.K. Maikhuri	Scientist-E & In-charge	Plant Ecology; Rural Ecosystems
S.C. Joshi	Scientist-E	Plant Physiology; Stress Physiology
Paromita Ghosh	Scientist-C	Plant Science; Soil Science
S. Tarafdar	Scientist-C	Weather & Climate Change; Glaciology; Hydrology
NORTH-EAST UNI		
P.K. Samal	Scientist-E & In-charge	Social Science; Anthropology
M.S. Lodhi	Scientist-C	Environmental Assessment
S.C. Arya	Scientist-B	High Altitude Ecology
S. Chaudhary	Tech. Grade IV (2)	Conservation; Biological Diversity