ANNUAL REPORT
2010-2011







G.B. Pant Institute of Himalayan Environment & Development

(An Autonomous Institute of Ministry of Environment and Forests, Govt. of India)

Kosi-Katarmal, Almora - 263 643, Uttarakhand, India

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CONTENTS

FOREWORD

This Institute's mandate includes, amongst other issues, providing suggestions for sustainable development of the Indian Himalayan Region (IHR); suggesting a developmental roadmap that is able to address and reconcile important environmental concerns of the IHR, indeed a challenging task. Given the physiographic and cultural diversity of the Himalaya, that is ecologically fragile and highly sensitive to climate change, such an endeavour needs good understanding of the Himalayan environment, natural resource dynamics, developmental concerns, institutional set-ups and governance issues. The Institute through its R&D activities under six Thematic Programmes attempts to analyze some of these aspects so as to provide meaningful support for informed policy planning, and decision making in the IHR.

The progress of work for presenting the reporting year 2010-11 includes the salient achievements of various in-house projects which include studies on developmental issues pertaining to watershed management; SEA and EIA of hydropower projects; sustainability aspects of tourism; conservation prioritization and policy implication of studies on biodiversity conservation under natural and managed systems; pan-Himalaya and long-term environmental monitoring studies on tectonic deformations; climate change impact studies related to future water resource availability and structural and compositional changes in vegetation patterns; studies on important social issues like migration; and the economic upliftment of the rural Himalayan population through livelihood enhancement via capacity building and use of simple technologies, as also by creating opportunities in sustainable, eco-friendly and responsible tourism.

The prominent among R&D highlights of the year include assessment of tectonic deformation rate and strain building across IHR, development of germination protocols of a few important medicinal plants like *Aconitum heterophyllum, Corylus jacquemontii, Buxus wallichiana, Rubia cordifolia*, etc., participatory initiatives on biodiversity conservation of heritage sites and creation of community conserved areas in Arunachal Pradesh, and the establishment of tourism/ eco-tourism interpretation centres in Garhwal Himalaya. The Northeast Unit of the Institute was honoured with two SCHOLL Research Challenge awards based on achievements in two projects under "Sustainable Development and Preservation of Ecosystem" and "Technology for Development" categories. The R&D outcomes of the year were brought into public domain through publication of around corroborated with 75 research papers, 60 articles and book-chapters. The R&D endeavours strongly supported by capacity building trainings and demonstrations on farmers' field and at the Institute's Rural Technology Centre. In addition to a new regional collaborative programme on Biodiversity Conservation along a Trans-boundary Kailash Sacred Landscape with facilitation by ICIMOD, the Institute has also tried to address biodiversity issues of protected areas in the Himalaya, and the subject of ecosystem services in the context of climate change scenario in the Sikkim Himalaya.

I feel pleasure in bringing out the Annual Report (2010-11) of the Institute for perusal by stakeholders, administrators and expert readers, and shall look forward to their constructive comments/ suggestions for betterment.

(L.M.S. Palni)
Director

MAJOR ACHIEVEMENTS

- The five year study was completed to throw light on the present rate of tectonic deformations and strain rate using continuously operating GPS receivers installed in the urban towns i.e. GBNL-Nainital (Kumaun Himalaya), GBSK-Srinagar (Garhwal Himalaya) in Uttarakhand, GBKL-Kullu (HP), GBZR-Zero (AP) along with existing permanent stations in GBPK-Almora (Kumaun Himalaya, Uttarakhand) and GBSK-Gangtok (Sikkim Himalaya).
- Electronic bibliographic database prepared for research publications on HBRs. Detailed analysis revealed the total 639 studies on Himalayan BRs, 44.2% pertain to NDBR. 385 species pages, 350 species information as per the format of Indian Botanical Information Facility and samples of 99 data sets were prepared. A model of execution of information was generated.
- Seed germination protocols for two populations of *Aconitum heterophyllum, Corylus jacquemontii, Buxus wallichiana, Rubia cordifolia and Spondias axillaris and* Vegetative propagation protocols of *Taxus baccata* subsp. *wallichiana* and *Cinnamomum tamala* were developed.
- Arboreta, Herbal Gardens and Nurseries at Mohal, Doharanala and Kasol in Himachal Pradesh, Kosi-Katarmal in Uttarakhand and Pangthang in Sikkim were strengthened and maintained. In Himachal Pradesh, campuses of GHS, Manglore, (Distt. Kullu) and GSSS Panarsa, (Distt.-Mandi) were developed through plantations of multipurpose and ornamental species.
- A study on Aerosols climatology- when conducted with the help of Multi-wavelength Radiometer (MWR) brought into light that with an increase in per unit aerosols optical depth (AOD), there is an increase of ~0.64 K/day in atmospheric temperature.
- Conservation of rich biodiversity of selected proposed heritage sites in Arunachal Pradesh through community participation addressing critical issues such as hunting, shifting agriculture, community welfare and alternative livelihood through formation of 22 Biodiversity Management Committees (BMCs) that are now proposed to be adopted by Arunachal Pradesh Biodiversity Board.
- Creation/declaration of five Community Conserved Areas (CCAs) - 'Mihin-Radhe' Community Conserved Area (5000 ha) and 'Siikhe-Bo' Community Conserved Area (20 ha) in Ziro plateau; 'Ritosa Ree-Mainarang Ree' CCA (100 ha), 'Hugore Sewaphu' CCA (50 ha) and 'Thembang Bapu' CCA (3000 ha) in Tawang and West Kameng (proposed) BR in Arunachal Pradesh.
- The NE Unit bagged two SCHOLL Research Challenge Awards in 2010. The awards were given to two of its projects for high calibre action research in development and governance that has had or have potential for demonstrated impact on policy or society at large. The case studies are "Biodiversity conservation through community based natural resource management in Arunachal Pradesh" in the category 'Sustainable Development and Preservation of the Ecosystem' and "Technology backstopping: a key to agricultural and entrepreneurship development in North-East India" in the category 'Technology for Development'.
- Tourism/ ecotourism/ rural tourism interpretation centre has been established through participatory approaches at Triyuginarayan for imparting training and capacity building programme to the stakeholders.
- In Khangchendzonga National Park, in north Sikkim, study discovered, first time, two new populations of a rare and endemic species, *Rhododendron niveum* (the state tree) at 3,000 m (150 individuals) and 3,300 m (15 individuals) in KNP.

Publications:

Peer Reviewed Journals			
	National	-	**31**
	International	-	**44**
Book Chapters		-	**32**
Popular Articles		-	**28**

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 in 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 2010-11 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. To meet the goal of the WPM theme following R&D activities were investigated:

Research

- The project on Optimizing hydrological response in a functional land use model indicates that Kosi river is able to meet the present water demand of the supply area for 290 days a year which may further reduce to 145 days a year by 2030. This highlights the need for immediate river conservation plan.
- Project Energy use pattern in rural domestic sector of Uttarakhand State – Issues, Options & Challenges reveals the people's perception on impact of firewood collection from forests as most of the villagers (82.2% of the total respondents) were aware of reason(s) responsible for the poor recruitment of seedlings in the forest. Only 17.8% respondents were not able to connect any reason/factor for this (share of women was higher than the men). *Kutir Jyoti* connections (electricity for poor and BPL families) are growing in the state.
- In project, "Nematode diversity in the traditional agro ecosystem of Central Himalaya, their impact on soil health, crop growth and development of demonstration model for agro-ecotourism," nematodes were isolated and identified as per standard protocol 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. The identified nematodes belonged to five orders. The study indicates that paddy and foxtail millet sown in equal proportions supported maximum nematode diversity and faster decomposition channel that probably created a better synchronization of soil faunal structure and function
- Project Development of analytical models through establishment of "Modelling & Statistical Computing laboratory: An attempt towards Capacity Building Programme" reveals that increasing trends in temperature at different rates have been observed in the last century. Significant increase in winter temperature (both max & min) in J&K and UK, declining in HP and significantly increasing trends of maximum temperature during monsoon in all three states were observed. Overall significant decrease in precipitation in J&K and UK; significantly declining trends of monsoon precipitation in all three states and increase in winter precipitation in UK & HP have been observed.
- Project Recharge area identification and estimation of 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 highlights the need for additional storage structures to tap the surplus water available during the monsoon period to cope with the seasonal water

scarcity in the high mountain basins of Himalaya. Samples collected from different sources indicate that shallow unconfined ground water is the common source for springs as well as tube wells.

- In Project Indigenous Knowledge: traditional health care practices in rural areas of Uttarakhand phytochemistry of 67 medicinal plants (MP) used by the traditional *vaidyas* has been documented from published sources. 102 therapeutic properties and associated active principals have been documented. Antimicrobial therapeutic property was found in maximum number of 14 MP. Three Medicinal plant species such as *Punica granitum* (*Anar*), *Tinospora cordifolia* (*Giloe*), and *Cynodon dactylon* (*Doob ghas*) had antidiabetic therapeutic property. Highest numbers of 9 therapeutic properties were documented in *Nardostachys jatamansi (Jatamansi) & Azadirachta indica (Neem)*. 40 additional herbal formulations and 27 medicinal plants used in Upper Alaknanda valley have been documented.
- Project on Exploration, diversity, and mapping of vegetation in the urban forests of Kumaun Himalayan towns using Remote Sensing & GIS (funded by MOE&F, Govt of India, New Delhi) reveals that landscape of the Nainital town is very diverse in topography and vegetation due to a wide elevational difference (~1800 - ~2600 m) within the municipal limits of the town. Total municipal area is 13.79 km^2. Of the total Landuse/landcover tree cover occupies 58.8% (811.59 ha) of the total area, and remaining area 568.29 ha is under various uses (built up area, scrub, playground, etc.) or natural features (open rocks, lakes, etc.).Most of the settlement is confined to the lake catchment area of the Naini lake, other side of watershed has thin population but has rough and rock terrain in different parts.
- Results of completed study on *Soil nitrogen dynamics in relation to quality and decomposability of plant litter traditionally used as manure in the central Himalaya (funded by DST, Govt. of India, New Delhi) reveals that* litter quality may define the potential rates of microbial decomposition but these are significantly influenced by the biotic and abiotic environment in which decomposition takes place. The litters placed on north facing site decomposed faster than those on the south facing site. The litters placed at the top slope position decomposed slower than at those at either the bottom or middle positions.

Demonstration and Dissemination

- Training programme on "Soil Analysis & Data Interpretation" from 15-17 November, 2010. 15 research students participated in the training.
- Findings of assessment of water flow in district Pauri suggests availability of water during mansoon for development of storage for hay days. This has been conveyed to district administration and Jal Nigam.

Biodiversity Conservation and Management (BCM)

Research

- Electronic bibliographic database prepared for research publications on HBRs. Detailed analysis revealed the total 639 studies on Himalayan BRs, 283 (44.2%) pertain to NDBR.
- The revisit studies in Pindari region (Buffer Zone of NDBR), forest community wise changes at two point sampling (i.e., 1988-89 and 2008-2009) are described. In Mixed Oak deciduous forests the relative contribution of species richness showed no changes in all three layers. Remarkable changes in total tree density; maximum change in density of seedlings; and increase in seedlings from 81.7% to 94.6% were observed. *In Quercus floribunda forests* (2300-2500 m) assessment of species richness reveals changes in seedling and sapling layers. Significant increase in total tree density and maximum increase in density in seedling layers were observed. The relative contribution of seedlings has increased from 86.7% to 93.6%. ***In Quercus semicarpifolia forests,*** changes in total density particularly in seedling layer were observed. A slight decrease in the density contribution by sapling and tree layers was observed. **In Mixed Deciduous *forests*** 10 new species were recorded in seedling layers. Considerably large increase in total density was observed, maximum change in density was observed in seedling layer. Little increase in relative density was noticed in sapling layer. ***In Betula utilis forests*** nearly two fold increase in total density was observed. Maximum change in density was observed in seedling layer. The relative density contribution has changed rapidly in seeding and tree layers.
- 258 species of vascular plants from Nargu Wildlife Sanctuary were recorded, of which, 39.53% species were native and 22.48% endemic to the Himalayan Region. 178 species of economically important plants were used as medicine (123 spp.), wild edible/food (39 spp.), fodder (59 spp.), fuel (32

spp.), timber (05 spp.), religious purposes (09 spp.), fiber (07 spp.), making agricultural tools (08 spp.) and various other purposes (16 spp.). *Dioscorea deltoidea*, *Taxus baccata* subsp. *wallichiana* and *Zanthoxylum armatum* have been categorized as Endangered and 05 species; *Acer caesium*, *Rhododendron campanulatum*, *Rhododendron lepidotum*, *Valeriana jatamansi* and *Hedychium spicatum* as Vulnerable. 10 forest tree communities were identified from 23 sites. Total tree density ranged from 210.0-600.0 Ind ha^{-1} and total basal area, 1.9-60.7 $m^2 ha^{-1}$. Shrubs density from 450.0-3390.0 Ind ha^{-1}, herbs density, 44.8-156.8 Ind m^{-2}, saplings density, 50-450 Ind ha^{-1} and seedlings density,110-1060 Ind ha^{-1}. Species richness ranged from 43-111and Species diversity index (H') for trees ranged from 0.26-1.72, saplings, 0.26-1.70, seedlings, 0.17-1.84, shrubs, 1.07-2.8 and herbs, 2.70-3.60.

- Extraction trends of fuel and fodder species were assessed. Among the fuel species, mean collection was highest for *Quercus leucotrichophora* (1879.30 kg household^{-1} year^{-1}), followed by *Rhododendron arboreum* (433.57 kg household^{-1} year^{-1}), *Cedrus deodara* (425.22 kg household^{-1} year^{-1}), *Myrica esculenta* (385.05 kg household^{-1} year^{-1}) and *Persea duthiei* (370.96 kg household^{-1} year^{-1}). The remaining species showed relatively low values. 23 species were used as fodder by the inhabitants of 10 surveyed villages. *Quercus leucotrichophora*, *Neolitsea pallens* and *Desmodium elegans* were mostly used as fodder. Maximum total collection was done in Hurang village (8568 kg household^{-1} year^{-1}), followed by Shilh Badhani (8352 kg household^{-1} year^{-1}), Malwara (8028 kg household^{-1} year^{-1}) and Kutahar (7980 kg household^{-1} year^{-1}) villages.
- In KBR, Sikkim total 15 sites were investigated for woody structure and recruitment in Tholung-Kisong (TK) landscape and 51 trees and 30 shrubs recorded. Total species significantly declined along increasing altitude. For trees, dominance, diversity and species evenness index showed non-significant negative correlation, while the species richness index negatively correlated with altitude. For shrubs, diversity species evenness index positively correlated with altitude; relationship was non-significantly positive between species richness index and the altitude, and non-significantly negative between species dominance index and altitude. Adults in C-class (10-20 cm dbh) showed the highest density and in I-class (70-80 cm dbh) the lowest density. Two new populations at 3000m (150 individuals) and 3300m (15 individuals) of rare and endemic species of *Rhododendron niveum* along TK landscape in core zone, Kangchendzonga Biosphere Reserve were discovered. Amongst 06 indicators of biodiversity conservation and sustainability, forested area and species diversity had top priority index for Tingvong and Ship-Gyer villages in north Sikkim.
- In Tawang-West Kameng Biosphere Reserve (proposed) of Arunachal Pradesh a total of 311 species of flowering plants including endemic, primitive and ethnomedicinal were recorded. 52 medicinal plants were documented, which were being used by Monpas for the treatment of various ailments. Most of these species were harvested from wild stands. 11 species were overexploited.
- In Himachal Unit, nativity and endemism of the 476 medicinal plants was updated. Parbati Watershed, Upper Banjar Valley and Upper Beas Valley had 36.97%, 35.08% & 34.45% natives and 21.63%, 20.58% & 17.43% endemics and near endemics, respectively. Mohal Khad watershed (natives 25.42% & endemics & near endemics, 11.76%) and Chandra Valley (natives 28.57% & endemics & near endemics, 19.53%) had relatively less native and endemic species. 44 medicinal plants are reported as Critically Endangered (09spp.), Endangered (16 spp.), and Vulnerable (14 spp.).
- Seed germination protocols for two populations of *Aconitum heterophyllum, Corylus jacquemontii, Buxus wallichiana, Rubia cordifolia and Spondias axillaris and* Vegetative propagation protocols of *Taxus baccata* subsp. *wallichiana* and *Cinnamomum tamala* were developed.
- Phytochemical analysis of *Acorus calamus* collected from different localities and altitudinal gradients showed the variation in total phenols and antioxidant activity. Total phenolic content was found maximum in Jyoli population and minimum in Matela population. Similarly, *in vitro* antioxidant assay showed maximum activity in the samples collected from Jyoli population and minimum in Bari Population in ABTS assay. Similar results on other two antioxidants assay were observed in DPPH and FRAP, where samples collected from Jyoli population showed highest antioxidant activity. Relationship among Altitude, Antioxidant Assays, Total Phenolics, Flavonoids and Phenolic compounds in *Myrica esculenta* fruits were investigated. Results revealed a significant negative correlation of catechin with altitude. Correlation matrix revealed that total phenolic and flavonoid contents have significant positive impact on antioxidant activity. Linear regression analysis

showed that phenolic contents contribute 46.3 to 47.6% of radical scavenging property ($r^2 = 0.463$ for DPPH and $r^2 = 0.476$ for ABTS) and 56.6% of reducing property ($r^2=0.566$). Similarly, flavonoids contribute 55.4% to 70.9% radical scavenging property ($r^2 = 0.554$ for ABTS and $r^2 = 0.709$ for DPPH) and 47.8% of reducing property ($r^2 = 0.478$).

- At Headquarters 385 species pages, 350 species information as per the format of Indian Botanical Information Facility and samples of 99 data sets were prepared. A model of execution of information was generated and quality photographs of 35 plant species added to the species pages.
- Environment Management Plans of PHEP Stage III were reviewed. Information on the socio-economic status of 24 affected villages was generated through structured questionnaires, interviews and Participatory Rural Appraisal. The inhabitants of the villages are largely dependent on agriculture, horticulture, vegetables, livestock and traditional handicrafts. Developmental activities carried out by PHEP Stage III were documented. Among them, educational facilities, medical and human health, transportation and communication, water supply schemes, construction of houses, temples and other buildings, village road/bridge work, Water Supply Schemes, work related to social & cultural aspects, improvement of markets, hospitals, religious places, electricity, pathways, etc. are notable.
- Under GPP in Himachal STEP Site 20 orchards (10 far from the natural habitats and 10 near natural habitats) in different altitudes and diverse landscapes were selected to implement Pollination Deficit Protocol (i.e., Flowering Phenology, Scan and Sweep Net Sampling, etc.). Scan sampling of apple pollinators was done. Bowl Trap Experiment was conducted in 20 orchards. A group of 42 orchardists/ farmers from 20 Target Areas was selected for the crop specific best practices in pollination management plan and socio-economic assessment. 175 farmers of seven locations were interviewed for the status of their basic knowledge on pollination and its services.
- In Uttarakhand STEP Site 19 farmers from 11 villages were identified for the implementation of pollination protocol. Socio-economic valuation of pollinator-friendly practices was done in Patharkot village. Knowledge about pollination and its services among different target groups were tested with predesigned formats. 40 references were compiled.
- In Sikkim STEP Site, the village survey revealed that out of 117 households, 60 managed traditional honeybee hives in Upper Jaubari and Lower Jaubari villages. The research experiment was carried out during the peak flowering time of target crop (i.e., large cardamom) in 3 distinct areas. Opened flowering frequency was observed maximum in sites close to protected areas (i.e..13 flowers/plant) and during 2-13 June (i.e., 11 flowers/plant) significantly.
- In the Pinjoli watershed of West Kameng, Arunachal Pradesh sampling was done in 7 grids and 207 species were recorded. Of these 13 were medicinal plants, 32 wild edibles and 2 species were used in fish poisoning and 1 species as fish bait. The survey listed 13 local bamboo made craft items which were used for various purposes.

Demonstration

- Arboreta, Herbal gardens and nurseries at Mohal and Doharanala in Himachal Pradesh, Kosi-Katarmal, Uttarakhand and Pangthang in Sikkim were strengthened and maintained. In Himachal Pradesh, campuses of GHS Manglore (Distt-Kullu) and GSSS Panarsa (Distt-Mandi) were developed through plantations of multipurpose and ornamental species.
- Consultation Meetings were organized at Jibhi, Banjar and Jana Villages in Kullu district, Ropa, Sundarnagar and Smaila in Mandi District and Khangsar in Chandra Valley of the Lahaul & Spiti district. Group of 20 farmers in Chandra Valley was developed to initiate the cultivation of *Aconitum heterophyllum* and *Picrorhiza kurrooa*, and that of 54 farmers from Jana, Burua, Kothi, Ropa, Jhiri, Smaila and Sundernagar for the cultivation of *Aconitum heterophyllum* and *Withania somnifera*.
- About 15,000 seedlings of *Aconitum heterophyllum* were raised by the 16 farmers in the fields at Jana village, 20,000 seedlings at Burua village, 1,000 seedlings at Kothi and 1,000 seedlings at IRMT, Naggar. One farmer from Jana village developed > 2, 50,000 seedlings of *Aconitum heterophyllum* and generated > Rs. 1, 25,000/- from the seeds and seedlings. Over 5,000 seedlings of *Withania somnifera* were developed and over 2,000 seedlings of *Withania somnifera* were planted in Prodhar, Ropa, Jhiri, Smaila and Sundernagar of Kullu and Mandi districts.

Dissemination

- Seedlings of over 35 multipurpose species and medicinal plants were distributed among different stakeholders in Himachal Unit, Mohal-Kullu, Himachal Pradesh, Headquarters (Kosi-Katarmal), Uttarakhand and Sikkim Unit, Pangthang, Sikkim.

300 seedlings of *Withania somnifera* were distributed to different stakeholders during the State Level Children Science Congress at Hamirpur in Himachal Pradesh. Also, seeds of different medicinal plants were distributed to the Stakeholders. Agrotechniques developed for the 26 commercially viable medicinal plants were distri buted among the stakeholders for the promotion of cultivation of medicinal plants. Publications/ brochures produced on KBR were widely disseminated at Sikkim Unit.

- Training Programme on "Weather Monitoring, Climate Change and Biodiversity Conservation and Management" at Himachal Unit (Himachal Pradesh) for the teachers, students, farmers and Mahila Mandals, and Training Workshop on *Conservation of Biodiversity* for Students and Teachers at Sikkim Unit (Sikkim) were organized. The pre and post training feedbacks of the participants showed significant improvement in their knowledge. World Environment day, International Biodiversity Day, Wild Life Week and Herbal Day were celebrated at Headquarters, Himachal Unit, and Sikkim Unit with the Students and Teachers of the Government and Public Schools. Exposure visits for over 1000 diverse stakeholders of Himachal Pradesh, Uttarakhand and Sikkim were organized. Stakeholders Consultation Workshop on 'Biodiversity Conservation and Management in KBR' was organized in collaboration with FEWMD, Govt. of Sikkim at W. Sikkim; related issues were highlighted.
- Under GPP Inception and National Project Coordination Meeting-India was organized on July 19, 2010 at GBPIHED, Himachal Unit, Mohal-Kullu for the Conservation and management of pollinators for sustainable agriculture through an ecosystem approach. National Partners of the project i.e., Himachal STEP Site, Uttarakhand STEP Site and Sikkim STEP Site and farmers participated. Meeting of the Partners of the Himachal STEP Site was organized at Mohal-Kullu on February 04, 2011 to discuss the approach/methodology and mechanism for running the project activities smoothly. Also an Interactive Meeting of the Partners of HP STEP Site with Fruit Grower's Association, Upper Kullu Valley was organized at Patlikuhl on February 05, 2011 to discuss the aims and objectives of the project.

Environmental Assessment and Management (EAM)

The reporting period (2010-11) for Environmental Assessment and Management (EAM) has been very signiticant and fruitful in achieving its targets. Work during this year under EAM theme was executed mainly in 11 projects out of which 5 were in-house, 4 externally funded from ISRO Bangalore, DST New Delhi and Lake Development Authority (LDA), Govt. of Uttarakhand. The remaining two were consultancy projects for a year funded from MoEF, New Delhi and Uttarakhand Jal Vidyut Nigam Ltd. (UJVNL), Dehradun. (I) Small holder farming systems- strategies for economic and environmental viability in the Western Himalaya, aims at developing a horticultural model at a representative village- Patharkot in district Almora so that on-farm rural income could be diversified. (II) Forest Eco-system Services in the Central Himalaya Mountains- quantification and valuation approach focusing to evaluate various ecosystem goods and services accrued from major two forest types; oak and pine. (III) Strategic Environmental Assessment (SEA) and Environmental Impact Analysis (EIA) of hydropower projects in Western Himalayan region, targets to obtain overlapping area from one hydropower project to another in the upper River Sutlej basin in Himachal Pradesh and SEA is considered to be an effective tool for strengthening these projects. (IV) Urbanization vis-à-vis solid waste management and air pollution in sprawling urban towns of Himachal Himalaya, *studies background values of ambient air quality in three hill towns Hamirpur, Kangra and Chamba.* (V) Appraisal of tourism for Sustainable Management– case studies from Sikkim Himalaya, comprises assessment of economic significance of tourism and to make an appraisal for sustainability of tourism. The externally funded projects have mainly been concerned with aerosols and its impact on climate change in addition to their adverse impacts on living organisms. These projects are: (vi) aerosol climatology over the northwestern Indian Himalayan region, Himachal Pradesh, (vii) gaseous air pollution in the background site of sprawling urban Environment of Himachal Pradesh, and (viii) ambient air pollution and its sources in the background sites of different hill spots in the northwestern Himalaya, Himachal Pradesh. However, one project funded by LDA on (ix) Participatory management of Bhimtal Lake Catchment' was completed, suggesting mainly a horticulture model to upgrade degraded land for the livelihood options for its maintenance and management. The two consultancy projects were: (x) environmental and social impacts of hydropower projects in Ganga River Basin (between Dharasu and Gangotri) in Uttarakhand, and (xi) comprehensive Environmental Impact Assessment and preparation of management plans for Tamak-Lata and Nandprayag-Langasu hydroelectric projects. Both these projects focused mainly on assessing positive and

negative impacts due to upcoming hydropower projects, to suggest possible mitigation measures and to maximize positive impacts in the two different regions through a sustainable management plan.

Research

- The Strategic Environmental Assessment (SEA) study of the River Satluj comprises a buffer zone of 10 km on either side of a river. This area lies 165 km from northeast to southwest from Nathapa village (Kinnaur district) to Bilaspur town (Bilaspur district). Of the total buffer zone (**2945** km^2), the highest share of land use/land cover (LULC) of the Sutlej catchment stood to be barren (40.9%) followed by forest land (36.48%), agricultural land (21.91%), and settlement (0.71%). There is a high anthropogenic pressure on the catchment area which 8730 households inhabit. The three major zones; the buffer, influence zone and overlapping zones were demarcated with the help of RS & GIS. Influence zone of HEPs was estimated to be 31.30% of the total buffer zone and 6.07% overlapped area of the total influence zone indicating over crowding of HEPs in this catchment which may create other environmental disorders in due course.
- The sprawling urban environment and its impact mainly on ambient air quality study in three towns (i.e. Hamirpur, Kangra and Chamba) in Himachal Pradesh shows PM_{10} 40.3±4.4 µg m^{-3} as highest at Hamirpur followed by 35.2±2.7 µg m^{-3} at Chamba and 24.6±2.3 µg m^{-3} at Kangra. On diurnal basis, highest concentration of PM_{10} was found between 16-0 h IST (evening to midnight) followed by 8-16 h (day) and lowest between 0-8 h (midnight to morning) at all the sites except at Chamba. At all sites, there were high concentrations of particulate pollution compared to gaseous pollution. The gaseous pollutants like SO_2, NO_2 and NH_3 were found below the permissible limits. The vehicular influx, burning of biomass, coal and solid waste and operation of gen sets are considered to be the local/point sources for ambient air quality deterioration in these hill towns.
- Aerosol Optical Depth (AOD), Black Carbon (BC) and Surface Ozone (O_3) studies were carried out at Mohal-Kullu in Himachal Pradesh. On an average, forenoon and afternoon AODs for a day at ten wavelengths under clear sky conditions from the last four years (2006 -10) showed maximum AOD 0.27 in 2010 while minimum 0.22 in 2007. An increase of 22% AOD at 500 nm during the past three years (2007-10) was noted. BC concentration, a heat absorbing aerosol considered to melt glaciers faster in the Himalayan region, was measured as much as 6596 ngm^{-3} in January 2010 and as low as 3253 ng m^{-3} in June 2010. It increases with the activities like biomass burning, vehicular emission and forest fires. Surface Ozone, one of the growing green house gases in the modern world, on high insolation days was estimated to be 41.7±13.8 ppbv. Overall, aerosols (colloidal system of solid, gaseous and liquid pollutants) especially heat absorbing like BC is considered to increase our global temperature. Upon one unit increase in AOD at Mohal, there is an increase of 0.64 K/day in atmospheric temperature.

Demonstration

- A representative village- Patharkot located in district Almora, was selected mainly for development of horticulture model. Here, about 5.9 ha community wasteland was developed with the plantation of 890 different fruit saplings. The survival of saplings after 2 years was 40% in March 2011 which was higher (63%) in home gardens indicating higher success among individual farmers. Besides, 1500 saplings of different fuelwood and fodder species at Patharkot and their survival after 4 months was noted to be 89%. So the study indicates that participation of stakeholders has an important role in it.

Dissemination

- Microbial bio-composting technology was developed mainly for municipal waste, traditional farmyard manure or biodegradable agricultural waste through which pure organic compost could be developed within 35±5 days in summer and 55±5 days in winter under control conditions (25±5° C). This technology has been very popular not only to the municipal committees, village panchayats, and schools, but also for the hoteliers, hydropower project proponents, National Parks and Sanctuaries, etc. This is open, at a time, to all such stakeholders for dissemination in the Himachal Unit, Mohal-Kullu.

Socio-Economic Development (SED)

During the reporting year, the projects on priority areas that were initiated during XI plan period continued, i.e., (i) Scaling up innovative resource management practices for improved livelihood in the mid hills of the central Himalaya (HQs), (ii) Assessing the eco-tourism potential (Garhwal & Sikkim Unit), (iii) *Shifting agriculture: issues and options with focus on adaptive interventions to make it ecologically;*

economically and socially viable, (NE Unit), (iv) Indigenous Knowledge: traditional health care practices in rural areas of Uttarakhand (HQs), (v). Pesticide residue contamination of food chain: appropriate monitoring and control measures from field studies in Himachal Pradesh (Himachal Unit), and (vi). Migration: socioeconomic and cultural implication 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, which continued from the previous years, such as (i). Biodiversity conservation though community based natural resource management in Arunachal Pradesh (NE Unit), (ii). Cultural landscape: the basis for linking biodiversity conservation with sustainable development of Arunachal Pradesh (NE Unit), (iii). Institutionalizing technology backstopping and capacity enhancement for sustainable agricultural development and encouraging entrepreneurship development based on simple rural technologies within the tribal areas of north east India (NE Unit), (iv). Participatory management of Bhimtal lake catchment (HQs), (v). Enhancement of livelihood security through sustainable farming systems and related farm enterprises in north-west Himalaya (HQs). During this reporting year one more externally funded project was also added, namely, Development of baseline information and identification of potential corridors for Namdapha National Park (Tiger Reserve) and Mouling National Park (NE Unit).

The R&D projects of the Theme continued to strengthen/generate data base on various aspects of IHR, emphasize 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. Imparting hands-on-training on various rural and simple technologies and developing of manuals on them for effective adoption at grass root level continued as a well devised activity of the Theme. Technology dissemination and backstopping is continuously upscaled in the states of the NE region working jointly with various organizations like CAPART. During the reporting year, the group has significantly contributed in the conservation of rich biodiversity of selected proposed heritage sites in Arunachal Pradesh through *community participation addressing* critical issues such as hunting, shifting agriculture, community welfare and alternative livelihood through formation of 22 Biodiversity Management Committees (BMCs) that are now proposed to be adopted by Arunachal Pradesh Biodiversity Board, creation/declaration of five Community Conserved Areas (CCAs) to promote conservation of ecologically and socially valued wild flora and fauna, etc. The other significant contributions of the group in biodiversity conservation and livelihood promotion in the IHR include large scale plantation of *Taxus wallichiana* and large cardamom (*Amomum subulatum)* in more than 60 ha of land each. The work of the Theme is widely acknowledged through two SCHOLL Research Challenge Awards in the areas of Sustainable Development and Preservation of the Ecosystem and Technology for Development during the reporting period.

Biotechnological Applications (BTA)

During the reporting year emphasis was given on large scale multiplication of selected plant species for which protocols were already developed, and such plants were subsequently field planted and monitored. Two important *Rhododendron* species of Sikkim, namely, *R. maddeni* and *R. dalhousiae* were selected for this purpose. Efforts continued to standardize propagation protocols in other economically important species using both conventional and in vitro methods. Studies on molecular characterization of two species of high medicinal value, namely, *Podophyllum* sp. and *Ginkgo biloba* are underway. Exploration of microbial diversity with specific reference to plant growth promoting micro-organisms and mycorrhizal associations are being successfully carried out in Himalayan soils, including the north-east region of India. The rhizosphere populations associated with various age groups of *Ginkgo biloba* were investigated. Besides colonization of free living micro-organisms and arbuscular mycorrhizae, the occurrence of endophytic organisms deserves attention. A large number of *G. biloba* plants were raised using bacterial (isolated from cortical cells of the plant) based broth formulation, under net house conditions. Investigation on microbial communities in river Jataganga (Jageshwar, District Almora) during festival and different seasons is continuing. Among extremophiles,

various species of *Streptomyces* (cold tolerant) and *Aspergillus* (cold and pH tolerant) have been investigated for their antagonistic and enzyme producing properties. Field assessment of microbial inoculants yielded positive results and are being continuously monitored on a long term basis. Characterization of pyschrotolerant fungi with particular reference to lignin degradation under mountain ecosystems has been initiated under an ICMR funded project. Two DST funded projects are underway; the first focuses on determination of phosphate solubilization and litter decomposition potential of dominant fungi, isolated from the Himalayan soil. While the other concentrates on the role of mycorrhizae on gas exchange characteristics, particularly photosynthesis and water relations in three central Himalayan *Quercus* species (oak). Initiatives on capacity building for rural folks and training of students for (M.Sc. & Ph.D.) continued. Under the pond-based integrated farming system, two new sites were developed in this region; these sites demonstrate the involvement of rural women in the application of appropriate technologies for income generation as well as development of the region.

Knowledge Product and Capacity Building (KCB)

During the reporting year major emphasis was given on eco-tourism product development using locally available resources and strengthened capacity and skill of local communities and youth on cultivation, production, and marketing of products to enhance the local livelihood opportunities along with creating economic incentives for conservation. Efforts were also made to develop micro and small enterprises (household level enterprise activities including off-seasonal vegetable cultivation) that are part of a larger local market chain. In order to generate awareness on various livelihood enhancement and income generating activities through appropriate technological interventions and ecotourism promotion, a total of 8 training programmes on different aspects were organized through which the skill and capacity of more than 378 men and women was developed. The ecotourism models such as Dhanaulti (Tehri) and Dhaulachhina (Almora) were studied with reference to ecological impact analysis and cost-benefit analysis. Assessment of carrying capacities of lodges/hotels from Guptakashi to Kedarnath was carried out. Awareness and capacity building of local tour guides and students on avi-fauna diversity and its linkages with ecotourism promotion was created.Monitoring and regeneration status of wild edible plant species such as *Vibarnum mullaha* and *Paeonia emodi* has been worked out and nurseries of these species along with some high value medicinal plants i.e. *Picrorhiza kurrua, Saussurea costus* have been developed for their conservation and large scale cultivation.

Successful demonstration of different prototypes with major focus on horticultural model development and degraded land rehabilitation on 23 ha of community land with active support of three village clusters has been developed under NAIP /ICAR project. Nutritional and bio-chemical analysis of a few potential wild edible fruit and wild herbal species i.e. *Allium strechyei, Angelica glauca and Pleurospermum angelicoides* were estimated. In-depth study was undertaken to ascertain the radical changes in transhumance and pastoral nomadism, livelihoods, the extent of cultivation of MAPs and exploitation of wild bio-resources and crops in the Niti and Mana villages after 1962. Studies on climate change impact on central Himalayan agro-ecosystem with particular reference to eco-physiological, drought and insect-pest related impacts and adaptation strategies were carried out. Assessment report for Nanda Devi Biosphere Reserve has been prepared as a baseline for further studies related to the implementation of global change in mountain regions(GLOCHAMORE) research strategies (UNESCO-Paris initiative).

1. INTRODUCTION

The year 2010-11 is the twentyfirst financial year of R&D activities being executed by the Institute at different locations of the 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 Committees 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 has developed a perspective plan for XIth plan period (2007-12). The identified thematic categories include the following: (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, have been presented in this report. The Institute would be most grateful to receive critical comments and suggestions for the improvement of its activities of research & development

2. MILESTONE EVENTS

Training on Earthquake Resistant Buildings

A two-day training programme was organized by Land Revenue and Disaster Management Department, Government of Sikkim in collaboration with Disaster Management Faculty, GBPIHED, Sikkim Unit of the Institute (March 1-2, 2010). The demerits of present building structures in Sikkim state were, discussed and retrofitting and earthquake resistant building designs were suggested to the participants. The training programme was attended by a total of 70 participants including, town planners, architects, and engineers from various departments of the Sikkim state.

Exposure Visits

Exposure visit for University students of Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) was organized (March 8, 2010). On this occasion, the Scientist In-charge, GBPIHED, Himachal Unit briefly presented the Institute R & D activities. The participants visited Herbal Garden, Arboretum, Medicinal Plants and Multipurpose Species Nurseries, demonstrations on Solid Waste Management technique, Vermicomposting, Weed Composting, Weather and Pollution Monitoring Stations and Institute Laboratories. A total of 34 students including two professors participated. Similarly, exposure visit for Farmers, Forest Guards and Range Officer of Nanda Devi Biosphere Reserve was also organized (27 May, 2010).

Workshop on Promoting Ecotourism

Garhwal Unit of the GBPIHED organized a two-day workshop on "Promoting Ecotourism and Biodiversity Conservation in Upper Kedar Valley, Garhwal Himalaya" (March 19-20, 2010). Padamshree Chandi Prasad Bhatt was the Chief Guest, and Prof. D.R. Purohit, Director Folk and Culture Department, HNB Garhwal University, Srinagar-Garhwal was the Special Guest of the programme. Scientist In-charge, GBPIHED, Garhwal Unit welcomed the participants, followed by detailed presentation on the potential and management issues in eco-tourism in Kedar Valley. Stakeholders expressed their views and problems. Over 80 participants from KEDAR (Kedar Ghati Ecotourism Development Action and Research) Association, Govt. Departments, NGOs, women farmers, etc. participated in the programme.

National Conference on Orchids

To celebrate the International Year of Biodiversity 2010, the Institute organized a "National Conference on Systematic and Diversity Analysis for Conservation and Sustainable Utilization of Orchids", jointly with The Orchid Society of India (March 19-21, 2010). In this Conference appropriate measures for effective conservation and sustainable use of orchids were recommended. Besides, it was suggested that orchid based vocations need to be initiated especially for women and unemployed youth considering the potential of orchid diversity in the Indian Himalayan Region.

The conference was attended by over 60 participants from various Research Institutions, Universities, Forest Department, and non Government organizations. Among many others, Dr. Manju Sharma, Former Secretary, Department of Biotechnology and President of The Orchid Society of India, Prof. H.Y. Mohan Ram, New Delhi, Prof. A.K. Bhatnagar, University of Delhi, Prof. Pradeep Chandra Deka, Vice-Chancellor, Sir Padampat Singhania University Udaipur, Prof. S.R. Rao, North Eastern Hill University, Shillong, Dr. J.S. Rawat, IUCN India Office, New Delhi, Mr. Manoj Chandran, IFS, Pithoraharh, Dr. Anil Sood, Scientist, IHBT Palampur, participated in the Conference.

Training on Strengthening Fodder Resources

Two trainings for capacity building were organized in village Maikhand, Kedarnath Valley, Uttarakhand (January 29, and March 30, 2010) under DST (SYSP) sponsored project entitled "Strengthening Fodder Resources and Developing a Pilot Model for Reducing Drudgery of Rural Women". Local activist Shri Raja Ram Semwal chaired the workshop sessions. Vinod Ghildiyal, Malupani (Tehri Garhwal) and resource persons of the Institute delivered lectures on the fodder

problem and appropriate measurse to combat fodder scarcity in the region. *Introduction of fast growing, high biomass yielding fodder trees were suggested and seedlings of Morus alba (50) and Pennisetum purpureum (1500) were distributed among the village people of the area.*

GBPIHED Society Meeting

The 33rd Society Meeting of GBPIHED was held on April 9, 2010 at the Ministry of Environment & Forests, New Delhi under the Chairmanship of Hon'ble Minister of State (Independent Charge), Environment and Forests, Govt. of India, Shri Jairam Ramesh (President of the GBPIHED Society). At the outset President Shri Jairam Ramesh extended a warm welcome to all the members of the Society, which was followed by confirmation of the minutes of the 32nd Society Meeting. Following this, Dr. L.M.S. Palni, Director, GBPIHED, made a detailed presentation on the progress of the Institute. Among others, this meeting was attended by Shri Satyavrat Chaturvedi, Hon'ble Member of Parliament (Rajya Sabha); Shri Manoj Tiwari, Hon'ble MLA, Uttarakhand; Shri M.F. Farooqui, Additional Secretary, MoEF; Shri Saurabh Chandra, Additional Secretary and Financial Adviser (Representative of Secretary - Expenditure), MoEF; Shri Hem Pande, Joint Secretary, MoEF; Dr. R.R. Rao, Emeritus Scientist, CIMAP, Bangalore; Shri S.K. Pande, Ex Director General (Forests) and Special Secretary, MoEF; Prof. K. Kannan, Vice-Chancellor, Nagaland University, Nagaland; Prof. Varun Sahani, Vice-Chancellor, University of Jammu, Jammu; Shri S.S. Negi, E.A., Ministry of Rural Development, New Delhi; Dr. R.B. Lal, Director, IIFM, Bhopal; Dr. G.S. Rawat, ICFRE, Dehradun; Prof. C.L. Acharya, Palampur (H.P.); Dr. P.B. Gangopadhyay, Additional DG (Forests, MoE&F); Shri Vivek Saxena, IFS, Director (CS), MoEF; Dr. B.P. Singh, DST, New Delhi; etc. The Society approved the draft Annual Report and Statements of Accounts of GBPIHED for the year 2009-10 and discussed the various R&D issues of the Institute.

Regional Workshop on Kailash Sacred Landscape Initiatives

A three-day workshop on "Kailash Sacred Landscape Conservation Initiative (KSLCI)" was held at Kasardevi, Almora (April 11-13, 2010). A Regional Co-operation Framework (RCF) by coordinating efforts between the participatory countries, namely China, India and Nepal was discussed and developed in this workshop. This trans-boundary initiative, first of its kind, was facilitated by the International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, with support from United Nations environment Programme (UNEP), and the workshop was hosted by GBPIHED. The workshops aimed at developing collaboration and cooperation on a number of important issues, such as (i) Trans-boundary biodiversity and environmental and cultural conservation, (ii) Scientific and technical cooperation, (iii) Information exchange and sharing, and (iv) Regional guidelines, policy and soft legal instruments. The workshop was inaugurated by Shri Hem Pandey, Joint Secretary, MoEF, Govt. of India. In his address he stressed the need of incorporating the concerns, developmental aspirations and livelihood needs of the local inhabitants. Dr. L.M.S. Palni, Director, GBPIHED, welcomed all the participants. Dr. Krishna Prasad Oli, regional Coordinator KSLCI, briefly outlined the progress made so far and stressed the need to clearly delineate the actual area of KSLCI within each country by the participating countries, and for using common methodology during the implementation. Dr. Eklavya Sharma, Programme Manager, ICIMOD emphasized the need for more such flagship projects to generate authentic scientific data for gap filling. Mr. Tim Karsten, Deputy Director of UNEP Headquarters at Nairobi expressed his happiness on being here along with his colleague, Dr. Subrato Sinha, UNEP Regional Office, Bangkok. He hoped that KSLCI would help expand the strong cultural, spiritual and social trans-boundary linkages across the region. The workshop was attended by over thirty participants from China, Nepal and India.

Scientific Advisory Committee (SAC) Meeting

XVIIth Meeting of the SAC of the GBPIHED was held (April 20-22, 2010) under the Chairmanship of Prof. Jayanta Bandyopadhyay, Indian Institute of Management, Kolkata. Dr. A.K. Dubey, Prof. I.A. Hamal (Special Invitee), Dr. R.K. Maikhuri and Dr. K.K. Singh (GBPIHED nominee) were present in the meeting. The meeting started with welcome address by Director of the Institute, Dr. L.M.S. Palni and confirmation of minutes of XVIth SAC Meeting. At the

outset, the Director of the Institute welcomed the Chairman and the Members of SAC. The Director highlighted the significance of this SAC meeting w.r.t. critical mid-term evaluation of the progress of ongoing in-house projects of the Institute. The SAC Chairman, in his opening remarks, placed on record the contribution made by Dr. B. R. Arora, ex-Director, Wadia Institute of Himalayan Geology, Dehradun, for his valuable contribution in previous meetings of SAC and welcomed, Dr. A. K. Dubey, the present Director of WIHG in the SAC of GBPIHED. He emphasized that the Himalayan region is both fascinating as well as a complex system to understand, and that the inbuilt interdisciplinary nature of the mandate of the Institute allows it to contribute in this direction. Following the opening remarks of the Chairman, SAC, Director, GBPIHED made a brief presentation on the progress of the Institute during the reporting year. This was followed by individual presentation by the Institute scientists on the in-house projects. The members of the SAC keenly observed and discussed the 5-years rolling plans of each in-house project. The Chairman and SAC members expressed satisfaction on the progress of various R&D projects and mentioned that the quality of presentations has improved considerably. Besides, a brain storming session on thematic areas, integration of R&D activities/future directions was held by the SAC member under the chairmanship of Prof. Bandhyopadhyay. Also, two proposals of the Institute (i) Holding an International Workshop on "Mountain biodiversity and climate change with special reference to Himalayan biodiversity hotspot", and (ii) Programme on "Ideal Himalayan Habitats", were approved by the SAC during the meeting. At the end, the Director thanked the SAC Chairman, and members for their critical inputs and constant help.

Consultation Meeting

A Consultation Meeting with the farmers of Chandra Valley in Lahaul & Spiti district (H.P.) on "Cultivation of Medicinal Plants in Lahaul Valley" was organized at village Khansar (May 8, 2010). Scientist In-charge, GBPIHED, Himachal Unit briefly explained the farmers about the medicinal plants diversity in Lahaul valley and agro-techniques of cultivation of *Aconitum heterophyllum* and *Picrorhiza kurrooa*, the commercially valuable medicinal plants. The farmers showed keen interest for the cultivation of these species at a commercial scale. A total of 40 people participated in the meeting.

International Biological Diversity Day

International Bio-diversity Day was celebrated at the GBPIHED, HQs at Kosi-Katarmal, Almora and its four regional units on the theme "Biodiversity, Development and Poverty Alleviation" (May 22, 2010) 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). Addressing a gathering of over 96 students from 17 different schools, Dr. R. S. Rawal, Scientist of the institute described the intricate relationship among different biodiversity components and its importance in poverty alleviation. In his telephonic message, Dr. L. M.S. Palni, Director of the Institute briefed on the importance of technological intervention and new scientific innovations on poverty alleviation but at the same time he emphasized on sustainable use of natural resources. Besides, various activities reflecting the theme was organized which included drawing, debate, essay writing, etc. In GBPIHED, Himachal Unit, various lectures were organized to celebrate the day. Over 500 participants including Institute staff attended the occasion.

World Environment Day

The 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 "Biodiversity and climate change in Himalaya" Kosi-Katarmal, Almora (5 June, 2010). On this occasion students from various schools of the region were exposed to various 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 nature, space, biodiversity, etc. were shown to the students. Welcoming the participants, the Director of the Institute described the importance of the 'World Environment Day' and its objectives. Dr. G. S. Bhardwaj from Wildlife Institute of India, Dehradun delivered a lecture supported with slideshow on wild-life diversity and its importance. A CD on 'Weather Observatory and Weather of Dwarahat' prepared by Sri. M. P. Pandey, G.I.C. Dwarahat in collaboration with GBPIHED was also released.

The Himachal Unit of the Institute celebrated the Environment Day with Satya Mohan Senior Secondary School, Tegubehar (Kullu). Various activities such as Declamation contest; Poster and Slogan Competitions and Cultural programmes related to the environmental conservation were organized. The Scientist In-charge, GBPIHED, Himachal Unit addressed the participants and stressed that plantation of broad leaved native trees should be promoted as they play an important role in environmental conservation.

In the Sikkim Unit, the day was celebrated with the personnel of Sikkim Armed Police. Tree saplings of different species like *Symingtonia populnea* (fodder and timber), *Michelia excelsa* (fodder and timber) and *Spondias axillaris* (fruit, fodder and timber) were planted. Similar celebrations were also held at Garhwal and NE Unit of the Institute to mark the World Environment Day.

Interactive Meeting

An Interaction Meeting with Mrs. Sarojani Ganju Thakur, Additional Chief Secretary, Himachal Pradesh and Er. Chetan Joshi, S.E., State Pollution Control Board, Kullu was held on July 05, 2010. On this occasion, the Scientist In-charge, Himachal Unit a gave brief presentation about the mandate of the Institute and the on-going R & D activities of the Himachal Unit. Discussion on various aspects to explore the possibilities for collaborations with the State Government Departments was held. Visit was arranged to different demonstration, of the Institute and laboratories. Efforts made by the GBPIHED, Himachal Unit of the Institute was appreciated by the visitors.

Exposure Visits

Exposure visits for the Officers and Trainees of Forest Training Institute, Sunder Nagar (July 09-10 & October 21, 2010), students of Manali Public School (October 08, 2010), Principal and Students of Bachpan School, Bhunter, Kullu (December 03, 2010), Director, SARA and farmers (December 2, 2010), Professors and students of Solapur University, Solapur, Maharastra (December 20, 2010), D.D.M., NABARD, Kullu and Staff and farmers of Himachal Pradesh (December 24, 2010), and Teachers and Students of the Govt. Senior Secondary School, Panarsa, District Mandi, Himachal Pradesh (December 22, 2010) were organized. On these occasions, Scientist In-charge Himachal Unit gave brief presentations to the participants about the Institute and its R & D activities. Exposure on the Herbal Garden, Arboretum, Medicinal Plants and Multipurpose Species Nurseries, living germplasm of medicinal plants, Solid Waste Management technique, vermi-composting, weed composting, shade houses, green house, Weather and Pollution Monitoring Stations, Environmental Observatory, Laboratories, Library, Tissue Culture Laboratory, etc was given to the participants.

The participants highly appreciated the efforts made by the GBPIHED, Himachal Unit and desired for the frequent visits to the Institute.

Inception Meeting and National Co-Ordination Meeting

One day Inception and National Co-Ordination Meeting under Global Pollination Project – Indian Part for *"Conservation and Management of Pollinators for Sustainable Agriculture through an Ecosystem Approach"* was organized by GBPIHED, Himachal Unit at Mohal-Kullu on July 19, 2010. Prof. T.N. Lakhanpal, Emeritus Scientist, Department of Bio-sciences, Himachal Pradesh University, Shimla was the Chief Guest. Dr. R.S. Rawal, Nodal Person, Headquarters briefly presented the progress of the project. Discussion was held on targets and deliverables, work assignments to the partners, STEP site management plans and co-ordination, formulations of National Steering Committee and Project Advisory Committee, exhibition on pollinator diversity, pollination services and finalizing network project for DST. All the partners briefly presented the progress of the project. Prof. T.N. Lakhanpal, Chief Guest highly appreciated the active participation of the partner institutions and said that the project will help in the conservation and management of pollinators for sustainable agriculture in the Indian Himalayan Region.

Dr. L.M.S. Palni, Director of the Institute, in his closing remarks said that this partnership in the above project will go a long way and establish new dimensions for the sustainable agriculture in the IHR. Prof. I.A. Hamal and Dr. Sanjay Bhatia from J&K, Dr. J.K. Gupta, Prof. V.K. Mattu, Dr. H.K. Sharma, Mr. Vinay Kumar Seth and Mr. A.P. Kapoor from Himachal

Pradesh, Prof. Uma Melkania, Dr. M.S. Khan and Dr. Sobhanna from Uttarakhand and Dr. K.K. Singh and Dr. Dattatraya from North East India attended the meeting. Dr. S.S. Samant, Scientist In-charge, GBPIHED, Himachal Unit proposed vote of thanks to the Chief Guest, the Director and all the partners for their active participation.

Consultation Meeting with Farmers

A one day Consultation Meeting on "Conservation and Cultivation of Medicinal Plants" was organized for the farmers of Ropa Village in Mandi district (July 25, 2010). Dr. S.S. Samant, Scientist In-charge, Himachal Unit briefly apprised the farmers about the medicinal plants and agrotechniques of *Withania somnifera*, a commercially viable medicinal plant. The farmers showed keen interest for the cultivation of this species at a commercial scale. A total of 35 participants including Institute Scientists and Research Scholars participated in the meeting

Herbal Day

Herbal day was celebrated at the Suryakunj of the Institute in order to generate awareness towards conservation of Himalayan medicinal plants (August 4, 2010). On this occasion, Dr. L.M.S. Palni, Director of the Institute emphasized on the importance and potential of herbal products especially in the Himalayan region where most of the people depend on natural resources. He also expressed his concern over the depletion of Indian traditional health-care system of Ayurveda, which is entirely based on the herbal produce. The day was celebrated with the plantation of medicinal plants at Suryakunj. Over 100 plants of *Euonyms hamiltonii* (Agnyo), *Cinnamomum tamala* (Tejpat) and *Embelica officinalis* (Amla) were planted. Over 30 participants including Institute faculty and researchers participated on this occasion.

State Level Steering Committee Meeting

The NE Unit organized the second meeting of State Level Steering Committee (SLSC) for the GOI-UNDP CCF-II project entitled "Biodiversity conservation through community based natural resource management in Arunachal Pradesh", on 27th August 2010. The meeting was chaired by Shri B.S. Sajwan, Principle Chief Conservator of Forests (PCCF) and Principal Secretary, Department of Environment and Forests, Govt. of Arunachal Pradesh. The other members who attended the meeting were Mr. J.L. Singh, PCCF and Chief Wildlife Warden, Mr. L.K. Pait, Addl. PCCF, Mr. G.N. Sinha, CCF & Director SFRI, Mr. B. Pradhan, Divisional Forest Officer, Tawang, Mr. K. Bida, ACF, Hapoli Forest Division, Ziro and representatives from NERIST, Nirjuli and SFRI, Itanagar, WWF-India and NCADMS, Ziro, Arunachal Pradesh. The committee reviewed the progress of the partner Institutions involved in the project and suggested that programs on natural resources management/conservation must be broadcast and telecast over radio and television for the project villages to create awareness. It was also suggested that a 'Best BMC Award' may be instituted in order to encourage and motivate the Biodiversity Management Committees constituted at project villages to function more competitively and effectively.

Training Workshop on Low Cost Appropriate Technologies

The North East Unit organized a two day training workshop on low cost appropriate technologies for capacity building of farmers at its Multi Technology Demonstration Centre, Midpu, Doimukh, Arunachal Pradesh (September 2-3, 2010). Training was imparted to the participants on seventeen low cost technologies such as production enhancement, soil erosion control, water management, post harvesting, energy/fuel saving, Nursery techniques, etc. which would benefit the farmers by improving crop productivity or providing scope for earning through entrepreneurship development. Some of the technologies like bio-briquetting have the potential to serve as alternative source of energy and could replace fuel-wood, thereby, reducing pressure on forests. The training programme was organized under the GOI-UNDP CCF-II Project entitled "Biodiversity through Community Based Natural Resource Management in Arunachal Pradesh" implemented by the Institute in an effort to promote participation of local communities in biodiversity conservation measures and resource management. Over 40 participants from 10 villages of Lower Subansiri District and West Kameng District, Arunachal Pradesh participated.

Workshop on Black Carbon and Climate Change

One Day National Workshop on "Black carbon

(BC) and other non CO_2 gases and establishment of round table on climate change in Himalaya (RCCH)" was organized by International Union for Conservation of Nature (IUCN), New Delhi office at G. B. Pant Institute of Himalayan Environment and Development GBPIHED, Kosi- Katarmal, Almora (September 17, 2010). In his welcome address Dr. LMS Palni, Director of the Institute mentioned that government has set up National Action Plan on Climate Change and sustaining the Himalayan Ecosystem is the only one location specific among the 8 missions. He also highlighted the need to generate data on climate change issue and particularly black carbon, as IPCC has also identified the Himalaya as data deficient region. Dr. J. S. Rawat (IUCN), briefed about the objectives of this one day workshop and outlined the need to establish that weather the BC has local or regional effect on glacier melting and warming. Dr. R. B. S. Rawat (PCCF, Uttarakhand) thanked IUCN for organizing the workshop at GBPIHED and providing the platform for many hardworking people in the region. He also mentioned that keeping in view the economic development of IHR we must come up with practical solutions. He told that the forest department would extend all its support to GBPIHED on studies on climate change and mitigation measures. He presented a talk on forest fire mitigation plan in Uttarkhand and informed that the pine needle production per year is about 1.5-2 million ton.

Mr P. C. Maithani, Director, MNES, mentioned that apart from emission of CO_2, other green house gases including black carbon is occupying the deable of climate change. Only 17% energy use in the form of LPG, karosine and electricity and rest comes from biomes in rural area of IHR. He opined that sustainability and affordability would be the main issue in the alternatives for biomas energy. Col. C. P. Muthanna, Environment and Health Foundation, India in his presentation outlined the climate change impacts in the Himalayan Mountains and informed about the Army's initiatives about the afforestation of wastelands in Pauri District. This one -day workshop was attended by over 30 people from Forest department, Uttarakhand, local NGOs, IUCN representatives, GBPIHED scientists/ and research scholars.

Annual Day Celebrations

The Institute celebrated 123rd Birth Anniversary of Pt. Govind Ballabh Pant and Annual Day function of the Institute at its HQs Kosi - Katarmal and all the four Units (NE Unit - Itanagar; Sikkim Unit - Pangthang; HP Unit - Kullu; Garhwal Unit - Srinagar) on September 10, 2010. The function was inaugurated with lightening of the lamp by the Chief guest Dr. Andreas Schield, Director General, International Center for Integrated Mountain and Development, Kathmandu. In this inaugural lecture, Dr. Schield highlighted the need of collaborative research between ICIMOD and GBPIHED in different aspects of Himalayan environment conservation and sustainable development. He also showed his pleasure towards initiatives of GBPIHED in different projects with ICIMOD. Padam Vibhushan Shri Chandi Prasad Bhatt Ji said that the Institute can play an important role in making policies for Himalayan Environment and development. The participation of diverse group of stakeholders on this occasion was appreciated by Shri Bhatt Ji. Dr. L. M. S. Palni, Director of the Institute briefly highlighted the Institute R & D activities conducted through its HQs, Kosi - Katarmal, Almora and throughits four regional Units. The new initiatives in the research including Glaciers study, Kailash Sacred Landscape, Climate Change, etc. were briefly highlighted and emphasized Institute's commitment for promotion and up scaling of environmentally friendly and cost effective techniques in the region. Member of Parliament Almora - Pithoragarh region, Shri Pradeep Tamta stressed on the conservation of water resources and emphasized the need on assessment of Hydropower projects in the Indian Himalayan Region. Member of Legislative Assembly (MLA) Shri Manoj Tewari emphasized on the need conservation of Kosi river and appreciated the Institute initiatives in this context.

On this occasion 16th Pt. Govind Ballabh Pant Memorial lecture entitled "Interrogating an Insect Society" was delivered by Prof. R. Gadakar, FNA, Center for Ecological Sciences, Bangalore. Through his lecture, Prof. Gadakar enlightened the audience on the importance of insect in the society. Over the year research on Indian paper wasp, he concluded that insect are the best to show their ability to work in a society and human beings need to learn from them.

Besides, Photo exhibition on different aspect of Himalayan Biodiversity organized by Institute was inaugurated by Padam Vibhushan Shri Chandi Prasad Bhatt Ji. Dr. Andreas Schield, DG, ICIMOD released a book "Compendium of Statistics of Himalaya Region". Vote of thank was proposed by Dr. P. P. Dhyani, Senior Scientist of the Institute. Over 300 participants participated in this event.

Wild Life Week Celebrations

Wildlife Week was celebrated at the HQs and its four regional units namely NE Unit, Himachal Unit, Garhwal Unit and Sikkim unit of the Institute (6-7 October 2010). The aim of the celebration was to aware the youth (school children and teachers) on Biodiversity Conservation. On this occasion, a Biodiversity exposure and interpretation campaign for students and teachers of Almora District were organized and particular emphasis was given on inculcating interest among the children for diversity of life in their immediate surrounding. Exposure visit to the 'Suryakunj' - Nature Interpretation and Learning Centre established within the Institute Campus at Kosi-Katarmal, Almora, was the main event followed by various on-spot competitions for the students. Over 110 students and 13 teachers from 12 schools participated in the programme.

Also, an Interactive session on "Surya-Kunj Nature Interpretation& Learning Centre- Next five year and beyond" was organized at Surya- Kunj. At the outset convener of the session, Dr R. S. Rawal, welcomed the participants and briefed about the objectives and progress of Suryakunj. The Chairman, Dr S. K. Nandi, emphasized on the need for inputs from all the participants. He indicated that the main goal of this session is to provide guidelines to Biodiversity Conservation and Management (BCM) theme for further strengthening its activities in Surya- Kunj. The interaction was focused on *Surya-Kunj (i-as Nature Interpretation and Interactive Learning Center(NILC) (ii) an integrated demonstration site (iii) an outreach facility and (iv) a self sustaining programme*. Finally the need for such interactive session on regular basis was highlighted by the participants. The session was attended by the Institute faculty and researchers. The session ended with a vote of thanks to the Chair.

At North East Unit of the Institute, the day was celebrated by distributing LPG kits and piglets among villagers of West Kameng district of Arunachal Pradesh under its GOI-UNDP CCF-II project entitled "Biodiversity conservation through community based natural resource management in Arunachal Pradesh". Piglets were distributed among identified beneficiaries in Namshu, Sangti and Jamriri villages and LPG kits were distributed in Chander village, the remotest villages of the district. Also an awareness workshop was conducted in these villages which were represented by villagers, members of Biodiversity Management Committee (BMCs), SHGs and others. Also an awareness rally on biodiversity conservation was organized during Wildlife Week at Ziro valley in Arunachal Pradesh with the collaboration of Forest Department, Govt. of Arunachal Pradesh and Nature Care and Disaster Management Society. Over 500 people including school children, teachers, officials from line departments, general public, NGOs, etc. participated.

Brainstorming on Biodiversity Conservation & Transboudary Landscapes

A brainstorming workshop on the project entitled "*Assessment of biodiversity values and ecosystem services in the protected areas of Sikkim Himalaya*" was organized by the Sikkim Unit of GBPIHED (November 10, 2010). The project executed in the protected areas (PAs) of Fambonglho wildlife sanctuary (WLS), Kyangnosla WLS and WLS.Dr.Dr. K..K.Singh, Scientist-in-Charge of the GBPIHED-Sikkim Unit and Coordinator BCTL Project, welcomes the the participants and briefed on the progress of the Institute. Discussion and presentation was deliberated on various issues related to fuelwood use during the winters in the wildlife sanctuaries, NTFP scenario, decreasing population of Pamsee trees (Himalayan avocado *Machilus edulis*), Katus (*Castanopsis tribuloides*), Book (*Quercus lamellosa*), the rise of bear menace in villages, and many other aspects on conservation. Concerns were also placed for the prospect of nature tourism at WLS, training of the nature guides and related personnel as well as the evident climate change in the locality, etc. The participants were from forest department, Panchayat Presidents and members, Joint Forest Management (JFM) representatives, meteorological department and the village eco-tourism work groups, etc.

State Level Exhibition

The Himachal Unit of the Institute participated in the exhibition organized by State Council for Science, Technology & Environment, Himachal Pradesh and Department of Education, Himachal Pradesh at Government Senior Secondary School, Hamirpur, Himachal Pradesh from 14th -17th November, 2010. Various posters of R & D activities on Biodiversity Conservation and Management, Environmental Assessment and Management, Biotechnological Applications and Socio-Economic Development and equipments (GPS, Respirable Dust Sampler, Noise Meter, Personal Sampler, etc.) were displayed. The Exhibition was inaugurated by Smt. Rajwant Sandhu, Chief Secretary, Govt. of Himachal Pradesh. Smt. Sarojani Ganju Thakur, Additional Chief Secretary, Govt. of Himachal Pradesh, Dr. Nagin Nanda, Director, State Council for Science, Technology and Environment, Dr. R.K. Sood, Joint Member Secretary (Rtd.), and other Officers of the State Government were present during the inaugural session. On November 17, Hon'ble Chief Minister Prof. Prem Kumar Dhumal and other dignitaries of the state visited the exhibition. Over 5,000 students, teachers, Principals, Officers and Staff of State Council for Science, Technology and Environment and other stakeholders visited the exhibition. All the dignitaries and other visitors actively interacted with the Scientists and Research Scholars and highly appreciated the efforts made by Himachal Unit of the Institute.

Short Term Training Program on Soil Analysis and Data Interpretation

A short term training program on *"Soil Analysis and Data Interpretation"* was organized at Institute HQs, Kosi-Katarmal, Almora (November 5-17, 2010). The goal of the training program was to provide basic information on soil sampling methods, laboratory procedures for analysis and interpretation of the data. The program included lectures on basics of soil analysis, statistical procedures used in the field for soil sampling, hands-on training on chemical analysis of the soil samples in the laboratory, analysis of the data for interpretation of the result using various statistical techniques. The training was provided by the resource persons from Institute and invited guests from outside institution. Besides, practical exposure of soil sampling techniques was given to the participants. A total of 15 research scholars participated in the training program.

International Mountain Day

The NE Unit celebrated International Mountain Day (December 11, 2010) by conducting biodiversity conservation awareness campaigns and patrolling on forest areas for 21 days from December 11-31, 2010 in the project villages of GOI-UNDP CCF-II project of the Institute. The compaign was jointly conducted with Biodiversity Management Committee (BMCs) of Hong-Niichii and Hong-Niitii villages, Divisional Forest Office, Nature Care & Disaster Management Society, Ziro for tracking in surrounding forests across Apatani plateau. The patrolling throughout the period was carried out by teams consisting members from BMCs, Goan Burahs (Village Heads), NCADMS, forest officials, etc. The awareness campaigns focused on biodiversity management including prohibition of hunting. The event was broadcast in local TV channels to promote biodiversity conservation.

International workshop on Biodiversity and Climate Change

Three days International Workshop on "Mountain Biodiversity & Impacts of Climate Change with special reference to Himalayan Biodiversity Hotspot" was organized by the G.B. Pant Institute of Himalayan Environment and Development (GBPIHED), Kosi Katarmal, Almora at its HQs during December 6-8, 2010. The International Center for Integrated Mountain Development (ICIMOD), Kathmandu was the co-organizer of the workshop. Other collaborators/special session organizers include UNESCO, New Delhi Office; IUCN India Office; Herbal Research and Development Institute (Govt. of Uttarakhand), Gopeshwar, Chamoli; State Biotech Programme (Govt. of Uttarakhand), Haldi; Uttarakhand Council of Science and Technology (Govt. of Uttarakhand), Dehradun; GEF/UNDP Small Grants Project CEE; Global Pollination Project – India Component and Kailash Sacred Landscape Conservation Initiative (KSLCI)- India Part.

The workshop was inaugurated by Prof. S.P. Singh, FNA, Former Vice Chancellor H.N.B. Garhwal University and Advisor Planning Commission, Govt. of Uttarakhand and Prof. A.N. Purohit, Padam Shree, presided over the inaugural function. In his inaugural lecture, Prof. S.P. Singh explained ongoing changes in mountain biodiversity which could be attributed to

changing climate. He emphasized on the need for undertaking in-depth studies to undertake process and future implication of such changes, especially considering that the mountains are the unique source of biological diversity. Prof. A.N. Purohit, in his presidential address appreciated the efforts of GBPIHED for timely initiative to organize this workshop on globally important subject which include mountain biodiversity and climate change impacts. Realizing the paucity of reliable datasets on various aspects of mountain biodiversity and climate change impacts, he highlighted the need for collecting/generating authentic datasets, following standard protocols, so as to provide research based information backup for development of strategies for conservation and sustainable use of mountains biodiversity. Dr. L.M.S. Palni, Director, GBPIHED, while welcoming the participants from different parts of 'Himalayan Biodiversity Hotspot, focused on the importance of Himalayan Ecosystem as resource and service provider for sustenance of millions of people within and well beyond its boundaries. The concept of the workshop, overall objectives and outcomes of envisaces were explained by Dr. R.S. Rawal, Convener of the workshop. Dr. P.P. Dhyani, Scientist 'G', GBPIHED proposed Vote of Thanks.

During three days of the workshop, presentations/discussions were made under Technical Session (I - Himalayan Biodiversity – Stock Taking; II - Climate Change: Genes & Species Level Responses; III - Climate Change: Habitat & Community Level Responses; IV - Contemporary Thinking: Approaches, Initiatives, and Incentives; V - Climate Change & Biodiversity: Socio-economic Concerns; and VI - Climate Change, Farming Systems & Livelihood Options), and special session (GEF/UNDP SGP Projects; II- Climate Change and Transboundary Landscapes – Focus on KSL; III - Development of Medicinal Plant Sector in Uttarakhand: Issues & Prospects (HRDI); IV - Diversity of Pollinators under Changing Climate; V - Conservation & Management of Biodiversity vis a vis Climate Change (IUCN, New Delhi Office); VI - Role of Biosphere Reserves in Changing Climate (UNESCO, New Delhi Office). Besides, Young Researcher Forum and Himalayan Knowledge Network were also the major focus of the Workshop.

During the three day workshop 50 papers on different aspects were presented by scientists/ researchers and 44 posters by research scholars. Over 150 participants from Myanmar, Bhutan, Nepal and different Institutions/universities of India participated in the workshop.

The workshop was attended by Prof. T.N. Lakhanpal, Himachal Pradesh University, Shimla; Prof. S.P. Singh, FNA, Former Vice Chancellor,HNB Garhwal University Srinagar Garhwal , Advisor, State Planning Commission, Govt. of Uttarakhand; Dr. G.S. Rawat, Wildlife Institute of India, Dehradun; Dr. B.S. Bisht, Vice Chancellor, G.B. Pant University of Agriculture & Technology, Pantnagar; Dr. R.S. Tolia, IAS, Chief Information Commissioner Uttarkhand; Dr. E. Sharma, ICIMOD Kathmandu; Prof. A.N. Purohit, former Director of GBPIHED Kosi, Almora and Vice Chancellor, HNB Garhwal University, Srinagar Garhwal; Dr. J.C. Bhatt, Director VPKAS, Almora; Dr. Sangya Dema, Bhutan; Dr. Thet Tun, Myanmar; Dr. S.P. Gurang, Nepal; Dr. Lalit Pandey, Almora, Dr. R.C. Sundriyal, Director, HRDI, Gopeshwar; Dr. Rajendra Dobhal, Director, UCOST Dehradun; Manoj Chandran, IFS, Pithoragarh; Dr. D.K. Upreti, NBRI, Lucknow; Prof. Uma Melkania, Pantnagar; and many others.

Workshop on Climate Change

Citizens' Global Platform - India (CGP-India) in collaboration with G. B. Pant Institute of Himalayan Environment and Development, Almora organized a national level workshop on "Search of Alternative Paradigms in the context of Climate Distortion" to understand and join hands in combating Climate change at Kosi-Katarmal, Almora (December 29-30, 2010).

The discussions were focused on the problems related to global warming and its impact on the livelihood of mountain populations. Around 100 social activists, environmental activists, research scholars, journalists, representatives of NGOs, civil society movement groups, grass root workers from different parts of India participated in the workshop.

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 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, the changing world scenario stresses the need for increasing food production, pharmaceutical and other products, along with heavy industrialization, which has 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.

Theme

WATERSHED PROCESSES & 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 the dynamics of the watershed processes and evaluation of ecosystem components on a watershed scale; ii) Develop ways and means of optimal uses of watershed services for improved economic and ecological viability; and iii) Evolve 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)*

This project focuses on interface of water demand & availability, major land uses (forest land, agriculture / waste land and urbanization) for water sustainability in the fragile Himalayan watersheds. The study is conducted in the northern part of the Kosi basin (upper Kosi watershed between 29° 30' and 29° 55' N Latitudes and 79° 30' and 79°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 1080m and 2720 m from the mean sea level. To summarize catchment hydrologic response and to link land use and hydrological response, flow duration curves (FDC) for different years have been constructed. By using Optimization technique water allocation for different competing uses within a watershed is attempted. For forecasting the future water demand, water demand growth rates are calculated. Based on these rates three scenarios are developed and water demand of our study area is forecasted till the year 2030. 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, lying 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°15' to 27°20' N and 88°37'30" to 88°42'30" E, embracing an area of 35.42 sq. km.

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

- Water has been allocated among the four sectors namely Rural Household, Urban Household, Livestock and Agriculture. Agriculture is the highest water demanding sector followed by the livestock demand, which generates maximum net economic return. The Available water is less than total demand of the sectors for the months of April, May, June, July and December.
- Results of water demand forecast show that at low consumption rates (40LPCD) demand will increase by 4.96 to 6.3 MLD in 2030. *At medium consumption (51 LPCD) demand will increase by 6.32 to 7.95 MLD in 2030(Fig.1, 2 and 3).* Low demand satisfaction indicates conservative use of water whereas *high demand satisfaction indicates high use of water with improved socio-economic condition.*
- The flow duration curve of Kosi for water year 2009-10 describes the changing flow pattern during the year. A large part of the year falls under dry weather and low flow conditions. Only about 10 % time in the year the high flow conditions are observed. For almost 60 % of the time the river flow is sustained by the base flow (Fig.4). The river flow at the present demand level can supply for nearly 290 days per year. The rise in demand for

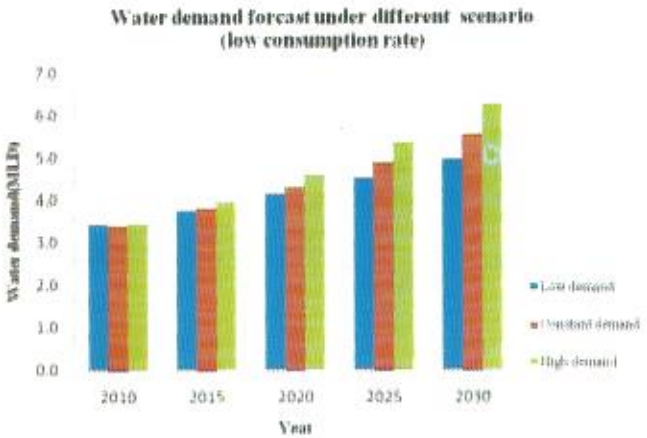


Fig.1. Water demand forecast for low consumption rate.

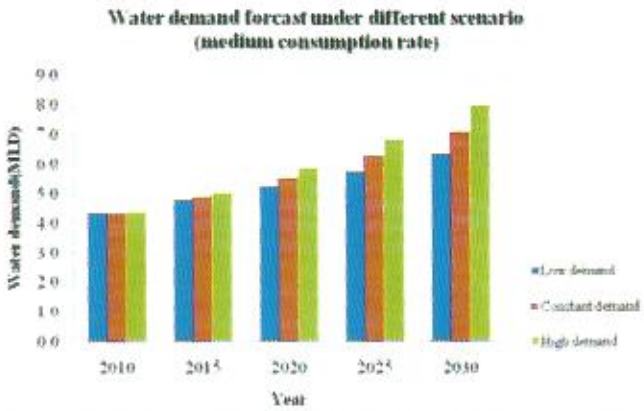


Fig. 2. Water demand forecast for medium consumption rate.

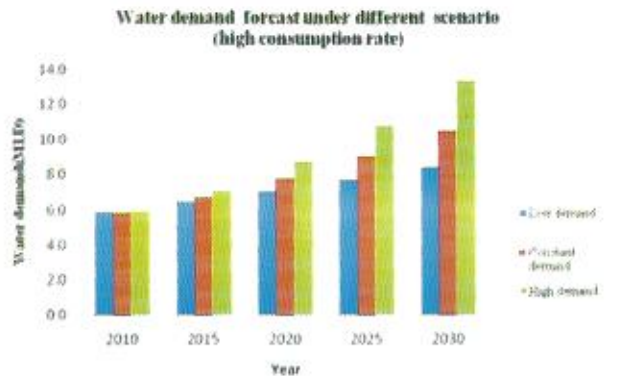


Fig. 3. Water demand forecast for high consumption rate (Case of urbanization).

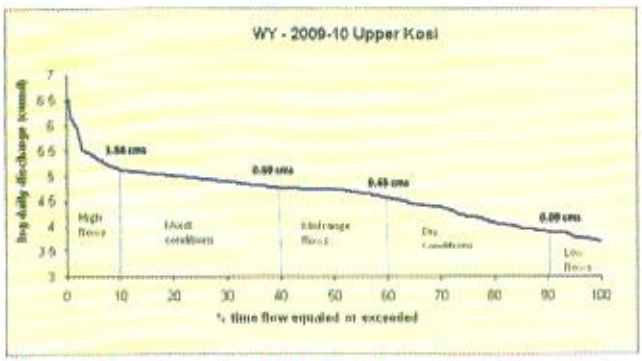


Fig. 4. Flow duration curve for Upper Kosi Watershed.

2030 will further increase the water shortage for nearly 145 days for a normal rainfall year.

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 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 the utilization of sacred and cultural 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

Fig. 5. Multipurpose Tree Model (MTM) at Kolidhaik village (Lohaghat, Uttarakhand).

Fig. 6. Fodder collection from Multipurpose Tree Model (MTM) site (Kolidhaik, Lohaghat, Uttarakhand).

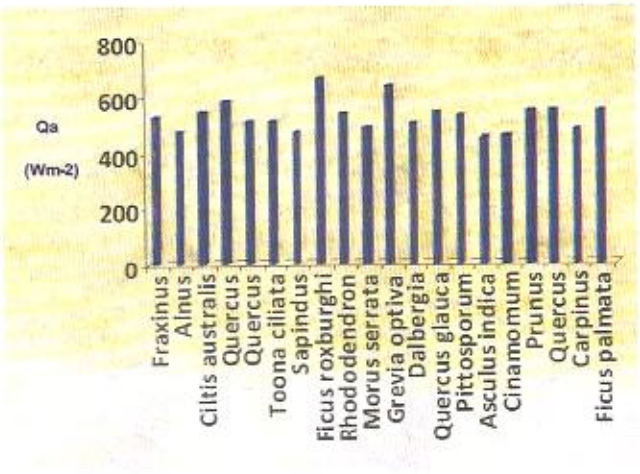


Fig. 7. Total leaf energy absorption (Qa) by the leaves of 20 promising tree species when planted at the Multipurpose Tree Model (MTM) site (Kolidhaik, Lohaghat, Uttarakhand).

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 develop guidelines for the development, management and protection of sacred forests/landscapes in the Indian Himalayan region.

Achievements

Following R&D interventions for 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 Kolidhaik village (Lohaghat, Uttarakhand) were carried out during the year 2010-11.

- About 900 well-established saplings of 5 tree species namely, Banj (*Quercus leucotrichophora*), Phalyant (*Quercus gluca*), Tilonj (*Quercus floribunda*), Utis (*Alnus nepalensis*) and Bitain (*Melia azedarachta*) were planted at the MTM project site; 3 eco-paths (total length – 481m) were also made at the site.
- Almost 1600 well-established saplings of 6 tree species namely, Deodar (*Cedrus deodara*), Padam (*Prunus cerasoides*), Utis (*Alnus nepalensis*), Banj (*Quercus leucotrichophora*), Phalyant (*Quercus gluca*) and Bedu (*Ficus palmata*) were planted at the SFM project site by the involvement of local stakeholders; 4 eco-paths (total length – 414m) were also made at the site.
- Almost 700 plant saplings of 2 promising fodder tree species namely, Banj (*Quercus leucotrichophora*) and Phalyant (*Quercus gluca*) were distributed, free of cost, among the local villagers for plantation in and around their habitation.
- At the MTM site (Fig.5), the average survival of plants was recorded 85% whereas at the SFM site, it was 86%. At the HTM site, the average survival of plants was 75%; the farmers/women of 88 families (of 6 villages) collected 18 tonne green fodder (Fig.6) from the project sites during the year 2010.
- The data obtained on leaf energy budget of 20 promising tree species, when planted at the MTM site in Kolidhaik village, revealed that most of the energy absorbed by the '*undertemperature*' plants was lost from the leaves by re-radiation and transpiration whereas in '*overtemperature*' plants the absorbed energy was lost from the leaves by re-radiation, transpiration and convection of heat; the results obtained on total leaf energy absorption revealed lowest amount of energy absorption by the leaves of *Aesculus indica* whereas the leaves of *Ficus roxburghii* absorbed highest amount of energy (Fig.7).
- A two-day on-site training programme on "*Aajeevika sambardhan hetu varsa jal sanrakshan evam prabandhan*" was organized at Kolidhaik village in the Champawat district of Uttarakhand on 17-18 December 2010. Almost 50 stakeholders from local areas attended the programme and their skills were upgraded.

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

Use of energy is an 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, depend on traditional fuels often using primitive and inefficient technologies. Rural domestic energy requirements are mainly for cooking, lighnting, and space heating. Thus, in addition to affluence as a variable, geography also plays a crucial role in energy use and associated processes. Increasing demands of the growing rural population has put additional pressure on the local resources. The 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

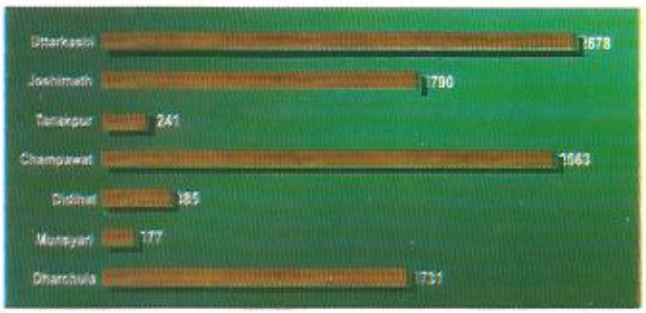
- Major policy interventions are required to popularize and adopt energy alternatives in rural areas (Fig. 8). *Kutir Jyoti* connections (electricity for poor and BPL families) are growing in the state.
- Environmental perception on impact of firewood collection from forests - Most of the villagers (82.2% of the total respondents) were aware that some reason(s) exists which are responsible for the phenomenon of no recruitment of seedlings in the forest. Only 17.8% respondents were not able to connect any reason/factor for this (share of women was higher than men, Table-1).

- The nodal agency for renewable, UREDA, in Uttarakhand has initiated a Bundled Microhydel Projects (3.115 MW) approach. The proposed project activity involves construction and operation of 29 Microhydel projects in the state of Uttarakhand.

Table 1: Perception on impact of fire wood collection from forests

Sl. No.	Category/ Class	Perceived Factors (% Respondents)				
		Climatic	Fire	Management	Anthro. Activity	No Idea
1	Total Respondents (%)	17.8	32.1	17.8	42.8	17.8
2	Male	100.0	77.7	80.0	16.6	40.0
3	Female	0.0	22.3	20.0	83.3	60.0
4	Education Level					
a	College	40.0	33.4	40.0	-	-
b	Below College	60.0	55.5	40.0	75.0	60.0
c	No formal Education	-	11.1	20.0	25.0	40.0
5	Employment					
a	Service	20.0	12.5	20.0	-	20.0
b	Self Employed	60.0	33.3	40.0	-	20.0
c	No Commercial Activity	20.0	55.5	40.0	100.0	60.0
6	Economic					
	BPL	40.0	22.2	20.0	25.0	40.0

Gas Agency



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)*

Trees and vegetation contribute to the beauty, distinctiveness, and material value of communities by incorporating the natural environment into the built environment. Urban trees 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. 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. It 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 policies for management of urban green areas.

Achievements

- Landscape of the Nainital town is very diverse in topography and vegetation due to a wide elevational difference (~1800 - ~2600 m) within the municipal limits of the town. Landuse/ Landcover map using LISS-IV satellite image was prepared which consists of eighteen different classes. Mapable urban vegetation in the town area are - Oak, Cypress, Cedar, Pine, Mixed Oak, Mixed broadleaf & Conifer, Mixed Conifer, Mixed broadleaf, Broadleaf deciduous, Broadleaf Evergreen, and Plantations (Fig.9). Total municipal area is 13.79 km^2. Of the total Landuse/landcover tree cover occupies 58.8% (811.59 ha) of the total area, and remaining area 568.29 ha is under various uses (builtup area, scrub, playground, etc.) or natural features (open rocks, lakes, etc.)
- Among the various tree covers maximum forested area is occupied by mixed oak communities (56% of the total forest area; co-dominated by *Quercus floribunda* and *Q. leucotrichophora*) than followed by oak (14.2%, *Q. leucotrichophora*), and Mixed Braodleaf & Conifer (10.3%). A sizeable portion of

the municipal landscape is under cover of cypress (9.6%, *Cupressus torulosa*).

- However most of the settlement is confined to the lake catchment area of the Naini Lake. Open rocks and Open areas without trees in the Nainital town constitute a considerable portion of the landscape (23.5% of the entire Naintal Municipal Area).

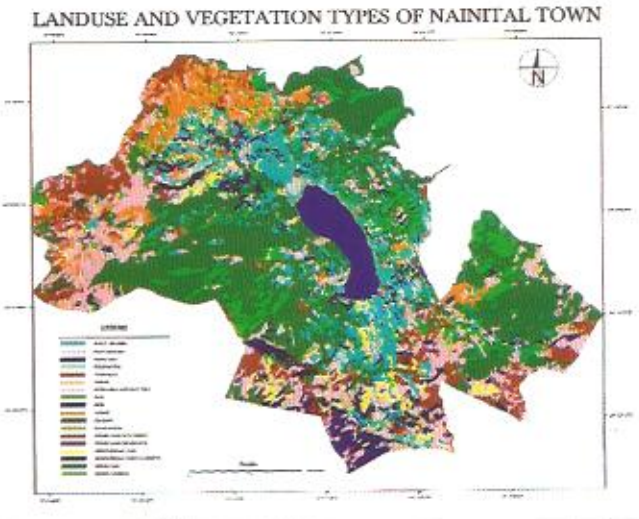


Fig. 9. Land use – Land cover map of Nainital Town

Nematode Diversity in the Traditional Agro-ecosystem of Central Himalaya, Their Impact on Soil Health, Crop Growth and Development of Demonstration Model for Agro-ecotourism *(2007-2012, In-house)*

Nematodes are important mineralizers, in systems poor in nitrogen. Information on soil nematode diversity and their role in the traditional cropping system is fragmentary. 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_4. 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

- The NCR (nematode channel ratio) a ratio representing the proportion of bacterivores and fungivores indicated that paddy and foxtail millet sown in equal proportions were best for supporting a faster bacterial driven decomposition channel as it showed the highest NCR ratio of 0.76. This is followed by paddy foxtail millet 4:2, paddy sole cropping, paddy foxtail millet 2:4 and foxtail millet sole cropping (Table-2).
- 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 resolution of the faunal analysis was enhanced by calculating the faunal diversity and maturity indices which reflected their importance in the food web structure and decomposition channel (Table-3). Diversity indices showed high nematode diversity (H' = 2.52) and high values of maturity indices (2.50– 3.32) depicted fewer disturbance.

Table-2. Nematode Channel Ratio (NCR) for *Kharif* cropping season.

S. No.	Treatment	NCR	C:N ratio
1.	Paddy sole cropping	0.68	12.6
2.	Paddy: Foxtail millet 4:2	0.75	11.29
3.	Paddy: Foxtail millet 3:3	0.76	10.5
4.	Paddy: Foxtail millet 2:4	0.67	12.6
5.	Foxtail millet sole cropping	0.62	15.0

Table-3. Indices of nematode fauna under five treatment plots.

Indices of nematode fauna	Paddy sole cropping	Intercropped ratios			Foxtail millet sole cropping
		4:2	3:3	2:4	
Margalef index Species richness (Margalef 1958)	2.99	3.28	3.67	2.79	2.37
Shanon-Weiner's index H' species diversity (Shanon & Weaver, 1949)	2.37	2.41	2.52	2.29	2.39
Simpson's index (Simpson 1949)	1.92	2.12	2.05	1.98	1.96
Equatibility or evenness index or Pielou's index (Pielou 1966)	0.82	0.85	0.86	0.79	0.77
Maturity Index (MI) for free living soil nematodes (Bongers 1990)	3.07	2.50	3.32	2.79	2.63

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

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 areas as they are inexpensive, culturally familiar and readily available. In Uttarakhand majority of traditional health care practitioners (THCP), locally called *vaidyas*, are found in remote rural areas and have great utilities to the community in absence of modern health services, particularly in remote areas. The *vaidyas largely* use largely medicinal herbs for preparation of formulations and treatments. Documentation of phytochemiclas and associated therapeutic properties of medicinal plants used by the traditional *vaidyas* has been done

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 used in traditional health care practice
- Identification of possible IPR value.

Achievements

- Phytochemistry of 67 medicinal plants (MP) used by the traditional *vaidyas* has been documented from published sources. 102 therapeutic properties and associated active principals have been documented. Antimicrobial therapeutic property was possessed by maximum number of 14 MP (*Cuscuta reflexa, Psidium guajava, Origanum vulgare, Ajuga parviflora, Solanum nigrum, Ficus religiosa, Ricinus communis, Emblica officinalis, Terminalia bellirica, Matricaria camomillia. Foeniculum vulgare, Butea monosperma, Mimosa pudica. & Triticum aestivum*), followed by anti-inflammatory property which was found in 13 MP, antioxidant property in 12 MP, anticancer property in 11 MP, antibacterial property in 10 MP and antifungal therapeutic property in 7 MP (Fig.10 & 11).
- Three Medicinal plant species such as *Punica granitum* (*Anar*), *Tinospora cordifolia* (*Giloe*), and *Cynodon dactylon* (*Doob ghas*) had antidiabetic therapeutic property. Anti HIV and radioprotective properties were found respectively in *Bergenia ciliata* (*Pashan bhed*) and *Podophyllum hexandrum* (*Van kakri*).
- Highest number of 9 therapeutic properties were documented in *Nardostachys jatamansi* (*Jatamansi*) & *Azadirachta indica* (*Neem*), followed by *Centella asiatica* which had 8 therapeutic properties and 4 MP species (*Cuscuta reflexa, Cassia fistula, Matricaria camomillia, Podophyllum hexandrum*) had 6 therapeutic properties (Table-4). 19 MP has only one therapeutic property.

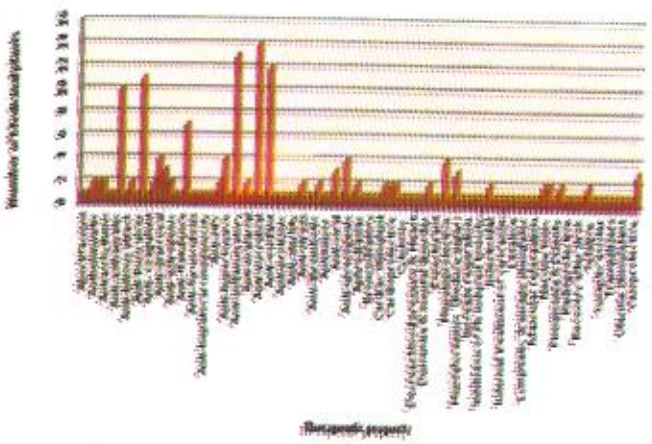


Fig. 10. Therapeutic properties of medicinal plants used in Upper Alaknanda valley.

Table-4. Medicinal plants and numbers of their therapeutic properties.

S.N.	Name of MP species	Number of therapeutic properties of each MP
1.	*Nardostachys jatamansi* and *Azadirachta indica*	9
2.	*Centella asiati ca*	8
3.	*Cuscuta reflexa, Cassia fistula, Matricaria camomillia* and *Podophyllum hexandrum*	6
4.	*Psidium guajava, Ajuga parviflora, Withania somnifera, Achyrantus bidentata* and *Zanthoxylum armatum*	5
5.	*Aconitum heterophylu, Ocimum sanctum. Solanum nigrum, Adhat oda vasica. Betula utilis, Citrus medica, Foeniculum vulgare, Piper longum, Butea monosperma, Tinospora cordifolia* and *Asparagus racemosus*	4
6.	*Juglans regia, Punica granitum, Emblica officinalis, Saussurea costus, Allium humile, Astragalus sp, Rheum australe, Galium aparine, Diplocyclos palmatus* and *Curculigo orchioides*	3

7.	*Colebrookea oppositifolia*, Ocimum americanum, *Origanum vulgare*, *Mentha arvensis*, *Ficus racemosa*, *Barleria prionitis*, *Abrus precatorious*, *Hedychium spicatum*, *Satyrium nepalense*, *Citu llus colocynthis*, *Nerium indium*, *Rauwolfia serpentine*, *Mimosa pudica*, *Carica papaya* and *Cynodon dactylon*	2
8.	*Ficus religiosa*, *Ricinus communis*, *Mallotus philippensis*, *Terminalia bellirica*, *Terminalia chebula*, *Swertia chirayita*, *Boswellia serrata*, *Dactylorrhiza hatagirea*, *Cissus adnata*, *Picrasma quassioides*, *Pistacia integerrima*, *Picrorrhiza currooa*, *Calotropis procera*, *Bergenia ciliate*, *Fumaria parviflora*, *Sapindus mukorosii*, *Argemone Mexicana*, *Taxus baccata* and *Triticum aestivum*	1
9.	*Ficus religiosa*, *Ricinus communis*, *Mallotus philippensis*, *Terminalia bellirica*, *Terminalia chebula*, *Swertia chirayita*, *Boswellia serrata*, *Dactylorrhiza hatagirea*, *Cissus adnata*, *Picrasma quassioides*, *Pistacia integerrima*, *Picrorrhiza currooa*, *Calotropis procera*, *Bergenia ciliate*, *Fumaria parviflora*, *Sapindus mukorosii*, *Argemone Mexicana*, *Taxus baccata and Triticum aestivum*	1

Fig. 11. Phytochemicals found in Centella asiatica (Brahmi buti) has therapeutic properties of anti-leprosy, anti-tuberculosis, anti-protozoal, spasmolytic, anti-cancer effect, grafting of wounds, psychotropic, sedative, anti-convulsant, dementia and treatment of mental disorder.

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. GBPIHED, through its R&D activities, has produced considerable amount of data on different aspects which is scattered and thus needs to be organized and integrated with other research activities. These issues were raised in the previously held 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. First such attempt is made with the analysis of climate data available in the Institute. An analysis of long term climatic variability and changes in twentieth century over North-Western Himalaya (NWH) of IHR for past 101 years (1901-2001) has been carried out. For this study the CRU TS2.1 dataset of Climate Research Unit (CRU), UK (available at 0.5^{0} lat. long. grid) was used. The analysis includes three parameters namely; precipitation, temperature (maxi, min) and diurnal temperature range (DTR) on seasonal (i.e. Pre-monsoon: March-May, Monsoon: June-September, Winter: November-February) & annual basis.

Objectives

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

- Increasing trends in temperature at different rates have been observed in the last century (Fig.12). Significant increase in winter temperature (both

max & min) in J&K and UK, declining in HP and significantly increasing trends of maximum temperature during monsoon in all three states are observed.

- Overall significant decrease in precipitation in J&K and UK; declining but not significant in HP; significantly declining trends of monsoon precipitation in all three states; increase in winter precipitation in UK & HP; decrease in J&K has been observed (Table-5).
- Rate of increase in temperature in North-West Himalaya is higher than Indian annual mean (0.51 °C/100 yr) and global mean (0.74 °C/100 yr, *INCCA Report #2, 2010*).

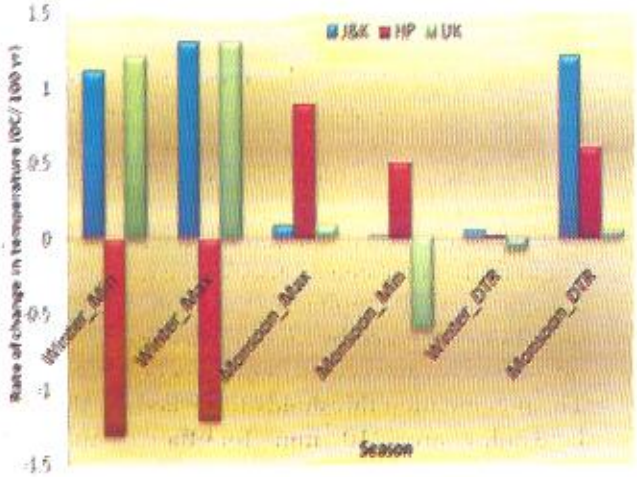


Fig. 12. Rate of change in temperature in North-West Himalaya during past century (1901-2001).

Table-5. Trends in temporal variation in precipitation North-West Himalaya during past century (1901-2001).

State	Season	Trend Analysis	
		Mann-Kendall Method	Linear Regression
J & K	Winter	( )**	( )**
	Pre-Monsoon	( )*	( )*
	Monsoon	( )**	(-)**
	Annual	( )*	( )*
H P	Winter	(+)	(+)
	Pre-Monsoon	(+)*	(+)*
	Monsoon	(-)*	( )*
	Annual	(-)	( )
UK	Winter	(+)**	(+)**
	Pre-Monsoon	( )*	( )*
	Monsoon	(-)*	( )*
	Annual	(-)*	( )*

(+): Increasing, (-): Decreasing, *Significant at 95 % level of confidence, ** Significant at 90 % level of confidence

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 water resource in two microwatersheds, one urban micro-watershed (Pauri Urban Area) and the other rural micro-watershed (Dugar-gad watershed).Through this project we will also attempt 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, landuse/landcover with the spring discharge
- To implement rainwater recharge structure in the catchment area and execute water harvesting structures to enhance the productivity of the fracture hard rock aquifer.

Achievements

- Stable isotope results of samples collected from rainfall, spring and tube wells indicate that shallow unconfined ground water is the common source for springs as well as tube wells. Local meteoric line of study area matches with regional meteoric line of N.W. Himalaya (Fig.13).
- Assessment of water availability during the lean period and surplus period was done for a few springs with the help of flow duration curve analysis (Fig.14). Assessment of water availability indicates that additional storage structures should be constructed to tap the surplus water available during the monsoon period to cope with the seasonal water scarcity in the high mountain basins of Himalaya.

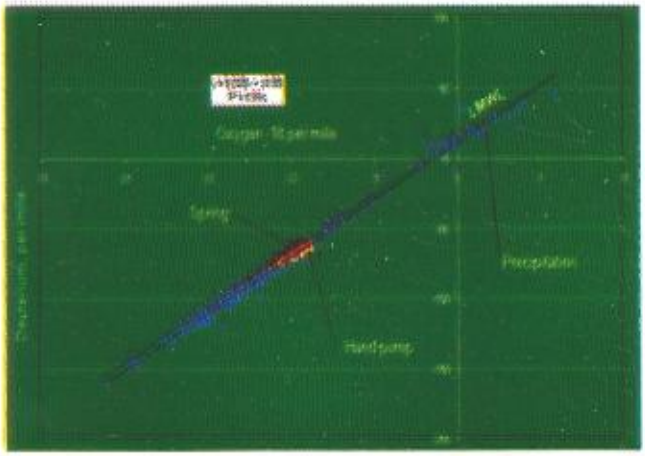


Fig.13. The δD and δ 18O plot of rainfall, springs and handpumps in the study area.

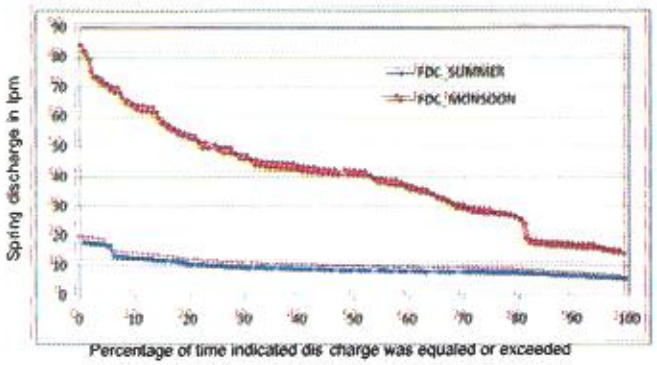


Fig. 14. Seasonal flow duration curve for Lower market spring highlighting the surplus water availability during the monsoon period.

Development of Early Warning Model for Landslide Using Remote Sensing and GIS: Case Study From Sikkim *(2008-2011, Space Application Centre, Ahmadabad)*

In the Sikkim Himalaya most of the landslides occur during monsoon season. Prominent factors controlling landslides are lithology, slope, drainage, landforms, different land use and unusual behavior of rainfall pattern in the hilly terrain. Satellite remote sensing with improved spatial resolution in recent years has made it possible to map and monitor geo-environmental factors affecting landslides and to understand the underlying mechanism behind them. Many a time landsides cause colossal loss to life and property. The early warning of triggering of landslide in a known area could be of immense importance. Early Warning model would be helpful in disaster mitigation and management, saving life and property of the dwellers. An attempt is being made (jointly by Space Application Centre, Ahmedabad and G.B. Pant Institute of Himalayan Environment and Development, Sikkim Unit) for the development of Early Warning System for landslides using Remote Sensing and GIS tools. The present study will enable us to warn about the landslide occurrences, well before their triggerence and the Early Information can be developed for the safety of the dwellers

Objectives

- Attempt to establish threshold value of rainfall for landslide occurrence.
- Attempt to generate probable landslides initiation points using slope stability models using GIS.

Achievements

- The general land use and land cover map of Sikkim was prepared. The major landuse features mapped were reserved forests, agricultural and other land, rural and urban settlements, water bodies and moraines (Fig.15).
- Statistical analysis of the rainfall data was carried out to find out the consistency of the rainfall in the various years. Precipitation threshold for the few landslides triggered by rainfall was also estimated on the basis of antecedent rainfall records.
- The precipitation thresholds furnished for the few landslides are 210 mm for the Chanmarai,

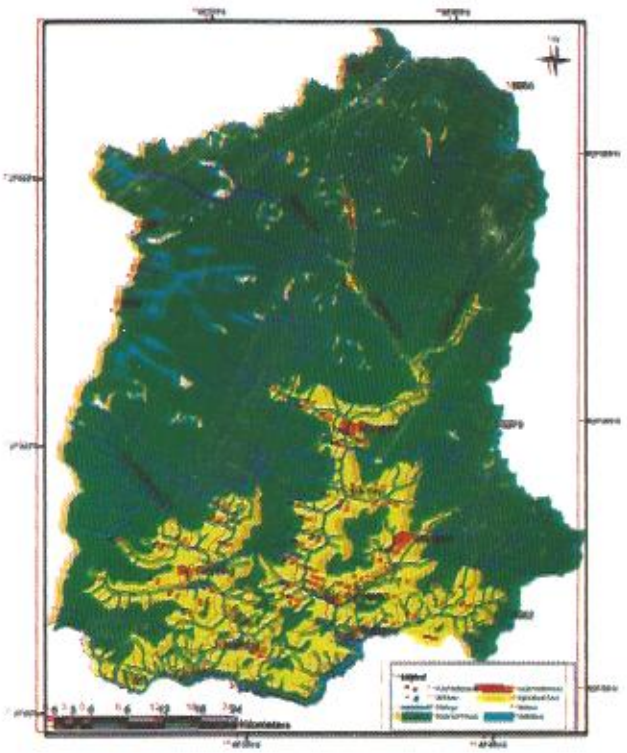


Fig.15. Land use and land cover map of Sikkim.

Tatchenchen, Zero Point and the Development area landslides. However, it was 250 and 158 cm for the Lanta Khola and Mangan rock cum debris slides in the North district of Sikkim. An average rainfall of 208 mm actually triggered the above mentioned landslides in the Himalayan state of Sikkim with an event co-efficient of 6.2 for the city of Gangtok and its surroundings in the year 1997.

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

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 was conducted in Railakot, Manaun, Supakot and Pachchisi villages of Almora Disrtrict. Water availability analysis was done by measurement of available water sources in villages in two different seasons i.e. monsoon and summer. Water availability and consumption estimates are based on standard coefficients (e.g., water use /capita, irrigation need of crops, livestock need/cattle unit) relating water use to another characteristic such as number of users, and by measuring a statistical sample of the user population. PRA (Participatory Rural Appraisal) was carried out in representative villages to understand villagers' views on water availability and use pattern. The secondary data of water availability (rainfall) was used for developing three scenarios, i.e., drought year, high rainfall year and normal rainfall year. A mathematical formulation of the scenario was developed and analyzed 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.

Achievements

- In every village available water was less than demand in summer season but in monsoon season more than sufficient water was available (Fig.16).
- According to villagers, decrease in rainfall (25% respondents), drying up of springs (22% respondents), change in rainfall timing (12% respondents), population growth (10% respondents), deforestation (10% respondents) and others (21% respondents) are the main causes of water shortage in their region. According to their views, plantation of broad leaf trees (38%), construction of percolation tank (28%), construction of water storage structure (15 % respondents), maintenance of water resources (9% respondents) and other (15% respondents) are the main solutions to overcome the water shortage.
- Based on optimization result, hamlet wise water management plan was developed for a village situated in north sub-watershed of Upper Kosi-Watershed. Based on the PRA exercise, household sector was the priority demand sector and we have to satisfy 100% demand of this sector and remaining available water will be allocated to livestock sectors in each hamlet of the village, to get maximum net economic return (Fig.17). A good portion of water is released to downstream uses.

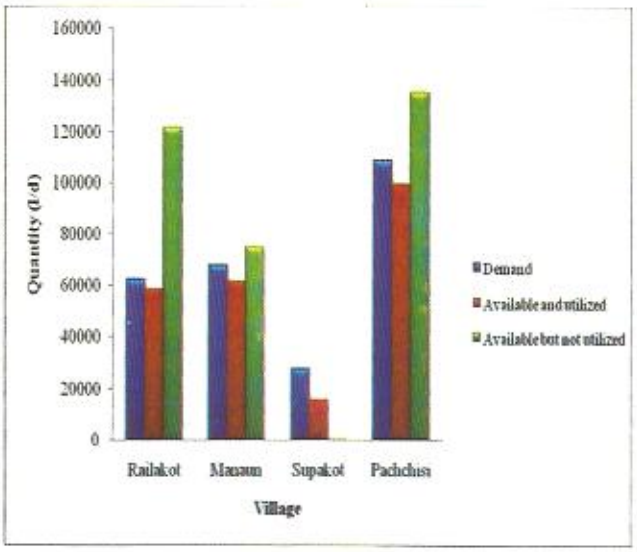


Fig.16. Demand and available water in summer months.

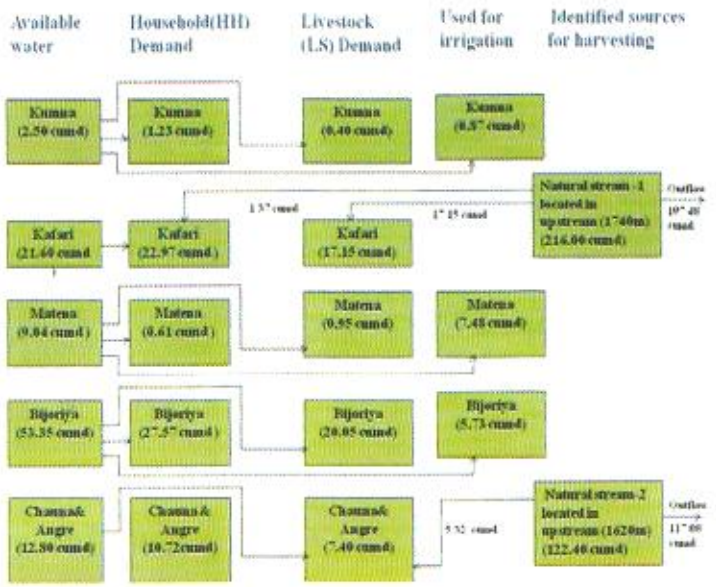


Fig.17. Proposed water management plan for maximizing domestic water supply (objective function1) and demand of economic sectors (objective function2) of village Pachchisi.

Summary of Completed Project / Activity

Installation and Operation of Permanent GPS Stations for Quantification of Tectonic Deformation and Assessment of Stability of Himalayan Urban Centres ***(2005–2010, Ministry of Earth Sciences, New Delhi)***

The results of the study throw light on the present rate of tectonic deformations and strain rates using continuously operating GPS receivers installed in the urban towns i.e. GBNL-Nainital (Kumaun Himalaya), GBSK-Srinagar (Garhwal Himalaya) in Uttarakhand, GBKL-Kullu (HP), GBZR-Zero (AP) along with existing permanent stations in GBPK-Almora (Kumaun Himalaya, Uttarakhand) and GBSK-Gangtok (Sikkim Himalaya). Baselines of all the six permanent GPS stations are obtained from different IGS stations. The average baseline change between Almora (GBPK) and Bangluru (IISC) is of the order of 3.26±2.17mm to 3.59+ 2.57mm in years 2010-09 and 2009-08, respectively. This change is very small considering the error of measurement. The values are comparable with baseline change between GBPK and Hyderabad (HYDE) which is located on the Indian plate. The other two stations located within central part of IHR (GBSN and GBNL) indicate similar rate of baseline changes. The baseline between GPS stations at Sikkim (GBSK) and IISC is changing at 1.67 to 1.92 mm/yr in 2008-2010 with error of ~2 mm rendering these changes negligible. The values are in similar range for GBPK-HYDE stations. In the western Himalaya, Kulu (GBKL) station is showing maximum changes in baselines between Kulu (GBKL) and both IISC/HYDE stations. In E-W direction, Increase in baseline between GBPK and GBSK is of the order of ~7 mm /yr with error of ±2.5 mm indicating the expansion along the Himalayan arc. These values are similar to the values obtained for other two stations located in Central Himalaya. The baseline between stations located within the Central Himalaya (GBPK-GBNL and GBPK-GBSN) indicates some changes between Almora and Nainital stations. This may-be possible due to movements along active local faults and proximity to MBT. Velocity observations show that, the velocity of IISC and HYDE is ~ 53 mm/year, and velocity of our permanent station GBPK ,GBSK ,GBKL ,GBNL and GBSN is ~46 mm/year , 49 mm/year ,43 mm/year ,46 mm/year and 47 mm/year respectively for year 2010 . Results of baseline changes for the year 2010-2008 show that baseline changes of GBPK, GBSK, GBSN and GBNL with respect to IISC and HYDE is approximated similar. GBPK is moving towards East in comparison to GBSN.

Summary of Completed Project / Activity

Soil Nitrogen Dynamics in Relation to Quality and Decomposability of Plant Litter Traditionally Used as Manure in the Central Himalaya *(2007–2010, DST, New Delhi)*

Farmers attempt to maintain agricultural productivity by employing leaf litter collected from forest floor and standing dead after decomposing them in cattle shed or spreading them directly in crop fields. A clear understanding of plant litter impacts on various aspects of soil fertility, including mineralization and microbial biomass turnover is essential for developing a sustainable production and land use systems. An insight into the dynamics of nitrifier population and their related processes i.e. N – mineralization and nitrification will provide knowledge for improving crop management to optimum nutrient use efficiency. What changes in manure quality and nutrient release can enable better nitrogen synchrony and consequently higher yields with lesser intensity of biomass removal from forests resulting in sustainable utilization of land resources.

Objectives

- To assess concentration of N, C, lignin and total phenolics and the C/N ratio in senesced leaves as indicators of litter quality of five plant species traditionally used as manure.
- To compare N and organic C concentration, rate of N-mineralization, nitrification and microbial biomass C, N, flush in the soil amended with the five litter manure under paddy (*Oryza sativa*) and wheat (*Triticum aestivum*) cropping systems.

Achievements

- The main effects of aspect, species and slope position on decomposition rates were all satistically significant.
- Oak leaves showed highest decomposition rates followed by Lyonia, Pyrus, Rhododendron and Pine (Fig.18).
- The litters placed on north facing site decomposed faster than those on the south facing site.
- The litters placed at the top slope position decomposed slower than at those at either the bottom or middle positions.
- Initial lignin concentrations explained most of the variation in decomposition rates between species and within species for the aspects and the slope positions.
- The results illustrate the important point that litter quality may define the potential rates of microbial decomposition but these are significantly influenced by the biotic and abiotic environment in which decomposition takes place.

Fig. 18. Litter bags containing l itter from five different species kept in wheat cropping system (2008 winter).

Summary of Completed Project / Activity

Development of Ecosystem Integrity Profile Using Ecometric Methods for Ecological Risk Assessment in Mountains *(2007–2010, DST, New Delhi)*

The Himalayan Mountain has great diversity of climate, topography, hydrology and ecology as well as diversity of culture and communities. Therefore sustainable development of mountain ecosystems demands integration of research and development programs having strong emphasis on ecosystem components with social, cultural and ecological consideration. The objective of the project was to develop approaches which provide authentic and precise details of the state of health of mountain ecosystems. This project was implemented in the three catchments namely, Gaula catchment, Upper Kosi catchment and Pindar catchment. The runoff coefficients of Upper-Kosi catchment for the period 1981 and 1999 were 0.84 and 0.18 respectively. Similarly, the runoff coefficients of Gaula catchment for 1985 and 2005 were 0.22 and 0.01 respectively. The analysis of double mass curve and slope of trend curve shows that the runoff of Gaula catchment in the period 1968-1977 is more than the periods 1958-1967, 1978-1986 and 1986-2005 with similar rainfall. The rate of change in requirement factors (e.g. fuel wood, fodder, food) of the Upper-Kosi and Gaula catchment have increased whereas the availability of the corresponding factors have decreased during the period 1981-2005. In Upper-Kosi catchment the fuel wood availability is maximum value in the elevation range 1000-1250m, whereas in the Gaula catchment the availability factors maximum in the altitudinal range 750-1000m and 2000-2250m which is due to the maximum value of land use index of forest. The calculated value of available per cattle grazing land is 0.169-0.167 ha for Upper-Kosi catchment and 0.138-0.068 ha for Gaula catchment during the study period (1981-2005). These values of grazing land of the study catchments are quite low against the ecologically permissible carrying capacity of per cattle grazing in the Himalayan region. The cropping land per capita of the Upper-Kosi catchment ranged between 0.43- 0.67 ha/capita and in case of Gaula catchment this value ranged between 0.18- 0.21 ha/capita. The ecologically recommended cropping land per capita in the Kumaon hills is 0.2ha. Therefore the cropping land per capita of the Upper-Kosi catchment has a bit higher value than the permissible limit; however, in case of Gaula catchment its value is lying in the minimum requirement value in the study period. During the study period (1981-2005), the intensity of land use change in Gaula catchment was higher than the Upper Kosi catchment.

Theme

BIODIVERSITY CONSERVATION AND MANAGEMENT (BCM)

The recognition and characterization of biodiversity critically depends on intensity of taxonomic, genetic and ecological investigations. In this context, the long-term research programmes provide essential background information, which also helps in understanding trends of biodiversity changes and segregating impacts of and responses to anthropogenic and natural perturbances. Among others, human dependence issues and economic valuation of biodiversity have emerged as an important area of concern under changing global scenarios. This has necessiated investigation and monitoring of biodiversity elements at different levels and climatic regimes so as to define appropriate conservation measures. While considering such measures, programmes for improving capabilities and skills of diverse group of stakeholders to ensure their participation in programme pertaining to conservation and sustainable use of biodiversity assume high priority. Besides, integration of biodiversity knowledge base with other components of ecosystem like water, air, and socio-cultural aspects become essential for sustainable management of biodiversity. The studies conducted under the BCM theme during previous years have focused on assessment, valuation, monitoring and prioritization of biodiversity including medicinal plants diversity in protected and unprotected areas, response assessment of Himalayan biodiversity under changing climatic conditions, development and upscaling of propagation protocols, improvement of bio-resource based livelihood options, strengthening and maintenance of Arboreta, Herbal Gardens and Nurseries and promotion of conservation education among diverse stakeholders. Biodiversity Conservation and Management (BCM) theme envisages to i) 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) evaluate response of Himalayan biodiversity under changing climatic conditions across the IHR; iii) 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) 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; and v) sensitize diverse stakeholders and building 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 selected MPAs as a major challenge to the management of integrity and diversity of representative ecosystems. The studies continue in Nanda Devi Biospheare Reserves of West Himalaya, Nargu Wildlife Sanctuary of Northwest Himalaya, Kanchendzonga Biosphere Reserve of Central Himalaya and Tawang West Kameng proposed Biosphere Reserve of East Himalaya.

Objectives

- Synthesise and use information on biodiversity components of selected areas.
- Investigate on recruitment trends and compositional patterns of forest communities along altitudinal gradient.
- Understand use patterns by the inhabitants.
- Identify and prioritize human wildlife conflicts.
- Study the grazing competition among livestock and wild ungulates.
- Determine the live stock depredation and retaliatory killing of Wild carnivores.
- Identify threat categories of the biodiversity.
- Suggest policy interventions with a view of general applicability.
- Draw comprehensive biodiversity management plans for alternative scenarios.

Achievements

Nanda Devi Biosphere Reserve, Uttarakhand

- Continuing with the revisit studies in Pindari region, Kumaon west Himalaya (Buffer Zone of NDBR) forest community wise changes at two point sampling (i.e., 1988-89 and 2008-2009) have been described w.r.t. possible cause of changes as well as possible direction/intensity of change in forest composition in near future.
- In Mixed Oak deciduous forests (2100-2300 m), the relative contribution of species richness showed no changes in all three layers. A remarkable change in density of seedlings with an increase in seedlings from 81.7% (1988-89) to 94.6% (2008-09) was observed. The maximum contribution in this increase was due to *Quercus floribunda* species for which the values have gone up from 4.5% (1988-89) to 53% (2008-2009).
- *In Quercus floribunda* forests (2300-2500 m) assessment of species richness reveals changes in seedling (7 new species) and sapling (4 new species) layers. Significant increase in total tree density (3768 ind ha^{-1}: 1988-89 to 8015 ind ha^{-1}: 2008-09) was recorded. Maximum increase in density was observed in seedling layers wherein *Q. floribunda* showed an increase from 6% to 36.6%. The relative contribution of seedlings has increased from 86.7% (1988-89) to 93.6% (2008-09).
- *In Quercus semicarpifolia* forests (2500-2900 m) no major changes were observed in species richness. Changes in total density were observed (4421 ind ha^{-1}: 1988-89 to 6778 ind ha^{-1}: 2008-09). Maximum change in density was observed in seedling layer. The relative contribution of seedlings has increased 84.3% (1988-89) to 90.7% (2008-09).
- In Mixed Deciduous *forests* (2600-2850 m) no major changes were observed in species diversity of saplings and tree layers, however, 10 new species were recorded in seedling layers. Considerable increase in total density was observed (2931 ind ha^{-1}: 1988-89 to 4984 ind ha^{-1}: 2008-09).
- *In Betula utilis* forests (3300 m), no major changes in species diversity were observed in all the three layers. However, nearly two fold increase in total density was observed (1765 ind ha^{-1}: 1988-89 to 3340 ind ha^{-1}: 2008-09).Maximum change in density was observed in the seedling layers.

Nargu Wildlife Sanctuary, Himachal Pradesh

- 258 species of vascular plants i.e., Angiosperms (229 species), Gymnosperms (6 species) and Pteridophytes (23 species) have been recorded. Families, Asteraceae (25 spp.); Rosaceae (18 spp.) and Lamiaceae (15 spp.) were dominant.
- 10 forest tree communities were identified from 23 sites. Tree density ranged from 210-600 Ind ha^{-1} and total basal area, 1.9-60.7 m^2ha^{-1}. Shrub density from 450-3390 Ind ha^{-1}, herb density, 44.8-156.8 Ind m^{-2}, sapling density, 50-450 Ind ha^{-1} and seedling density, 110-1060 Ind ha^{-1}. Species richness ranged from 43-111. It was highest in *Quercus leucotrichophora* community, followed by *Quercus semicarpifolia* and *Cedrus deodara* communities. Species diversity index (H') for trees ranged from 0.26-1.72, saplings, 0.26-1.70, seedlings, 0.17-1.84, shrubs, 1.07-2.8 and herbs, 2.70-3.60 (Fig.19).
- In the studied area, 86 native to Himalayan region, 3 endemic, 55 near endemic, 5 endangered and 178 economically important (medicine-123; wild edibles/food – 39; fodder – 59; fuel – 32; timber – 5; religious – 9; fiber – 7; agricultural tools – 8; miscleancous – 16) species were identified (Fig.20).
- Among the fuel species, mean collection was

highest for *Quercus leucotrichophora* (1879.30 kg household^{-1} year^{-1}), followed by *Rhododendron arboreum* (433.57 kg household^{-1} year^{-1}), *Cedrus deodara* (425.22 kg household^{-1} year^{-1}), *Myrica esculenta* (385.05 kg household^{-1} year^{-1}) and *Persea duthiei* (370.96 kg household^{-1} year^{-1}). 23 species were used as fodder in 10 surveyed villages. *Quercus leucotrichophora*, *Neolitsea pallens* and *Desmodium elegans* were mostly used as fodder. Maximum fodder collection was done in Hurang village (8568 kg household^{-1} year^{-1}), followed by Shilh Badhani (8352 kg household^{-1} year^{-1}), Malwara (8028 kg household^{-1} year^{-1}) and Kutahar (7980 kg household^{-1} year^{-1}) villages (Fig 20).

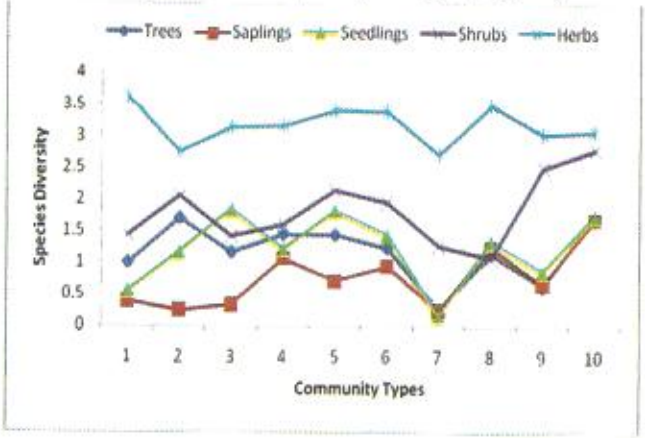


Fig.19. Community wise species diversity of trees, saplings, seedlings, shrubs and herbs in Nargu Wildlife Sanctuary. *[**Abbreviations used:** 1= Cedrus deodara; 2= Myrica esculenta-Alnus nitida* mixed; *3= Pinus roxburghii; 4= Quercus leucotrichophora; 5= Quercus leucotrichophora- Myrica esculenta* mixed; *6= Quercus leucotrichophora - Rhododendron arboreum mixed; 7= Quercus semecarpifolia; 8= Quercus semecarpifolia-Abies pindrow* mixed; *9= Rhododendron arboreum and 10= Rhododendron arboreum-Symplocos chinensis* mixed]

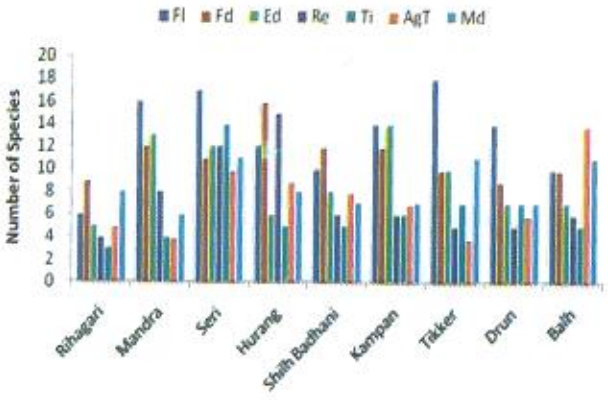


Fig. 20. Utilization pattern of the economically important species in some villages. [**Abbreviations used:** Fl=Fuel; Fd=Fodder; Ed=Edible; Re Religious; Ti=Timber; AgT=Agricultural tools; and Md=Medicinal]

Khangchendzonga Biosphere Reserve, Sikkim

- Investigation made in eight high altitude sites in Tholung-Kisong (TK) landscape, in south-east KBR, north Sikkim. With 51 tree and 30 shrub species, the total species significantly declined ($r = -0.874$; $p<0.01$) along increasing altitudes (Fig.21).

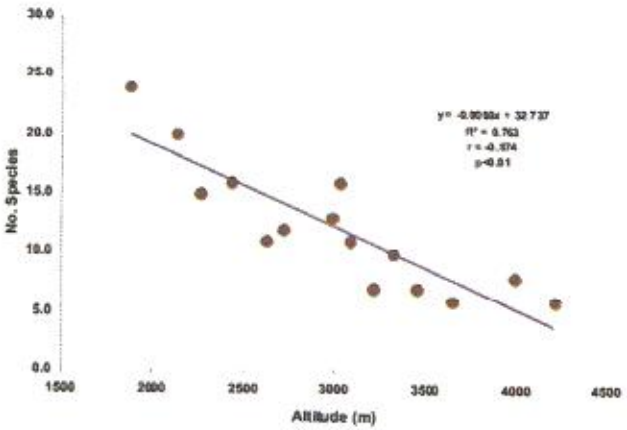


Fig. 21. Number of species for different study sites along altitudes in Tholung-Kisong transect in south-east Kangchendzonga Biosphere Reserve (north Sikkim).

- For trees, dominance, diversity and species evenness index showed non-significant negative correlation, while the species richness index negatively correlated with altitude ($r = -0.944$; $p<0.01$). For shrubs, diversity ($r = 0.726$) and species evenness ($r = 0.740$) index positively correlated with altitude ($p<0.01$); relationship was non-significantly positive between species richness index and the altitude, and non-significantly negative between species dominance index and the altitude. Tree individuals in C-class (10-20 cm dbh) showed highest and in I-class (70-80 cm dbh) lowest density.
- Two new populations at 3000m (150 individuals) and 3300m (15 individuals) of rare and endemic species of *Rhododendron niveum* were discovered.
- Amongst 06 indicators of biodiversity conservation and sustainability, forested area (80.5 & 87.6, respectively) and species diversity (73.6 & 73.9, respectively) had top priority index for Tingvong and Ship-Gyer villages in north Sikkim. Fuel, fodder and timber appeared as top indictors in either village.
- Stakeholders Consultation Workshop on 'Biodiversity Conservation and Management in KBR' organized in collaboration with FEWMD, Govt. of Sikkim at W. Sikkim; related issues were highlighted (Fig.22).

Fig. 22. Stakeholders' Consultation Workshop for KBR (Sikkim) at Labdang, West Sikkim.

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

- Total 311 species of flowering plants including endemic, primitive and ethnomedicinal were recorded. Of these, *Aconitum lethale*, *Petasites kamengicus*, *Begnonia arboensis*, *Coptis teeta*, *Cotoneaster assamensis*, *Rhododendron tawangensis* and *Agapetes arborensis were endemic*. While *Magnolia griffithiii*. *Illicium griffithii*, *Houttuynia cordata*, *Exbucklandia popunea*, *Betula alnoides*, *Alnus nepalensis* and *Myrica esculenta* were listed as primitive plants.
- A total of 52 medicinal plants (51 genera and 39 families) were being used by Monpas for the treatment of various ailments. Families Fabaceae and Myrsinaceae had 3 species each and Asteraceae, Ericaceae, Euphorbiaceae, Polygonaceae, Ranunculaceae, Rutaceae, Saxifragaceae, Theaceae and Urticaceae had 2 species each.
- Extensive and unsustainable harvesting of 11 ethnomedicinally important plants has threatened their survival in natural habitat, therefore, such species may be prioritized for conservation (Table-6).

Table-6. Conservation prioritization of ethno-medicinal plants

Botanical name	Family	Altitudinal range (m)	Conservation status	Part used	Cost per Kg (Rs.)
Aconitum ferox	Ranunculaceae	3000-4000	Critically Endangered	Rhizome	1500.00-4000.00
Acorus calamus	Araceae	Upto 2200	Vulnerable	Rhizome	25.00-45.00
Euphorbia officinalis	Euphorbiaceae	Upto 1500	-	Fruit	20.00-40.00
Illicium griffithii	Illiaceae	Upto 1500	Vulnerable	Fruit	150.00-300.00
Myrica esculenta	Myricaceae	500 - 2500	-	Fruit & bark	60.00-150.00
Picrorhiza kurroa	Scrophulariaceae	3300-4300	Endangered	Rhizome	150.00-300.00
Rheum australe	Polygonaceae	2000 - 3500	Endangered	Root	50.00-150.00
Rubia cordifolia	Rubiaceae	Up to 2600	-	Stem & root	15.00-30.00
Terminalia chebula	Combretaceae	Upto 1500	-	Fruit	60.00-300.00
Thalictrum foliosum	Ranunculaceae	1000-3400	Vulnerable	Rhizome	30.00-120.00
Zanthoxylum armatum	Rutaceae	Upto 1800	-	Fruit	50.00-150.00

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

The Himalayan Region has been identified as one of the richest habitats for medicinal plants. In the region, most medicinal plants are being extracted for drug, pharmaceutical industries and oils. Majority of the medicinal plants are also used in Ayurvedic, Unani, Tibetan and other traditional systems of medicine. With the increasing world demand and renewed global interest in traditional ethnopharmacy coupled with the increasing preference for natural substances in the health care systems, the natural stock of medicinal plants of Indian Himalayan Region (IHR) is under tremendous pressure. The State, Himachal is being seen as an herbal state and medicinal plants as a major source of income generation for the inhabitants. The Kullu and Lahaul & Spiti districts of the State are rich in medicinal plant diversity. There is plenty of scope for the promotion of medicinal plant cultivation and conservation. 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 districts have been selected to conduct studies on conservation and sustainable utilization of medicinal plants.

Objectives

- Assess, monitor and map the medicinal plant diversity.
- Evaluate medicinal plant diversity.
- Assess threat categories.
- Prioritize potential medicinal plants for conservation and socio-economic development of the inhabitants.
- Develop strategies and promote ex-situ and in-situ conservation of medicinal plants.
- Impart training to different stakeholders on conservation and sustainable utilization of medicinal plants.

Achievements

- Consultation Meetings were organized at Jibhi, Banjar and Jana Villages in Kullu district, Ropa, Sundarnagar and Smaila in Mandi district, and Khangsar in Chandra Valley of the Lahaul & Spiti district (Fig.23a-b). A group of 20 farmers in Chandra Valley was developed to initiate the

cultivation of *Aconitum heterophyllum* and *Picrorhiza kurrooa*. Another group (54 farmers) from Jana, Burua, Kothi, Ropa, Jhiri, Smaila and Sundernagar was also developed for the cultivation of *Aconitum heterophyllum* and *Withania somnifera*.

- About 15,000 seedlings of *Aconitum heterophyllum* were raised by the 16 farmers in the field at Jana village, 20,000 seedlings at Burua village, 1,000 seedlings at Kothi and 1,000 seedlings at IRMT, Naggar. One farmer from Jana village developed > 2, 50,000 seedlings of *Aconitum heterophyllum* and generated > Rs. 1, 25,000/- from the seeds and seedlings (Fig.24a-b). Over 5,000 seedlings of *Withania somnifera* were developed in the Medicinal Plants Nursery and Herbal Gardens. Cultivation of *Withania somnifera* in Prodhar, Ropa, Jhiri, Smaila and Sundernagar was initiated and over 2,000 seedlings have been planted in Kullu and Mandi districts.
- Seed germination studies of Aconitum heterophyllum, collected from Jana and Lahaul valley were conducted and germination percentage was improved upto 96% (Jana) and 93% (Lahaul).
- Vegetative propagation (stem cuttings) of Munjak population of *Taxus baccata* subsp. *wallichiana* was tested by giving different treatments at Doharanala. IBA 100 µm showed maximum rooting (70%).
- 300 seedlings of *Withania somnifera* were distributed to different stakeholders during the State Level Children Science Congress at Hamirpur. Also, seeds of *Withania somnifera* were distributed to the Forests Department, farmers, local inhabitants and NGO's. Exposures visits (10 Nos.) of the Herbal Gardens and Medicinal Plants Nurseries for over 1,000 stakeholders representing Himachal Pradesh and others were organized. Agrotechniques developed for the 26 commercially viable medicinal plants were disseminated to the stakeholders for the promotion of cultivation of medicinal plants.

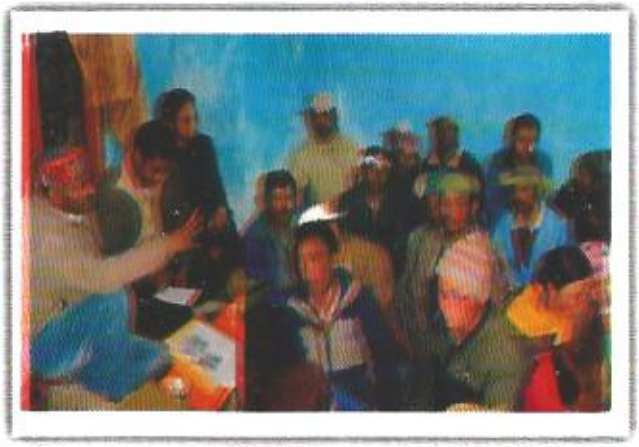


Fig. 23 (a-b). Consultatuion Meetings at Khangsar in Chandra Valley and Ropa in Mandi district.

Fig. 24 (a-b). Cultivation of Aconitum heterophyllum in Jana Village, Kullu valley.

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)*

The Indian Himalayan Region occupies a significant position on the earth due to its rich and unique bioresources. While focusing on strategies to harness the potential of these resources for the well being of people in the region, maintenance and optimal use issues of high value species emerged as priority agenda for Research and Development. Especially, at the time when gaps between demand and supply have widened and incidences of indiscriminate collection and destructive harvesting from the wild have gone up. Therefore, conservation approaches based on the concepts of sustainable utilization involving technology based innovations are greatly required. 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 beings together with maintaining the biodiversity. Indian Himalayan Region occupies a significant position in the world as far as biodiversity is concerned. The propagation protocols need to be further put to test their efficacy and up scale the applicability in the field conditions 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. Capacity building of the stakeholders on conservation education must be undertaken through field demonstrations. 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

- Apply ex-situ conservation techniques for developing appropriate technologies of mass multiplication and storage of germplasm.
- Upscale the applicability of existing protocols in selected sites.
- Ensure quality planting material through phytochemical and genetic investigation.
- Understand the growth responses of the target species in wild and cultivated land.
- Develop a centre for on-site training and extension programmes.
- Inculcate excitement among students about biodiversity conservation.

Achievements

Himachal Pradesh-Himachal Unit

- Over 183 seedlings/plantlets of 15 species of ecological, economical and ornamental importance were planted in the arboretum. Maximum survival was shown by *Adhatoda vasica, Pistacia integerrima* and *Pittosporum eriocarpum* (100%), *Cornus capitata* (95%), *Pinus gerardiana* (94%) and *Pyrus pashia* (89%). *Buxus wallichiana* (70%) and *Ginkgo biloba* (60%) showed relatively low survival.
- Seed germination protocol for the *Corylus jacquemontii, a multipurpose tree* was developed in polyhouse. The treatments of GA_3 showed maximum germination (GA_3 100µM, 100%; GA_3 150µM, 95.24% and GA_3 50µM, 90.48%), followed by KNO_3 100mM, Thiourea 150µM (80.95%, each) (Fig.25). Seed germination protocol for the *Buxus wallichiana*, a multipurpose tree showed highest germination in GA_3 100µM and IAA 100µM (82.22%, each).
- Vegetative (stem cuttings) propagation of *Cinnamomum tamala showed* maximum rooting (27%) in NAA 50µM (Fig.26).
- One Day Training Programme on "Weather Monitoring, Climate Change and Biodiversity Conservation and Management" was organized at Mohal on March 25, 2011 for the teachers, students, farmers and Mahila Mandals (Fig.27a-b). The pre and post feedback of the participants are presented in Fig.28. Exposure visits for over 700 participants representing students, teachers of the Schools and Universities, farmers, Forest officials, NGOs, Professors and Students of Sholapur University, Maharashtra and farmers of the Nanda Devi Biosphere Reserve were organized.

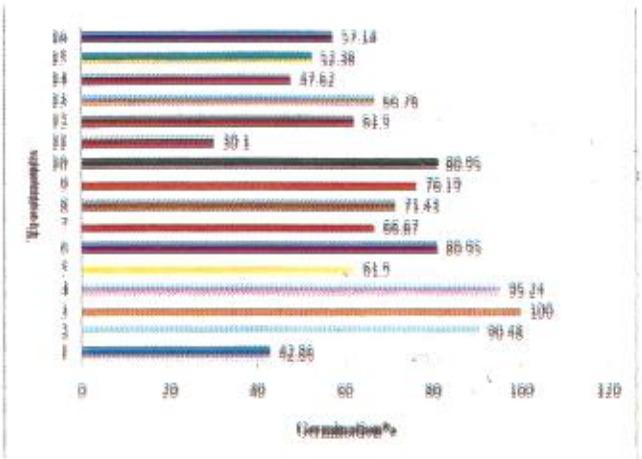


Fig.25. Seed germination performance of *Corylus jacquemontii* in different treatments.

[Abbreviations used: 1=Control Direct; 2=GA_3 50µM; 3=GA_3 100µM; 4=GA_3 150 µM; 5=KNO_3 50 mM; =$KNO_3$100mM;7=$KNO_3$150mM;8=Thiourea50µM;9=Thiourea100µM;10=Thiourea150µM;11=IAA50µM;12=IAA100µM;3=IAA150µM;14=$NaHClO_3$3minute;15=$NaHClO_3$6minute and 16=$NaHClO_3$9minute]

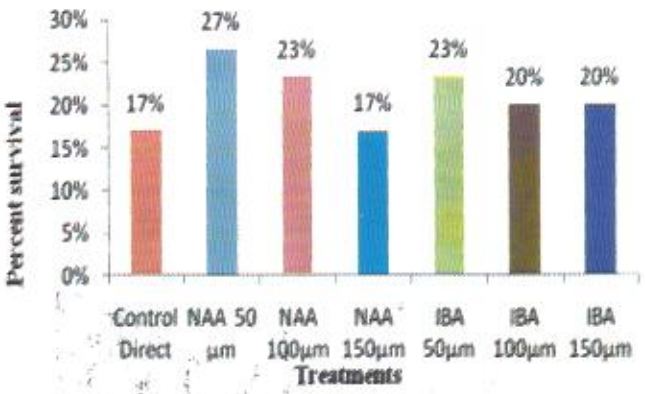


Fig.26. Vegetative propagation of *Cinnamomum tamala* in different conditions

Fig. 27 (a-b). Participants during Training Programmes at Mohal.

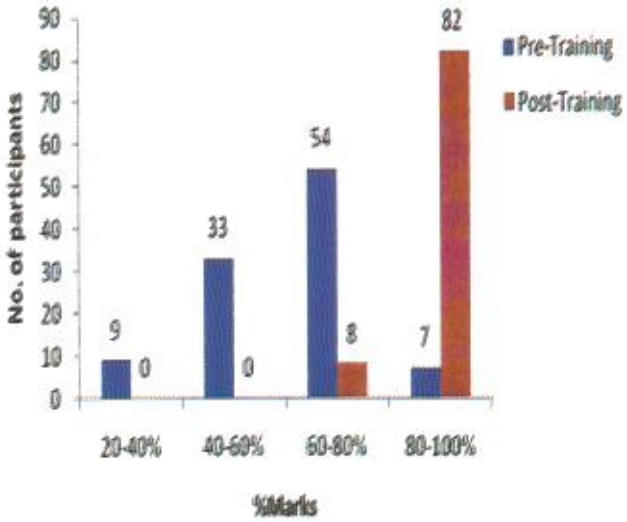


Fig. 28. Pre & post Training Programme feedbacks of participants.

Uttarakhand –Headquarters

- Phytochemical analysis of *Acorus calamus* collected from different localities showed variations in total phenol and antioxidant activity. Total phenolic content was found maximum in Jyoli population (8.86 mg/g DW) and minimum in Matela population (4.12 mg/g DW). *In vitro* antioxidant assay showed maximum activity in the samples collected from Jyoli population (13.67 mM AAE/100 g) and minimum in Bari Population (6.42 mM AAE/100 g) in ABTS assay.
- Relationship among Altitude, Antioxidant Assays, Total Phenolics, Flavonoids and Phenolic compounds in *Myrica esculenta* fruits has been investigated. Results revealed a significant negative correlation of catechin ($r=-0.778$; $P<0.05$) with altitude. Correlation matrix revealed that total phenolic and flavonoid contents has significant ($p<0.05$) positive impact on antioxidant activity (Table-7). Phenolic contents contribute 46.3 to 47.6% of radical scavenging property ($r^2 = 0.463$ for DPPH and $r^2 = 0.476$ for ABTS) and 56.6% of reducing property ($r^2=0.566$). Similarly, flavonoids contribute 55.4% to 70.9% radical scavenging property ($r^2 = 0.554$ for ABTS and $r^2 = 0.709$ for DPPH) and 47.8% of reducing property ($r^2 = 0.478$).

Table-7. Correlation matrix between altitude, total phenols, total flavonoids and antioxidant b activity measured by different assays in selected populations of *Myrica esculenta* (n= 9).

r value*	Altitude	Total phenols	Flavonoids	ABTS	DPPH	FRAP
Altitude	1					
Total phenols	-0.360	1				
Flavonoids	0.004	0.771*	1			
ABTS	0.057	0.691*	0.744*	1		
DPPH	0.176	0.68*	0.843**	0.878**	1	
FRAP	-0.132	0.753*	0.691*	0.949**	0.856**	1
Gallic acid	-0.165	0.057	0.078	0.017	0.264	0.078
Catechin	-0.778*	0.256	0.036	-0.215	0.130	0.036
Chlorogenic acid	-0.379	-0.404	-0.293	-0.371	-0.188	-0.293
	-0.101	0.019	0.078	0.017	0.264	0.0 8

a - Correlation coefficient, Level of significance: *P<0.05; ** P<0.01

- In order to sensitize the School children towards biodiversity conservation, International Biodiversity Day (22 May 2010), Wild Life Week, Herbal Day, etc. were celebrated in the Nature Interpretation and Learning Site (Suryakunj) of the Institute in which 227 participants (31 teachers & 215 students) from 17 schools participated.

Sikkim-Sikkim Unit

- Arboretum, nursery and herbal garden were strengthened and maintained; low cost net-houses/nurseries were improved. Over 43 accessions (propagule/plants) of high value and multipurpose species, viz., *Pandanus nepalensis, Machilus edulis, Spondias axillaris, Juglans regia, Swertia chirayita, Rubia cordifolia, Heracleum wallichii, Michelia* spp., etc. were introduced. Phenology of the tree species was monitored. Seed germination protocol for *Spondias axillaris was* developed using 10 chemical treatments. Seedling emergence greatly improved on treating seeds with H_2O_2-6% (32%; P<0.05), followed by GA_3 (250 µM; 25%; P<0.05) and $NaHClO_3$ (60 min; 25%; P<0.05), over control (17%) (Fig.29).
- Out of previously tested 10 laboratory chemicals on 11 populations, 3 best treatments on 3 potential populations were tested under green house aiming mass multiplication of *Rubia cordifolia*. $NaHClO_3$ (30 min) proved best to stimulate maximum seedling emergence (47 to 58%). On transferring seedlings to open beds, 70 to 100% survival was achieved after 8 months.
- A two day Training Workshop on *Conservation of Biodiversity* for Students (class 10th and 12th) and Teachers was organized at Pangthang involving 10 schools of Sikkim (**Fig.30**). The programme comprised of experts' presentations/lectures by in-house and guest faculty from Forest Department, Lab & Nursery demonstrations, exposure, Painting competition, and Field exercises in functional arboretum on vegetation survey and analysis, etc.
- Seedlings of 9 species including *Ficus* sp. and *Michelia excelsa* as top preference were distributed to various stakeholders. Growth and survival of 6 multipurpose trees was monitored.

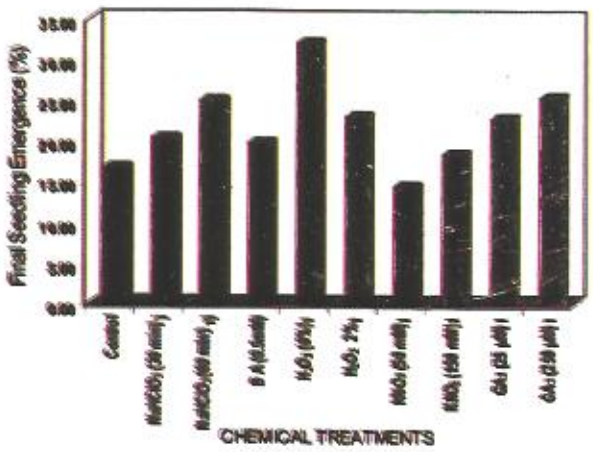


Fig. 29. Seedling emergence influence by various pre-soaking chemical treatments in Spondias axillaries.

Fig. 30. Field exercise during a Training Workshop, Conservation of Biodiversity at Pangthang, Gangtok.

Financial Assistance for Improvement of Infrastructural Facilities and Establishment and Maintenance of Rare, Endangered, Threatened and Endemic Plants in the Arboretum at Mohal and Herbal Garden at Doharanala, Himachal Pradesh *(2009-2011, MoEF, New Delhi)*

The Himalayan region is one of the Mega Biodiversity Hot Spots. The Indian Himalayan Region supports 18,444 species of plants, 1748 medicinal plants, 675 wild edibles, 960 orchids and 155 sacred plants. But due to over exploitation, habitat degradation and changing environmental conditions the populations of many species have decreased to a great extent. As a result, many species are recorded under various threat categories. This calls for planning of conservation and management of such species. Various steps have been taken for *in situ* and *ex situ* conservation at Government level. The Ministry of Environment and Forests under Botanical Garden Scheme has been promoting the conservation of rare, endemic and threatened species through various State and Central Government Organizations by establishing new Botanical Gardens, and strengthening the infrastructural facilities and promoting conservation of rare, endemic and threatened species in the established Botanical Gardens. The present attempt has been made in the Mohal Arboretum and Doharanala Herbal Garden of the institute.

Objectives

- Ensure establishment and maintenance of the rare, endangered, threatened and endemic plant species.
- Provide adequate facilities (research back-up and infrastructure) for plantation and acclimatization.
- Develop conventional propagation protocols.
- Ensure availability of base material.
- Meet the demand of planting material by different stakeholders.
- Develop as a center for on-site training and extension programmes.
- Establish and maintain exchange relations with other Arboreta, Botanical and Herbal Gardens.

Achievements

- Creating walls (Crate size: 2.5x1.5m; length 240m) along the left and right banks of the Mohal Khad at Mohal Arboretum were erected to protect the arboretum land from flood. Barbed Wire fencing (length 210m) was done and cemented pathways (length 200m) were developed at Doraranala. Two water harvesting tanks (Size: 15x15x5') one each at Mohal arboretum and Dowharanala Herbal Garden were developed.
- Seeds of *Corylus jacquemontii*, *Quercus leucotrichophora*, *Ulmus wallichiana* and *Withania somnifera* were collected, dried and stored at room temperature. Seedlings of *Cornus capitata* (12), *Ginkgo biloba* (20) and *Pinus gerardiana* (15) were planted in the botanical garden at Mohal and Doharanala and *Roylea cinerea* (20) seedlings were planted in the botanical garden at Mohal. Over 500 seedlings of >20 RET/E species were planted at Mohal and Doharanala sites of the Botanical Garden. Almost all the species showed > 80% survival.
- Seed germination protocols for the *Cornus capitata*, *Pinus gerardiana* and *Corylus jacquemontii* were developed. In *Cornus capitata* all the treatments of KNO_3, H_2SO_4 and soaking in distilled water showed maximum germination, in *Pinus gerardiana* all the treatments of KNO_3 showed maximum germination and in *Corylus jacquemontii* GA_3 showed maximum germination (GA_3 100µm, 100%; GA_3 150µm, 95.24% and GA_3 50µm, 90.48%), followed by KNO_3 100mM, Thiourea 150µm (80.95%, each).
- Over 700 participants representing students, teachers of the Schools and Universities, farmers, Line Departments and NGOs of Himachal Pradesh and other parts of the country visited the Botanical Garden.

Assessment Study on Socio-economic Development of Local Area Following the Onset of Construction Activities of Parbati Hydro-Electric Project Stage-III in Sainj Valley of Kullu District, Himachal Pradesh *(2010-2011, NHPC)*

Himalaya is the source of origin of many famous rivers on which the livelihood of the people depends. The perennial rivers originating from the Himalaya are not only the source of drinking water and irrigation, but also a major source of electricity generation. The undulating topography of the Himalaya provides a great scope for the construction of Hydro-Electric Projects. A large number of Hydro-Electric Projects have been constructed, are under construction and are proposed for construction on the rivers originating from the Himalaya. They are considered as an integral part of the economic development of the country. The estimated total hydropower potential is about 25000 MW in Himachal Pradesh. In Himachal Pradesh, Hydro-Electric projects are one of the major sources of income generation. The Parbati Hydro-Electric Project Stage-III located in Sainj Valley is under construction. The valley is inhabited by a large number of villages. Since the inception of PHEP Stage III, a lot of developmental activities have been carried out by the NHPC. The proper documentation of these activities has not yet been carried out. In view of the above, assessment studies on socio-economic development of

the local area in Sainj Valley following the onset of construction activities of the PHEP has been proposed to update the socio-economic development of the valley due to construction of Parbati Hydro Electric Project Stage III, so that the native communities of the valley become aware of the benefits which are helping in the sustainable development of the Sainj valley

Objectives

- Review the EMP, DPR and CAT Plans available for the Parbati Hydro-Electric Project Stage- III.
- Assess the socio-economic development of local area following the onset of construction activities of Parbati Hydro-Electric Project Stage- III in the Sainj Valley.
- Compare the primary information with the secondary information and update the developmental activities helping in the sustainable development of the inhabitants of Sainj Valley.

Achievements

- A Survey was conducted in 24 affected villages and information generated through structured questionnaires, interviews and Participatory Rural Appraisal. The socio-economic status of the villages indicated males (50.63%), females (49.36%) and literacy rate (78.62%). Their engagement was as follows: Government Sector, 16.72%, agriculture, 63.82%, business 9.2% and as daily wagers 10.2% (Fig.31a-b). Total livestock population in the surveyed villages was 1053.
- The inhabitants of the villages are largely dependent on agriculture, horticulture and vegetable cultivation. 16 Species of crops, 14 species of fruits and 24 species of vegetables are grown. The inhabitants are also dependent on agroforestry species, medicinal plants, wild edibles, fuel and fodder species, etc. for their sustenance.
- The major sources of domestic energy include electricity (20%), fuelwood (18%), LPG (8%), kerosene (8%), coal (1.7%), dung cakes (8.1%), crop waste (16%), and fodder waste (16%). The sources of potable water are kuhl, hand pumps, tap water, talai and Bawari. 7 % talai, 3% river, and 88% tap water is used. Majority area is rainfed, however, in some villages irrigation is done by the water obtained through kuhls, pipe lines, water harvesting tanks, etc.
- Among the various developmental activities documented, Educational facilities, Medical and Human Health, Transportation and Communication, Water supply schemes, Construction of houses, temples and other buildings, Village Road/bridge work, Water Supply Schemes, Work related to Social & Cultural Aspects, improvement of markets, Hospitals, Religious places, electricity, pathways, etc. are notable.

Fig. 31(a-b). Information generation from villagers through interviews and PRA.

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

The crop pollination issues have become a global concern due to several highly localized crop pollination failures. This may be due to rapid decline in populations of pollinators including honeybees. There is a need to identify multiple agro-ecosystems and ecological practices that will prevent the loss of pollination services. Unfortunately, the level of capacity to manage pollination services, and the public awareness of their importance is very low, both in traditional and modern societies. In view of the importance of pollinators and pollination for the high productivity of crops, FAO in collaboration with seven countries namely Brazil, Ghana, India, Kenya, Pakistan, Nepal and South Africa

initiated a GEF/UNEP/FAO project that addresses the need to identify practices and build capacity in the management of pollination services. The development objective of the project is improved food security, nutrition and livelihoods through enhanced conservation and sustainable use of pollinators. The immediate objective is to harness the benefits of pollination services provided by wild biodiversity for human livelihoods and sustainable agriculture, through an ecosystem approach in selected countries. In India, the STEP Sites are: Himachal (Upper Beas Valley); Uttarakhand (Upper Kosi Valley) and Sikkim (Namchi Watershed). The primary focus of this effort is on the development of pollination management plans for priority cropping systems with a high dependence on pollinators, which also have important links to human livelihood and sustainable development.

Objectives

- Build local, national, regional and global capacities among farmers, the agricultural research and extension community, and policy-makers to design and implement of management practices that secure the pollination services of wild pollinators for horticultural crop production.

Achievements

- Project Management Unit (PMU) of the project was established and project coordination meeting-India and partners meeting STEP site was organized.
- 20 orchards (i.e., 10 far from the natural habitat and 10 near the natural habitat) at different altitudes and with diverse landscapes were selected in the Upper Kullu Valley to implement Pollination Deficit Protocol (i.e., Flowering Phenology, Scan and Sweep Net Sampling, etc.) (Fig.32). Scan sampling of apple pollinators revealed a high population of indigenous honey bee (*Apis cerana*) around orchards which varied between 3.9 to 7.75 bees per 250 apple flowers. The population of *Apis mellifera* was relatively low as compared to *A. cerana* in control and treatment conditions. Diversity of non-Apis pollinators i.e., 0.7 bumble bees per 5 min sweeps on an average in orchards near the natural habitat as compared to 0.0 orchards far from natural habitat was observed.
- For the crop specific best practices in pollination management plan and socio-economic assessment, a group of 42 orchardist/ farmers from 20 Target Areas was selected. Detailed profile of two progressive farmers employing good agricultural practices for the conservation of pollinators and sustainable agriculture was prepared.

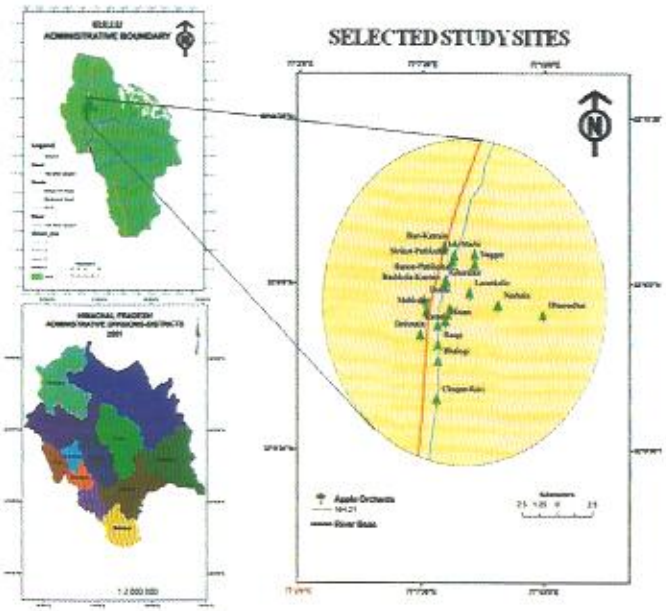
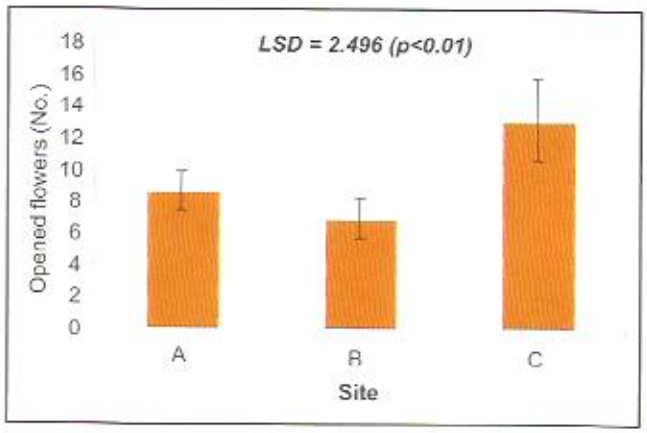


Fig.32. Location map of the Himachal STEP Site and Selected Orchards.

- Socio-economic valuation of pollinator-friendly practices in Patharkot village (Uttarakhand STEP site) was conducted. Knowledge about the pollination and its services among different target groups viz., Farmers, Research Scientist and Agricultural institutions of the Kosi-watershed region were tested with pre-designed formats.
- Towards strengthening pollinator bibliography, 40 references (*Brassica campestris*: 6, *Cucurbita moschata*: 7, *Fagopyrum esculentum*: 14, & Honey bees: 13) were compiled. Five new references on *Cucurbita moschata* were added.
- Village survey was conducted in Mamlay watershed (STEP Site Sikkim) to understand the bee-keeping status of the area. Out of 117 households, 60 managed traditional honey-bee hives.
- The research experiments carried out during the peak flowering time of target crop (i.e., large cardamom), in the 3 distinct areas of the STEP site revealed maximum opened flowering frequency in site close to protected area (i.e., 13 flowers/plant) (Fig.33a-b).
- Honey bees (*Apis cerana* F.) were found maximum in site C (close to protected area) while bumble bees (*Bombus haemorrhoidalis* Smith) in site A (within village boundary). *Apis cerana* were found in 3rd recording time (June 13) while *Bumble bee* during 4th recording time (23 June). The combined analysis indicated that the proportion of pollinators showed significant difference ($p<0.01$). The interaction effect was observed with site and time ($p<0.01$).



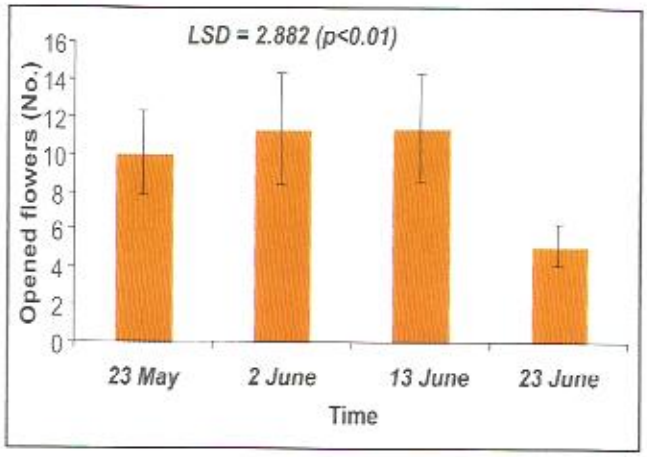


Fig. 33 (a-b). Density of flowers between; a) sites (*LSD = 2.496; p<0.01) and* b) times (*LSD = 2.882; p<0.01*).

Assessment of Plant Diversity and Dependency in West Kameng District of Arunachal Pradesh *(2009-2012, DST, New Delhi)*

Arunachal Pradesh is well known for its rich plant diversity and the unique cultural diversity. The whole area is well recognized as one of the Mega Biodiversity Hotspots of the world and supports 4117 species of flowering plants. More than 100 species of mammals belonging to Schedule-I of Wildlife Protection Act, 1972 and 650 species of birds have been so far recorded in the state. The state is inhabited by 26 major tribes & 110 sub-tribes belonging to different social and distinctive cultures. The economy of these Tribes is largely based on the forests. Due to over exploitation and habitat degradation the forest resources are depleting fast. In view of this the Pinjoli watershed of district West Kameng, Arunachal Pradesh has been selected for assessing the plant diversity and dependency of the human communities on this resource, and prioritizing some rare and endangered species, sensitive habitats and communities for conservation

Objectives

- Assess the plant diversity in the selected watershed.
- Identify human dependency on plant resources.

Achievements

- The Pinjoli watershed (27°05'30" N and 92°35'20" E), inhabited by Aka tribe, is also known as Hrusso (Fig.34). Survey and data collection, following the standardized biological survey method was done in seven grids and 207 species reported.
- Total 13 species of medicinal plants have been recorded. The used parts of these plants include leaves (6 spp.), whole plant (1 sp.), flowers (2 spp.) and roots (3 spp.). Two species are used in fish poisoning and one i.e., *Ficus hirta* is used as fish bait (Table-8). 32 species of wild vegetables used by Aka tribe have been recorded. Whole plant, leaves, tubers, fruits, stems, flowers and roots are used for vegetable.
- Bamboo and cane made handicrafts are designed by the artists among Aka people. These crafts are used to carry out day to day activities like carrying agricultural products, tools, wood, vegetables, etc. The survey listed 13 local made craft items which are used for various purposes. Among all these *Bio* (a local term) is the most used craft item while *Maeri* that of lesser user value.

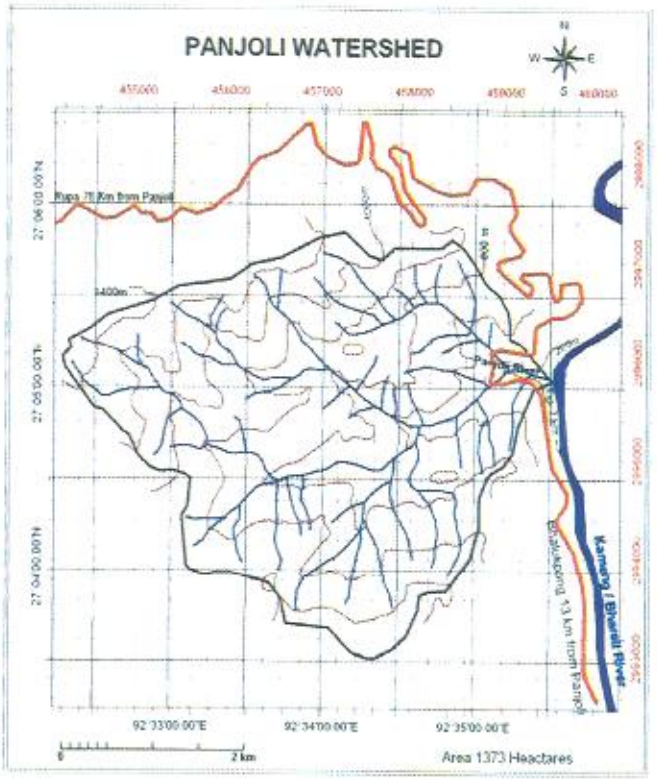


Fig. 34. Location map of Pinjoli Watershed.

Table-8. Plants of Ethno-medicinal importanc

Botanical Name	Local Name	Part(s) Used	Habit & Habitat	Ailments	Mode of Preparation
Ageratum conizoides L.	Phaso	Leaves	Herb, found wild in the roadside	Cut wounds	The plant paste is applied externally to the wounds.
Begonia josephii A.DC.	Papatcho	Root	Herb, found wild in moist and shady areas	Dysentery	Bulbils are consumed raw to cure the ailments
Centella asiatica L.	Longta	Leaves	Herb, found in the moist and shady areas	Dysentery	Leaves are ground to prepare the extract and consumed.
Chromolaena odorata L.	Min shoin	Leaves	Herb, found wild in the roadside	Cuts wounds	The plant paste is applied externally to the wounds.
Cissus quadrangularis L.	Aekjumuthu	Leaves	Herb, found in shady areas	Bone Fracture	Leaves are used to prepare the extract.
Houttuynia cordata Thunb.	Thupa	Whole plant	Herb, found in moist and shady areas	Dysentery	Whole plant is washed and consumed raw.
Jatropha curcas L.		Stem	Tree, planted nearby houses	Jaundice	A portion of stem bark is cut & separated; the bark is tied to suck tightly with thread. After 3-4 weeks, it is seen that the thread becomes quite lose. It gives the indication that jaundice is cured.
Mikania micrantha Kunth ex. H.B.K	Atscheja	Leaves	Herb, found wild in the roadside	Cuts wounds	The plant paste is applied externally to the wounds.
Mimosa pudica L.	-	Roots	Herb, found in shady & moist areas	Toothache	The roots are chewed or ground and kept in the teeth.
Parthenium hysterophorus L.	Shogung	Leaves	Shrub, found in shady areas	Buds and cold	Leaves are boiled in water and bath is taken with this water. The paste of leaves is smeared and inhaled for of cold.
Prunus persica L.	Shoben lio	Root	Tree, planted trees near house	Toothache	The plant paste is chewed & applied on the decayed tooth.
Spilanthus acmella L.	Pathina	Flower	Herb, found wild at roadsides	Toothache	The mature flower is ground and applied to the infected tooth.

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. Keeping in view the vast gap of this Biodiversity Information knowledge, digital database of the Western Himalayan vascular plants is essentially required so that proper utilization of the database is done for developing a management plan for the conservation of vascular plants

Objectives

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

Achievements

- A total number of 385 species pages have been prepared. These pages belong to 66 families and 187 genera (Fig.35).
- As per the format of Indian Botanical Information Facility (a toolkit of GBIF) of GBP herbarium, information on 350 species and a sample of 99 data sets of family Ranunculaceae – Fabaceae has been tested and hosted in Indian Botanical Information Facility (Fig.36).
- A model of execution of information has been generated in the species. Good quality photographs of 35 plant species have been added to the species pages. The species information on 22 RET species of Uttarakhand has been prepared.

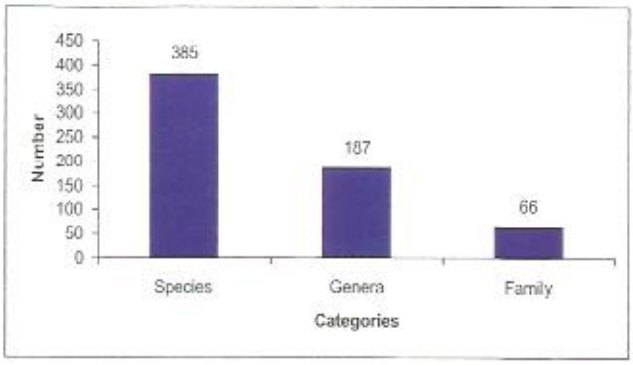


Fig. 35. Species pages for development of database.

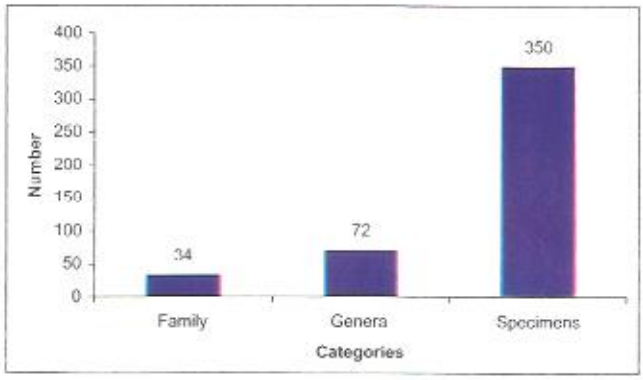


Fig. 36. Data sets of species information as per IBIF format.

Summary of Completed Project / Activity

Evaluation and Propagation of Two Vitality Strengthening Astavarga Plants in West Himalaya *(2006-2011, NMPB, New Delhi)*

The project was focused on phytochemical evaluation and propagation of two vitality strengthening Astvarga plants: Ridhi (*Habeneria intermedia*) and Vridhi (*H. edgeworthii*). Major outcome of the study includes:

- Phytochemical analysis of the sample of *H. edgeworthii and H. intermedia*, collected from different populations of Uttarkhand revealed that total phenolic content, total flavonoid and antioxidant activity varied significantly among populations. In *H. edgeworthii*. Samples collected from Pithoragarh populations possess higher total phenolic (8.57 mg GAE/g dw), total flavonoid (5.72 mg QE/gdw) and antioxidant activity (ABTS - 6.26; DPPH - 1.54 and FRAP - 2.74 mM AAE/100 g dw). However, in *H. intermedia*, Nainital populations showed maximum total phenolic (8.45 mg GAE/g dw), total flavonoid (5.37 mg QE/g dw) and antioxidant activity (ABTS - 5.14; DPPH -1.60 and FRAP - 2.81 mM AAE/100 g dw) (Fig.37).
- Asymbiotic *in vitro* seed germination of *H. edgeworthii* and *H. intermedia* were developed, in *H. edgeworthii* 90-94% *in vitro* seed germination was observed in MS medium supplemented with NAA. However, in *H. intermedia* 60-65% *in vitro* seed germination was recorded in MS medium supplemented with Kinetin.
- Towards developing mass scale planting material, callus was induced in *H. edgeworthii*. Callus piece transferred to MS medium supplemented with different BA and NAA combination and concentration, showed maximum shooting (83.3%) and maximum shoot number 10.83 shoot/callus. *In vitro* raised shoots were successfully rooted in ½ MS medium supplemented with NAA concentration. Over 70% plantlets were hardened in soil and sand ratio.
- The outcome of the project can be applied for commercial production of the plantlets for its medicinal uses and at the same time promotes conservation of *H. edgeworthii*. The efficient plant regeneration system of *H. edgeworthii* developed in the project will be useful for conservation and homogenous controlled production of this important Astvarga plant. The propagation protocols can be applied to other Himalayan orchids of

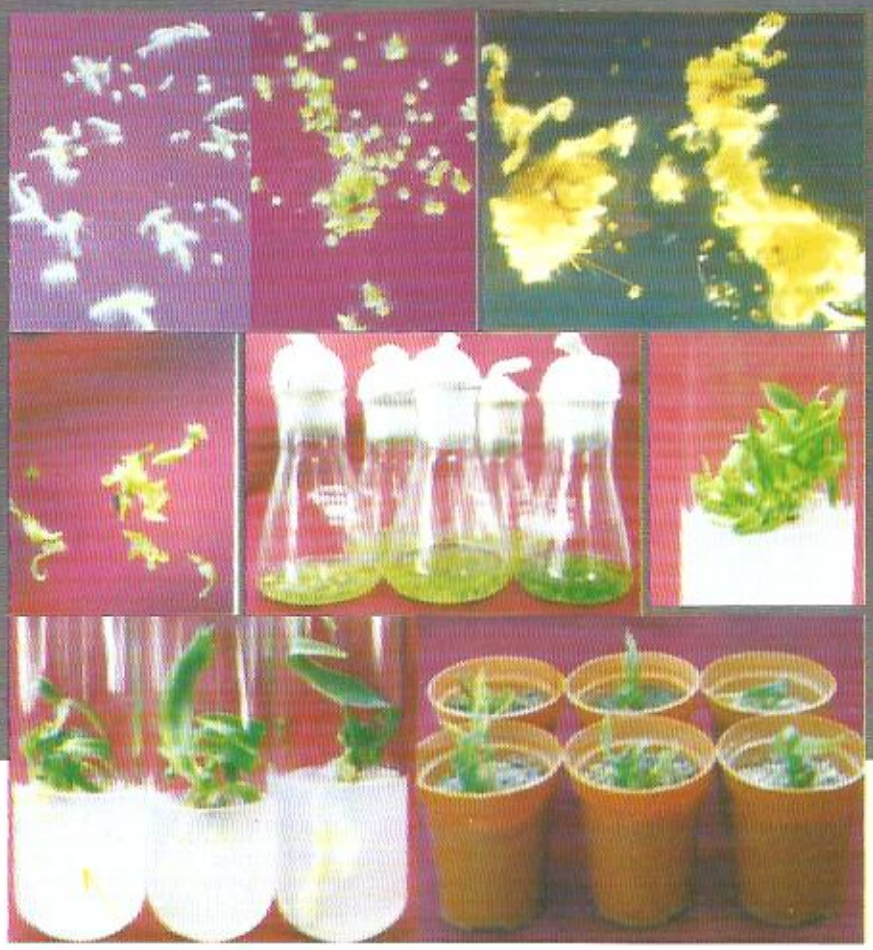


Fig.37. Phytochemical analysis of the sample of *H. edgeworthii and H. intermedia.*

Summary of Completed Project / Activity

Population Status Assessment and Screening of Active Constituents in the Selected Medicinal Plants of Uttarakhand Himalaya *(2006-2010, UCOST, Dehradun)*

Hedychium spicatum and *Roscoea procera* are two very important Himalayan medicinal plants used in different traditional and ayurvedic preparations. Considering the importance of both the species, and gaps in our knowledge, the study was undertaken to quantify their phytochemical and antioxidant activity in different populations of Uttarakhand Himalayan Region.

Achievements

- Total phenolic and flavonoids content significantly ($p<0.01$) varied among populations and in *H. spicatum* ranged from 2.81 (Thakurh) to 4.75 mg gallic acid equivalent/g dry weight (Suakholi) populations, while, in *R. procera* total phenolic content ranged from 2.11 mg to 3.58 mg GAE/g dw.
- Essential oil varied from 0.15 % (Chinapeak) to 1.36 % (Kalika) among the different populations of *H. spicatum*. Total phenolic and flavonoid content showed a significant positive relationship ($p<0.05$) with altitude in *H. Spicatum* (Fig.38). However, *R. procera* did not show any relationship with altitude.
- Antioxidant activity measured by three different *in vitro* assay methods (i.e., ABTS, DPPH and FRAP) revealed a significant variation ($p<0.01$) among populations of both the species and showed significant positive relationship ($p<0.01$) with total phenolic content.
- GC-MS analysis of essential oil obtained from rhizome of *H. spicatum* revealed the highest percentage of 1,8-cineole (33.32%) followed by β-cudesmol (22.17 %). Other major compounds present in the essential oil of the species were elemol, linalool, bornyl acetate, terpineol, γ-epoxy alememe, 10-epi-γ-eudesmol, ρ-menth-1-en-8-ol, β-pinene.
- Among the different microclimatic conditions of *H. spicatum*, total phenolic content and antioxidant activity was recorded higher in rocky and dry habitats. While, gallic acid was recorded higher in grassy slopes. Total phenolic compounds and antioxidant activity was found higher in South sun facing aspect. Among the different forest types total flavonoid content was recorded highest in oak forests.

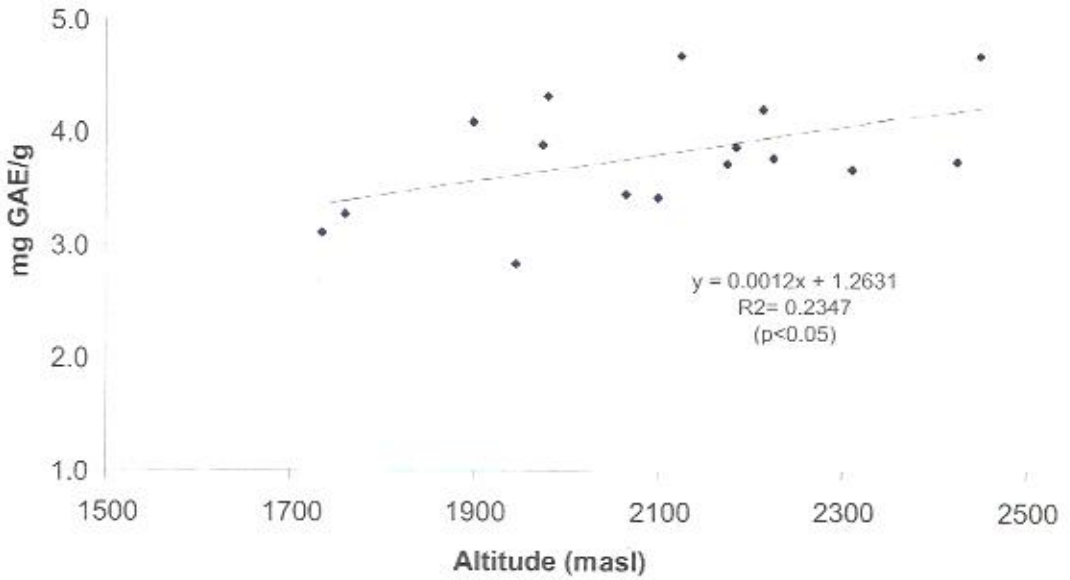


Fig. 38. Linear regression between total phenolic content and altitude in *Hedychium spicatum*

Summary of Completed Project / Activity

Expanding Outreach through Participation of Youth in Real-time/field Observations to Benefit the Education (PROBE) in the Indian Himalayan Region *(2007-2009, DST, New Delhi)*

The project activities were carried out in Himachal Pradesh to provide an opportunity for participatory and interactive learning for school children; shift emphasis for a student from being a passive recipient of information and knowledge (i.e., downloading) to become an active author of relevant and useful information (i.e., uploading); generate/gather information and convert such information into useful knowledge; use data/information gathering as means of generating interest in science; bring schools/institutions of higher learning and grassroots community organization into networking relationship; create a data base on meteorology, climate, natural resources and related fields of building village/watershed level data infrastructure; and contribute to scientific understanding of weather and climate in mountain region and study their local impacts. The outcome of the study is as follows.

- 22 Manual Weather Stations were established in the Government Schools of Kullu, Mandi, Bilaspur, and Hamirpur districts of Himachal Pradesh. Weather of all the stations monitored by the teachers at 8.30 am everyday and maintained in a register. The teachers and students were trained to handle the instruments and note the data properly from the installed stations.
- Two Training Programmes were organized in GSSS, Goshal, District- Kullu and GSSS, Ghumarwin, District- Bilaspur on "Weather Monitoring, Climate Change and Biodiversity Conservation". Lectures were delivered on Biodiversity in relation to Climate Change and Pollution and climate change. Demonstrations of Weather monitoring; data collection; Participatory Rural Appraisal exercise in the villages (Goshal & Ghumarwin) and Qualitative and quantitative assessment of biodiversity were given. Pre and post training programme feedbacks showed a significant improvement in the skill of the participants about the subject.
- Participatory Rural Appraisal (PRA) approach was introduced to the teachers and students during the training programmes. They were trained at Ghoshal & Ghumarwin. The Participants were given exposure of Historical Transect Analysis, resource, social and transect mappings, information generation on the natural resource utilization patterns, seasonal and annual calendars of the activities, cropping patterns, land use pattern, climate change, etc. They were trained about the validation and authentication of the information through Participatory Rural Appraisal.
- The average maximum temperature was recorded in GSSS, Barari (34.9°c) in June 2009, minimum in GSSS, Jallugran (-2.4 °c) in January 2009. The maximum dry bulb temperature was recorded in Gumarwin (29.0°c) in the month of June 2009 and minimum at Goshal (3.7 °c) in January 2009. Maximum Wet bulb temperature was recorded at Gumarwin (23.9 °c) in July 2009 and minimum at Goshal (2.1°c). Maximum Wind speed was recorded at Kharahal (11.3 km/h) and minimum at Ghumarwin (0.3km/h). The maximum rainfall was recorded at Hallan (199.0mm) and minimum at Kot-Hatli (2.1mm).
- Seedlings of ***Withania*** *somnifera* (Ash**wagandha**), *Grevillea robusta* (Silver oak), *Pittosporum eriocarpum* (Teera) and *Quercus leucotrichophora* (Ban) were distributed for the development of selected School Campuses

Summary of Completed Project / Activity

Study on the Assessment and Conservation Prioritization of Plant Diversity Along an Altitudinal Gradient in Himachal Pradesh, Northwest Himalaya *(2006-2010, DST, New Delhi)*

The study was conducted in Hirb and Shoja Catchments (HSCs), Chailchowk-Rohanda-Kamrunag Area (CRKA), Ghannahatti-Shimla Forests and Mandi Pandoh Area to assess plant diversity of Himachal Pradesh in relation to climate and altitude; assess status and distribution pattern of the native and endemic species in relation to climate and altitude; study the utilization pattern of plant diversity including indigenous knowledge and practices along an altitudinal gradient; identify rarity of the species; and prioritize potential sites for conservation and high value potential species for socio-economic development of the local communities. The major outcomes of the study are as follows.

- Qualitative and quantitative assessment of vegetation of the HSCs, CRKA, Ghannahatti-Shimla Forests and Mandi Pandoh Area were carried out. Over 800 species were recorded from all the locations. These species were analyzed for altitudinal distribution, resource utilization pattern, nativity, endemism and threat categories. The species richness decreased with the increasing altitude; utilization pattern and preference of the species varied from lower to higher elevations and proportionate number of native and endemic species increased with increasing altitude.
- Based on the regeneration pattern of tree species within the forest communities, 4 categories of the forest communities i.e., communities with highest regeneration of dominant species; communities with highest regeneration of co-dominant species; communities with poor regeneration of dominant and co-dominant species; and mixed communities with highest regeneration of one of the dominant species were identified.
- Fuel and Fodder extraction trends were assessed. In HSCs, Resource Use Index (RUI) for the fodder species varied from 1.95 (*Spiraea canescence*)- 946.80 (*Quercus semecarpifolia*) and Fuel species from 0.15 (*Deutzia staminea*)-1494.00 (*Picea smithiana*); in CRKA, RUI for the fodder species varied from 3.88 (*Ficus roxburghii*)- 701.38 (*Quercus leucotrichophora*) and fuel species from 0.68 (*Cotoneaster bacillaris*)-418.28 (*Quercus leucotrichophora*); and in Ghannahatti-Shimla forests, RUI for the fodder species varied from 3.0 (*Ficus roxburghii*)- 1697.8 (*Quercus leucotrichophora*) and fuel species from 2.40 (*Robinia pseudoacacia*)-1622.7 (*Quercus leucotrichophora*).
- 137 species belonging to 106 genera and 60 families were identified as Critically Endangered (28 species), Endangered (18 species), Vulnerable (37 species) and Near Threatened (54 species) in HSCs where as in CRKA 118 species belonging to 97 genera and 60 families were identified as Critically Endangered (16 species), Endangered (35 species), Vulnerable (67 species) and Near Threatened (40 species).
- Prioritization of habitats and communities in HSCs and CRKA was done on the basis of Conservation Priority Index (CPI). In HSCs, amongst habitats, shrubbery, bouldary and shady moist, respectively in the forest zone and alpine moist slope and watercourses, in the alpine zone amongst the forest communities, *Betula utilis*, *Juglans regia-Picea smithiana* mixed, *Quercus semecarpifolia* and *Quercus semecarpifolia-Taxus baccata* subsp. *wallichiana* mixed communities, and among alpine communities, ***Rhododendron anthopogon*, *Rhododendron anthopogon-Cotoneaster microphyllus*** **mixed and** ***Spiraea bella-Viburnum grandiflorum*** **mixed were prioritized for conservation**.
- In CRKA, amongst habitats, shady moist forest, dry forest, reverine and rocky habitats and amongst the communities, *Abies pindrow*, *Pinus roxburghii*, *Picea smithiana*, *Quercus leucotrichophora*, *Pinus wallichiana* and *Cedrus deodara* communities, were respectively **prioritized for conservation** based on Conservation Priority Index (CPI).

Theme

ENVIRONMENTAL ASSESSMENT AND MANAGEMENT (EAM)

The growing population and its continuously increasing demands together have led to over exploitation of natural resources. As a result, these resources are now getting scarce and are degrading. Low availability but high demand of the resources has posed high anthropogenic pressure on them beyond their carrying capacity. Consequently, a variety of environmental disorders and pollutions have arisen. 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 analyze impacts, set priorities, identify gaps, develop early mitigating approach and to find new technology to achieve a 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, resiliencies 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 stakeholders becoming 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. Adverse impacts due to developmental activities and sprawling urban environment such as aerosols and its impact on temperature rise, and solid waste problems, 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 development 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)*

The small farm is an integral part of the agroecosystem in the IHR where 60-80% families comprise of <1 ha landholdings. Moreover, most of the crop farming in the region is rainfed and is characterized by tiny and sloping terraces which in return produce very low yield. The farm yield is far less than that required to meet the adequate dietary demand of the small landholding farmers. Working with small

holders, therefore, forms an important priority area for the IHR. Simultaneously, handling the issues like degradation of arable land, diversification of rural income and rehabilitation of common property resources with respect to farmers' aspirations and constraints would help a lot in improving the status of these farmers. The development pathway could become possible only when need based intensification approach according to the small farmers be put forward. Increasing community access, participation in natural resource management and diversifying livelihood options at village level would be the primary steps in this regard.

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, and
- To develop pathways and policies for rural livelihood.

Achievements

- A representative village - Patharkot located in district Almora, was selected where a cultivable 5.9 ha community wasteland has been devoted to horticultural plantation for the last three years. Here, 890 saplings of different fruit trees were planted. Survival of saplings planted at this site after 2 years was noticed 40% in March 2011. The survival of fruit saplings planted around home gardens of the village after two years was about 63% indicating that community led plantation of fruit trees receives less attention than that of individual farmers.
- Looking at their growth parameters such as mean height, for *Prunus persica* and *Citrus reticulata* after 2 years of plantation, it was found to be maximum among all the 18 planted fruit species. *P. persica* recorded the highest survival (56%) across all the species planted. *Prunus amygdalus* was found among the slowest growing species.
- Promising farming practices in the region i.e. floriculture, dairy farming, vegetable cultivation and an integrated model of different farming practices were studied and cost:benefit was documented. Floriculture (output: input = 5) was found most remunerative among all the farming practices.
- Five poly houses were constructed in the Patharkot village during this year. Seasonal vegetable production and income from these poly houses were assessed (Table-9). A farmer earned as much as ₹ 2290 from vegetables for four annual consecutive cycles.
- An estimation for standing biomass, carbon stocks and carbon sequestration rates of three community managed forests of the region was made (Fig.39). The C-sequestration rate was found to be ranging between 4.16–5.36 t/ha/yr. Three community managed forests in the region were studied and their management practices were also documented.
- The shortage of fuelwood and fodder in Patharkot village when estimated, was found to be 207 MT and 120 MT respectively. 1500 saplings of different fuelwood and fodder species at Patharkot village were planted in a community wasteland and their survival after 4 months was noted to be 89%.

Table-9. Seasonal vegetable production and total income of a farmer from a poly house in Patharkot village.

Month	Crops sown	Production (kg/bundle)	Market cost (₹)	Total income (₹)	
Jun-July (2010)	Tomato	25	15	375	825
	Radish	30	10	300	
		10	15	150	
Aug-Sep (2010)	Radish	10	15	150	575
	Brinjal	15	10	150	
	Bell pepper	5	15	75	
	Coriander	40	5	200	
Oct-Nov (2010)	Spinach	15	5	75	240
	Brassica	15	5	75	
	Red amaranth	10	5	50	
	Fenugreek	8	5	40	
Dec-Jan (2010-11)	Tomato	5	20	100	650
	Lady's finger	10	25	250	
	Coriander	20	5	100	
	Radish	20	10	200	
Total				2290	

Fig. 39. (a) Vegetable production in polyhouse at Patharkot village and (b) permanent sample plots for estimating biomass and carbon from a community managed Van Panchayat forests.

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 represent the benefits human populations derive, directly or indirectly from ecosystem functions. In other words, ecosystem services are the conditions and processes through which natural ecosystems and the species that make them up, fulfill supply of goods and services to sustain human life. Ecosystem services are generated due to the interaction and exchange between biotic and abiotic components of an ecosystem. They are mainly divisible into (i) provisioning services such as, food, forage, timber, biomass fuel, natural fiber and many medicinal plants and raw materials for industrial products etc. and (ii) regulating and supporting services: purification of air and water, mitigation of floods and droughts, detoxification and decomposition of wastes, generation and renewal of soil and soil fertility, pollination of crops and natural vegetation, aesthetic etc. Traditionally, these services are considered as free gift of nature and therefore the economic value of these services is ignored or underestimated. This study was initiated to quantify and evaluate selected ES of the two major forest ecosystems of central Himalaya (viz., Oak and Pine) in the central Himalayan region.

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, 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

- Vegetation analysis was conducted for both Oak and Pine forests (Table-10). Density of Oak trees, saplings and seedlings in Oak forests was high (1160 ind./ha) as compared to the Pine forests (905 ind./ha). The total basal area of Oak forests was also found more than that of the Pine forests. The A/F ratio indicates the contagious, random and regular distribution of different species in Oak forests whereas in Pine forests only contagious distribution was found. The species richness (0.86 vs. 0.19) and total tree layer diversity (Shannon wiener index) (1.07 vs. 0.14) in Oak forests was also recorded higher as compared to Pine forests. The biomass (680.5 vs. 221.2 t/ha) and carbon (340.2 vs. 110.6 t/ha) in tree layer Oak and Pine forests was also recorded higher in Oak forests as compared to the Pine forests (see Table-10).
- Hydrological experiments were conducted to study the soil and water conservation (SWC) effect of the two forest types during August–September (total rainfall of 22 events= 396 mm; average rainfall intensity= 2.51 mm/hr). Only 13 rainfall-runoff events (rainfall= 298.2 mm) were considered that could be collected in the runoff collectors, rest (9) over flowed due to heavy rains and were discarded

from the analysis. Total runoff and sediment loss in Oak forests was about twice as compared to Pine forests, and the rainfall- runoff, runoff-sediment loss and rainfall- sediment loss were positively correlated ($P < 0.01$). The t- test value was significantly different (95% significant level) for both soil loss ($t = 2.73$) and runoff ($t = 2.80$) among Oak and Pine forests.

- Soil physico-chemical characteristics of Oak and Pine forests across the three depths (cm) were analyzed (Fig.40). Soil water holding capacity, organic carbon and nitrogen were found significantly higher in Oak forests as compared to Pine forests (t value significant at 95%) and values for these three parameters declined with increasing soil depth significantly.

Table-10. Phytosociological analysis and carbon of

Tree species	Density (ind./ha)	Frequency (%)	Total Basal Area (m^2/ha)	Abundance / Frequency (A/F) ratio	Distribution pattern	IVI	Biomass (t/ha)	Carbon (t/ha)
Oak Forests (species richness – 0.86)								
Quercus leucotrichophora	1160	100	37.89	0.116	Contagious	161	512.71	256.35
Lyonia ovalifolia	285	95	13.87	0.032	Random	70	127.67	63.83
Rhododendron arboreum	195	95	12.80	0.027	Regular	63	35.80	17.90
Q. semecarpifolia	5	5	0.04	0.200	Contagious	2	0.83	0.41
Viburnum cotinifolium	10	5	0.15	0.400	Contagious	2	2.38	1.19
Pyrus pashia	5	5	0.06	0.200	Contagious	2	1.08	0.54
Total	1660		64.8			300	680.49	340.25
Pine Forests (species richness – 0.19)								
Pinus roxburghii	905	100	57.13	0.091	Contagious	288.7	717.65	108.82
Lyonia ovalifolia	20	10	0.05	0.200	Contagious	11.3	3.53	1.76
Total	925		57.17			300	221.18	110.59

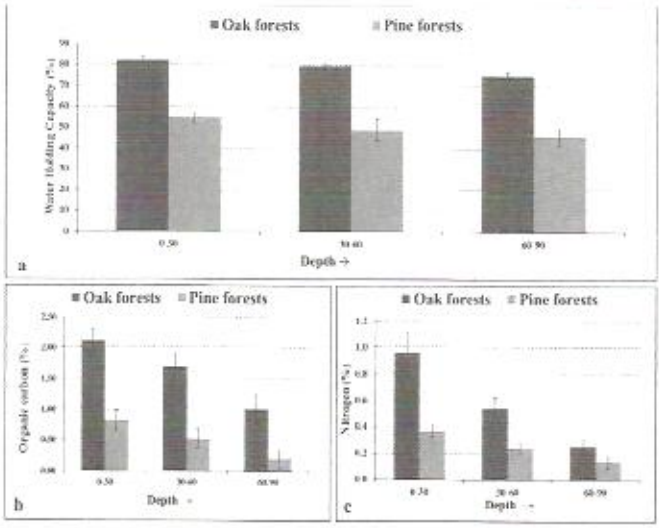


Fig. 40. (a) Depth wise water holding capacity, (b) organic carbon and (c) nitrogen in Oak and Pine forests. Oak and Pine forests (Lohajang, District Chamoli).

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

Hydropower projects, in general, remain in controversy among the local people, environmentalists and social activists due to largely environmental as well as economic concerns. This happens either due to lack of attention paid by the project proponents or absence of some concrete policy. The project authorities, who issue the tenders to the construction companies, scarcely verify the construction activities during construction. As a result, lot of anomalies by way of environmental concerns may occur during construction phases of the project in spite of applying Environmental Impact Assessment (EIA) as a tool to individual project prior to environmental clearance and inception of the projects. Improper environmental planning and management strategies at individual project levels through EIA have raised serious doubts about the sustainability of these upcoming hydropower projects. In many cases, EIA has not been so effective due to lack of application in legislation, weak organizational capacity, lack of training in baseline data generation, inadequate environmental information, low public participation, poor experience sharing, less effective donor policy and lack of policy interventions. Strategic Environmental Assessment (SEA), however, is a recent tool that overcomes the shortcomings being realized in EIA and is based on cumulative approach. It is more proactive; it accounts for cumulative effects of environmental problems, initiates and considers all plausible environmentally sound alternatives. Since a large number of hydropower projects in the Satluj River Basin in Himachal Pradesh are under operation, construction and proposed phases, the present case study is therefore focused in and around this basin

Objectives

- To overcome the challenges associated with project level EIA process and to try to conduct cumulative impact assessment (-ve/+ve) of various hydropower projects (existing/ proposed) on social, biological, and physical environment in the northwestern Himalaya.
- To develop a GIS based database that can be used by project proponents/consultants apart from assisting policy planners to reach strategic decisions regarding individual projects.
- To suggest the optimal number and types of hydropower projects in such a way that the development be environmentally viable.

- To incorporate ecological-economical based prospecting for compensation of eco-system services.
- To make recommendations for the MoEF/state government or other like agencies for modifications or formulations of separate policy/plans.

Achievements

- To assess the erosion prone area of the Satluj catchment, a buffer zone of 10 km on either bank of the River Satluj was demarcated (Fig.41). This area is lying from northeast to southwest from Nathapa village (Kinnaur district) to Bilaspur town (Bilaspur district). The total length of River Satluj included under present analysis is 165 km. Based on estimation of stream orders, 636 streams were identified in the 1st order, 178 streams in 2nd order, 43 streams in 3rd order, 7 streams in 4th order and 1 stream in 5th order.
- With the help of Geographic Information System (GIS), land use and land cover classifications (LULC) were made under the present selected buffer zone of the River Satluj Catchment area. The highest share of LULC stood to be barren land covering 40.90% (1205 km^2) of the total buffer zone (**2945** km^2). This LULC component was followed by 36.48% (1074 km^2) forest land, 21.91% (645 km^2) agricultural land and 0.71% (21 km^2) settlement area. Also, there is a high anthropogenic pressure on the catchment under study. For example, there are 8730 households which inhabit the identified settlement area.
- The locations of hydroelectric projects within the demarcated buffer zone of the selected catchment were obtained using Global Positioning System (GPS ± 5 m). With the help of GPS, 11 hydropower projects from mini to large were pinpointed. Out of the total projects, 1 project was found under mini (<5 MW), 5 under small (>5 to < 25 MW) and 5 under large (>25 MW). Accordingly, the influence zone for each category of hydropower projects were defined with a 3 km radius of an aerial distance for mini projects, 5 km radius for small projects and 7 km radius for large projects. Coding systems to different category of these projects were applied to obtain overlapped area from one project to another. The coding system was A for large, B for small and C for mini projects, while the numbers 1, 2, 3 and so on depicted their respective numbers which are to be overlapped from one project to another. For example, projects A1 and B2 overlapped in 38 km^2 as highest, followed by B2 and B3 in 29 km^2 and A4 and C in 28 km^2. The influence zone of HEPs in this way was estimated to be 31.30% (922 km^2) of the total buffer zone and 6.07% (179 km^2) overlapped area of the total influence zone. Most of the overlapped zone was found to be in the Upper Satluj catchment area which indicates further urgency to apply Strategic Environmental Assessment.
- Peoples' perception survey to know the satisfaction level of the villagers due to introducing hydropower projects was carried out in and around the six villages of the Karchham HEP (1000 MW) (Fig.42). The villages considered to be affected were Meeru, Urni, Kilba, Kanai, Punag, Chagaon and Choling in Kinnaur District. According to them the development activities took place in their area, however, environmental degradations in the form of illegal dumping of debris, siltation, crop damage, soil erosion, air pollution and solid waste problem were the important ones. Also, they were not satisfied with the role of Local Area Development Authority (LADA) and level of satisfaction about overall management plan for HEPs (Fig.43).

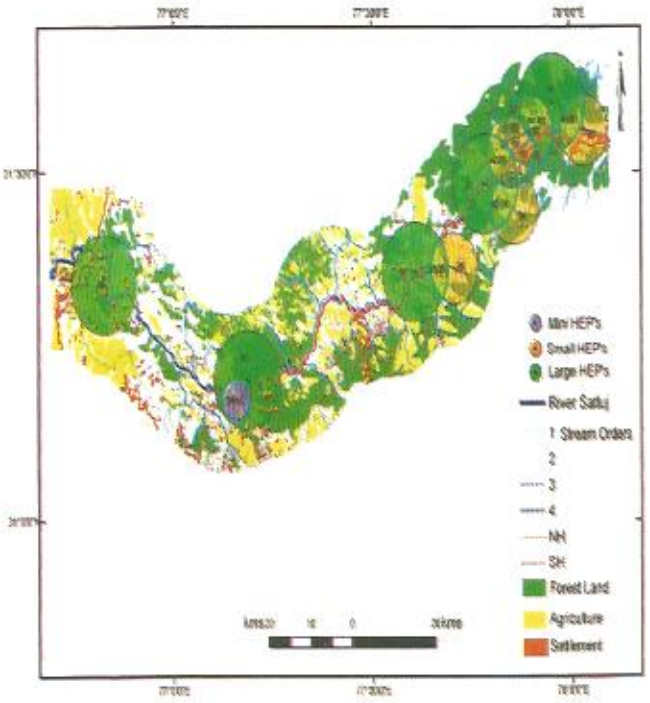


Fig. 41. Project influence zone and overlapping of HEP Projects in the Satluj catchment.

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

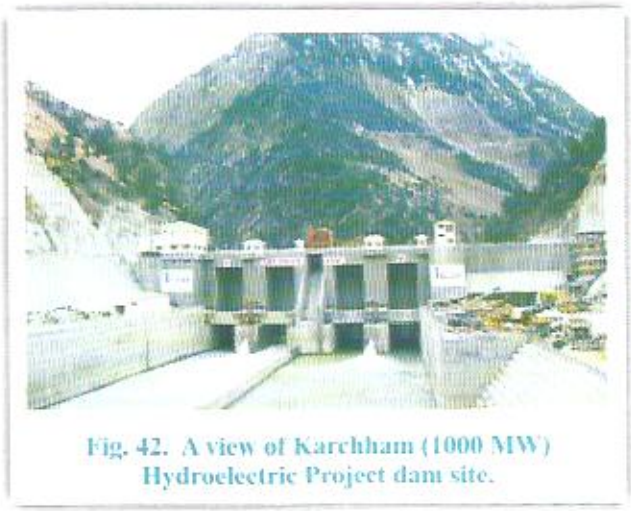


Fig. 42. A view of Karchham (1000 MW) Hydroelectric Project dam site.

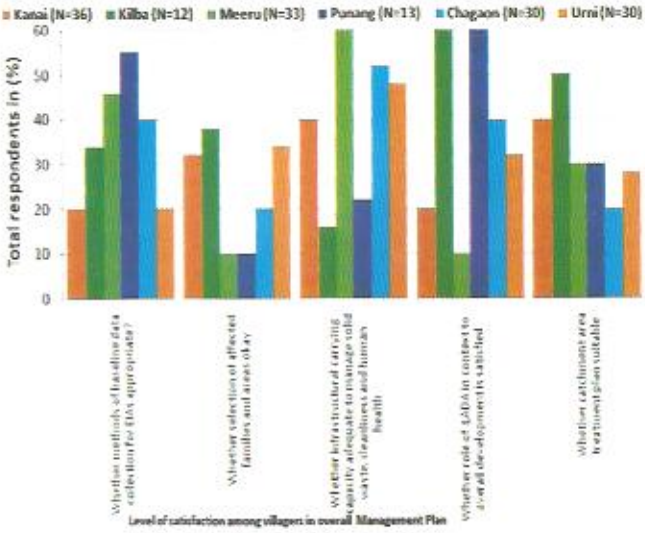


Fig. 43. Level of satisfaction among the villagers in overall Management Plan of project proponents in Kinnaur District, Himachal Pradesh.

urban towns and at the same time ever growing urban population itself within these towns and their activities have collectively been considered a cause of pollution. The 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 waste dumping create unhygienic conditions building up a home for breeding cockroaches, insects, worms and rats which later become a menace caus to 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 and coal, etc. causes AAQ degradation in the sprawling towns. Keeping in mind alike environmental problems, the study under the present project has been initiated on solid waste management (SWM) and ambient air quality in six hill towns of Himachal Pradesh, 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 within the state. For the present reporting period (April 2010 to March 2011), ambient air quality monitoring (AAQM) study was carried out simultaneously in a campaign mode during monsoon period 2010 as background values for three towns; Hamirpur, Kangra and Chamba.

Objectives

- To identify solid waste compositions and its generation.
- 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

- The mean concentration of PM_{10} was recorded highest with 40.3±4.4 µg m^{-3} at Hamirpur followed by 35.2±2.7 µg m^{-3} and 24.6±2.3 µg m^{-3} at Chamba and Kangra respectively (Table-11). These values were found within the prescribed limit (i.e. 100 µg m^{-3}) set by the Central Pollution Control Board (CPCB) at all the sites. Due to washout effect in initial sampling days, there remained less concentration of PM_{10} at all sites.
- On diurnal basis, highest concentration of PM_{10} was found between 16-0 h (IST) followed by 8-16 h and lowest between 0-8 h at all the sites except at Chamba. These values at Chamba remained highest between 8-16 h followed by 16-0 h and lowest between 0-8 h (Fig.44a). The high concentration of PM_{10} from morning 8 h to midnight showed the impact of day time anthropogenic activities in the towns.
- At all sites, there were high concentrations of particulate pollution compared to gaseous pollution. The gaseous pollutants like SO_2, NO_2 and NH_3 were recorded far below the permissible limits (i.e. 80 µg m^{-3} for SO_2 & NO_2, and 400 µg m^{-3} for NH_3 set by CPCB).

- The mean concentration of SO_2 was recorded highest with 0.6+ 0.1 µg m^{-3} at Hamirpur followed by 0.3±0.03 µg m^{-3} at Chamba and 0.2+0.02 µg m^{-3} at Kangra. This value for NO_2 was recorded highest with 6.9±0.6 µg m^{-3} at Hamirpur and lowest with 3.3±0.3 µg m^{-3} at Kangra. However, NH_3 was recorded highest as 27.8 µg m^{-3} at Chamba and lowest with 15.4 µg m^{-3} at Hamirpur (Table-11). On sample basis, there was high fluctuation in terms of all three gaseous pollutants at every site.
- On diurnal basis, the concentration of SO_2 remained highest between 16-0 h at Kangra and Chamba, while at Hamirpur, it was found highest between 8-16 h (Fig.44b). NO_2 remained highest between 16 h to midnight at all the sampling sites (Fig.44c). In case of NH_3, different time periods for highest concentration were noted (Fig.44d).
- It is observed that for five days (120 h) air mass back trajectories have followed a path of south-west, south-east monsoon winds at all sites, while trajectories for two days (July 11 & 12, 2010) at Kangra moved from north-western direction. Overall, the air mass remained dominated with moisture content rather than dust and aerosols. As a result, PM10 could not go beyond 88.4, 50.4 and 65.3 µg m^{-3} at Hamirpur, Kangra and Chamba respectively.
- The washout effect caused low concentration of PM_{10} is validated with Terra MODIS satellite AOD data. Before AAQM at all the sites, Aerosol Optical Depth (AOD) in these locations was very high (0.52 to 0.9) but during monitoring period, these values went down (0.26 to 0.58) drastically.

Table-11 Salient features of the study sites and mean concentration of ambient air quality monitoring (AAQM) parameters in Himachal Pradesh.

Study sites	Altitude (m amsl)	Population	Area (km^2)	Immediate surroundings	Location in IHR	Pollutants (in µg m^{-3})			
						PM_{10}	SO_2	NO_2	NH_3
Hamirpur	790	17,219	5.34	Residential (urban)	Siwalik	40.3 -	0.6 (±0.1)	6.9 (±0.6)	15.4 (±2.6)
-	776	9,156	3.12	Residential -	Lesser	24.6 -	0.2 (±0.02)	3.3 (±0.3)	24.6 (±2.9)
Chamba	936	20,327	4.33	Residential cum official (urban)	Lesser	35.2 (±2.7)	0.3 (±0.03)	5.5 (±0.5)	27.8 (±2.5)

IHR=Indian Himalayan Region

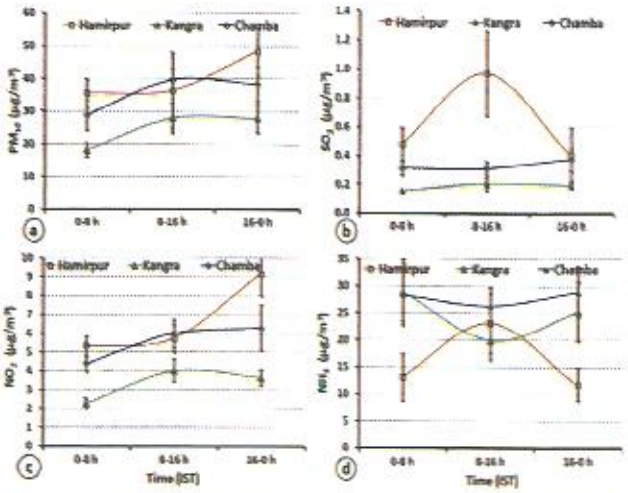


Fig. 44. Diurnal mean concentration of (a) PM10, (b) SO2, (c) NO2 and (d) NH3 at Hamirpur, Kangra and Chamba towns of Himachal Pradesh.

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

Aerosols are the colloidal system of particulate, gaseous and liquid pollutants which remain in suspension in the earth's atmosphere. If these remain in higher concentrations, they may have direct adverse impacts not only on human health and plant life but also on earth's radiative balance and subsequently on climate change. Fine particles, generated through anthropogenic activities, are also responsible for a formation of haze, mist and fog. These particles are also highly responsible for respiratory problems in human beings sometimes leading to be a cause of carcinogens. Moreover, study of aerosols in the Himalayan region is important because it will have long term effects like temperature rise, shifting of vegetation and crops from low altitude to higher altitude and glacier melting, etc. The solar energy that reaches at top of the atmosphere (TOA) reaches at the earth's surface with attenuation. Some of its energy is reflected back into the atmosphere while some is absorbed within it. The sulphate aerosols have reflective quality, while black carbon aerosols have heat absorbing quality. As a result of sulphate aerosols, there is a cooling effect while due to BC aerosols there is heating effect. The phenomena of scattering and absorption from incoming solar radiation alter the radiation budget of the earth's atmosphere which results in climate change. Aerosols optical depth (AOD) is a unit for the measurement of columnar aerosols monitored through Multi-wavelength Radiometer (MWR), while BC is measured 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 analyse aerosol size distribution and atmospheric turbidity using Ångstrom parameters; α (alpha) and β (beta).
- To obtain black carbon aerosol (BC) concentrations using Aethalometer.
- To determine the impact of aerosols on climate change in the Himalayan region

Achievements

- The average forenoon (FN) and afternoon (AN) AODs for a day at ten wavelengths under clear sky conditions between 2006 to 2010 showed maximum AODs in 2010 and minimum in 2007. An increase of 22% AOD during the past three years (2007-10) at 500 nm was obtained (Fig.45a). However, during a reporting year, the maximum FN AOD for the clear sky days at 500 nm was 0.59 on 30 May 2006, 0.45 on 5 November 2007, 0.43 on 14 September 2008, 0.37 on 2 September 2009 and 0.33 on 21 December 2010. While the maximum AN AOD for the clear sky days at the same wavelength was 0.59 on 8 May 2006, 0.48 on 22 April 2007, 0.48 on 31 January 2007, 0.81 on 19 October 2009 and 0.76 on May 8, 2006.
- With the advancement of a day from FN to AN, temperature of the Earth's atmosphere increases. The pollutants, known as aerosols, are lifted above the ground due to convective activity with the sunrise and remain in suspension in the atmosphere. As a result, this process causes more concentration of aerosols in the AN than in the FN. Hence, the AOD values increase from FN to AN (Fig.45b).
- The monthly mean value for the reporting period 2010, α and β was calculated for the clear days. The maximum value of α stood to be 1.54 in August, while minimum was 0.54 in March. The turbidity coefficient β was noted to be 0.31 as highest in July and 0.07 as lowest in August. It is interesting that these two parameters were found inversely proportional to each other (Fig.45c).
- The monthly mean of BCA concentrations at Mohal was also taken into account. BCA concentration was noticed as much as 6596 ngm-3 in January, 2010 and as low as 3253 ng m-3 in the month of June, 2010. The black carbon aerosols were found generally to increase with the increase in activities like biomass burning, vehicular emissions and forest fires (Fig.45d).

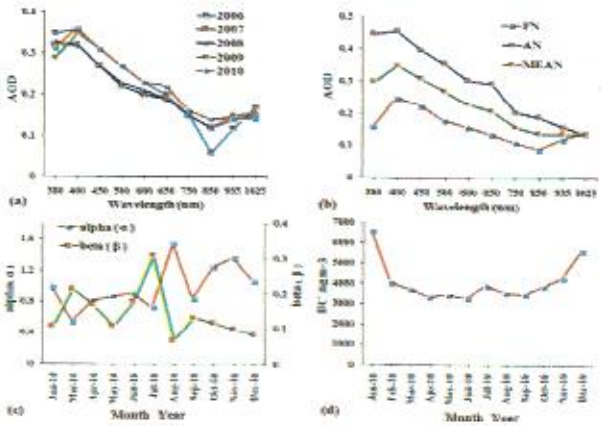


Fig. 45. (a) Trend of AOD from 2006 to 2010, (b) FN, AN and mean AOD for 2010, (c) monthly mean values of alpha and beta, 2010 and (d) monthly mean BC aerosols concentration 2010.

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

Surface ozone is a secondary pollutant, photo-chemically produced in the atmosphere from reactions involving a variety of volatile organic compounds (VOCs), composed mainly of non-methane hydrocarbons, in presence of sufficient sunlight and nitrogen oxides (NOx) such as nitric oxides (NO) and nitrogen dioxide (NO2). Being a trace as well as an important greenhouse gas after carbon dioxide (CO2) and methane (CH4), surface ozone (O3) plays a key role in controlling the chemistry and climate of the tropical troposphere. Ozone is recognized as an important gas responsible for changes in air quality and global climate. It is a major precursor of highly reactive hydroxyl (OH) radicals, which determine the lifetime of many gases in the atmosphere. Aerosols have become an important area of research in the atmospheric science. Higher levels of ozone lead to serious health problems, damage natural ecosystems and reduce crop yields. Ozone production takes place at higher rates in summer which is largely determined by the level of NOx concentrations from fossil fuel combustion. Ozone has a lifetime only of a few days in summer but of several weeks in the free troposphere. Surface ozone is strongly influenced by anthropogenic sources in the surrounding areas. The major sources of NOx include fossil fuel burning, lightening, emissions from the biosphere, stratospheric intrusions and biomass burning. SO2 sources are dominated by fossil fuel burning, industry (ore smelting), volcanic eruptions, etc. The fossil fuel sources for both NOx and SO2 are among the largest contributors

Objectives

- To measure important concentrations of gaseous pollutants such as surface ozone (O3), nitrogen dioxide (NO2) and sulphur dioxide (SO2) in ambient air to establish background values in the Himalayan region.
- To observe local meteorological parameters and relate these with gaseous pollutants, and analyze long range transport sources in the background.
- To suggest some feasible mitigating measures implementable at policy level.

Achievements

- Surface ozone if it goes above 50 ppb for 1 h duration starts to create problems in human beings as well as plant life (Fig.46a). The hourly highest ever O3 concentration in 2010 was observed as 157.5 ppb on May 4, 148 ppb on May 3 and 145 ppb on May 26 at Mohal (Fig.46b). During the same year, the maximum number of O3 episodes were also observed in the month of May.
- The average O3 rate of change in the morning is 7.29 ppb/h which may be considered higher due to fast production of O3 by a daily freshly emitted precursors as well as low -5.94 ppbv/h in the evening because of low production of NOx at this site as compared to the urban site.
- O3 episodes observed in summer months due to transport of its precursors like NO2 and CO from Middle East countries were reasonably high in the immediate surrounding of the present study region.
- The annual average of surface ozone on high insolation days (excluding August and September when surface ozone data was not available) was estimated to be 41.7±13.8 ppbv and on low insolation days these values were 33.3+9.76 ppbv. The difference between ozone concentrations on high and low insolation days shows a role of photochemistry in building up of surface ozone. The largest ozone build up between high and low insolation days were 14.7 ppbv in May, 13.3 ppbv in June and 1.0 ppbv in July.
- Solar flux has an important influencing role in determining O3 concentrations. Its highest values were 595 Wm-2 and 549 Wm-2 in March and May respectively. During these summer months, more than 3000 plying vehicles per day were also registered at Mohal. Vehicular emissions and actinic solar flux have been the primary reasons for high concentration of O3 in summer. Low concentration of O3 (i.e. 30 ppb) in July may be due to low amount of solar flux (393 Wm-2), short duration of sunshine and washout effect due to high rainfall (243 mm).
- NO, NO2 and NOx values showed bimodal distribution in a day; one at 800-900 hrs IST and other at 1900-2000 hrs IST (Fig.46b). It is notable that all the pollutants including NOx have biomodal distribution in a day; one in the morning (800 h IST) and other in the evening (1900 h IST). This biomodal distribution is mostly goverened by shallow boundary level in the morning as well as in the evening supported by the local emissions from vehicular influx and biomass burning.
- The diurnal value of surface ozone showed negative relation with NOx. The day time ozone mixing ratio is basically due to photo-oxidation of precursor gases, CO, CH4 and other hydrocarbons in presence of sufficient amount of NO/NOx (see Fig.46b).
- The four days back trajectories to analyze the role of external source of pollutants from outside the region show transboundary pollutants. However, local sources also play a role due to anthropogenic sources. With a view to pinpoint these external sources, each back trajectory was calculated for a duration of 96 hrs at 1500 m from above ground level (AGL). During the episode days, the air mass flow remained from the northwestern direction at 1500 m AGL at Mohal.

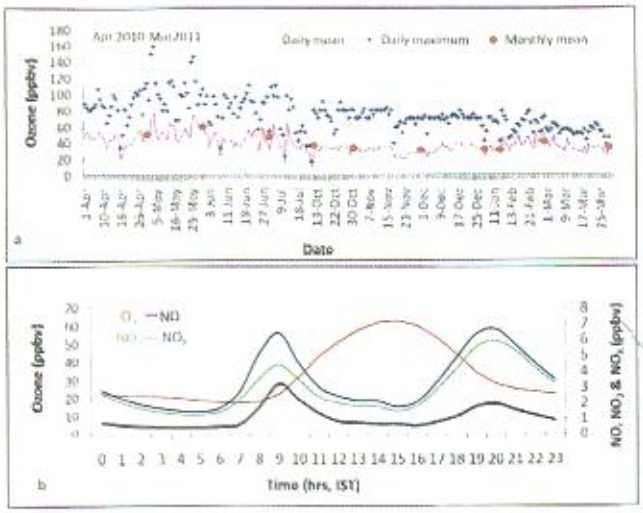


Fig. 46. (a) Hourly maximum, daily and monthly mean concentration of O3 at Mohal, and (b) its behaviour with NO-NO2 and NOx.

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 respirable particulate matter below 10

micron (PM10) and fine particulate matter below 2.5 micron (PM2.5) in two different altitudinal locations close to two important hill spots, Kullu-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 PM10 and PM2.5 were used to expose 8 to 24 hourly samples on an alternate day basis at both experimental locations. The Whatman Glass Micro fibre Filter paper GF/A (20.3×25.4 cm) and GF/A (47 mm) were used to expose PM10 and PM2.5 respectively. 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. The rainfall collection gadget combines a system of a 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 April 2010 to March 2011 at Mohal and Kothi. Besides, the Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model was used to understand the pollution sources mainly from external 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 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.

Achievements

- Based on the accepted samples, particulate pollution levels are analysed (Table-12). The highest diurnal average PM10 at Mohal was 86.3± 4.0 µg m-3 during 16:00-00:00 hrs IST, while at Kothi it was 36.8 ± 5.4 µg m-3 during 08:00-16:00 hrs IST. At Mohal, the highest daily average PM10 concentration was 138±18.1 µg m-3 on January 7, 2011 while at Kothi it was 85±9.6 µg m-3 in December 8, 2010 (Fig.47a). Back trajectories analysis shows the wind was coming from northwestern direction on a particular episode day at Mohal (1500 m) and Kothi (3000 m, Fig.47b). On monthly basis, maximum mean PM10 was 61±3.6 µg m-3 at Mohal in May 2010, while this value at Kothi was 33.5±4.5 µg m-3 in December 2010.
- The daily highest PM2.5 was 104.9 µg m-3 on July 7, 2010 at Kothi, but this value at Mohal was 71.1 µg m-3 on January 29, 2011 (Fig.47c). Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) also show that the columnar aerosols at Mohal during these episode days were maximum (Fig.47d). Monthly maximum PM2.5 concentration was 49.6±12 µg m-3 in July 2010, while at Mohal it was 43.3±2.3 µg m-3 in December 2010.
- The highest number of incoming plying vehicles based on 12 hourly census (06:00-18:00 hr IST) at both the sites stood to be highest in May 2010; i.e. 2,572 per day at Kothi and 3,110 per day at Mohal. This was due to tourist peak season during this time in the Kullu valley.
- Rain water samples were analyzed for Potential of Hydroginii (pH), Electrical Conductivity (EC) and Total Dissolved Solids (TDS). The daily average of pH values of the rainwater at Mohal and Kothi were 6.7 and 6.6 respectively. The pH value was also recorded acidic showing 4.2 and 4.1 at Mohal and Kothi respectively. The rainwater at both the locations was observed to be slightly acidic in nature. The daily average EC values of rainwater at Mohal and Kothi were 46.8 and 50.5 µS respectively. Daily average values of TDS at Mohal were 20.9 ppm which at Kothi remained 25.2 ppm.
- The daily highest average temperature shows the warmest day at Mohal to be July 16, 2010 with 37.10C and the coldest day January 17, 2011 with 4.10C. On the other hand, this highest value at Kothi was 27.20C on May 26, 2010. The average humidity throughout the observation period at Mohal remained 68% and at Kothi it was 72.5%. The total annual rainfall and snowfall at Kothi was measured as much as 1,377 mm and 4,765 mm respectively, while at Mohal- a low altitude valley topography, it was measured 1309.2 mm from April 2010 to March 2011.
- The maximum wind speed recorded at Mohal was 4.3 km h-1 on April 30, 2010 at 18:00 hr IST and at Kothi it was 55 km h-1 on August 8, 2010 at 15:00 hr IST. The wind movement at both the experimental sites, Mohal and Kothi were mostly from the northwestern direction (270-337.50). This means that the existing meteorological conditions also played an important role in affecting adversely the particulate pollution in the present study region

Table-12. Eight hourly exposed samples for particulate pollutants (PM10 and PM2.5) from April 2010- March 2011.

Month/Year	PM_{10}				$PM_{2.5}$			
Apr 10-Mar 11	Mohal		Kothi		Mohal		Kothi	
	SA	SR	SA	SR	SA	SR	SA	SR
	141	40	122	62	148	26	103	21

SA = Samples considered for analysis
SR = Samples rejected due to electricity failure, rainy days and due to other technical reasons

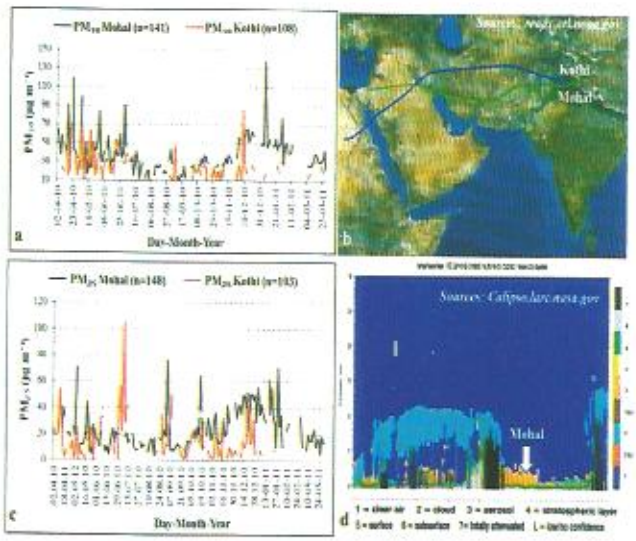


Fig. 47. External sources of PM10 and PM2.5: (a) PM10 concentration during April 2010-March 2011, (b) back trajectories drawn for PM10 episode day on January 7, 2011 at Mohal and on March 17, 2011 at Kothi, (c) PM2.5 concentration during April 2010-March 2011, and (d) CALIPSO drawn for PM2.5 episode day on January 29, 2011 at Mohal.

Appraisal of Tourism for Sustainable Management – Case Study from Sikkim Himalaya (2009-2013, In-house)

The Himalaya which is endowed with the bounty of nature, sacredness and purity of environment, and religious and cultural diversity, contains an innate appeal for the growth and development of tourism. Tourism in Himalaya has emerged as a priority sector and its economic potential is being harvested at different levels. However, the limitations of development characterized by complexities of hill topography warrant that continued growth of hill economy, this potential to tapp in a sustainable way. But, the cyclic nature of tourism as manifested in theoretical paradigms and its trade-offs with deteriorating quality of environment, is an inherent threat to its sustainability. Thus, a holistic approach is of utmost importance for sustainability of existing tourism in the light of tourist trends, impacts and management; this study of Sikkim is therefore an important attempt in this context. Tourism in Sikkim is mainly nature based. The pristine and unspoiled nature, rich biodiversity, panoramic views of snow clad mountains and valleys, monuments and artifacts of Buddhism are the main tourism resources. The state is harvesting these resources cautiously keeping in view of its sustainability. However, the tourist inflow patterns, which show a spectacular growth though suggesting sanguine prospects, do not augur well in terms of increasing pressure on limited resources, infrastructure and the demand-supply systems. This calls for an appraisal of management options.

Objectives

- To study and document nature and process of tourism.
- To assess economic significance of tourism and its impacts.
- To make an appraisal for sustainability of tourism through suggesting management options for policy implications.

Achievements

- A field survey was conducted in Gangtok town to know the sociological attributes, source of origin, expenditure patterns, and the perception of tourists on impacts and services, etc. A preliminary survey of 88 randomly selected tourists was conducted to know the break-ups of tourist expenditure (Fig.48). Of the total expenditure of tourists, 72 % of the money was found to be spent in Sikkim to meet the expenditures for food, accommodation, travel and shopping. While the miscellaneous expenditure accounts for 28 % of the total tourist expenditures.
- A survey of local business groups was conducted at Gangtok to understand the income impacts by comparing income during the tourist season and the off-season. Two tourist seasons were recognized by most of the respondents i.e. summer season (3-4 months) and autumn-winter season (2-3 months). The preliminary survey based on random sampling of 150 respondents business community denotes that the overall earning from the business for summer season (season I), and autumn-winter season (season II) around 37.81% and 25.94% respectively, suggesting season contribution around 63.75% of their total annual income. This is significantly higher than the normal earning under no-tourism condition.

Travel agents and hoteliers are among the main beneficiary group who earn over 75% of the total annual income during tourist season. This is followed by the beneficiary groups from souvenir shops, restaurant and bars, and confectionary shops with mean annual earning over 65%, and wine shops and grocery shops with mean earning over 60 % of their annual income.

- The case study of Tsomgo Lake-Baba Mandir nature tourism site suggests significant revenue generation for the government. The travel agents and taxi owners at Gangtok are the main beneficiaries. However, the benefits to local communities in their vicinity are negligible. The vibrations generated due to vehicular movement in this geologically weak landslide prone topography pose a threat to the high altitude biodiversity and sensitive habitats, wet-land sedimentation and waste problem.
- According to a projection statistics of tourists inflow based on 1980-2009, 1985-2009, 1990-2009, and 1995-2009, as many as 14,67,658 tourists were estimated to visit Sikkim. Though this would result in increased earnings and employment avenues for the local business communities in the state, yet this would also enlarge the magnitude, spread domain and intensity of negative impacts.

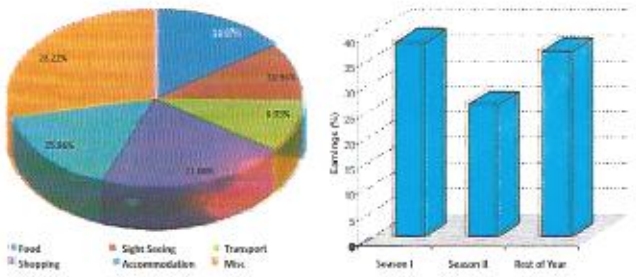


Fig. 48. Break-up of tourist expenditures (left) and earning patterns of business community (right)

Summary of Completed Project / Activity

Participatory Management of Bhimtal Lake Catchment (2005-10, LDA, Dehradun)

The project emphasized to achieve the goal in two-phases: (i) by devising a prototype in 20 ha land that depicts selected models of land rehabilitation vis-à-vis livelihood up-gradation, and (ii) large scale replication of the model-components (in 45 ha land) by the local communities.

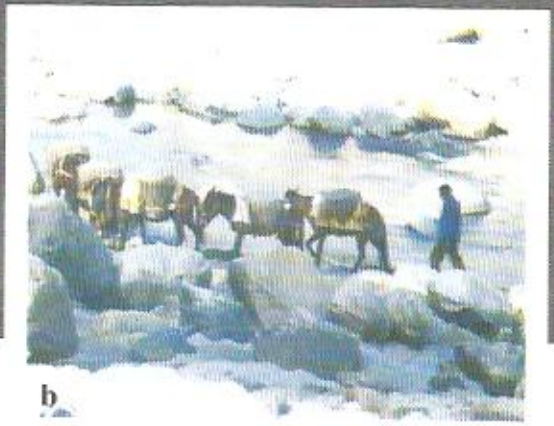
- In Phase-I (2005-10), four models (viz. Model I - multi-purpose tree species; Model II - silvi-pasture development; Model III - aromatic plants cultivation and Model IV - agri-horticulture) were developed in 7, 3.5, 5 and 5 ha land respectively in Sangurigaon and Songaon Van Panchayat land - the two major villages in the Bhimtal lake catchment.
- The Phase-II activities (2007-10) aim at replicateing the above mentioned land use models in the remaining 45 ha land area under a participatory mode with the local communities. However, only 14 ha land in three Van Panchyats namely Mehragaon, Bhagtura and Songaon were replicated.
- During Phase-I, a multi-purpose and silvi-pasture model having 23071 seedlings of more than 20 species were planted during 2005-10 where 21.6% survival was recorded. In the horticulture model, a total of 2445 plants of different species/varieties were planted during the project period, out of which only 5.4% survival was recorded till December 2010. In addition, a total of 10751 fruit plants of more than seven varieties were given to the villagers for plantation in and around their settlements and abandoned croplands. This time survival was recorded 65%.
- During Phase II (2007-10), 3168 seedlings of more than 5 species in Songaon Van-panchayat were planted and 45.6% survival was reported. While at Mehragaon and Bhagtura Van-panchayat areas, 4042 and 4548 seedlings during the same period were planted where 23.9% and 35.8% survival in December 2010 was recorded respectively.
- With a view to achieve soil and water conservation, a total of 36 trenches (size = 5 × 1 × 2 ft), 10 water percolation tanks (size = 18×10×8 ft) were constructed in the degraded community land of Bhimtal lake catchment.
- A retaining wall (43 m long, 3 ft. wide and 5 m high) was constructed to control soil erosion and sliding premises of Karkotak temple. The two solar lights and two iron resting shed (one rectangular shape 15'×10'×10' and another round umbrella shape 3m×3m×3.5m) were installed at Karkotak temple area.
- A total of 43 poly houses, 24 roof rainwater harvesting tanks and three polyethylene lined tanks were constructed in the villages of project area till March 2011. The farmers are being benefited due to these structures.
- More than 100 exposure visits for bio-composting, hedgerow plantation, off-season vegetable cultivation, food processing, bio-briquetting, candle making, local art (Alpana) and fancy bags were conducted for marginalized women farmers and unemployed youths from the villages of Bhimtal lake catchment (Fig.49a&b).

Summary of Completed Project / Activity

Environmental and Social Impacts of Hydropower Projects in Ganga River Basin (Between Dharasu and Gangotri) in Uttarakhand (2009-10, MoEF, New Delhi)

- Uttarakhand is rich in hydropower potential as it harbours many perennial snow fed rivers. In the upstream from Dharasu-Gangotri in Bhagirathi valley, over a dozen hydroelectric Projects (HEPs) of both small and medium size are either proposed (such as Pala-Maneri) or under construction (such as Loharinag Pala; construction halted by the Hon'ble Supreme Court in 2009) or operational (such as Maneri-Bhali Phase I & III). There has been a wider public concern about the environmental and socio-economic impacts of these HEPs. Consequently, the Hon'ble Supreme Court halted the construction work of the HEPs in the Bhagirathi basin in 2008. In this regard, one year pilot study was assigned by the MoEF where stakeholders were consulted in the HEPs affected villages with respect to both positive and negative and other socio-economic impacts.
- Stakeholders' responses for the Loharinag-Pala (LNP) mostly indicate negative impacts due to HEPs on various environmental parameters (Fig.50a). The flora and fauna are on decline. Agriculture and pasture based activities are adversely impacted. Air, water and sound pollution increased and water flow in rivers also declined. However, in case of Maneri Bhali-I (MB-I; commissioned long back) these components are either on positive side (+) or have remained same except a decrease in water flow in River Bhagirathi. Similar is the view in case of Maneri Bhali-II (MB-II) and LNP HEP (Table-13).
- Assessment of socio-economic impacts was also done after studying the affected stakeholders from LNP project. Although public amenities, means of transport and tourism activity have increased due to introduce on of LNP project in the area, yet there was also an increase in wildlife attacks, destabilization of river beds due to quarrying, mining and stones transport for construction activities (Fig.50b), encroachments either of the river bank and social evils. The aesthetic beauty of the valley has been eroded and quality of life, however, remains stable. In case of MB-I, there has been an increase in wildlife attacks (as the flow of river water is no more a barrier for wildlife movement), quarrying and mining for sand from the river bed and stone for construction activities, and encroachment along the river banks. The stakeholders are also of the opinion that social evils are increasing and aesthetic beauty of the region has ecreased. However, they acknowledge the fact that quality of life has been improved due the HEP. Stakeholders of MB-II were of the similar opinion as that of MB-I except social evils due to introducing HEPs.
- According to the stakeholders till the HEPs are under construction the benefits (primary, secondary and tertiary) could not be visible to the people due to direct harm to the natural assets on account of various construction activities of the HEP as is the case of LNP. However, in the later stages of production the landscape would be stabilized and the negative impacts would also be minimized, the projects like MB-I HEPs would start to prove beneficial to the local communities

a



b

Table-13. A summary of environmental and socio-economic impacts in the three HEPs of the Bhagirtahi valley (between Dharasu to Gangotri).

HEPs	Flora	Fauna	Aquatic life (fish)	Agri-culture	Pasture	Water pollution	Air temp.	Air pollution	Noise pollution	Land slides	Soil erosion	River turbidity	Flow of river
Loharinag Pala	(-)	(-)	S	(-)	(-)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(-)
Maneri Bhali - I	S	S	(+)	(+)	S	(+)	(+)	(+)	S	S	S	S	(-)
Maneri Bhali - II	(-)	(-)	S	(-)	(-)	(+)	(+)	(+)	(+)	(+)	(+)	(+)	(-)

(+): Increased/Improved; (-): Decreased; S= Stable/unchanged

Summary of Completed Project / Activity

Comprehensive Environmental Impact Assessment and Preparation of Management Plans for Tamak-Lata and Nandprayag-Langasu Hydroelectric Projects (2010-11, UJVNL, Dehradun)

- Hydropower projects occupy a considerable share within the total investment in energy sector in the Uttarakhand state. The Uttarakhand Jal Vidyut Nigam Ltd. (UJVNL), formed in 2001, played an important role. Out of the 1130 MW total capacity, 1005 MW are generated by UJVNL, 5 MW by an independent power producer and remaining 120 MW by the National Hydroelectric Power Corporation (NHPC). The study on Tamak-Lata and Nandprayag-Langasu projects are located in Chamoli district of Uttarakhand (Fig.51a&b). These projects are on the River Alaknanda and its tributaries basically on run-of-river schemes. With a view to practise Environmental Impact Assessment (EIA) for positive and negative impacts, to suggest suitable Environmental Management Plans (EMP), to ameliorate the adverse impacts and to enhance the positive impacts, the present study was carried out.
- The primary survey on various environmental parameters was conducted within the influence zone (IZ) of the project. The IZ includes circular areas of 10 km radius considering dam/barrage, powerhouse, reservoir boundary and other major project components as centre.
- Apart from IZ, catchment area of the project is another important part of the project implementation. A free draining catchment area for Nandprayag-Langasu HEP was delineated adopting the standard method between barrage sites of a proposed Nandprayag-Langasu and Bowala-Nandprayag HEPs (300 MW). The upstream Bowala-Nandprayag HEP is also a similar kind of hydropower project owned by the UJVNL itself which is located at the immediate downstream of confluence of River Alaknanda and River Birahi. The total area of the delineated free draining catchment of Nandprayag-Langasu barrage is about 76141 ha. The total area of this influence zone is about 34677 ha. Fig.52a&b depicts the free drainage catchment and influence zones of Nandprayag-Langasu and Tamak-Lata HEP.
- The baseline data on air, water, noise, flora, fauna, etc. under Environmental Impact Assessment was collected from the field and analyzed. Catchment Area Treatment (CAT) Management Plan was prepared using RS-GIS. Land use/land cover, soil, and slope raster images were used to estimate soil erosion intensity. According to the erosion intensity categories, treatment measures were suggested according to land use types and estimation of cost was done in a phase wise manner for a period of 5 years.
- Both the hydropower projects are run-of-river types and the height of barrage is very low, i.e. 13 m in case of Nandprayag-Langasu HEP and 16 m in Tamak-Lata HEP. Considering these factors, disaster management plan for these projects was also prepared with an emergency action plan for ensuring real time alert to the inhabitants of the downstream.

Fig. 51. (a) Tamak-Lata Tunnel outlet, and (b) view of Nandprayag-Langasu HEP Tunne 2.

Fig. 52. DEM of free draining catchment of: (a) Nandprayag-Langasu, and (b) Tamak-Lata HEPs.

Theme

SOCIO-ECONOMIC DEVELOPMENT (SED)

The Indian Himalayan region (IHR) is a unique zone of convergence harbouring diverse cultures of the plethora of ethnic communities. Bio-physically, this ecosystem is very rich. However, the ability of this mountain ecosystem is fast approaching many of its limits and it (the ecosystem) is gradually losing its ability to provide the minimum standard of living to its continually growing population, thereby, inducing poverty. The continued population growth and consequential poverty are fast depleting the finite natural resource base and breaking down the indigenously evolved resource-base use patterns that were socially sanctioned and culturally patterned. Therefore, reduction in poverty in this ecosystem through appropriate interventions 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 environmental protection. With this in view, SED Theme has focused on identified activities such as innovative livelihood options, 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 and thus reverse 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 holder's farming systems, scaling of innovative resource management practices by communities themselves, assessment of eco-tourism 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 the 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)

Shifting agriculture is practiced in 21 states covering about 22.78 lakh ha of land and 6,07,536 families in India and about 19.82 lakh ha of land and 4.43 lakh families in north east (NE) India. However in the 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 the 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 therefore, 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 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 the state and central Governments for the 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 twenty-five villages in five districts of the State of Arunachal Pradesh viz. East Siang, West Siang, Upper Siang, Papumpare and West Kameng and three major tribal communities, - Adis, Nyshis and Akkas were studied. Keeping in view, the suggestions of the Scientific Advisory Committee (17th Meeting on April 20-21, 2010), two more districts (Tawang and Lower Subansiri) and two more tribal communities, Monpas and Apatanis) were included in the study during the reporting year.
- During the reporting period, the major activities carried out included: 1. Analysis of policies and acts, 2. Socio-economic and ecological viability from the perspectives of Knowledge, Attitude and Perception (KAP) of the practitioners of shifting agriculture, 3. Development of an appropriate model to address fallow management and 4. Status and variations in the practices of shifting agriculture in north eastern states.
- The review revealed many positive and negative aspects of the policies and acts. For example, Arunachal Pradesh Forest (Removal of Timber) Regulation Act, 1983 positively restricted the trading of timber out of Arunachal Pradesh without proper license from the competent authority, which checked deforestation and commercial felling of trees. Negatively, the blanket ban on timber logging affected subsistence livelihood of some sections of people. The analyses also revealed strengths and weaknesses of many programmes and schemes implemented to address shifting agriculture. For example, introduction of kiwi *(Actinidia deliciosa)* as a horticultural crop proved beneficial, yielding to high economic returns. Negatively, it was cultivated in some areas that were basically primary forests and were cleared for its cultivation, thereby effecting deforestation.
- Since shifting agriculture is a well integrated assemblage of socio-cultural and religious life of tribal communities in NE India, the intangible aspects of culture, i.e., faith, beliefs, festivals and rituals associated with it were studied in depth during the reporting period in an effort to codify these institutionalized sacred concepts and quantify their role in conservation of biological resources. The social protections of biological diversity relating to ritually valued species by the shifting agriculturists is to sustain cultural practices and maintain cultural identity. As the cultural practices are threatened by the loss of biodiversity, conversely, the cultural value attributed to plant and animal species could be used as an argument to support to conservation of biodiversity. In the process, the linkages of the cultural calendar with the agricultural calendar was also traced. It was found that more than 15 plant species are used in more than 10 festivals/rituals associated with shifting agriculture.
- It was recorded that shifting agriculturists are adopting terrace cultivation and cultivated jhum plots from 1990-2010 are reducing as they have been transformed to terracing, horticulture, secondary forests and bamboo forests. In the nine villages that were surveyed during the reporting period, the number of cultivated jhum plots had reduced from 365 in 1990 to 170 in 2010.
- Further, development of a workable model has also been initiated based on toko *(Livistona jenkinsiana)*. The model will have alternate rows of normal shifting agricultural crops with toko along the slopes and ridges. Toko is a highly socially and economically valued species and it was observed that within the last five years, the economic value of

a bundle (about 40 leaves) of its leaves has nearly doubled from Rs. 55-60 in 2005 to Rs. 100-150 in 2010 in the local markets.

- Physiographically, nature of slope appeared to be a determining factor for practice of settled agriculture and non-practice of shifting agriculture by the Apatani tribal community in Ziro valley, Arunachal Pradesh (Table-14 and Fig.53).

Table-14. Nature of slope in Ziro valley and neighbouring areas.

Slope Class	Percent Area	
	Neighboring Area	Ziro Valley
Less than 20	24	45
20 - 35	35	33
35 - 50	26	18
50 - 80	14	4
Greater than 80	1	0

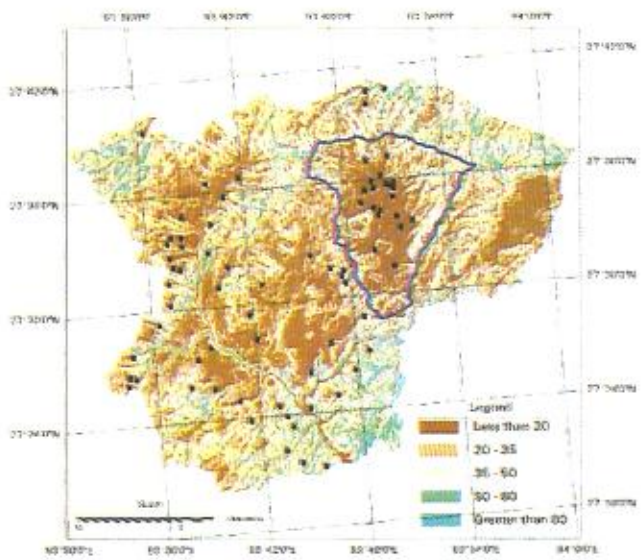


Fig. 53. Nature of slope in Ziro valley (encircled by blue boundary) and neighbouring area.

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

The mountains of the Himalaya, which vitally contribute to the ecological sustainability of the region are threatened by increasing population, open grazing, soil/nutrient erosion, deforestation and overall losses of biodiversity. Probably, the follow up of the efforts made under different activities, aiming to address these problems, was 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 from different studies and innovations tested for improved livelihood of the people, 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/ innovations and facilitate the improved management of the natural resources through up scaling farm based interventions, strengthening market linkages, soil and water conservation, rehabilitation of community degraded lands and 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

- Base line survey dating back to the last fifteen years for adoption/adaptation of different options for improved livelihoods and management of natural resources has been completed in 56 villages covering 394 households. The preliminary results suggest that the farming system, as a whole, is under stress due to uncertainty of weather conditions, scarcity of water, sectoral approach of the developmental activities, weak backstopping, and unstructured monitoring and evaluation system. In fact, overall improvement in livelihoods of the people during the period has been realized by the stakeholders but the scenario had also impacted adversely on the status of the natural resources and overall farming system of this region.
- Major impact of the deteriorating state of the natural resources has been observed on the traditional agriculture, which is either in a process of transformation to cash crop (if water is available) or 'no agriculture' due to a number of reasons.
- Adoption scenario (Table-15) clearly indicates that the farmer is a selective taker and adopts a very few

out of a long list of options provided under different programmes.

- Due to the ownership issues and limited monitory mechanism, most of the Van Panchayats are non functional and as a result, waste land/community land rehabilitation is not in the list of people's priority. Like wise, introduction of hybrid live stock merely helped in improving livelihood due to non-availability of the desired climatic conditions, improper management and quality feed.
- Up scaling of a few options, knowledge dissemination, conservation and storage of water linked with fish culture and protected cultivation, etc.(Table-16) have already been initiated with small land holders of remote locations, which need continued regular backstopping and material support.

Table-15.On-farm livelihood options: adoption/ adaptation during the reporting period.

Major Livelihood options	Demonstrations	Adoption/Adaptation	
		Villages	No. of house holds
Off season vegetable cultivation	-	07	11
Improved grasses	-	09	36
Integrated fish farming	-	10	16
Water harvesting & storage	03	03	19
Soil/ water conservation	02	02	05
-	-	01	02
Composting	-	05	18
Cash crop cultivation	Facilitation	09	18
Horticulture	Facilitation	02	09

Table-16. Average household income from different sectors (average of last five years).

Sampled Village	Average H.H. income/year (, 000 Rs.) Farming System sectors							
	A	B	C	D	E	F	G	T
Jarapani	4.5	4.0	6.7	2.4	3.6	16.4	9.0	54.8
Jura	12.3	7.2	5.0	-	32.9	9.7	10.3	77.4
Gewar	17.9	12.3	9.7	-	38.9	3.7	9.5	72.0
Majher Chaura	29.9	18.0	14.7	-	32.9	1.2	7.8	105.0
Patali	19.5	4.2	1.5	-	40.6	1.3	13.9	81.0
Lawbanj	42.2	8.9	7.6	2.6	32.0	4.3	8.6	106.2
Bheta	45.6	3.2	5.3	-	42.8	1.4	22.2	120.5
Nakuri	7.5	6.7	8.8	4.3	32.7	9.3	10.3	79.5
Sauli	5.9	17.6	12.3	8.3	34.5	12.9	13.3	105.0
Badrinath	4.7	2.2	6.3	2.6	4.3	29.7	4.8	55.0
Damloat	35.3	8.7	9.4	15.3	14.4	17.3	3.7	104.0
Thakala	22.3	1.0	4.4	12.7	38.9	8.7	3.0	91.0
Bhatarkot	21.7	8.4	7.9	4.3	35.8	12.3	2.6	85.1
Arah	36.5	9.3	7.8	4.2	7.9	1.7	12.7	80.3
Kapkotdhunga	19.0	4.3	12.3	2.4	29.6	7.8	4.4	67.5
Bantoli	46.6	0.9	1.4	-	39.6	5.4	3.3	97.2
Duba	27.6	5.9	12.3	1.0	27.8	12.3	6.9	93.6

A: Agri + Horti+ Tea cultivation; B: Vege +Cash crops; C: Fish+ Dairy+ Poultry; D: NTFPs; E: Service+ Pension; F: Labour; G: Business +Tourism; T: Total

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

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 in the 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 a 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 a particular age group from the state like Uttarakhand creates regional imbalance, adversely impacting agricultural productivity, and therefore, the economy of the region as out-migration results in loss of a larger proportion of able, educated and active work force. Out-migration could be 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
- 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

- Preliminary surveys carried out in the villages of Dailakote, Sahknari & Daulla using structured questionnaire revealed that lack of social infrastructure like education and health coupled with scarcity of natural resources scarcity is the prime reason of out-migration. For example, about fifteen families to have permanently out-migrated from these villages for better education and health.
- The preliminary surveys revealed occurrence of economic upliftment in the villages brought in by outmigration, which has supplemented earning.
- Further, it was observed that scarcity of natural resources like productive agricultural land, water and forest, etc. also manifest out-migration.
- With an aim to enhance the capacity of the villagers in better resource management, efforts have been made during the reporting year by way of conducting training programs for villagers, where training has been imparted on skill development and resource management (Fig.54).

Fig. 54.Training to the villagers on skill development.

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

Heavy metals such as copper (Cu) and zinc (Zn) are essential micronutrients required for the growth and development of all the organisms at low concentration but their higher concentration i.e. above safe limit as defined and prescribed may adversely affect the physiological and biochemical activities of both plants and human beings. The frequent use of heavy metals containing pesticides, fertilizers, solid waste compost or waste water may increase their concentration in soil up to toxic levels. Cypermethrin (CPM), a synthetic pyrethroid is one of the extensively used insecticides to control pests and to increase productivity of vegetable crops such as tomatoes, cabbages, cauliflowers, etc. in Kullu, North West Himalaya. The excess use of cypermethrin will not only leave its residue in soil but will also lead to potential pollution of soil, air and ground water in the application areas. Cypermethrin is an active ingredient of different formulations such as Challanger, Cypermil, Ripcord, Goldsyp (10% or 25% EC), etc. and Cu in Blitox and Cu that of Blitox Bordex mixture, etc. Earlier studies have shown that cypermethrin and heavy metals had toxic effects of seeds of different crops.

Objectives

- To study the growth and yield responses of selected food crops in soil contaminated with heavy metals and pesticides.
- To quantify pesticide residue levels in soils, water and in crops grown locally and sold in local markets.
- To assess dietary exposure of local consumers to pesticide residue through contaminated crops and their health risks by comparing the generated database with their maximum residue limits (MRLs).
- To assess effect of household practices on accumulation of pesticide residue levels in edible part/s of crops grown locally and sold in markets.
- To assess the effect of organic matters and poly-house techniques on accumulation of pesticide residues in edible part/s of crops grown on contaminated soil.

Achievements

- Consumption rate of various food items for local male and female adults of Kullu were quantified during the year 2010-11.
- Zinc was found more toxic to tomato seeds as compared to Cu. The effects of Cu and Zn on seed germination and root and shoot elongations were antagonistic in nature. Zinc toxicity during seed germination of the tested plant can be minimized using Cu up to certain extent (Fig.55).
- Cypermethrin and Cu in soil may influence seed germination, seed germination rate and growth of seedlings of a crop. Cypermethrin has more toxic effects on seeds of palak (Spinacia oleracea L.) as compared to Cu (Fig.56).
- Cypermethrin could reduce toxic effects of Cu on french bean at growth and biomass levels. Antagonistic interaction between Cu and cypermethrin on growth and biomass of French bean are illustrated in Fig.57.
- Toxicity order of tested chemicals were as Cu > Cu + cypermethrin > cypermethrin > control.
- The study suggests that Cu and Zn had antagonistic effects on yield responses of tomato and cauliflowers under the local field conditions of Kullu, western Himalaya.

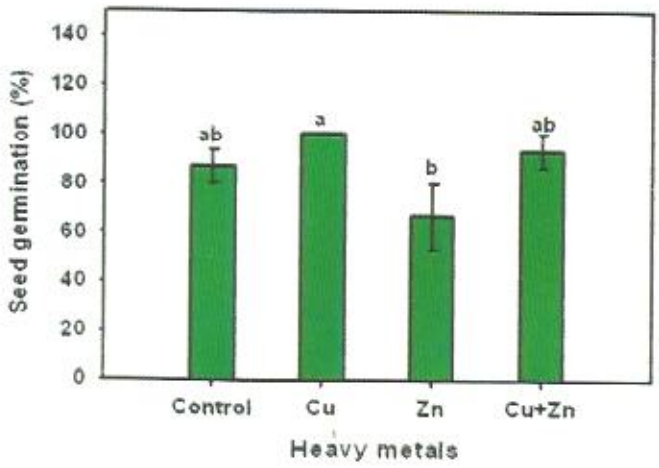


Fig. 55. Effects of Cu and Zn singly and in combination on seed germination (%) of tomato seeds. Bars are mean ± S.E. of three replicates. Bars shown with different letters are significantly different at p < 0.05 (Duncan's multiple range test).

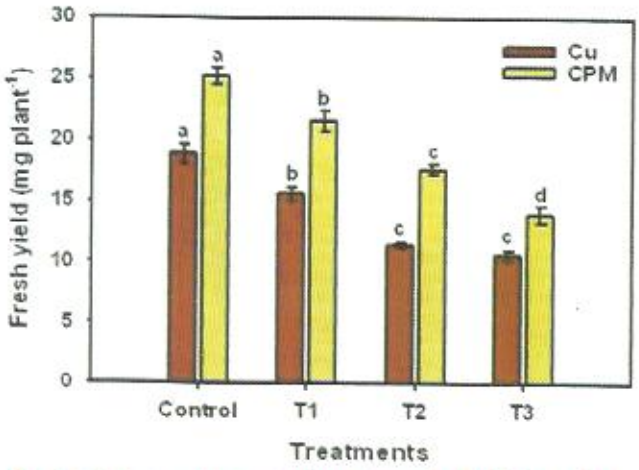


Fig. 56. Effects of chemical treatments (0-0.05mg ml-1) on fresh yield of seedlings of S. oleracea L. Bars are mean ± SE of five replicates. Bars of respective treatment followed by different letters are significantly different from each other at p < 0.05 (Duncan's multiple range test).

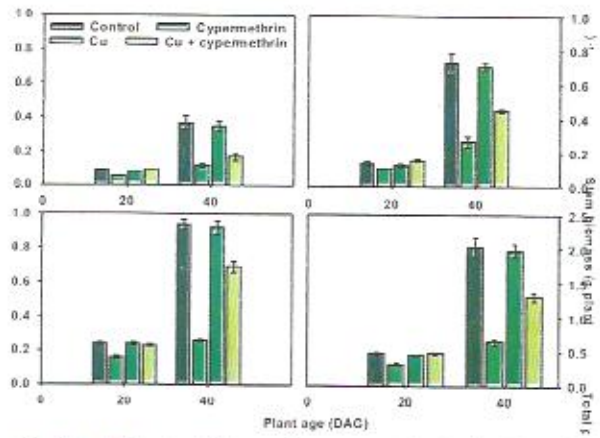


Fig. 57. Effects of Cu and cypermethrin singly and in combination on biomass production of French bean plant. Bars are mean ± S.E. of three replicates.

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 still 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 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 into 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

- Based on the eco-physiological conditions and needs of the villagers, different prototypes have been established in all the six identified village clusters of Champawat and Tehri districts in Uttarakhand. Over 12 ha of community land under different clusters has been rehabilitated through establishment of different prototypes during the period.
- Stakeholders consultation and need based assessments were made through meetings and discussions. Similar exercise was followed for species prioritization, participation and knowledge sharing. Community based natural resources management (CBNRM) approach has been adopted to achieve improved natural resource base.
- A gradual shift from small scale cultivation of local varieties to commercial cultivation of improved varieties of flowers has been introduced. Also legal status to the growers through registration with HRDI for marketing has been provided.
- A co-operative society named "Himalayan Jadi Buti Ewam Phool Utpadak Samiti" was set up in Dharaunj cluster to ensure equal share of benefits, proper execution and improved marketing of MAPs' produce and cut flowers.
- A formal MoU has been signed between the Society and buyers for purchase of raw materials of MAPs and flowers. In an effort to ensure marking of the products, networking has been done with the Girija Herbal Kalyan Samiti, who will purchase Tejpatta, Samyo and Satavar and the Himalayan Social & Environmental Development Society, Haldwani who will purchase flowers and other MAPs at current market prices. The details on the production of MAPs and flowers and income generated during the year are given in Table-17 and Table-18.
- Harvesting and storage of water, soil/water conservation practices and mass scale cultivation of improved grasses have been started under degraded as well as terrace bunds of agricultural land. Five such structures for storing rain water have been constructed and stored water is being used for life saving irrigation during summer and winters.

Table-17. Production of MAPs and income generated during the year.

MAP Species	Production (in Quintal)	Market Price (Dry; Rs./kg)	Net income generated (in Rs.)	No. of beneficiaries
Ocimum basilicum	11.50	Leaves :50.00 Whole plant: 35.00	38,500.00-	15
Valeriana jatamansi	1.00	Leaves :30.00 Whole plant: 80.00	12,200.00	2
Matricaria chamomilla	3.0	Flowers:120.00 Whole plant: 35.00	9,700.00	5
Total	-	-	60,400.0	-

Table 18. Production of improved varieties of flowers and income generated during the year

Species	Production	Market Price (Rs.)	Net income generated (Rs.)	No. of beneficiaries
Gladiolus	490 bundles (24 sticks/ bundle)	110/ bundle	42,100.00	32
Wild marigold	250 kg	25/kg	4,500.00	2
Lilium	85 bundles (06 sticks / bundle)	280.0 / bundle	16,000.00	6
Total	-	-	62,600.00	-

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 is the meeting ground of the Indo-Malayan and Indo-Chinese bio-geographical realms, as well as the Himalayan and peninsular Indian elements, and is among the world's ten most critical centres for biodiversity and endemism. The region also encompasses parts of the three global biodiversity hotspots, namely the Himalayas, Indo-Burma and the mountains of south-western China. The biodiversity of the Eastern Himalayas is already well recognized to be of global significance and 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 the poorest people from diverse cultures and social backgrounds who largely depend upon 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 is implemented in order to fill the knowledge gaps 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.

Objectives

- A comprehensive review report on floral and faunal diversity including status, distribution, threats and their use by local communities from the two protected areas (provide separate lists of species that are endemic or threatened species and traded or exported from the area).
- 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 and document local level traditional knowledge/ practices utilized by people to enhance conservation.
- Preparation of a landuse and cover change map of the area with dominant forest types and identify potential areas for developing buffer or connectivity between the said protected areas and also the preparation of a synthesis report.

Achievements

- As per the information collected from secondary sources, the forest types within the Namdapha National Park can be categorized as: 1. sub-tropical evergreen forests, 2. temperate broad-leaved forests, 3. abandoned jhum forests, 4. tropical moist deciduous forests, 5. tropical evergreen forests, 6. tropical semi evergreen forests, 7. degraded forests, 8. bamboo forests, 9. temperate coniferous forests, 10. hollong forests, 11. hollock forests, 12. riverbank side forests, 13. pine forests, 14. fir forests, 15. alpine grasslands, 16. subalpine forests and rhododendron, 17. alpine/subalpine scrub. The lowland tropical evergreen forests of Namdapha are perhaps the largest remaining Dipterocarpus forests in the whole of India.
- Compilation and analysis of information on faunal diversity of Namdapha National Park shows representation of 1278 species belonging to 47 orders, 196 families and 588 genera. This includes, Insects (427 species of 8 orders, 61 families and 261 genera); Mollusca (13 species of 7 families and 11 genera); Pisces (95 species of 8 orders and 22 families); Amphibia (22 species of 3 families and 5 genera); Reptilia (44 species of 2 orders, 10 families and 27 genera); Birds (490 species of 17 orders, 52 families and 217 genera) and Mammals (187 species of 10 orders, 34 families and 102 genera).
- The Park represents 187 species of Mammals belonging to 10 orders, 34 families and 102 genera; 490 species of birds belonging to 17 orders, 52 families and 217 genera; 13 species of Molluscs belonging to 7 families and 11 genera; 95 species of Fish distributed in 8 orders and 22 families; 22 species of Ambphibia belonging to 3 families and 5 genera; and 44 species of Reptiles belonging to 2 orders, 10 families and 27 genera. Class insecta in Namdapha NP is represented by 426 species of 8 orders, 61 families and 261 genera.
- Assessment for IUCN threat status of 490 avifauna species reported reveals 3 species (i.e. Ardea insignis , Gyps tenuirostris, Gyps indicus) as Critically Endangered (CR); 1 species (Cairina scutulata) as Endangered (EN); 7 species (Arbrphilla rufogularis; Sitta Formosa; Tragopon blythii; Pellornum palustre; Stachyris oglei; Aceros nipalensis) as Vulnerable (VU); and 12 species (Icthyophaga humilis; Aegypius monachus; Circus macrourus, Alcedo Hercules, Herpectus wardi, indicator xantonotus, Brachypteryx leucophrys, Prinia brunsii, spelaeornis chocolatinus, Garrulax nuchalis, Buceros bicornis and Annorhinus tickelli) as Near Threatened (NT). Threat status of under different IUCN category of total reported birds of Namdapha NP is given in Fig.58. Out of the total, 21 species of birds were reported to be having declining population.
- Namdapha National Park, falls within the Eastern Himalayas EBA 130. The key habitats of the Eastern Himalayas are Sub-tropical Hill Forests, Temperate Forests and Sub-Alpine Forests. They harbour 21 Restricted Range species out of which 18 species are found in Arunachal Pradesh. The Restricted Range species of the Park are Red-breasted Hill Partridges (Arborophila mandellii), Blyth's Tragopan (*Trapogon blythii*), Beautiful Sibia (Heterophasia pulchella), Grey Sibia (*H. Gracilis*) White-naped Yuhina (*Yuhina bakeri*), Brown-throated Tit-Babbler (*Alcippe ludlowi*), Striped Laughingthrush (*Garrulax virgatus*), Black-browed Leaf-Warbler (*Phylloscopus cantator*), Broad-billed Flycatcher-warbler (*Tickellia hodgsoni*), Wedge-billed Wren-Babbler (*Sphenocichla humei*), Austen's Babbler (*Stachyris oglei*), Black-breasted Parrotbill (*Paradoxornis flavirostris*) and Marsh Babbler (*Pellorneum palustre*). Thus, the Park is one of the National Parks in the northeast blessed with the largest number of Restricted Range species.

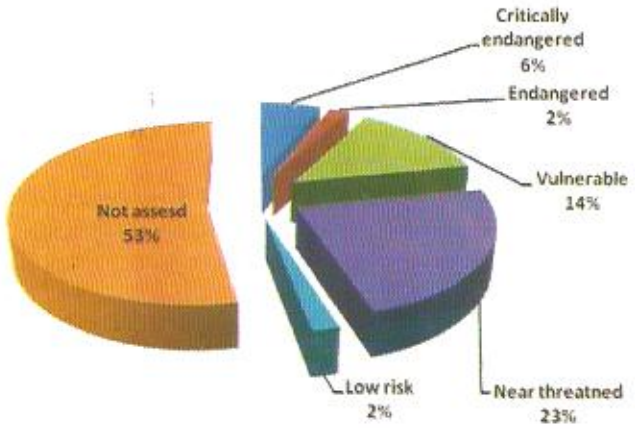


Fig. 58. Threat category of different birds showing IUCN status.

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 vide this project to conserve the rich biodiversity of the state, through community participation and by adopting an integrated approach considering 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 initiatives 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 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

- Efforts have been made during the reporting year to make the twenty two (22) Biodiversity Management Committees (BMCs) constituted across the project sites for conserving and sustainably managing the bioresources in the project villages, robust and functional, even after exit of the project by bringing them under Arunachal Pradesh Biodiversity Board. The APBB has consented to adopt these existing BMCs. The BMCs of a number of villages have also succeeded in creating a corpus fund for their efficient functioning through collection of agreed upon fees from members of the BMCs, who have benefited from other activities of the project. For example, the members who received LPG connections and piglets have donated Rs. 500 and Rs. 200, respectively, to the BMC.
- In order to promote biodiversity conservation, three more Community Conserved Areas (CCAs) namely 'Siikhe-Bo' CCA (20 ha) in Ziro plateau, 'Ritosa Ree-Mainarang Ree' CCA (100 ha) and 'Hugore Sewaphu' CCA (50 ha) in Tawang and West Kameng (proposed) BR (TWKBR) in Arunachal Pradesh were declared during the reporting year. The CCAs created under the project would promote conservation of ecologically and socially valued wild flora and fauna 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. In the state, the protected areas (PAs) form about 18% of the total forest area excluding the reserved forests (19%). For example, 'Siikhe-Bo' CCA would conserve the forest and thereby help in recharging of the Siikhe stream, which is drying-up probably as its upstream tree-cover is disappearing. The CCA would also promote conservation of biodiversity, particularly Schizotorax, a fish species locally known as Ngilyang-Nyige, which is culturally valuable and whose population has been gradually declining in the Siikhe stream, probably because of two basic reasons 1). drying up of the stream and 2). its over exploitation. Further, Ex-situ conservation has been ensured through plantation of 6000 saplings of Taxus wallichiana in 20 ha of lands in Apatani plateau.
- In an effort to meet the high fuelwood demand and reduce pressure on forests, LPG sets as an alternative energy were outreached to households in project villages, particularly those from the BPL group which are predominantly dependent on forests for fuelwood, with a pre-condition that they

would stop illegal felling of trees for fuelwood and bring more area under the forest. During the reporting year, 135 LPG Sets (Sets including single gas cylinder, oven, regulator, lighter, Apron) were distributed among 135 households in 19 project villages. The impact of the LPG connections is, visibly reduced fuelwood consumption by households with LPG compared to non-LPG households, as it was surveyed that a household with LPG set consumed an average of 9.50kg/day fuel wood lesser than that of the households without LPG sets in the project villages (Fig.59).

- Telecasting in local TV channels regarding biodiversity conservation and its value to future survival of mankind has been carried out throughout the year (19th to 25th April; 5th to 11th June; 18th to 24th June; 30th to 6th June; 8th to 30th Oct and 11th to 31st Dec, 2010). It has had a tremendous conservation awareness impact on local people.
- In order to promote Income Generation Activities (IGAs), 1 lakh fish seedlings were distributed among 120 households in Apatani plateau. The economic impact of the activity has been documented and analysed. The total project cost including cost for fish seedlings, transport and others labour was around Rs. 50,000.00 only and the gross return was about ` 4,41,150.00 with a net benefit of ` 3,91,150.00. Also, 72 more piglets were distributed among 72 households in 8 project villages in Apatani plateau and 3 project villages in TWKBR.
- Towards capacity building, 89 farmers were trained on nursery techniques, 80 villagers on basics of Community Based Tourism (CBT), 40 farmers on 17 simple low cost farming and soil and water conserving technologies, and 8 villagers on bamboo based handicrafts.
- The project has been awarded SCHOLL Research Challenge Award 2010 for high caliber action research in development and governance that has had or have potential for demonstrated impact on policy or society at in the category 'Sustainable Development and Preservation of the Ecosystem' by National Foundation for India and North East Development Foundation being sponsored by IDRC, Canada.

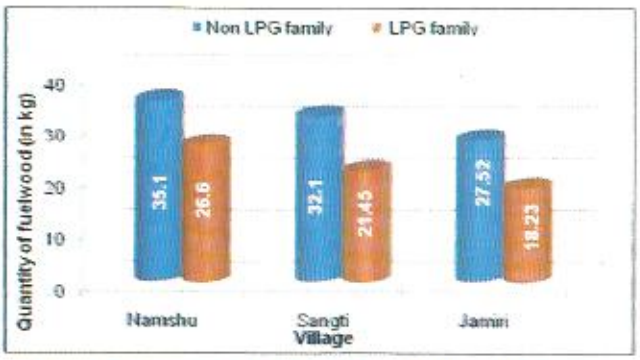


Fig. 59. Average fuel wood consumption in a day/ household in the project villages.

Cultural Landscape: The Basis for Linking Biodiversity Conservation with Sustainable Development of Arunachal Pradesh, India ***(2008-2011, 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 and 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 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.

Objectives

- 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 detailed 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 concerned with.
- Issues related to competition vs co-existence 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.
- The role of institutional arrangements for effective management of natural resources with emphasis upon the traditional institutional arrangements.

Achievements

- Community driven conservation practices of floral and faunal diversity have been documented during the reporting year. For example, in Zimithang region of the study area, the whole mountain of the Shockeng Gompa is considered sacred prohibiting use of any plant species, including Rhododendron species, which is used as NTFP elsewhere. *Daphne papyracea* is another plant species, which is traditionally used by Monpas for making hand paper for printing and writing scripts of monasteries. Further, many plant species are conserved valuing their cultural and religious importance like Juniper sp., which is considered highly religious and is used for incense by both Monpa and Sherdukpens.
- Many of the faunal species are also conserved by community driven conservation practices like totems and taboos. For example, many animal parts like bones of snake, tiger, etc. are used during rituals but they are only collected from the dead animals. It has been believed by Monpas and Sherdukpens that the killing of a tiger is very inauspicious and if someone kills one he will have to perform a ritual for forgiveness of his sin. On the day of celebration of a public rite, nobody undertakes hunting, fishing and cultivation to avoid injuring or killing of any living being on ceremonial days. Hunting is taboo for the family members during the pregnancy period. Consumption of meat is prohibited for a year in the occurrence of death in the family.
- The Buddhist Monpas basically hunt less; however, with increase in population and developmental activities, their traditional values have diluted. Further, over-population of the wild and domestic animals often results in man-animal conflict. Conservation conflict of the faunal species with the Monpas were identified and documented (Table-19).
- Major conflicts identified are crop raiding and retaliatory killing of carnivores for live stock depredation. About 40 species of mammals belonging to 8 orders, 18 familas and 34 genera in the study area have been recorded. About 13 animal species have been recorded, which are in direct conflict with human population. Asiatic Black Bear (Ursus thibetanus) was reported for having its unique distinction in the ability to raid crops and depredate livestock. Conflict intensity as per the local perception was recorded high for 5 species (38%) while 4 species (31%) show moderate intensity of conflict with man and therefore need proper attention before they become a threat. Another 4 species (31%) showed low intensity of conflict with man. Dhole (Cuon alpinus) has the highest conflict intensity (76.7%) of all the cases while Snow leopard (Unicia unicia) is having moderate level of intensity (21%) and Asiatic Black bear the lowest intensity (0.3%).
- It was also recorded that mountain ungulates are one of the major sources of protein for the people of the region. About 64 species of birds are recorded, which are being hunted by Brokpas (a pastoralist sect of Monpas).

Table-19. Conservation conflict of the faunal species with the Monpas.

Species	Scientific name	Conservation conflicts
Assamese macaque	*Macaca assamensis*	Crop raider
Capped langur	*Trachypithecus pileatus*	Fur is used to wrap cover of Dao (sword)
Arunachal Macaque	*Macaca munzala*	Crop raider
Himalayan musk deer	*Moschus chrysogaster*	Hunted intensively for its gland
Barking deer	*Muntiacus muntjak*	Hunted for trophy
Blue sheep	*Pseudois nayaur*	
Serow	*Naemorhedus sumatraensis*	Skin used for traditional storage apparatus
Himalayan Goral	*Naemorhedus goral*	Very rare Hunted for meat
Chinese Goral	*Naemorhedus caudatus*	Very Rare Hunted for meat
Takin	*Budorcas taxicolor*	Hunted for the meat and trophy
Wild boar	*Sus scrofa*	Crop-raider; retaliatory hunting. Hunted for meat.
Asiatic black bear	*Ursus thibetanus*	Crop-raider
Dhole	*Cuon alpinus*	Predates on various livestock - retaliatory hunting
Tiger	*Panthera tigris*	Very rare - traditionally not hunted
Leopard	*Panthera pardus*	Rare, Predates upon the livestock
Himalayan crestless porcupine	*Hystrix brachura*	Rare Hunted for meet consumption
Orange bellied Himalayan squirrel	*Dremomys lokriah*	Common,- Hunted for meet consumption

Summary of Completed Project / Activity

Institutionalizing Technology Backstopping and Capacity Enhancement for Sustainable Agricultural Development and Encouraging Entrepreneurship Development Based on Simple Rural Technologies within the Tribal Areas of North East India (2006-2010, DST, New Delhi)

In North East India, where most of the farmers are subsistence farmers, technologies in agricultural development that are based on high external inputs, become inappropriate and inaccessible. Technologies, therefore, need to be adapted to local conditions and based on the principles of Low External Input for Sustainable Agriculture (LEISA). Keeping the above scenario in view, the present project was implemented during 2006-2010 with financial support from SEED Division, Department of Science and Technology, Government of India, New Delhi. The project, primarily aimed at institutionalizing a process mechanism for technology backstopping and capacity building of rural upland farmers in simple, low-cost, appropriate technologies through a network of credible NGOs and also encourage entrepreneurship development.

The project succeeded in up-scaling of technology backstopping (technology development/modification, demonstration/dissemination, adoption/adaption and capacity building/enhancement) across five North Eastern states with the help of seven partner NGOs (PNGOs) covering eight districts, twelve development blocks, forty-nine villages and more than eleven tribal communities (Fig.60). In the process, capacity enhancement of more than 3670 tribal farmers (Table-20) has been done though hands-on-training on more than 17 low-cost and simple technologies. The project has a significant impact with more than 1500 households adopting to one or the other technology such as trellises, legume intercropping, bio-composting, vermi-composting and bio-briquetting, etc. As many as 69 SHGs, 3 Farmers Club and 1 Marketing Committee are formed by the PNGOs and number of entrepreneurships have developed across the NE India. The practical, policy and programme impact of the project in addressing the technology development and governance in the NE India could be gauged from the level of replication of the technologies that are developed/modified under this project in important programmes like IFAD-MRDS, Meghalaya; Watershed Development Programme of Govt. of Arunachal Pradesh and activities of NABARD in Mizoram; Recommendation of the technologies for rehabilitation of jhum lands by the Inter-Ministerial National Task Force of Ministry of Environment and Forests, Government of India on rehabilitation of shifting cultivation areas; Adoption of a model developed under the case study for rehabilitation of jhum land areas through integrated agro-horti-silviculture cultivation under State Compensatory Afforestation Management and Planning Authority (CAMPA) of Govt. of Arunachal Pradesh. The project is an excellent piece of success story of collaboration between GOs and NGOs and a multi-disciplinary approach in addressing technology development and governance in NE India. Because of its high level performance, the project was awarded "SCHOLL Research Challenge 2010" by National Foundation for India and North East Development Foundation, sponsored by IDRC citing that the project captured knowledge on technologies that have potential for the rural India's socio-economic ecosystem.

Table-20. Number of farmers trained in the case study during 2006-07 to 2009-10.

Sl. No.	Name of PNGOs	Peoples participation/coverage			No. of farmers trained		
		Districts	Villages covered	Communities covered	2006-07	2007-08	2008-09
1.	IIRM, Assam	Sonitpur	10	Boro	-	323	120
2.	CEP, Mizoram	Aizawl, Kolasib	5	Mizo	250	916	115
3.	SSRD, Manipur	Ukhrul	5	Tangkhuls	35	47	167
4.	NIDA, Manipur	Senapati	6	Mao Naga/ Liangmei Naga	155	323	120
5.	St. VWS, Tripura	Dhalai	10	Garos, Reangs, Debbarmas, Darlongs (Kukis)	20	79	270
6.	NAM-RHEN, Meghalaya	Jaintia Hills	8	Jaintias	103	266	113
7.	NCHHCO, NC Hills, Assam	NC Hills	5	Hmar, Biete	189	-	65
Total		8 Districts	49	11 Communities	752	1954	970

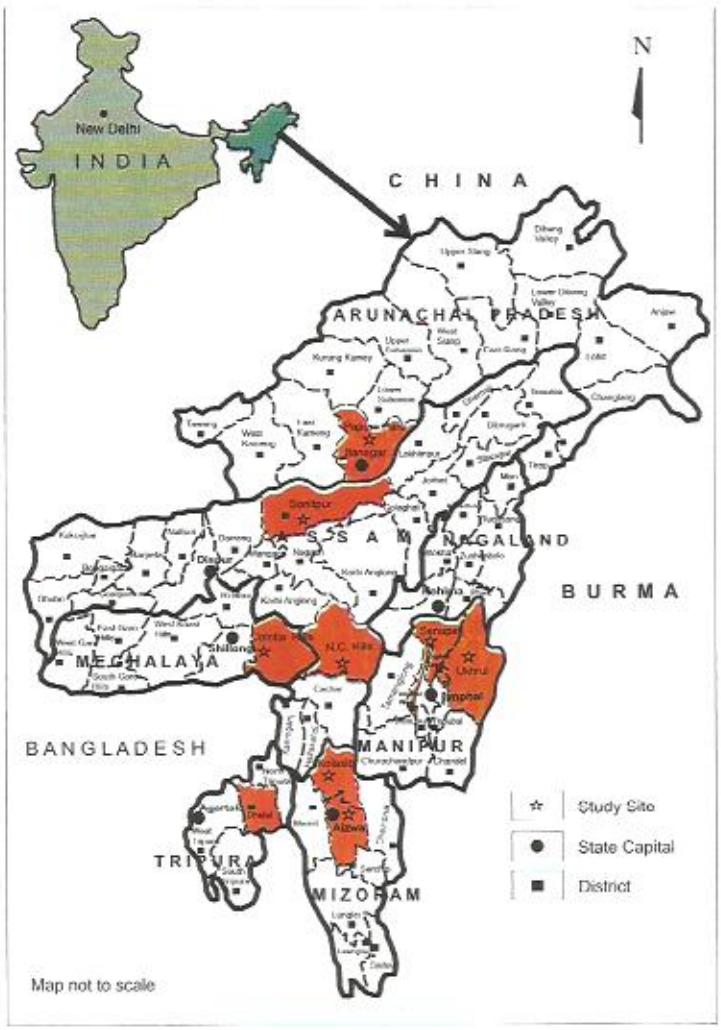


Fig. 60. Map of the project sites across NE India.

Theme

BIOTECHNOLOGICAL APPLICATIONS (BTA)

The broad activities of the theme are based on identification, documentation and applications of the bioresources of Indian Himalayan Region (IHR). Studies comprise mainly on three major groups of bioresources, viz. plants, animals and micro-organisms. The plants are the primary producers; therefore, a thorough understanding of the factors that govern their productivity and functioning is of paramount importance especially in the light of severe climatic conditions prevailing in the Himalaya, and current concern about the global climatic change. An understanding of the mechanism of plant adaptation to stress, be it of physiological, biochemical or molecular aspects, is extremely relevant for increasing productivity of the plants. Plant propagation packages, addressing the need of local people, have been developed using conventional and biotechnological tools; phytochemical and molecular profiling of medicinal and aromatic plants is also being carried out.

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 micro-organisms has been carried out which has led to the formulation of carrier based bio-inoculants for mountains. The micro-organisms that thrive under extreme environments, from polar deserts to geo-thermal 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 of the IHR, ii) generate technological know-how of the process development, and iii) build capacity of the human resources. The theme envisages to: i) identify and document bioresources of applied value of the IHR, ii) generate technological know-how of the process development, and iii) build capacity of the human resources.

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. 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 emphasis on: (1) rhizosphere microbial communities, and, (2) extremophiles. In addition, a research activity has been initiated on a microbiology based activity for NE region.

Objectives

- Assessment of diversity of micro-organisms growing in extreme conditions (thermophiles and psychrophiles) of Indian Himalayan Region.

- Determination of potential applications of selected micro-organisms 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

- Psychrotolerant fungi viz. Paecilomyces hepiali, *P. liliacinus, P. variotti* have been tested for production of diffusible and volatile antimicrobials against phytopathogenic fungi in dual plate assays. Qualitative experiments on production of lytic enzymes have been completed. Detailed experiments on chitinases are in progress.
- The enumeration of microbial communities with particular reference to water quality of river *Jataganga* (District Almora, Uttarakhand), as influenced by the anthropogenic activities and seasonal changes has been completed. Water samples, collected from five different sites, experiencing different anthropogenic pressures, have been analysed for total viable counts and the biological indicators, in four seasons, at two temperatures. Isolation of micro-organisms was conducted following standard procedures- Most Probable Number, and Standard Plate Count. The phenotypic and genotypic characterization of pure cultures is under progress. The isolates are being classified as coliforms, non coliforms, biological indicators, and soil micro-organisms.
- Selected cultures of bacteria, actinomycetes and fungi have been accessioned by MTCC, IMTECH, Chandigarh; ITCC, IARI, New Delhi and Agarkar Institute, Pune. The gene sequences of the important isolates have been accessioned by NCBI.
- The influence of fire event on soil microflora at agricultural sites under shifting cultivation in northeast India is being investigated. While the enumeration, identification and characterization of bacterial isolates has been completed, the experiments on actinomycetes are in progress.

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

Reduction in the forest cover from the Indian Himalayan Region (IHR), 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 IHR is a home to a large number of economically and ecologically important plants, large scale plantations need to be taken up to cope with such challenges, and thus 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 have 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

- Tissue cultures of *Olea ferruginea* were attempted using different explants, e.g. apical shoots, nodal explants and leaf segments from mature trees. High shoot induction was observed only from the nodal explants. MS medium containing half strength salts, BAP or kinetin alone or in combination with NAA was found suitable for shoot proliferation.
- Maximum shoot induction was recorded in half strength MS medium containing BAP (0.44-8.88µM) and NAA (0.46 µM). In two cytokinins, BAP was found to be better compared to kinetin (Table-21).
- Of the three multiplication techniques tried for mass propagation of *O. ferruginea*, mechanically

scarified seeds germinated at 25-30°C within 25 days and then their transfer to nursery was found to be the best.

- Mass scale propagation for conservation of endangered *Rhododendron maddeni* and *R. dalhousiae* using existing protocols are continuing. Large number of plants have been successfully produced and transferred to the field (Fig.61a-c); >500 tissue culture raised *R. maddeni* are currently being maintained at nethouse and ready for field plantation.
- A micropropagation method was developed for *R.griffithianum* from the cotyledonary nodal segments of 7-week-old seedlings. Multiple shoots were initiated on modified Anderson (AM) medium containing a growth regulator along with some antioxidants (Fig.62a).
- The effect of 2ip, BAP and/or GA3 (5, 15, 25, 35, 45 µM) on multiple shoot formation was examined; 25 µM 2iP showed better result with maximum number of multiple shoots (Fig.62b). Some of the shoots also formed prolific callus at the base and when these were sub-cultured they produced shoots showing direct organo-genesis.
- Field surveys were conducted in adjoining areas of the forest for collection of explants of all available *Quercus* spp. Over 300 plants of *Q. lamellosa* saplings raised from seeds are currently being maintained under nursery conditions and are ready for field plantation.
- Plant regeneration in *Q. lamellosa* is in progress. Leaf explants of different maturity were inoculated onto Woody Plant (WP) basal medium supplemented with various combinations of thidiazuron; callus induction was achieved in some cases. Efforts to standardize the method are in progress.
- Stem cuttings (15-20 cm) of *Z. armatum* were treated with various chemicals (NAA, IBA, Coumarin & Bavistin) and planted in polybags and/or soil under polyhouse conditions to induce root formation; roots were observed in cuttings treated with IBA. Air layering was found to be a suitable method for propagation of this species and a seasonal influence was observed; this technique is being used for multiplication.
- Seeds were scarified and treated with different concentrations of sulphuric acid (2-20 min); 50% sulphuric acid (15 min, washing and sowing in soil) resulted in about 85% germination (compared to 0% in control) after 140 days (Fig.63a).
- Nodal explants taken from branches of *Z. armatum* trees were used to develop in vitro cultures. The sprouted shoots were multiplied on MS medium supplemented with auxins and cytokinins; following shoot proliferation and further multiplication, different treatments were provided to induce root formation in these shoots.
- Multiple shoots of *A. subulatum* were cultured on the MS medium containing 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 (Fig.63b-f).

Table-21. Effect of different concentrations of cytokinins (BAP or kinetin) on in vitro shoot elongation in Olea ferruginea.

Treatment	Concentration (µM)	Shoot length (cm)
BAP		
1.	0.44	2.10
2.	2.22	2.60
3.	4.44	3.98
4.	8.88	4.30
Kinetin		
1.	0.46	1.30
2.	2.32	1.10
3.	4.64	1.60
4.	9.28	1.80

Fig. 61. Micropropagation of *R. maddeni*. (a) Multiple shoots on AM + 2ip (35 µM) + antioxidants after 45 days; (b) Root development on AM + IBA (1 µM); (c) In vitro raised plantlets grown under ex-vitro environment in plastic pots.

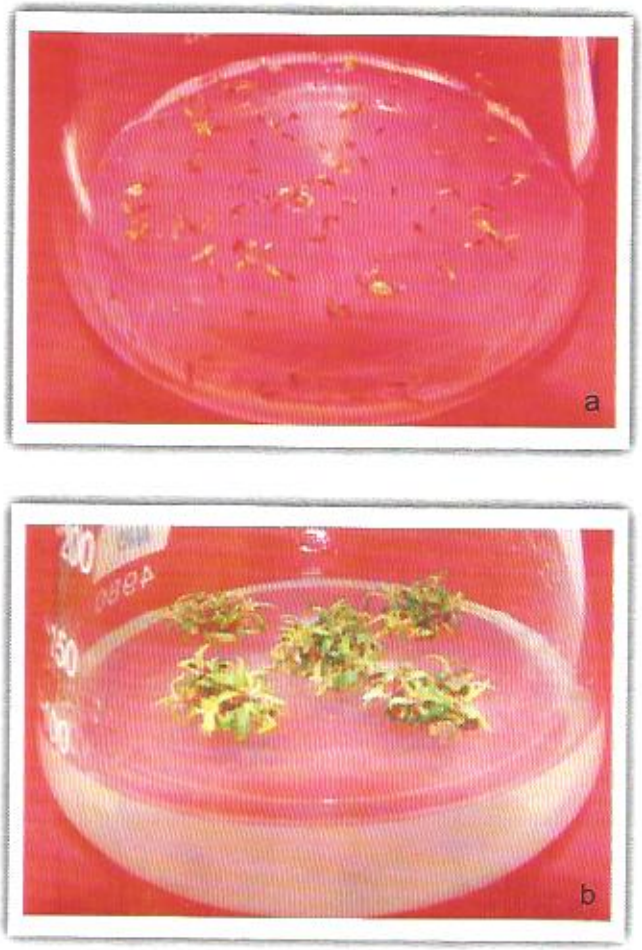


Fig. 62. In vitro regeneration of *Rhododendron griffithianum*: (a) Seed germination after 15 d on the AM medium; (b) Multiple shoot induction on AM +2ip (25 µM) + antioxidant.

Fig. 63. Propagation of *Z. armatum* and *A. subulatum*. (a) Seed germination in *Z. armatum* following acid treatment, (b-f) Vatious stages during in vitro propagation of *A. subulatum*.

Molecular Characterization of Selected Medicinal Plants of Himalayan Region *(2009-2012, In-house)*

Himalayan region is a rich reservoir or 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 Indian Himalayan Region. Most of the plant parts derived medicines are obtained from simple part of plants, in crude extract or mixture form. Some of the well known medicinal plants of Himalayan region include *Aconitum heterophyllum, A. balfaurri, Podophyllum hexandrum, Picrorhiza kurrooa, Valleriana wallichi, Taxus baccata, Pinus roxburghii, P. gerardiana, Zanthoxyllum armatum, Swertia angustifolia, Angelica glauca, Heracleum candicans, Ginkgo biloba* etc. Biologically active compounds and secondary metabolites have been identified and purified from these plants. In order to identify genetically high yielders in terms of selected active components (anticancer drug podophyllotoxin; gingolides used in memory loss; and antimalarial drug artemisinin) some high value medicinal plants have been selected.

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

Target species: *Podophyllum* species (P. *peltatum, P. hexandrum, P. sikkimensis*), *Ginkgo biloba* & *Artemisia annua*

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.
- 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 used to develop

molecular profiles; specific profile was observed with Operon primers.

- In P. hexandrum, plants collected from Kullu area, showed higher podophyllotoxin (1.5%) content whereas in P. sikkimensis only 0.336% podophyllotoxin was detected.
- In order to determine the specific gingkolides present in male and female trees, studies were undertaken in G. biloba (>25 years old trees) collected from the Kumaun region; survey showed the occurrence of only one male (in Snow View, Nainital) and six females, and their identity confirmed using sex specific primers. Cloning and sequencing are in progress.
- Poly cross matting in A. annua was carried out for gene pool exploitation; 220 plants were planted in polycross Random Block Design (50 x 20 cm row to row distance). A wide variation in artemisinin content (0.01-0.5%) was observed following HPTLC analysis.

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

Mic-roorganisms 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

- Phosphate solubilization efficiency of ten species of psychrotolerant fungi with particular reference to temperature has been evaluated. *Aspergillus niger* and *A. glaucus* solubilized maximum tri calcium phosphate and produced maximum biomass at 21°C. The other eight cultures among the ten showed maximum phosphate solubilization at sub-optimal temperature. Out of these, six species *(A. candidus, A. deflectus, A. flavus, A. fumigatus. A. parasiticus, and A. wentii)* solubilized maximum TCP at 28 °C. However, the optimum temperature for biomass production for these cultures was recorded at 21 °C. Similarly, two species *(A. nidulans and A. sydowii)* showed maximum phosphate solubilization and biomass production at 14 and 21 °C, respectively. This indicates that the optimal temperature for phosphate solubilization may generally be sub-optimal for biomass production.
- Cold tolerant phosphate solubilizing species of Aspergillus, Penicillium and Paecilomyces, isolated from the high altitude soil of Indian Himalaya were considered for detailed investigations on phosphate solubilization efficiency at different temperatures. These species exhibited tolerance to a wide range of pH and temperatures. Species of Aspergillus were found to be the best solubilizers, followed by Penicillium and Paecilomyces, respectively. The phosphate solubilization related parameters (reduction in pH, production of biomass, and phosphatase activity) were found to be temperature dependent.
- Plate based assays have been conducted for screening of cold tolerant fungi with a view of their biodegradation potential. Many species showed positive results for laccase 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 environment. 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 molecular diversity of laccase gene in the positive isolates.

Achievements

- Screening of fungal isolates for their lignolytic activity has been carried out. Phenotypic and genotypic characterization of positive isolates is under progress. Most fungal isolates showed their growth between 4 to 35 0C, and were hence considered psychrotrophs. Qualitative screening of the isolates for laccase activity has also been performed and efficient isolates have been selected for quantitative estimations.

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

Rhododendrons well known for their splendiferous flowers, are amongst the dominant species along the temperate, subalpine and alpine zones in the Sikkim Himalaya. *Rhododendron* L. possesses aesthetic, sacred, medicinal & aromatic, and fuel wood values. The genus is represented by about 85 species in India, and mainly distributed in the Himalayan region (one species, *R. nilagiricum* in South India). Out of this, a total of 36 species with 45 different forms, including subspecies and varieties, occur in Sikkim alone. A total of fourteen rhododendron species from the Sikkim Himalaya have been listed as critically endangered (CR) or vulnerable (V). The rise in human population with demand on land for farming, increased animal husbandry practices, construction of roadways, hydel power projects and allied works, and of late the tourist influx have collectively resulted in building up of considerable pressure on the very survival of *Rhododendron* species. The Sikkim Himalaya is still dependent, to a large extent, on natural fuel supply and in the countryside it is almost obligatory rather than an option. Towards the fuel needs of the common people, rhododendrons are always a prime target on account of the easy burning qualities of wood, and are therefore, exploited at a large scale wherever they grow in the Sikkim Himalaya.

Under the circumstances, an effort for the conservation of rhododendrons has been taken up to save the existing rhododendron germ pool of this keystone genus of the Himalayan region. Maintaining viable populations of rhododendron species is a crucial factor in conservation efforts, and this calls for adopting appropriate conservation approaches, including ex-situ and in-situ methods

Objectives

- Collection of seeds, shoots and twigs for proliferation.
- In vitro germplasm conservation for a few selected rare and endangered rhododendron species.
- Use of both conventional and in-vitro methods for propagation of selected species.
- To develop efficient micro-propagation protocol for mass propagation of a selected number of rare and endangered species.
- Test trials of seedlings, raised through tissue culture, in arboretum and field conditions.

Achievements

- Conventional methods of propagation using seeds were investigated in R. niveum using rhizospheric soil and garden soil (1:1, v/v).
- In order to develop in vitro cultures nodal explants were cultured on AM media using different concentrations of 2 iP, BA and GA3. Maximum number of multiple shoots (per explant) was obtained on media supplemented with 24.6 µM 2 iP.
- In a separate experiment IAA was used in different concentrations (0.57, 0.71, 2.85, 5.7, 17.1, 28.5 µM) in combination with 2 iP (24.6 µM). Better response was found using 2.85 and 5.70 µM IAA (Fig. 64a & b).

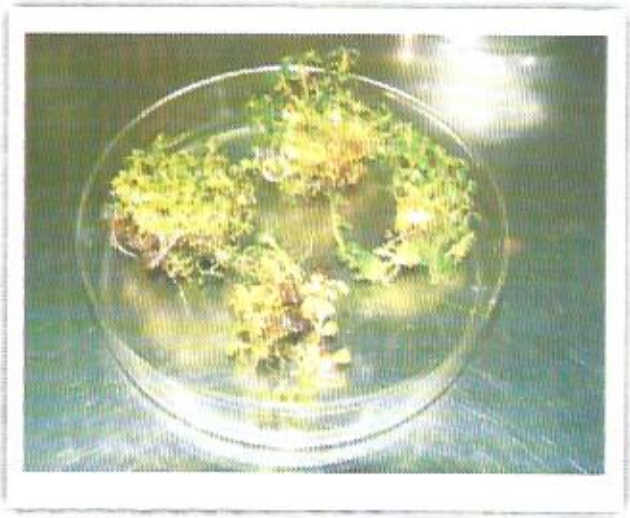


Fig. 64. The cultures of *R. niveum* on AM media supplemented with (a) 2 iP + IAA (24.6 +2.85 µM) and (b) 2 iP + IAA (24.6 +5.70 µM).

- In another experiment use of 2 iP + IAA (24.6 + 2.85 µM) showed excellent multiple shoot formation with more number of leaves. Incorporation of 2.85 µM IAA in the medium during the first subculture after establishment and initiation of shoot buds significantly improved the shoot elongation. Regular subculturing at every 4 weeks increased the rate of multiplication which showed maximum values after 3-4 subculture cycles.

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 at 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 CO2 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

- In order to understand the physiology of the species, initial studies were carried out on the photosynthetic performance and water relations. The parameters examined were net photosynthesis rate, stomatal conductance, intercellular CO_2 concentration, transpiration, water potential, relative water content, and chlorophyll content.
- After preliminary study it was observed that the net photosynthetic rates, stomatal conductivity and transpiration were high in *Q. leucotrichophora* and *Q. semecarpifolia* and least in *Q. glauca*. The water potential was high in *Q. leucotrichophora* and *Q. glauca* but low in *Q. semecarpifolia*. Further studies are in progress.

Summary of Completed Project/Activity

Field Evaluation of Microbial Inoculants Developed for Use in Mountains
(2007-2010, UCOST, Dehradun)

The major objective of this project was to bring awareness on the use of microbial fertilizers for agricultural and forest species, grown in mountains. On-farm demonstrations, with a view of bringing awareness about this microbe-based technology, have been conducted, in participation with local farmers.

The villagers have shown positive attitude to adapt this inexpensive and eco-friendly microbe based technology. The technology can be integrated with the traditional use of organic inputs and water management. The microbial inoculants along with the local farmyard manure may work as microbial fertilizers that will help in enhancing the overall plant productivity. There is need for the establishment of production unit(s) for large scale production of microbial inoculants in the form of cottage industry. This concept requires attention at policy level, specifically in mountain states, such as Uttarakhand.

The success of this project can be attributed to the fact that (1) the micro-organisms used as inoculants originally were isolated from temperate or alpine locations of high altitudes, (2) large scale screenings for desirable traits (mainly nitrogen fixation, phosphate solubilization, disease control and tolerance to low temperature), and (3) their ability to influence a 'microbial shift' in the native microflora, mainly in the form of stimulation of beneficial microbes and suppression of disease causing microbes

Summary of Completed Project/Activity

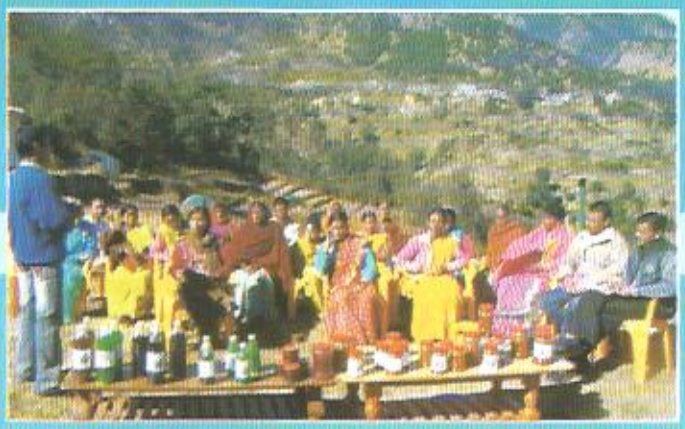
Capacity Development and Economic Upliftment of Rural Women through Pond Based Integrated Farming System Approach (2007-2010, DST, New Delhi)

Diversification of cereal crops to high value crops like fruits, vegetables, mushroom etc. along with poultry, fish and milk products has been identified the best option to increase productivity of farming system; it also provides substantial economic benefits to small hold farmers. Based on the leads from a previous project on integrated fish farming in hills, a study was proposed to incorporate several other components such as, composite carp culture, poultry/duckery, livestock, off season vegetables and mushroom cultivation, green fodder production and vermi-composting to develop model (s) for high economic returns in resource poor farmer's fields.

The main objectives of this project were optimum utilization of water, under used land resources and farm waste through integration of fishery with various compatible and complementary farming system components and to provide employment, income generation opportunities and nutritional security to rural folk, motivation and capacity building of farmers through training and demonstration programmes.

Three models of Integrated Farming System (at Sunola, Patherkote village and RTC, Kosi) comprising various complimentary components such as composite carp culture, poultry, vegetable, mushroom, fodder production and vermicomposting were evaluated (Fig.65). Fingerlings of exotic carps (3000/ha) and chick birds, Kuroiler (3000/ha) were stocked at each site. Substantial survival rate of fingerlings, chick birds and their subsequent growth was recorded. Fingerlings attained an average weight of 280-475 gm, while chick birds grew to 1.5-2.75 kg within rearing period of 8 months. Female birds attained sexual maturity in 24-26 weeks and produced more than 150 eggs in an 18 month cycle. More than one ton of different vegetables were produced annually at each site. Altogether, 26 species of extra-aquatic fungi and 19 species of water molds, including virulent pathogens of plants and fish were isolated from pond water. Six species of water molds were also detected from diseased fishes. Saprolegnia parasitica parasitized all three species, while S. diclina, Achlya debaryana and Aphanomyces laevis parasitized two fish species. These pathogens also appeared virulent under laboratory conditions. In all, capacity of 1297 persons including 468 women was strengthened to the IFS, through lectures, audio-visual and field visits. The technology has opened new horizons of increasing productivity of farming system with low cost inputs, through increased efficiency of resource utilization and diversification of farm produces.

Fig. 65. Integrated fish farming model at Rural Technology Complex, Kosi, Almora.



Theme

KNOWLEDGE PRODUCTS AND CAPACITY BUILDING (KCB)

The Himalayan mountain communities have acquired immense knowledge of their natural environment. Yet this accumulated knowledge is rapidly disappearing as the traditional communities are steadily becoming more culturally and biologically uniform. With greater realization of the value of this knowledge base, it is considered that the knowledge needs to be an integral part of a holistic and cost-effective approach to sustainable development. The knowledge accumulated, documented, produced/developed over a period of time in any field for human well being and natural resource management, is required to be transmitted or exchanged through capacity building efforts to empower all the stakeholders at different levels. The traditional ecological knowledge and wisdom of the indigenous people has become a major focus of attention within the past decades. It is considered to have fundamental importance in management of local resources in the husbanding of the world' biodiversity and in providing locally valid models for sustainable living. It is now widely recognized that along with the conventional science and technology, the traditional knowledge products of critical importance for over all development of the Himalayan region. Knowledge base of the different traditional societies and knowledge products developed through science and technology interventions, if succesfully adopted/implemented through capacity building programmes would certainly help ecologically sound, economically viable, socially acceptable and institutionally enforceable outputs. The objectives of the theme are: (a) undertake in-depth studies on documentation and validation of knowledge (traditional/indigenous/rural) system of traditional communities including cultural, biological, material, spatial, landscape as well as intellectual components and their on-going interactions as the basis for protecting, safeguarding and improving the knowledge base, (b) utilise natural resources for income generation using local knowledge and capacity building through S & T interventions, (c) translate existing knowledge related to bio-and natural resources into products, (d) enhance capacities and skill of rural and marginal societies in harnessing the potential of knowledge systems for socio-economic development, and e) provide opportunity for stakeholders to interact with each other and with institutions working on knowledge product systems together to address research, action, and policy needs and help to develop appropriate knowledge sharing and dissemination to the user community at large.

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

Tourism has been the strongest and fastest growing industry worldwide and tourism can be an important constituent of the country's economy. Development of tourism in India is a recent phenomenon compared to some other countries. In the past three decades Indian tourism has developed considerably and made rapid strides in bringing good chunks of profits to the country. Now tourism has established itself as a prime component in the Indian economy. Uttarakhand's, rich religious tourism tradition and adventure tourism potential is enjoying worldwide reputation as an international tourism hotspot. Tourism industry is felt to have ecological impacts on the hill/mountain environment as the rising numbers of tourists present both threats and opportunities. This industry is confronted with arguments about its compatibility with

environmental management and local community development. Therefore, there is an urgent and immediate need to create and increase awareness, advocate and impart necessary training for capacity building of various stakeholders to enable them to handle tourism in an environmentally responsible manner and develop tourism in areas making environment an integrated part of it.

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 a few potential sites.
- To create awareness, develop capacities and empower all the stakeholders at different levels in eco-tourism chain so that it results in a clean, green environment.
- To empower local communities to manage eco-tourism while linking it with local production systems, 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 plans for sustainable tourism/eco-tourism.

Achievements

- The net economic return earned by various stakeholders during tourist season involved in various income earning activities (hotel/lodge/shop owners and employees, persons supplying fuel wood, milkmen, sweepers, shop owners, shop employees, porters and horse owners) were quantified and worked out (Fig.66).
- Developed a map of eco-trekking/eco-expedition routes/treks to potential areas/sites/places in the upper Kedar valley in consultation with the local peoples, local tour guides and tour operators. Initially a few trek routes (Kedarnath to Vasukitall and Triyuginarayan to Pawalikantha etc.) were identified and a map was developed late for eco-tourism development in the valley.
- In-depth study on dung production by pack animals and its decomposition through suitable technique i.e. vermin-culture has been carried out while using various experiments under two different conditions in the field. Nutrient analyss of the decomposed dung was also carried out (Fig.67).
- Bioprospecting unit has been established for demonstration and processing of locally available bio-resources as an eco-tourism product. Three species of medicinal plants (*Angelica glauca, Allium spp. & Pleurospermum spp*) having huge potential for bio-prospecting have been selected.
- Developed capacity building of local tour guides/ students on avifauna diversity and its linkages with ecotourism promotion, biodiversity conservation and income generation.
- Assessment of carrying capacity of lodges/ hotels in different places between 35km distance in Kedarnath pilgrimage site were carried out.

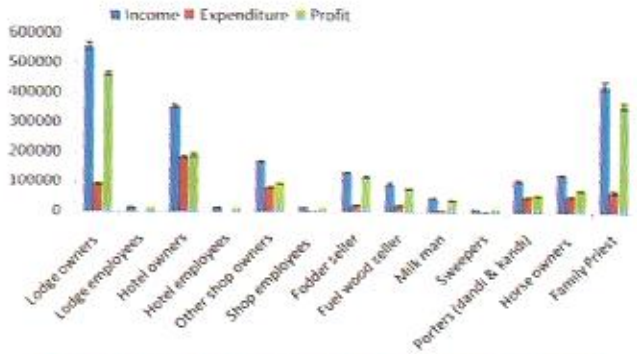


Fig. 66. Stakeholders involved in various income earning activities in Kedarnath pilgrimage/ tourism route.

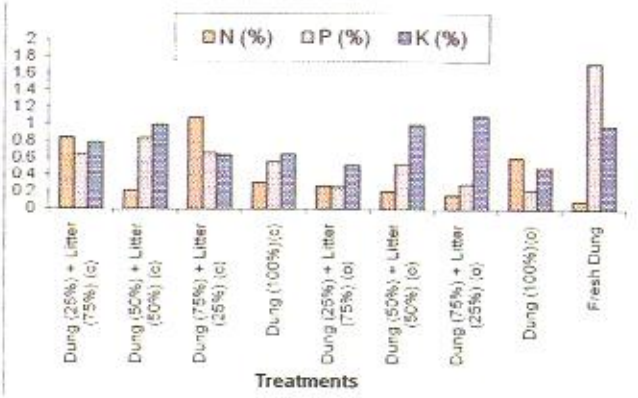


Fig. 67. Nutrient content (N, P, K) of pack animal manure under different treatments.

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

The central Himalayan region is rich in bio-resources but it is felt that the potential of science and technology has not been adequately and appropriately harnessed in overcoming the development constraints posed by the fragile environment and thus the need for large scale establishment of technology resource centre was realized. Poor access to appropriate technologies

due to difficult topographies and tough mountain conditions is one of the major causes of poverty, drudgery and natural resource degradation in the Indian central Himalaya. Of late, development planners have realized the importance of suitable or appropriate technologies and practices, and therefore, have stressed upon the need for a large scale demonstration, on-site training, capacity building and skill development of user groups in rural and marginal areas of the region. Technology change is an important instrument in the continuous process of socio-economic development. Therefore, introduction/development of appropriate and hill/mountain specific technologies and the requisite training of local farmers are two important aspects required in the transfer of technology in areas where it is needed.

With this rationale a center 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 in the form of a project. Capacity building through training, demonstrations of technology packages and field exercises of target groups carried out under this programme gained tremendous popularity and was appreciated by the end users. 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.
- To build capacity through trainings/ live demonstration/ field exercises of stake holders and training of trainers (TOTs) held on a regular basis.
- To guide 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

- A total of 40 technologies were collected, tested/modified and maintained at the RTC (HQs), Maletha and Triyuginarayan (Garhwal Unit) with a view to replicate and/ or disseminate.
- Most of the documented technologies were based on four major groups i.e., yield increasing, income generating, life supporting and value addition, and other supporting activities and are demonstrated in various easy to understand means viz., live and working demonstrations, models, posters, information folders, etc., and maintained or redone regularly throughout the reported period.
- The acquired skills/technology packages were disseminated by organizing capacity building programmes (training & awareness) of different user groups i.e., officials of different Government organizations, NGOs, farmer groups, students, etc.
- During this year (April, 2010 to March, 2011) a total of 22 trainings and awareness programmes were conducted for different user groups at different RTCs (farmers/officials selected by Govt. and non govt. organizations, farmers selected by Institute programme and students etc. of which 21% training/awareness programmes were for State Biotechnology Department, 21% NGOs, 20% Watershed management, 11% students, 11% Institute programmes and 11 % horticulture and other government departs and 5% Livelihood improvement programme. A total of 1260 persons (Female, 591 and Male, 839) covering 5 districts and 42 villages were benefited (Table-22).
- During the period (April, 2010 to March, 2011) an amount of Rs 2,54,000.00 (Rupees two lakh fifty four thousand) was generated through training, sale of planting material from RTC nursery and other activities.
- During this year 196 persons (04 Scientists & university teachers/Planners, 11 govt. officials, 181 Farmers) visited the RTC.
- The RTC has provided employment to Nine (9) persons (6 persons at RTC & 3 persons for supported activities).
- Based on the participatory discussion, training manuals on various technology packages were prepared, and distributed to the farmers and user groups.
- Nurseries of high value medicinal plants i.e. *Picrorahiza kurrooa, Sassurea costus, Podophyllum hexandrum, Aconitum heterophyllum and Verginia ligulata* were raised and established over two acres of land. Efforts are being made to integrate horticulture with MAPs cultivation (Photo A) so as to maximize the net return on per unit area basis and the same were demonstrated to the farmers. Some progressive farmers have adopted medicinal plant cultivation (Table-23) as an option of livelihood and to sustain the traditional healthcare system.
- Honey bee rearing was initiated at RTC, Triyuginarayan as an option of livelihood for local farmers.

Table-22. Training organized for different users (April, 2010 – March, 2011).

Users	Total	Male	Female
Farmers selected by Govt. organizations	381	300+50	81+75
Farmers selected by NGOs	605	273	332
Institute programme	31	19+20	12+25
Students	243	177	66
Total	**1260**	**839**	**591**
Districts covered		8	
Villages covered		42 + 6 = 48	

Table-23. Adoption of medicinal plant cultivation in high altitude villages of Kedar Valley.

Particulars	Villages	
	Triyuginarayan	Tosi
No. of families adopted	7	4
Land under cultivation/family (Nali)	2.4	1.9
Average no. of saplings/seedlings/family	96000.00	32000.00
Name of species cultivated	*Picrorahiza kurrooa, Sassurea costus, Podophyllum hexandrum, Aconitum heterophyllum, Verginia ligulata*	*Picrorahiza kurrooa, Sassurea costus*

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

India has one of the richest and most diverse cultural traditions associated with the cultivation and use of medicinal plants. 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 a 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 organic compounds that are formed by living systems. Our institute is already working on the ecological, biochemical and biotechnological aspects of these medicinal plants eg. *Aconitum balfourii, Podophyllum hexandrum, Picrorhiza kurrooa, Berberis spp. etc. Except these Taxus baccata, Ginkgo biloba, Rosa damascene* had also been studied.

Now there is a need to develop a 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 the 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 and analysis procedure of some of the medicinal plants of prioritized list of Uttarakhand were reviewed.
- Medicinal plants which are having volatile organic compounds as active ingredients are selected for current study, eg. Carum carvi, Cymbopogon flexuosus.
- Analysis of active ingredients present in Cymbopogon flexuosus (Citral, Myrcene, Geraniol, Linalool) was carried out using different solvent/ solvent ratio by Thin layer chromatography (TLC) and following observations were made:
  - Hexane as a pure solvent is found best for Myrcene separation
  - Dichloromethane is found best for citral, Geraniol and Linalool
  - 15:1 ratio of hexane: acetone, hexane: ethyl acetate and hexane: diethyl ether are found better for citral and linalool separation

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

In the Garhwal region of Uttarakhand inaccessibility of the area and deprived socio-economic status of locals is responsible for their total dependence on nearby forest areas. Animal husbandry largely based on different land base interventions plays a vital role in the rural economy. Vegetation is already in a degraded stage in most of the areas of Himalaya. Consequently, any depletion of this resource base can erode living standards as well as ecosystem stability. Huge amount of fodder deficiency is faced every year and unavailability of green forage adds to the drudgery of local women. The problem has led to resource extraction conflicts, malnutrition of women folk and their offspring increase in health related hazards, major and minor accidents because of collapse and improper education of girl child etc. In this project we are developing a fodder bank model using fast growing, high biomass yielding, nutritious tree, shrub and grass fodder both indigenous and introduced species. These species are selected on the basis of local people's preference as well as by suggestion of experts on fodder species.

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 total of 4.0ha of waste land has been developed into a fodder bank model at Maikhanda village. The model was rehabilitated with Ringal Bamboo (*Chimnobambusa falcata, Thamnocalamus spathiflorus, Arundinaria spp.*) while indigenous tree species that have been used in the model site development are *Alnus nepalensis, Quercus glauca, Quercus leucotricophora , Ficus nemoralis, Ficus auriculata , Debregeasia salicifolia , Ficus subincisa* the introduced tree species were Celtis australis, Morus alba, Bauhinia varigata and introduced grass species were *Pennisetum purpureum* Hybrid Napier 2 varieties.
- The result of assessment of the total green fodder collection was highest for Shersi village 84±6.23 kg/household/day whereas, it was lowest for lower altitude village of Maikhanda i.e. 64.4±3.60 kg/household/day (Table-24).
- A fodder plant nursery with two structures of polyhouse and net house have been developed for mass propagation of some lesser known but preferred fodder trees and grasses that are to be planted and distributed among locals of the area.
- The results of vegetative propagation revealed that the maximum propagation percentage was recorded for *Debregeasia salicifolia* followed by *Ficus auriculata* and *F. nemoralis* (Fig.68).

Table-24. Quantity of green fodder collected from March-October in selected villages located at different altitudes of Kedarnath Valley, Uttarakhand.

Village	Number of Backload/HH/ Day	Quantity Kg/HH/day	Quantity Kg/HH/month	Quantity Kg/HH/season
Tosi	2.38±0.10	83.52±3.63	2,505.68±108.86	20,045.46±870.88
Triyuginarayan	2.4±0.18	84±6.22	2,520±186.84	20,160±1,494.79
Shersi	2.3±0.15	84±6.23	2,522±187.85	20,167±1,496.82
Rampur	2.36±0.12	82.6±4.23	2,478±126.87	19,824±1,014.97
Sitapur	2.36±0.16	81.9±5.32	2,457±159.59	19,656±1,276.68
Maikhanda	1.84±0.10	64.4±3.60	1,932±108.10	15,456±864.83

*HH(Household)

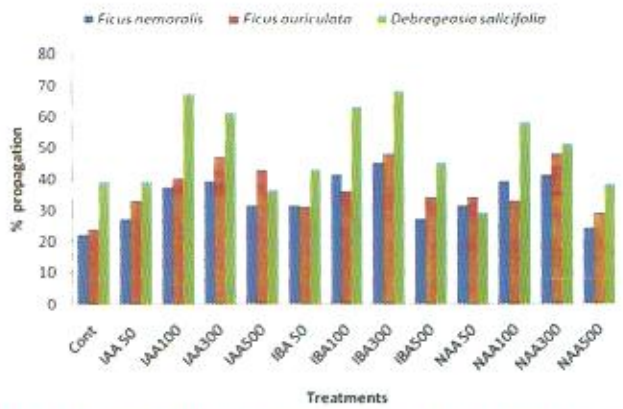


Fig. 68. Propagation percentage of different plant species under various hormonal treatments.

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

Forest based resources have played a key role in the sustenance of human civilization since time immemorial and are till now deeply associated with it and serve a large number of human population throughout the world. Wild edible fruits are one of the precious groups of non-timber forest products that played a prominent role in uplifting the socio-economy of human beings, particularly in tribal, rural and

marginal areas for thousands of years. The increasing unemployment in the rural sector of upper Kedar valley is likely to have serious ramifications on socio-economic and environmental balance. In spite of numerous laudable developmental programmes and huge investment, the reality of rural livelihood in this region is rather dismal. With the growing concern and commitment to hill area development and livelihood enhancement there is now an increasing interest as to how the untapped and under utilized wild bio-resources can contribute to the food security of the house-holds. These resources are recognized and valued not only for their short term economic benefits, but also for their socio-cultural richness and the sustenance that they offer to a large number of rural households.

Objectives

- To undertake in-depth survey to assess the extent of area under some potential wild edible 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 to 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 edible 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 products made from different wild bioresources.

Achievements

- Developed appropriate approaches & framework for capacity building & skill development in the area of bioprospecting and value addition of non-timber forest products NTFPs. Strong linkage and networking was developed with various institutions, NGOs and line departments for wider popularization of the use of wild edibles.
- Disseminated the package of practice regarding value addition of some potential species such as *Viburnum mullaha, Paeonea emodii* and *Rhododendron arborem* to some of the local NGOs and a few of them i.e. Swaraj Swayat Sanstha, (Masta, Guptakashi), Laxmi Fal Sanrakchan Avam Kutir Udhyog (Agustyamuni), Mohil Fal Sanrakchan (Silly,Agustyamuni) have started preparing and marketing the products of these species.
- Three training programmes have been organized for user groups/unemployed youth of the region by making a variety of value added edible products such as Jam, squash, juice, sauce, pickle etc.
- A small bioprospecting unit has been established for demonstration and processing of locally available bioresources. So far more than 165 families from upper Kedar valley have made strategic intervention in bioresources based products and enterprises development for enhancing local livelihood opportunities and creating economic incentives for conservation.
- Population study was carried out for a few selected potential selected wild edibles i.e. *Viburnum mullaha*, *Rhododendron arborium* and *Pyracantha crenulata* in the different locations of Kedar valley for conservation and management.
- Two wild edible species i.e. *Viburnum mullaha* and *Paeonia emodi* having huge economic potential for bioprospecting have been selected for nursery raising so as to meet the goal of large scale cultivation and conservation.

Enhancement of Livelihood Security through Sustainable Farming Systems and Related Farm Enterprises in North-West Himalaya (*2007-2012, NAIP/ICAR*)

All over the Himalayan region agricultural productivity is highly interlinked with the status of natural resources i.e. land, water, forests, minerals etc. However, the natural resources are in a poor status because of high dependency on them for diverse subsistence needs of the rural communities. Due to increasing diverse requirement for subsistence of growing population, a variety of problems related to ecosystem balances has been emerged in the central Himalayan region over the last few decades. Indeed, the environmental problem in Himalayan region is due to physical, biological and socio-economic factors. As a result, most of the common resources are now in a degraded state. In this context, appropriate science and technological interventions are required to manage

common property resources in this area. Therefore, up gradation of common resource base coupled with rehabilitation of degraded lands and requisite training of target groups/users are important aspects required in the hill region to sustain the livelihood of the local communities.

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

- Re-plantation of new seedlings in developed prototypes in three village clusters was carried out.
- Reassessment of survival percentage of plant species under different prototypes at three different village clusters were carried out.
- Under horticulture model the collective results illustrated that *Prunus domestica* showed the maximum survival of 96% followed by *Prunus armenica* (95.76%), Malus sp (92%), Juglans regia (88.31%), *Prunus persica* (79.33%), *Pyrus communis* (78%) at different locations (Fig.69).
- Under MPTs model results revealed that *Quercus glauca* showed maximum survival of (79%) followed by *Sapindus* spp, *Grewia oppositifolia* and *Morus alba* (76%). *Syzygium cumini* exhibited 71% of survival rate followed by *Bauhinia purpuria* (69.3%) at Manjgaon village cluster followed by Celtis *australis* 69%, *Melia azedarach* (64%) at different village clusters (Fig.70).
- Economic potential in terms of fodder biomass and fruit yield of developed prototypes has been assessed. The results revealed that the maximum economic benifit was recorded from Jaminikhal (Rs.6900) while the minimum economy was obtained for Bainspani (Rs.1660) MPTs model. For the Horticulture model the maximum economic return was assessed from Manjgaon horticultural model (Rs. 75630) while minimum was observed for Hadiya horticultural model (Rs. 1 5115.5).
- Two water harvesting tanks were constructed at Jaminikhal and Manjgaon village clusters.

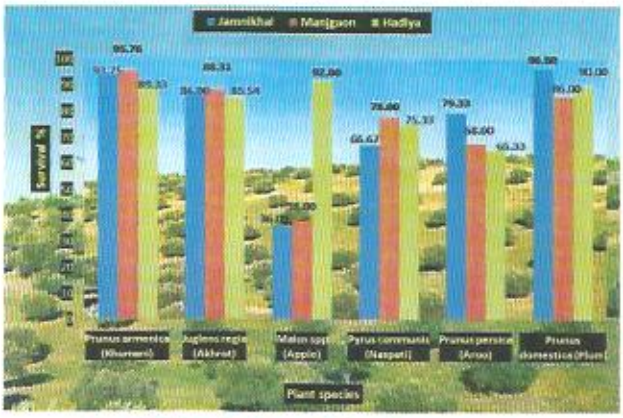


Fig. 69. Survival % of Horticulture plants.

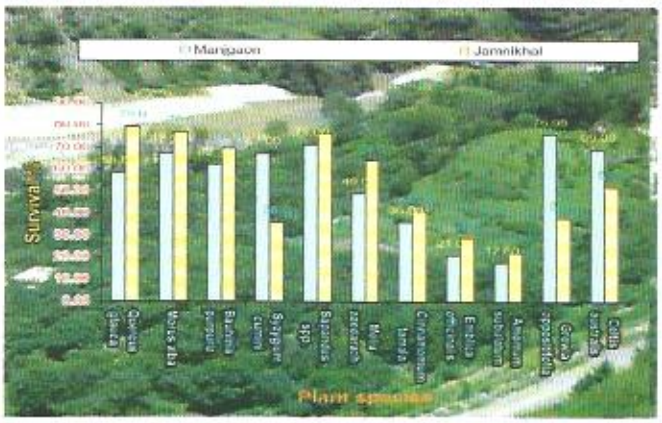


Fig. 70. Survival % of MPTs.

Theme

R&D HIGHLIGHT OF THE REGIONAL UNITS

GARHWAL UNIT

- A total of 8 training programmes (each of 2 to 3 and 5 days) on rural technologies/ wild bioresources utilisation patterns natural resource management, eco-tourism promotion and biodiversity conservation were organised during the reporting period reaching out to 378 farmers, and NGOs. The programmes gained wide popularity and created awareness. A large number of farmers, many from the outside the demonstration villages, adopted the demonstrated technologies.
- Nutritional and bio-chemical analysis of a few potential wild edibles (*Viburnum mullaha*) and wild herbal spices (*Allium humile, Angelica glauca* etc.) were estimated.
- In-depth study was carried out to ascertain the radical changes in transhumance/ pastoral nomadism, livelihoods, the extent of cultivation of the wild bioresources and crops in the Niti and Mana valleys of district Chamoli after 1962.
- Studies on climate change impact on central Himalaya agro ecosystem including eco-physiological; drought and insect pest related impacts and adaptation strategies were undertaken.
- Assessment report for Nanda Devi Biosphere Reserve was developed as a baseline for further studies related to the implementation of global climate change in mountain regions (GLOCHAMORE) research strategy (UNESCO Paris initiative).
- The eco-tourism models such as Dhanolti (Tehri district) and Dhaulachhina (Almora district) were studied for ecological impact analysis and cost-benefit analysis.
- Monitoring and regeneration status of plant species such as *Viburnum mullaha* and *Paeonia emodi* has been worked out and nurseries of these species have been established for promoting their large scale cultivation and conservation.
- Eco trekking/ eco-expedition map to potential areas/ sites, places in consultation with local peoples, local tour guides were developed.
- Tourism/ eco-tourism interpretation centre has been established through participatory approaches at Triyuguinarayan for imparting training and capacity building programme to stakeholders.
- Created awareness and capacity building of local tour guides/ students on avifauna diversity and its linkages with eco-tourism and biodiversity conservation and also prepared a detailed list of important birds of upper Kedar valley including rare, endangered, vulnerable species for the interest of tourist/ visitors with the help of local ornithologists.
- Local youth of the region have been encouraged to organise/ involve themselves in collection and marketing of local agro-products so as to replace the middlemen from this chain. Awareness created and skill developed on packaging and grading of agro-products which are being sold in the name of KEDAR (Kedarghati ecotourism development action and research) eco-tourism products.
- A nursery of high value medicinal plants under 2 acre of land as established with major focus on *Picrorhiza kurroa*, *Saussurea costus* and *Paeonia emodi* at RTC, Triyuginarayan.
- The nematodes were classified into their trophic groups on the basis of in their feeding habits and mouth parts. They were identified as bacterivores, fungivores, herbivores, omnivores and predators.

HIMACHAL UNIT

- 258 species of vascular plants from Nargu Wildlife Sanctuary were recorded, out of which 39.53%

species were native and 22.48% endemic to the Himalayan Region. A total of 178 species of economically important plants were used as medicine (123 spp.), wild edible/food (39 spp.), fodder (59 spp.), fuel (32 spp.), timber (05 spp.), religious (09 spp.), fiber (07 spp.), agricultural tools (08 spp.) and various other purposes (16 spp.). Amoung 10 forest tree communities were identified from 23 sites, total tree density ranged from 210.0-600.0 Ind ha^{-1} and total basal area, 1.9-60.7 m^2ha^{-1}. Shrub density from 450.0-3390.0 Ind ha^{-1}, herb density, 44.8-156.8 Ind m^{-2} sapling density, 50-450 Ind ha^{-1} and seedling density, 110-1060 Ind ha^{-1}. Species richness ranged from 43-111and Species diversity index (H') for trees ranged from 0.26-1.72, saplings-0.26-1.70, seedlings-0.17-1.84, shrubs-1.07-2.8 and herbs- 2.70-3.60.

- Extraction trends of fuel and fodder species were assessed. Among the fuel species, mean collection was highest for *Quercus leucotrichophora* (1879.30 kg household^{-1} year^{-1}), followed by *Rhododendron arboreum* (433.57 kg household^{-1} year^{-1}), *Cedrus deodara* (425.22 kg household^{-1} year^{-1}), *Myrica esculenta* (385.05 kg household^{-1} year^{-1}) and *Persea duthiei* (370.96 kg houschold^{-1} year^{-1}). The remaining species showed relatively low values. 23 species were used as fodder by the inhabitants of 10 surveyed villages. *Quercus leucotrichophora*, *Neolitsea pallens* and *Desmodium elegans* were mostly used as fodder. Maximum total collection was done in Hurang village (8568 kg household^{-1} year^{-1}), followed by Shilh Badhani (8352 kg household^{-1} year^{-1}), Malwara (8028 kg household^{-1} year^{-1}) and Kutahar (7980 kg houschold^{-1} year^{-1}) villages.
- Seed germination protocols for two populations of *Aconitum heterophyllum*, *Corylus jacquemontii* and *Buxus wallichiana and* Vegetative propagation protocols of *Taxus baccata* subsp. *wallichiana* and *Cinnamomum tamala* were developed.
- Environment Management Plans of PHEP Stage III were reviewed. Information on the socio-economic status of 24 affected villages was generated through structured questionnaires, interviews and Participatory Rural Appraisal. The inhabitants of the villages are largely dependent on agriculture, horticulture, vegetables, livestock and traditional handicrafts. Developmental activities carried out by PHEP Stage III were documented.
- In Himachal STEP Site 20 orchards (i.e., 10 far from the natural habitat and 10 near to natural habitat) in different altitudes and with diverse landscapes were selected to implement Pollination Deficit Protocol (i.e., Flowering Phenology, Scan and Sweep Net Sampling, etc.). Scan sampling of apple pollinators was done. Bowl Trap Experiment was conducted in 20 orchards.
- The Strategic Environmental Assessment (SEA) study of the River Satluj comprises a buffer zone of 10 km on either side of the river side. This area lies 165 km from the northeast to the southwest between Nathapa village (Kinnaur district) and Bilaspur town (Bilaspur district). Of the total buffer zone (2945 km2), the highest share of land use/land cover (LULC) of the Sutlej catchment stood to barren (40.9%) followed by forest land (36.48%), agricultural land (21.91%), and settlements (0.71%). There is a high anthropogenic pressure on the catchment area which 8730 houscholds inhabit. The three major zones; the buffer, influence zone and overlapping zones were demarcated with the help of RS & GIS. Influence zone of HEPs was estimated to be 31.30% of the total buffer zone and 6.07% was area of the total influence zone overlapped indicating over crowding of HEPs in this catchment which may create other environmental disorders in due course.
- The sprawling urban environment and its impact mainly on ambient air quality study in three towns (i.e., Hamirpur, Kangra and Chamba) in Himachal Pradesh shows PM10 40.3±4.4 µg m-3 as highest at Hamirpur followed by 35.2±2.7 µg m-3 at Chamba and 24.6±2.3 µg m-3 at Kangra. On diurnal basis, highest concentration of PM10 was found between 16-0 h IST (evening to midnight) followed by 8-16 h (day) and lowest between 0-8 h (midnight to morning) at all the sites except at Chamba. At all sites, there were high concentrations of particulate pollution compared to gaseous pollution. The gaseous pollutants like SO2, NO2 and NH3 were found below the permissible limits. The vehicular influx, burning of biomass, coal and solid waste and operation of gen sets are considered to be the local/point sources for ambient air quality deterioration in these hill towns.
- Aerosol Optical Depth (AOD), Black Carbon (BC) and Surface Ozone (O3) studies were carried out at Mohal-Kullu in Himachal Pradesh. On an average, forenoon and afternoon AODs for a day at ten wavelengths under clear sky condition from the last four years (2006 -10) showed maximum AOD 0.27 in 2010 while minimum 0.22 in 2007. An increase of 22% AOD at 500 nm during the past three years (2007-10) was noted. BC concentration, a heat absorbing aerosol considered to melt glaciers faster in the Himalayan region, was measured as much as 6596 ngm-3 in January 2010 and as low as 3253 ng m-3 in June 2010. It increases with the activities like biomass burning, vehicular emission and forest fires. Surface Ozone, one of the growing green house gases

in the modern world, on high insolation days was estimated to be 41.7±13.8 ppbv. Overall, aerosols (colloidal system of solid, gaseous and liquid pollutants) especially heat absorbing like BC is considered to increase our global temperature. Upon one unit increase in AOD at Mohal, there is an increase of 0.64 K/day in atmospheric temperature.

- Among the explants (i.e., shoot tips, nodal explants and leaf segments) tried for the micropropagation of *Olea ferruginea*, high percentage of shoot induction was observed in nodal shoot segments, whereas no shoot induction was observed in apical shoot segments. Maximum shoot induction was recorded in half strength MS medium containing BAP (0.44-8.88µM) and NAA (0.46 µM) and minimum when the medium was supplemented with kinetin (0.46 µM). The higher concentrations of cytokinins caused the early proliferation of nodal shoot segments. Maximum two shoots per nodal shoot segments was observed. Overall proliferation of nodal shoot segments was better in BAP containing medium. Of the two cytokinins tried for shoot elongation, BAP was found better compared to kinetin for shoot elongation. Addition of GA_3 in kinetin containing medium considerably improved shoot proliferation both in apical and nodal shoot segments. TDZ was not found effective in multiple shoot formation from the nodal shoot segments compared to BAP or kinetin.
- Data on consumption rate of various food items for local male and female adults of Kullu was collected. Toxicity of Zinc and Cu was assessed. Zinc was found more toxic to tomato seeds as compared to Cu. The effects of Cu and Zn on seed germination and root and shoot elongations were antagonistic in nature. Zinc toxicity during seed germination of the tested plant can be minimized using Cu up to certain extent. Cypermethrin has more toxic effects on seeds of palak (*Spinacia oleracea* L.) as compared to Cu. Cypermethrin could reduce toxic effects of Cu on french bean at growth and biomass levels. Antagonistic interaction between Cu and cypermethrin on growth, biomass of french bean were observed.
- Consultation Meetings were organized at Jibhi, Banjar and Jana Villages in Kullu district, Ropa, Sundarnagar and Smaila in Mandi District and Khangsar in Chandra Valley of the Lahaul & Spiti district, group of 20 farmers in Chandra Valley was developed to initiate the cultivation of *Aconitum heterophyllum* and *Picrorhiza kurrooa*, and that of 54 farmers from Jana, Burua, Kothi, Ropa, Jhiri, Smaila and Sundernagar for the cultivation of *Aconitum heterophyllum* and *Withania somnifera*.
- About 15,000 seedlings of *Aconitum heterophyllum* were raised by the 16 farmers in the field at Jana village, 20,000 seedlings at Burua village, 1,000 seedlings at Kothi and 1,000 seedlings at IRMT, Naggar. One farmer from Jana village developed > 2, 50,000 seedlings of *Aconitum heterophyllum* and generated > Rs. 1, 25,000/- from the seeds and seedlings. Over 5,000 seedlings of *Withania somnifera* were developed and over 2,000 seedlings of *Withania somnifera* were planted in Prodhar, Ropa, Jhiri, Smaila and Sundernagar of Kullu and Mandi districts.
- An Environmental Observatory was established. Mostly online equipments like Ozone Analyzer for assessing and monitoring surface ozone, Pyranometer for solar flux, Multi-wavelength Radiometer for columnar aerosols as AOD, Aethalometer for black carbon, Respirable Dust Sampler for particulate and gaseous pollutants and Ion Chromatograph for ionic components (anions/cations) have been installed. These equipments are being used for scientific analysis as well as a part of demonstration to awaken the various stakeholders.
- 300 seedlings of over 20 multipurpose species and medicinal plants were distributed to different stakeholders. Also, seeds of different medicinal plants were distributed to the Stakeholders. Agrotechniques developed for the 26 commercially viable medicinal plants and Hindi Booklets on Biodiversity and medicinal plants were disseminated to the stakeholdesr.
- Training Programme on "Weather Monitoring, Climate Change and Biodiversity Conservation and Management" at Himachal Unit, Mohal-Kullu for the teachers, students, farmers and Mahila Mandals was organized. The pre and post training feedbacks of the participants showed significant improvement in their knowledge. World Environment day and International Biodiversity Day were celebrated. Exposure visits for over 700 diverse stakeholders were organized.
- National Project Coordination Meeting-India was organized on July 19, 2010 at GBPIHED, Himachal Unit, Mohal-Kullu for the Conservation and management of pollinators for sustainable agriculture through an ecosystem approach. National Partners of the project i.e., Himachal STEP Site, Uttarakhand STEP Site and Sikkim STEP Site and farmers participated. Meeting of the Partners of Himachal STEP Site was organized at Mohal-Kullu on February 04, 2011 to discuss the approach/methodology and mechanism for running the project activities smoothly. Also an Interactive

Meeting of the Partners of Himachal STEP Site with Fruit Grower's Association, Upper Kullu Valley was organized at Patlikuhl on February 05, 2011 to discuss the aims and objectives of the project.

SIKKIM UNIT

- ICIMOD (Nepal)-GBPIHED (Kosi) sponsored BCTL event organized a brainstorming meeting on "Assessment of Biodiversity Values and Ecosystem Services in the Protected Areas of Sikkim Himalaya" by GBPIHED, Sikkim Unit, at Pangthang (Sikkim) on 10th November, 2010
- A training-cum-workshop on "Earthquake Risk Mitigation and Management for Engineers, Architects, Town Plannesr & Masons" was organized with Department of Building & Houses, Road & Bridges, Urban & Development & Human Resource, Govt. Sikkim
- Institute was represented as member, organizing Committee for the 'International Rhododendron Conference. '*Rhododendrons: Conservation and Sustainable Use*', organized by FEWMD, Govt. of Sikkim, Saramsa, Gangtok-Sikkim on 29th April 2010.
- Two day training workshop, *Conservation of Biodiversity* for Students and Teachers, involving 10 schools of Sikkim at Pangthang-Sikkim was conducted.
- Tholung-Kisong (TK) landscape in South-east Khangchendzonga Biosphere Reserve, north Sikkim), hitherto unexplored, investigated covering 15 sites for woody vegetation (51 tree and 30 shrub species). Total species significantly declined ($r = -0.874$; $p<0.01$) along increasing altitudes. Study discovered, first time, two new populations of *Rhododendron niveum* (rare and endemic) at 3000m (150 individuals) and 3300m (15 individuals) in KNP.

NORTH EAST UNIT

- In an effort to address the issues of shifting cultivation, during the reporting period, the major activities carried out included: 1) Analyses of policies and acts, 2) Socio-economic and ecological viability from the perspectives of Knowledge, Attitude and Perception (KAP) of the practitioners of shifting agriculture, 3) Development of an appropriate model to address fallow management and 4) Status and variations in the practices of shifting agriculture in north eastern states.
- It was recorded that shifting agriculturists are adopting terrace cultivation and cultivated jhum plots from 1990-2010 are found to be reducing as they are transformed to terracing, horticulture, secondary forests and bamboo forests. In nine villages that were surveyed during the reporting period, the number of cultivated jhum plots had reduced from 365 in 1990 to 170 in 2010.
- A comprehensive review report on floral and faunal diversity including status, distribution, threats and their use by local communities is done for two National Parks, i.e., Namdapha and Mouling in Arunachal Pradesh. Potential corridors between the NPs based on Rapid Biodiversity Assessment and human induced threats and conservation challenges (both local and transboundary) in the NPs area also identified.
- In order to promote biodiversity conservation, three more Community Conserved Areas (CCAs) namely 'Siikhe-Bo' CCA (20 ha) in Ziro plateau, 'Ritosa Ree-Mainarang Ree' CCA (100 ha) and 'Hugore Sewaphu' CCA (50 ha) in Tawang and West Kameng (proposed BR - TWKBR) in Arunachal Pradesh were declared during the reporting year. The CCAs created under the project would promote conservation of ecologically and socially valued wild flora and fauna in Arunachal Pradesh where the tribal communities are wary of using the existing Protected Area legislation and 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.
- During the reporting year, 135 LPG Sets (Sets including single gas cylinder, oven, regulator, lighter, Apron) were distributed among 135 households in 19 project villages of GOI-UNDP CCF-II Project, in an effort to meet the high fuelwood demand and reduce pressure on forests. Further, large scale plantation of *Taxus wallichiana* and large cardamom (*Amomum subulatum)* is carried out in more than 60 ha of land each.
- In order to promote Income Generation Activities (IGAs), 1 lakh fish seedlings were distributed among 120 households in Apatani plateau under GOI-UNDP CCF-II Project. The economic impact of the activity has been documented and analysed. The total project cost including cost for fish seedlings, transport and others labour was around Rs. 50,000 with gross return around Rs. 4,41,150 and a net benefit Rs. 3,91,150. Also, 72 piglets were distributed among 72 households in 8 project villages in Apatani plateau and 3 project villages in TWKBR.
- Community driven conservation practices of floral and faunal diversity have been documented in Tawang and West Kameng districts of Arunachal Pradesh during the reporting year. The major man-

animal conflicts were identified; crop raiding and retaliatory killing of carnivores for live stock depredation appeared to be major man-animal conflicts.

- The NE Unit bagged two SCHOLL Research Challenge Awards in 2010. The awards were given to two of its projects for high calibre action research in development and governance that has had or have potential for demonstrated impact on policy or society at large. The case studies are "Biodiversity conservation through community based natural resource management in Arunachal Pradesh" in the category 'Sustainable Development and Preservation of the Ecosystem' and "Technology backstopping: a key to agricultural and entrepreneurship development in North East-East India" in the category 'Technology for Development'.
- Up scaling of technology dissemination and backstopping, and capacity building of VOs and NGOs in the states of the NE region continued and further strengthened in collaboration with CAPARRT. Thirteen (13) NGOs/VOs were given training on various low-cost technologies during the reporting year. The Unit was identified as Technology Resource Institute by DST, Govt. of India. Capacity enhancement of more than 3670 tribal framers has been done though hands-on-training on more than 17 low-cost and simple technologies. The project has a significant impact with more than 1500 households adopting to one or the other technology such as trellises, legume intercropping, bio-composting, vermi-composting and bio-briquetting, etc.
- Towards capacity building, 89 farmers were trained on nursery techniques, 80 villagers on basics of Community Based Tourism (CBT), 40 farmers on 17 simple low cost farming and soil and water conserving technologies, and 8 villagers on bamboo based handicrafts.
- The Unit held the State Level Steering Committee (SLSC) Meeting of the GOI-UNDP CCF-II Project entitled "Biodiversity Conservation through CBNRM in Arunachal Pradesh" on August 27, 2010 for briefing the members of SLSC and policy planners on progress of the project and also other biodiversity conservation efforts of the Unit.
- The Unit conducted as many as 15 workshops /training programmes/awareness campaigns at various levels for diverse stakeholders on biodiversity conservation and capacity building. The Unit faculty participated/presented papers in about 20 workshops/seminars during the reporting period.

APPLICATION OF R & D OUTPUTS IN DEMONSTRATION AND DISSEMINATION

Integrated Eco-development Research Programme (IERP) in the Indian Himalayan Region *(1992 – Long Term scheme, **MoEF**, Govt. of India)*

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

- Strengthening and continuation of 43 location-specific IERP projects in 6 States of the Indian Himalayan region was carried out
- Funds for 25 ongoing/completed projects were released to different organizations after careful examination of their Utilization Certificates (UCs) and Statement of Expenditures (SEs).
- Annual Progress Reports (APRs) of 23 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 11 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.
- Based on the recommendations of the 15th PEC, 8 new projects (4 under BCM theme and 4 under SED theme) were sanctioned for execution in the two States (Himachal Pradesh, and Uttarakhand) of the IHR.
- Forty three IERP projects were on-going in 6 States (Assam, Himachal Pradesh, J&K, Meghalaya, Nagaland and Uttarakhand) of the Indian Himalayan region.
- Follow-up action on 90 project files (old/fresh/on-going/miscellaneous, etc.), excluding routine correspondences of about 549, was initiated/completed during the year 2010-11.

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 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 2010-11.
- 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. 18, pp. 1-74, 2010).
- About 41 research abstracts, related to the various aspects of Himalayan Ecology, were collected and added on the Abstract Database of the ENVIS Centre. At present, this database contains 1980 abstracts.
- State-wise and district-wise resource profile (related to demography, literacy, forest cover, protected areas and glaciers, etc.) of all the Indian Himalayan states has been prepared for uploading in the website of the ENVIS Centre.
- About 52 queries, related to Himalayan environment and development, were responded to the individuals/institutions during the year 2010.
- ENVIS Bulletin (Volume 18) and ENVIS Newsletter (Volume 7) on Himalayan Ecology were prepared, published and made online through the website of the ENVIS Centre.
- Website of the ENVIS Centre on Himalayan Ecology **<http://gbpihed.gov.in/envis/envis.html>** was re-designed, maintained and upgraded.

Central Library Facility

The Central Library of the Institute at its headquarters, at the end of financial year 2010-11, had 14801 books. The library is subscribing a total of 109 periodicals (71 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 Service (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 227 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

Strengthening & Management of IT Infrastructure

The Institute has two backbone networks, one is from NIC, New Delhi (NICNET network) which provides 128 kbps shared (HQs and Units) bandwidth for internet access and the other from BSNL-HUB, Bangalore which provides 512 kbps shared (HQs, Units and MoEF) bandwidth through VSATs for video conferencing & internet access. The bandwidth is distributed within the Institute HQs & Units through Local Area Network (LAN). The Institute website has been developed and hosted at the Internet Data Centre (IDC) of NIC, New Delhi. The URL of the Institute website is *http://gbpihed.gov.in*. A VPN (Virtual Private Network) has been created on NICNET for remote web site updation at Institute's end. The website of the institute has been updated at frequent intervals. A database of Scientific/Technical and Research Scholars has been developed and uploaded on the Institute website. The official e-mail accounts on NIC mail server (mail.nic.in) have been created and provided to

all Scientists, Technicians, Finance and Administrative staff. NIC is closing its VSAT service for Institute's six locations w.e.f. March, 2011 so that Institute has initiated the process to take the internet Leased Line of 2 mbps bandwidth from various Internet Service Providers (ISPs) for HQs and Broadband of 2 Mbps plan for the four regional units. A feasibility study has also been completed for the establishment of internet Leased Line for Institute HQs and broadband connectivity for Units.

Central Laboratory Facility

Institute has strengthened the facilities of physico-chemical, biological, heavy metal analysis of drinking, raw, waste water and quantification of volatile compounds of soil and plant samples. The heavy metals in the water and soil samples were detected with an Atomic Absorption Spectrophotometer (Make- Varian AA280Z, equipped with graphite tube atomizer). For the quantification of aromatic and volatile compounds institute has Gas Chromatography (make- Chemito, Ceres 800). Institute is also having the facility of detection of C, H, N & S with 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 to (NGO's and other Government Organization) on payment basis. In the financial year 2010-11, Institute has collected 4 lakh rupees as a central laboratory service charge from 55 organizations (18 - Govt. organization & 37 - NGO's). Fig.71 shows month wise collection of testing charges and service offered to different other organizations.

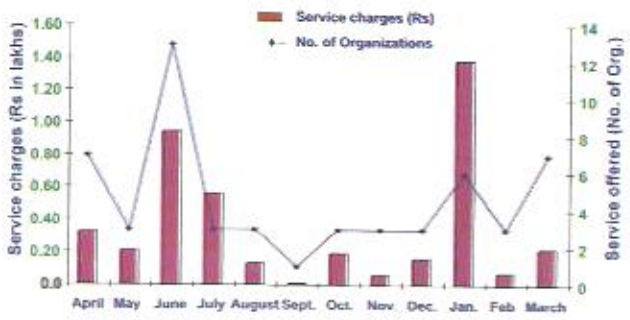
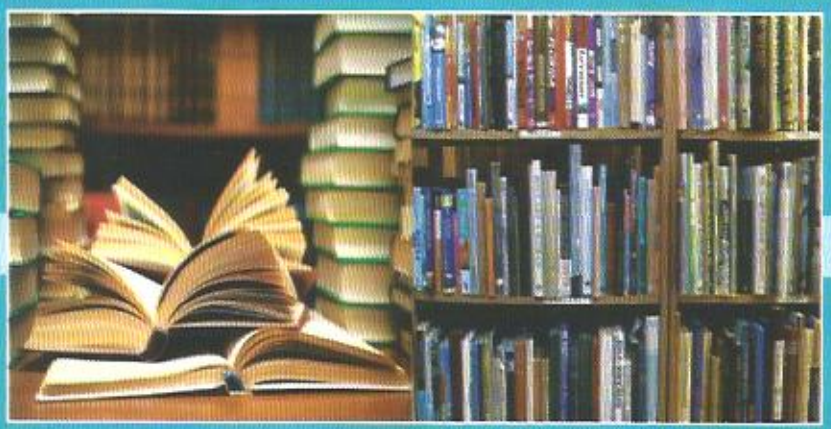


Fig.71. Graphic representation showing total fee collected from Central Laboratory Services in 2010-11.



MISCELLANEOUS ITEMS

1. SCIENTIFIC PUBLICATIONS

(I) Scientific Journals

Andola H.C., **R.S. Rawal,** M.S.M. Rawat, **I.D. Bhatt** & V.K. Purohit (2010). Variation of berberine contents in Berberis pseudumbellata: a high value medicinal shrub of west Himalaya, India. *Medicinal Plants-International Journal of Phytomedicines and Related Industries*. 2(2) ISSN.

Andola, H.C., **R.S. Rawal**, M.S.M. Rawat, **I.D. Bhatt** & V.K. Purohit (2010). Analysis of berberine content using HPTLC fingerprinting of root and bark of three Himalayan *Berberis* species. *Asian J. Biotechno*, 2: 239-245.

Badola, H.K. and B.K. Pradhan (2010). Population exploration of *Rhododendron maddenii* in Sikkim, bordering Khangchendzonga Biosphere Reserve – questioning rarity and endangerment. *NeBIO*, 1(1): 1-9.

Badola, H.K. and B.K. Pradhan. (2010). Discovery of new populations of a rare species *Rhododendron niveum* in Khangchendzonga National Park, Sikkim. *The Rhododendron (Off. Jour Australian Rhododendron Soc.)*, 50: 40-49.

Bagwari, H.K., **G.C.S. Negi** and N.P. Todaria (2010). Biomass production of forests in Rawanganga watershed in Garhwal Himalaya. *Indian Journal of Forestry*, 33 (1): 55-62.

Bagwari, H.K., **G.C.S. Negi** and N.P. Todaria (2010). Characterization of Rawanganga watershed in Garhwal Himalaya. *Indian Journal of Soil Conservation*, 38 (1): 37-41.

Ballabh, H., D.D. Chauniyal and **M.S. Lodhi** (2011). Geomorphic Evidence of Active Tectonics in the Dhundsir Gad Watershed of Alaknanda Basin, Uttarakhand, India. *Nature and Science*, 9 (6): 1-6.

Bisht, B.S. and **B.P. Kothyari** (2010). Influence of accessibility to the infrastructure and natural resources on lifestyle and workload of rural women: Scenario of Indian Central Himalaya. *Journal of Human Ecology*, 31(1): 27-35.

Butola, J. S. and S.S. Samant (2010). *Saussurea* species in Indian Himalayan Region: diversity, distribution and indigenous uses. *International Journal of Plant Biology*, 1: 43-51.

Butola, J.S. and A.R. Malik (2010). Survival and phenophases of some Himalayan medicinal plants cultivated at different altitudes: a case study of district Kullu, Himachal Pradesh, India. *International Journal of Forest Usufructs Management*, 11 (1): 00.

Butola, J.S., R.K. Vashistha, A.R. Malik and **S.S. Samant** (2010). Assessment of inter-population variability in *Heracleum candicans* Wall. with emphasis on seed characteristics and germination behaviour. *Journal of Medicinal Plants Research*, 4(15): 1523-1534.

Butola, J.S., R.K. Vashistha, **S.S. Samant and** A.K., Malik (2010). Technology for the propagation and cultivation of *Angelica glauca* Edgew.: a threatened high value Himalayan medicinal cum wild edible herb. *Medicinal Plants*, 2(1): 67-72.

Chandra Shekhar, K. and S.K. Srivastava (2010). A supplement to the flora of Lahaul – Spiti. *Journal of Non-Timber Forest Products*, 17 (2): 233-258.

Chandra Sekar, K. and S.K. Srivastava (2010). Rhododendrons in Indian Himalayan Region: Diversity and Conservation. *American Journal of Plant Sciences*, 1: 131-137.

Chandra, Abhishek, L.S. Kandari, Kusum Chauhan Payal, **R.K. Maikhuri,** K.S. Rao and K.G. Saxena (2010). Conservation and sustainable management of traditional ecosystems in Garhwal Himalaya, India. *New York Science Journal*, 3(2): 71-77.

Chandra, Abhishek, P. Partdha Saratdhi, K.S. Rao, K.G. Saxena and **R.K. Maikhuri** (2011). An investigation into the energy use in relation to yield of traditional crops in central Himalaya, India. *Biomass & Bioenergy,* 35: 2044-2052.

Chandra, Abhishek, P. Pardha Saradhi, **R.K. Maikhuri**, K.G. Saxena and K.S. Rao (2011). Traditional agrodiversity management: A case study of Central Himalayan village ecosystem. *Journal of Mountain Science*, 8(1): 62-74.

Chandra, S., H. Lata and **S.C. Joshi** (2011). Photosynthetic characteristics of Indian Rhubarb (*Rheum emodi* Wall): An endangered medicinal plant P-8. *Planta Medica*, 77: 515-516.

Dhyani, Deepak, R.K. Maikhuri and **Shalini Dhyani** (2011). Seabuckthorn: An underutilized resource for nutritional security and livelihood improvement of rural communities in Uttarakhand Himalaya. *Ecology of Food and Nutrition*, 50(2): 168-180.

Dhyani, Deepak, R.K. Maikhuri, Shalini Mishra and K.S. Rao (2010). Endorsing the declining indigenous ethnobotanical knowledge system of Seabuckthorn in Central Himalaya, India. *Journal of Ethnopharmacology,* 127: 329-334.

Dhyani, Shalini, R.K. Maikhuri and **Deepak Dhyani** (2011). Energy budget of fodder harvesting pattern along the altitudinal gradient in Garhwal Himalaya, India. *Biomass & Bioenergy*, 35: 1823-1832.

Gurung, B. and **Singh, K. K.** (2010). Propagation of Sikkim Himalayan Rhododendron (*R. dalhousiae* Hook. f.) through *in vitro* shoot proliferation from cotyledonary nodes. *Journal of Applied Horticulture,* 12(1): 42-45.

Idrisi, M.S., **H.K. Badola** and R. Singh (2010). Indigenous knowledge and use of medicinal plants by local communities in Rangit Valley, South Sikkim, India. *NeBIO,* 1(2): 34-45.

Joshi V., Rawat M. S., Sharma A.K., **Kumar K.** and Panda A.K. (2011). Traditional knowledge of natural disaster mitigation and ethno medicine practices in Himalaya with special reference to Sikkim, *Indian Journal of Traditional Knowledge*, Vol. 10 (1), pp. 198-206.

Joshi, S.C. and **L.M.S. Palni** (2010). Is dew useful for Himalayan Plants? *Current Science*, 99: 1434-1439.

Jugran, A., I.D. Bhatt and R.S. Rawal (2010). Characterization of Agro-diversity by Seed Storage Protein Electrophoresis: Focus on Rice Germplasm from Uttarakhand Himalaya, India. *Rice Science,* 17(2): 122–128.

Kala, C.P. and **R.K. Maikhuri** (2011). Mitigating people-park conflicts on resource use through eco-tourism: A case of the Nanda Devi Biosphere Reserve, Indian Himalaya. *Journal of Mountain Science*, 8(1): 87-95.

Kholia, B. S. and **R. Joshi** (2010). International Year of Biodiversity – Adopting Innovative Measures for Conservation. *NeBio,* 1(2): 55-51.

Lodhi M.S., P.K. Samal and **M. Dollo** (2011). Hydroelectric Power Projects vis-a-vis Air Pollution: Second Thought Needed. *Environmental Science: An Indian Journal*, 6 (2): 2-4

Lodhi, M.S. and **P.K. Samal** (2010). Hydropower development in Arunachal Pradesh: Issues and concerns. *NeBIO*, 1(2): 25-27.

Maikhuri, R.K., Lakhpat Rawat, Vikram Negi, Abhay Bahuguna, Sunil K. Agarwal, N. A. Farooquee, Prakash Phondani, and C.S. Negi (2010). Demonstration dissemination of simple eco-friendly technologies for natural resource management in central Himalaya. *Indian Journal of Science and Technology*, 3(7): 823-831.

Maikhuri, R.K., L.S. Rawat, Vikram S. Negi, Sunil K. Agarwal, K.S. Rao and K.G. Saxena (2011). Managing natural resources through simple and appropriate technological intervention for mountain development, *Current Science*, 100(7): 992-997.

Maikhuri, R.K., Vikram S. Negi, L.S. Rawat, Deepak Dhyani, Abhay Bahuguna and Prakash Phondani (2010). Creating interest and curiosity among science students through learner centered and action oriented approaches. *National Academy Science Letter,* 33(3 & 6): 123-131.

Mili, Rajiv, **Mihin Dollo, P.K. Samal** and **S.C. Arya** (2010). Ethnomedicinal knowledge on treatment of pneumonia and asthma diseases by Mising tribe of North East India. *J. Econ. Taxon. Bot.*, 34 (3): 548-560.

Milli, Rajiv, **Prasanna K. Samal** and **Mihin Dollo** (2010). Extraction of non-timber forest produces from shifting agriculture fallow land by Adi tribe in Siang districts of Arunachal Pradesh, North East India. *Journal of Non-Timber Forest Products*, Vol. 17 (1): 7-18.

Mishra, J., Singh, M., **L.M.S. Palni, and S.K. Nandi,** (2010). Assessment of genetic fidelity of encapsulated microshoots of *Picrorhiza kurrooa*. *Plant Cell Tissue and Organ Culture,* Springer online: dos10.1007/s11240-010-9816-3.

Negi, Vikram S., **R.K. Maikhuri** and D.P. Vashishtha (2011). Traditional healthcare practices among the villages of Rawain valley, Uttarkashi, Uttarakhand. *Indian Journal of Traditional Knowledge,* 10(3): 533-537.

Negi, Vikram S., **R.K. Maikhuri,** L.S. Rawat and D.P. Vashishtha (2010). The livestock production system in a village ecosystem in the Rawain valley, Uttarakhand, Central Himalaya. *International Journal of Sustainable Development and World Ecology*, 17 (5): 431-438.

Negi, Vikram, **R.K. Maikhuri** and Lakhpat Rawat (2011). Non-timber forest products (NTFPs): a viable option for biodiversity conservation and livelihood enhancement in Central Himalaya. *Biodiversity Conservation*, 20: 545-559.

Negi, Vikram, **R.K. Maikhuri**, L.S. Rawat, and P.C. Phondani (2010). Current status and future potential of fiber yielding crop *Hibiscus cannabinus* L. in mountains region of Central Himalaya, India. *Environment & We: an International Journal of Science & Technology*, 5:87-96.

Pandey, A., S. Chaudhry, A. Sharma, V.S. Choudhary, M.K. Malviya, S. Chamoli, K. Rinu, P. Trivedi and **L.M.S. Palni** (2011). Recovery of *Bacillus* and *Pseudomonas* spp from the 'Fired Plots' under Shifting Cultivation in Northeast India. *Current Microbiology*, 62 (1), 273-280.

Pant, S. and S.S. **Samant** (2010). Ethnobotanical observations in the Mornaula Reserve Forest of Kumaun, West Himalaya, India. *Ethnobotanical Leaflets*, 14: 193-217.

Panwar, S., D.K. Agrawal, **G.C.S. Negi**, K.S. Kanwal, V. Sharma, **M.S. Lodhi**, J. Singh and V. Bhatt (2010). Impact assessment of a hydroelectric project on the flora in the western Himalayan region based on vegetation analysis and socio-economic studies. *Journal of Environmental Planning & Management*, 53 (7): 907-923.

Phondani P. C., **R.K. Maikhuri**, L. S. Rawat, N. A. Farooquee, C.P. Kala, **S.C.R. Vishvakarma**, K.S. Rao and K.G. Saxena (2010). Ethnobotanical uses of plants among Bhotiya tribal communities of Niti valley in central Himalaya, India. *Ethnobotany Research and Application*, 8: 233-244.

Phondani P. C., **R.K. Maikhuri** and C. P. Kala (2010). Ethno-veterinary uses of medicinal plants among traditional herbal healers in Alaknanda catchment of Uttarakhand, India. *African Journal of Traditional, Complementary and Alternative Medicines (AJTCAM)*, 7 (3): 195-206.

Phondani, P.C., **R.K. Maikhuri**, L.S. Rawat, N.A. Farooquee, C.P. Kala, **S.C.R. Vishvakarma**, K.S. Rao and K.G. Saxena (2010). Ethnobotanical uses of plants among the Bhotiya tribal communities of Niti valley in Central Himalaya, India. *Ethnobotany Research and Aplications*, 8:233-244.

Phondani, P.C., **R.K. Maikhuri**, Vikram S. Negi, L.S. Rawat, Abhay Bahuguna and K.P. Chamoli (2010). Effect of provenance variation and temperature on seed germination of Himalayan Silver Birch *(Betula utilis* D. Don) in Central Himalaya. *National Academy Science Letter*, 33: 7-8.

Pradhan, B.K. and **H.K. Badola** (2010). Chemical Stimulation of seed germination in *ex-situ* produced seeds in *Swertia chirayita*, a critically endangered medicinal herb. *Res. Jour. Seed Sci.*, 3 (3): 139-149.

Rana, M.S. and **S.S. Samant** (2011). Population Biology of *Lilium polyphyllum* D. Don ex Royle – A Critically Endangered Medicinal Plant in a Protected Area of Northwestern Himalaya. *Journal for Nature Conservation*, 19(3): 137-142.

Rawat S., **I.D. Bhatt** and **R.S. Rawal** (2011). Total phenolic compounds and antioxidant potential of *Hedychium spicatum* Buch. Ham. ex D. Don in west Himalaya, India. *Journal of Food Composition and Analysis*, doi:10.1016/j.jfca.2010.12.005.

Rawat, L.S., R.K. Maikhuri, Vikram S. Negi, Abhay Bahuguna, K .S. Rao, Sunil K. Agarwal and K. G. Saxena (2010). Managing natural resources with eco-friendly technologies for sustainable rural development: A case of Garhwal Himalaya. *International Journal of Sustainable Development and World Ecology*, 17(5): 423-430.

Rawat, L.S., S.S. Narwal, H.S. Kadian and Vikram S. Negi (2011). Allelopathic effect of sunflower (*Helianthus annuus*) on germination and growth of *Parthenium hysterophoru. Allelopathy Journal*, 27(2): 225-236.

Rawat, L.S., Vikram S. Negi and **R.K. Maikhuri** (2011). Screening phytotoxicity of sunflower rhizoshere soil at various stages on crops and weeds. *National Academy Science Letter*, 34(1&2): 1-7.

Rawat, Lakhpat, Vikram Negi and **R.K. Maikhuri** (2010). Allelopathic effect of sunflower (*Helianthus annuus*) rhizosphere soil on germination and seedling growth of kharif crops and weeds. *National Academy Science Letter*, 33(9&10): 271-278.

Rawat, **S., A. Jugran, L. Giri, I.D. Bhatt** and **R.S. Rawal** (2010). Assessment of Antioxidant Properties in Fruits of *Myrica esculenta*: A Popular Wild Edible Species in Indian Himalayan Region. *eCAM*, doi:10.1093/ecam/neq055.

Rawat, Y.S, **S.C.R Vishvakarma**, S.S. Oinam, N.P. Todaria and **R.K. Maikhuri** (2010). *Salix fragilis* L.: Pollarding potential of willow in cold desert environment of the Lahaul valley, North-Western, Himalaya, India. *Range management and Agroforestry*, 31(1):1-6.

Rawat, Y.S., **S.C.R. Vishvakarma**, S.S. Oinam and **J.C. Kuniyal** (2010). Diversity, distribution and vegetation assessment in the Jahlmanal watershed in cold desert of the Lahaul valley, northwestern Himalaya, India. *iForest – Biogeosciences and Forestry*, 3: 65-71.

Rawat, Y.S., **S.C.R. Vishvakarma**, Santaram S. Oinam, N.P. Todaria, **R.K. Maikhuri** (2010). *Salix fragilis* L.: Pollarding potential in dry temperate environment of the North-Western Himalaya, India. *Range Management & Agroforestry*, 31(1): 1-6.

Rawat, Y.S. and **S.C.R. Vishvakarma** (2010). Diversity, distribution and utilization of fodder species in sub-temperate, temperate and cold desert region of the Himachal Pradesh, north-western, Himalaya. *Journal of American Science*, 6(6): 72-81.

Rinu K. and **A. Pandey** (2011). Slow and steady phosphate solubilization by a psychrotolerant strain of *Paecilomyces hepiali* (MTCC 9621). *World Journal of Microbiology and Biotechnology*, 27 (5): 1055-62.

Rinu, K and **A. Pandey** (2010). Temperature dependent phosphate solubilization by cold and pH tolerant species of *Aspergillus* isolated from Himalayan soil. *Mycoscience*, 51 (4): 263-271.

Sahani, A.K., (2010). Health and morbidity status of displaced people in upper Indravati dam in Kalahandi district of Orissa. *Man In India*, 90 (3-4): 573-581.

Samal, P.K., P.P. Dhyani and **Mihin Dollo** (2010). Indigenous medicinal practices of Bhotia tribal community in Indian Central Himalaya. *Indian Journal of Traditional Knowledge*, Vol.9(1):140-144.

Saran, S., **R. Joshi, S. Sharma,** H. Padalia, and V.K. Dadhwal (2010). Geospatial Modeling of Brown Oak (*Quercus semecarpifolia*) Habitats in the Kumaun Himalaya under Climate Change Scenario. *J. Indian Soc. Remote Sensing (Springer)*, 38: 535-547.

Sharma R.K., P.P. Dhyani and **S.S Samant** (2010). Toxic chemical in fruits and vegetables: an overview. *Everyman's Science*, 45 (04): 215-218.

Sharma, N.L., **J.C. Kuniyal**, M. Singh, M. Sharma and R.P. Guleria (2011). Characteristics of aerosol optical depth and Ångstrom parameters over Mohal in the Kullu valley of northwest Himalayan region, India. *Acta Geophysica*, 59(2): 334-360.

Sharma, P., S. Vidyarthi and N.K. Mishra (2010). Medicinal uses of plants in and around a cement factory in Bilaspur district of Himachal Pradesh, North-Western Himalaya. *Journal of Non-Timber Forest Products*, 17(4): 477-486.

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.

Sharma, R.K., M. Agrawal and S.B. Agrawal (2010). Physiological, biochemical and growth response of lady's finger (*Abelmoschus esculentus* L.) plants as affected by Cd contaminated soil. *Bulletin of Environmental Contamination and Toxicology*, 84: 765-770

Singh K.K. Gurung, B., **Rai, L.K.** and L.H. Nepal, (2010). The influence of temperature, light and pre-sowing treatment on the seed germination of an endangered Sikkim Himalayan Rhododendron (*R. niveum* Hook f.). *Journal American Science*, 6(8): 172-177.

Singh, K.K. (2009). Notes on the Sikkim Himalayan Rhododendrons: a taxa of great conservation importance. *Turkish Journal of Botany*, 33: 305-310.

Singh, S., **A. Pandey**, B. Kumar and **L.M.S. Palni** (2010). Enhancement in growth and quality parameters of tea [*Camellia sinensis* (L.) O. Kuntze] through inoculation with arbuscular mycorrhizal fungi in an acid soil. *Biology and Fertility of Soils*, 46, 427-433.

Sridevi Jade, H.J.Raghavendra Rao, M.S.M.Vijayan, V.K.Gaur, B.C. Bhatt, **Kireet Kumar**, Saigeetha Jaganathan, M.B.Ananda and P.Dileep Kumar (2010). "GPS –derived deformation rates in northwestern Himalaya and Ladakh", *International Journal of Earth Science (Geol Rundsch)*. (DOI 10.1007/s00531-010-0532-3).

Tarak, Doi, Roshmi Koyu, **P.K. Samal** and S.P. Singh (2009). Wild vegetable plants used by Galo tribe of west Siang district, Arunachal Pradesh. *Bulletin of Arunachal Forest Research*, 25 (1 & 2): 34-36.

Vashistha, R.K., **J.S. Butola,** B.P. Nautiyal and M.C. Nautiyal (2010). Phenological attributes of *Angelica* species expressed at two different climatic zones in western Himalayas, Uttarakhand. *Online Access Journal of Medicinal & Aromatic Plants*, 1 (1): 07-12.

Vikram S. Negi, **R.K. Maikhuri**, P.C. Phondani and L.S. Rawat (2011). An inventory of indigenous knowledge and cultivation practices of medicinal plants in Govind Pashu Vihar Wildlife Sanctuary, Central Himalaya, India. *International Journal of Biodiversity Science, Ecosystem Services and Management*, 6 (3 & 4): 96-105.

(II) Chapter in Books/Proceedings

Badola, H.K. (2010). Phenology and climate responses in Himalayan rhododendrons. In: A. Mainra, H.K. Badola & B. Mohanty (Eds.) *Proceedings of International Conference, Rhododendrons: Conservation and Sustainable Use*, FEWMD, Government of Sikkim, Gangtok-Sikkim. Printed at CONCEPT, Siliguri, India. pp. 48-59.

Bhatt, I.D., L. Giri, R.S. Rawal and **K. Chandra Sekar** (2010). Diversity, distribution and economic potential of genus *Habenaria* (Family: Orchidaceae) in Indian Himalayan Region. In: L.M. Tewari, Y.P.S. Pangtey & G. Tewari (Eds.) *Biodiversity Potentials of the Himalaya*. Gyanodaya Prakashan, Nainital. pp. 351-362.

Dahal D.R., Sharma A.K., Joshi V., and **K. Kumar** (2010): Land-Use Land Cover study in Rongli Chu Watershed using

Remote Sensing and GIS: A case study of part Rani Khola River Basin, Proc. of the workshop on *Integrated Water Resource Management* held at Gangtok, Nov. 27, 2009, pp. 63-68.

Dhyani, Shalini, R.K. Maikhuri and Deepak Dhyani (2011). Participation of community in conserving biodiversity and managing natural resources: a case study of the Kedarnath Wildlife Sanctuary. Gokhali, Yogesh and Ajeet K. Negi (eds.), *Community-based Biodiversity Conservation in the Himalayas*. The Energy and Resources Institute, New Delhi, pp. 87-99.

Farooquee, Nehal A., Nabi Kant Jha and **R.K. Maikhuri** (2011). Changing livelihoods in cold desert: A case study from Niti valley in Indian Himalaya. In: Saxena, K.G., Luohui Liang and Xian Xue (eds.), *Global Change, Biodiversity and Livelihoods in Cold Desert Region of Asia*. Bishen Singh Mahindra Pal Singh, Dehradun, pp. 127-134.

Gawali, R., K.G. Saxena, K.S. Rao and **R.K. Maikhuri** (2011). Management of grazing lands in Indian cold desert: A village livel study from Spiti, India. In: Saxena, K.G., Luohui Liang and Xian Xue (eds.). *Global Change, Biodiversity and Livelihoods in Cold Desert Region of Asia*. Bishen Singh Mahindra Pal Singh, Dehradun, pp. 147-159.

Joshi, Gunjan and **G.C.S. Negi** (2011). Ecosystem services provided by Oak and Pine forests in the Western Himalayan region: some preliminary investigations. In: Singh, O. and V.R.R. Singh (eds.) *Proc. of IV National Forestry Conference*, FRI, Dehradun, pp. 386-390.

Kandari, L.S., K.S. Rao, **R.K. Maikhuri** and Abhishek Chandra (2010). Conservation and cultivation of medicinal plants for sustainable development in Nanda Devi Biosphere Reserve, Uttarakand, India. In: Kala, C.P. (ed.), *Medicinal Plants and Sustainable Development*. Novel Science Publishers, Inc., pp. 1-11.

Kothyari, B.P. and **P.P. Dhyani** (2010): Water resources: Quantity, quality and management. In, Sanitation and health in rural India: Problems and management options (edited by Kumar, A. and Bisht, B.S.), NIAR-LBSNAA Publ. (Governance Challenges Series, Volume 2), pp. 73-87.

Kothyari, B.P. and S.K. Bhuchar (2010). Eco-restoration of community land & associated livelihoods in mid altitudes of the central Himalaya. In: R.P. Yadav et .al (Eds), *Emerging Trends in Watershed Management*, Pp 461-475.

Lodhi, M.S. and **P.K. Samal** (2011). Hydropower development in Arunachal Pradesh: Policy issues in downstream impacts perspective. In: *S. Bhuyan, D. Baruah, B. Chutia and S. Borah (eds.)* Proc. of *Ecological and Social Socio-Economic Consequences of Large Dams,* National Seminar organized by Lakhimpur Girls College, Lakhimpur, Assam (India), pp. 20-29.

Maikhuri, R.K., L.S. Rawat, V. S. Negi, C.S. Negi, K.P. Chamoli, P.C. Phondani and Abhay Bahuguna (2010). The biosphere reserves: an institution for conservation, environmental research, education and development. In: Indoo Pandey Khanduri (ed.), *Human Freedom and Environment (Contemporary Paradigm and Moral Strategies)*, pp. 169-179.

Maikhuri, R.K., P.C. Phondani, K.S. Rao, R.L. Semwal, L.S. Kandari, Kusum Chauhan, L.S. Rawat, **Deepak Dhyani** and K.G. Saxena (2010). Ethnobiology and traditional knowledge of medicinal plants in healthcare system. In: Uniyal, P.L., B.P. Chamoli and D.P. Semwal (eds.). *The Plant Wealth of Uttarakhand*. Jagdamba Publishing Co., New Delhi, pp.369-379.

Maikhuri, R.K., Vikram Negi, Lakhpat Rawat, Prakash Phondani, Abhay Bahuguna, Deepak Dhyani, C.S. Negi, K.P. Chamoli and **S. Tarafdar** (2010). Involvement of Panchayatiraj Institutions (PRIs) in planning and implementation of eco-technologies for integrated rural development in central Himalayan region (Uttarakhand), In: Rawat, S.S., Sood C.S. and Sarita Panwar (eds.), *Panchayatiraj and Rural Development*, Research India Press, New Delhi, pp. 102-116.

Mazumdar, Kripal, Rakesh Soud, Lohit Gogoi, Pijush K. Dutta, and **Prasanna K. Samal** (2011). Avifauna of proposed Tsangyang Gyatso Biosphere Reserve: conservation prospective of high altitude avifauna in Western Arunachal Pradesh. In: Choudhury M.D., G.D. Sharma, S. Choudhury and A.D. Talukdar (eds.), *Status and Conservation of Bio-Diversity in North East India,* PP. 171-185, Swastik Publisher, New Delhi.

Mili Rajiv, **Mihin Dollo, Prasanna K. Samal** and **L Jitendro Singh** (2010). Shifting cultivation in North East India: Transition and contemporary issues. In Behera M.C. and Basar Jumyir (ed.). *Interventions and Tribal Development: Challenges before Tribes in India in the Era of Globalization*, PP.132-158. Serial Publications, New Delhi.

Nautiyal, Sunil, **R.K. Maikhuri**, K.S. Rao and K.G. Saxena (2011). Livelihood and natural resources in Asian cold desert: A case study from selected villages in central Himalaya. In: Saxena, K.G., Luohui Liang and Xian Xue (eds.), *Global Change, Biodiversity and Livelihoods in Cold Desert Region of Asia*. Bishen Singh Mahindra Pal Singh, Dehradun, pp. 161-176.

Negi, G.C.S., Vimla Bisht and D.K. Agrawal (2010). Tea plantation in the Central Himalaya: ecological and socio-economic impacts. In: L. M. Tiwari, Y.P.S. Pangtey and Geeta Tewari (eds.). *Biodiversity Potentials of the Himalaya*, Gyanodaya Prakashan, Nainital, pp. 495-520.

Negi, Vikram, **R.K. Maikhuri**, V.K. Purohit, Divya Dangwal, Shalini Mishra and N.A. Farooquee (2010). Value addition in potential wild edibles of central Himalaya for

sustainable livelihood and small scale enterprise development. In: Gupta, R.K. and R.T. Patil (eds.). *Processing Technologies for Value Addition of Minor Forest Produce in Tribal Areas: A Step in Rural Development*. Central Institute of Post Harvest Engineering & Technology, Ludhiana, pp. 413.

Palni, L.M.S., G.C.S. Negi and **R.K. Maikhuri** (2011). Climate change impacts on Central Himalayan Agroecosystems. In: V.N. Sharda, G.P. Juyal, O.P. Chaturvedi and M. Madhu (eds.), Proc. of Workshop on *Mountain Agriculture in Himalayan Region: Status, Constraints and Potentials*. CSWRTI, Dehradun, pp. 177-192.

Pandey, A., L.M.S. Palni, B. Kumar, A. Sharma, P. Trivedi, M.K. Malviya, K. Rinu., N. Aishvarya and P. Sati (2010). Extremophiles from Himalaya: Diversity, Bioprospecting and Conservation. In: Proceedings National Conference on Bioprospecting: Access for sustainable Development, (Eds) R Mathur, S Sharma, NK Singh Organized by Department of Applied Mechanics (Biotechnology), Motilal Nehru National Institute of Technology, Allahabad, pp. 1-8.

Rai, Y.K., R. Joshi, and **P.P. Dhyani** (2010): Sikkim ka prakritik evam paryavaraniya swaroop: Aik Avalokan. In, Himprabha (Vol. 3) [eds. Singh, R.G.], GBPIHED Publ., pp. 67-69.

Rawal R.S., M. Pandey, K. Kumar, R. Joshi & I.D. Bhatt (2010). Biodiversity representativeness and conservation: importance of biosphere reserve in Indian Himalaya: A case study in avian diversity In: L.M. Tewari, Y.P.S. Pangtey and G. Tewari (Eds.). *Biodiversity Potentials of the Himalaya*. Gyanodaya Prakashan, Nainital, pp. 351-362.

Rawat M.S., **V. Joshi , A.K. Sharma, K. Kumar** and Sundriyal Y.P.: (2010): Study of Landslides in Parts of Sikkim Himalaya, Indian Landslides (Scientific) Vol.-3, No.-2, November 2010, NIIM-Shillong, pp. 47-54.

Rawat, Y.S., **S.C.R. Vishvakarma,** S.S. Oinam and **J.C. Kuniyal** (2011). Supply and demand of fuel wood and fodder in cold desert of the Lahaul valley, North Western Himalya, Himachal Pradesh. *In Proceedings of IV National Forestry Conference*, (Eds) Singh, O. & V.R.R. Singh; pp 334-346. Forest Research Institute, Dehradun, 9-11 November, 2009.

Samant, S.S. and **L.M.S. Palni** (2010). Status and conservation issues of medicinal plants in the Indian Himalayan Region. In: *National Seminar on Medicinal Plants of Himalaya: Potential and Prospects, organized by Regional Research Institute of Himalayan Flora*, Tarikhet and Department of Ayush, Ministry of Health and Family Welfare, Govt. of India, New Delhi. Souvenir, pp. 1-5.

Samant, S.S., A. Singh, M. Lal & P. Sharma (2011). Diversity and Conservation Prioritization of Economically Important Species in Lahaul Valley, North-Western Himalaya, India. In K.G. Saxena, Luohui Liang & Xian Xue (Eds.) *Global Change, Biodiversity and Livelihoods in Cold Desert Region of Asia*, pp. 31-42.

Saxena, K.G., **R.K. Maikhuri** and K.S. Rao (2011). Ecotourism in Nanda Devi Biosphere Reserve: A win-win option for environmental conservation and sustainable livelihoods. In: Austrian MAB Committee (ed.), *Biosphere Reserves in the Mountains of the World: Execellence in the Clouds?* Austrian Academy of Sciences Press, Vienna, pp. 77-80.

Sharma A.K., **V. Joshi** and **K. Kumar** (2010). Landslides disasters in Sikkim and their possible mitigation measures, Indian Landslides (Scientific) Vol.-3, No.-2, November 2010, NIIM-Shillong, pp 55-60.

Singh, K.K. and **L.K. Rai** (2010). Assessment of endangered status and conservation initiatives on the rhododendrons from the Sikkim Himalaya. *Proceedings, International Conference, Rhododendrons: Conservation and sustainable use*, FEWMD, Government of Sikkim, Gangtok-Sikkim. In: Mainra, A., Badola, H.K. and Mohanty, B. (eds), pp.67-87

Vishvakarma, S.C.R., J.C. Kuniyal, Y.S. Rawat and S.S. Oinam (2011). Cold desert agro-ecosystem: a case study from Lahaul valley, India. In: **Global Changes, Biodiversity and Livelyhoods in Cold Desert Region of Asia.** (Eds) K.G. Saxena, Luohui Liang & Xian Xue. Bisen Singh Hahendra Pal Singh, Dehra Dun. An outcome of *International Workshop on "Environmental Conservation for Sustainable Livelihoods in the Cold Desert Regions of Asia" organized by JNU and UN University, Japan at Solan October15-17, 2008*, Pp 107- 126.

Vishvakarma, S.C.R., J.C. Kuniyal, Y.S. Rawat and S.S. Oinam (2011). Cold Desert Agro-ecosystem: A case study from Lahaul Valley, India. In: Saxena, K.G., L. Liang, and X. Xue (eds.) *Global change, biodiversity and livelihoods in cold desert region of Asia*. Singh, B. and M.P. Singh, Dehradun, pp.107-126

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

Ecotone: A quarterly newsletter on environment and Biodiversity (ISSN-0976-3589) published by Environ, Guwahati and North East Centre for Environmental Education and Research, Imphal (**K Majumdar: Editor-in chief**).

NeBIO: An international peer reviewed quarterly journal published by North East Centre for Environmental Education and Research (NECEER), Imphal (**K Majumdar: Managing Editor**).

Chandra Shekhar, K., I.D. Bhatt, R.S. Rawal, S.K. Nandi & P.P. Dhyani (2010). Promising fibre-yielding plants of the

Indian Himalayan Region. G.B. Pant Institute of Himalayan Environment & Development, Kosi – Katarmal, Almora – 263 643, Uttarakhand. pp. 1-48.

Kumar K., D.S. Rawat, S. Sharma, S.C.R. Vishvakarma, G.C.S. Negi, I.D. Bhatt, A.K. Sahni, K. Chandrasekar, R. Joshi and S. Airi (Investigators from GBPIHED: 2010). Kailash Landscape Conservation Initiative: Feasibility Assessment Report India, submitted MoEF, Govt. of India. (the report also contains a team of 5 investigators from WII, Dehra dun)

Mainra, A., **H.K. Badola** and B. Mohanty (2010). Proceedings of International Conference on *Rhododendrons: Conservation and Sustainable Use*, Forest Environment & Wildlife Management Department, Government of Sikkim, Gangtok-Sikkim, India. Printed at CONCEPT, Siliguri, India. 100 p.

Palni, L.M.S., K. Kumar, R. S. Rawal and **R. Joshi** (Contributors from GBPIHED: 2010). Climate Change Impact Assessment in the North-Western Himalaya" for the Indian Network for Climate Change Assessment (INCCA): Climate Change and India-A 4x4 assessment report; submitted MoEF, Govt. of India. (the report also includes a team of investigators from other institutions).

Palni, LMS and **S. Sharma** (2010). Compendium of Statistics for the States of Indian Himalayan Region. GB Pant Institute of Himalayan Environment & Development, Kosi-Katarmal, Almora.

P.P. Dhyani (2010). ENVIS Bulletin on Himalayan Ecology 18: 1-74 (2010)

P.P. Dhyani (2010). ENVIS Newsletter on Himalayan Ecology 7: 1-12 (2010).

Samant, S.S. (2010). *Jaiv Vividhta Sanrakshan Main Janta Ki Bhagidari - III.* GBPIHED, Himachal Unit, Mohal-Kullu, Himachal Pradesh.

(IV) Popular Articles

Badola, H.K. (2010). *Picrorhiza kurrooa*, an endangered medicinal plant offering high commercial potential in Himalaya. *Non Wood News, Rome* 21: 11-12.

Bahukhandi, A., S. Rawat, I.D. Bhatt and **R.S. Rawal** (2010). Antioxidant potential of *Acorus calamus* A medicinal plant in Himalaya. *Hima Paryawaran* 21: 28-19.
Bhutia, D.T. Joshi, V., Rai, L.K., Singh, K. K. (2010). Perceived Impact of climate related parameters and adaptation measures at Pangolakha wildlife sanctuary, East Sikkim. Hima-Paryavaran 22(1): 15-17.

Devi, S., **R.K. Sharma** and **P.P. Dhyani** (2010). Single and combined effects of copper and zinc on tomato (*Lycopersicon esculentum* L. var.Him Sohna) seeds. *Hima-Paryavaran*, 22 (1): 14-15.

Ghosh, P. (2010). Importance and diversity of nematodes in central Himalayan agro-ecosystem. *Hima-Paryavaran* 22 (1):23-24.

Joshi, R. and **P. P. Dhyani** (2010). Tourism in Sikkim – An Overview and Analyses. *Hima – Paryavaran,* 21 (1 & 2): 18-20.

Kholia, B.S., **R. Joshi, P.S. Das** and U. Lachungpa (2010). International Year of Biodiversity – Revisiting Curricula for Conservation, *Current Science,* 99 (12): 1637.

Kuniyal, J.C., H.K. Thakur and **K. Chand** (2010). Solid waste management in the Himalayan towns: a waste to energy initiative in Himachal Pradesh. *Hima – Paryavaran,* 22(1) June 2010, pp. 20-22.

Lodhi, M.S. and K.Majumdar (2011). Living with hazards and dealing with disasters: curse of Arunachal Pradesh. *Envis Bulletin,* 17:19

Maikhuri, R.K. Vikram S. Negi, and L.S. Rawat (2010). Paryavaraniye anukul taknikiyon ke maadhyam se prakratik sansadhano ka samuchit dohan v aajeevika sudhar: G.B. Pant Himalayan Paryavaran evam Vikas Santhan ki bhumika. *Him Prabha - Raajbhasa Patrika,* 21-24.

Maikhuri, R.K., P.C. Phondani and Vikram S. Negi (2010). Dharti par jeevan ki nirantarta ka aadhar jaiv vividhta, *Regional Reporter*, 36-37

Maikhuri, R.K., Prakash Phondani and Vikram Negi (2010). Jaivvividhata: Dharti par jeevan ki nirantarta ka adhar. *Regional Reporter*, September, 36-37.

Negi, Vikram S. and **R.K. Maikhuri** (2011). Legume crops: Nutritional and livelihood security to hill farmers *HIMA-Paryavaran Newsletter*, 22(1): 22-23.
Negi, Vikram, **R.K. Maikhuri** and Prakash Phondani (2010). Parvatiya kshetra ki Paramparik phasalein. *Regional Reporter,* March, 28-29.

Negi, Vikran, **R.K. Maikhuri** and Lakhpat Rawat (2010). *Hibiscus cannabinus* (Sann): an important unexploited fibre plant of Uttarakhand. *HIMA-Paryavaran Newsletter*, 21(1&2), 24-25.

Phondani, P.C., **R.K. Maikhuri** and Vikram S. Negi (2011). Kedar ghati mai ek Sanskritic dharohar hai "Gothi". *HIMA-Paryavaran Newsletter*, 22(1): 28-30.

Pradhan, B.K. and **H.K. Badola** (2010). *Swertia chirayita*, a high value endangered medicinal herb: potential in north-east India. *Ecotone*, 2(1): 24-27.

R. K. Maikhuri and **Vikram S Negi** *(2011).* Agroforestry for ecological and economic benefits, *LEISA India*, 10-11, June 2011.

Sahani, A.K., (2010). Outmigration in Uttarakhand. *Hima-Paryavaran*, 22 (1).

Sharma A.K., **V. Joshi** and **K. Kumar** (2010). Use of Remote Sensing and Geographic Information System in Disaster Management in Gangtok area, Sikkim, GIS Development.net, Vol. 6, Issue 16

Sharma, A., **S.S. Samant** and **P. Sharma** (2010). Himachal Pradesh ki vanspati tatha uska vitran. In: S.S. Samant (Ed.) *Jaiv Vividhta Sanrakshan Main Janta Ki Bhagidari - III.* Booklet in Hindi by GBPIHED, Himachal Unit, Mohal-Kullu-175126, Himachal Pradesh. pp. 8-12.

Sharma, P., A. Sharma and **S.S. Samant** (2010). Himachal Pradesh ke sanrakshit Kshetva. In: S.S. Samant (Ed.) *Jaiv Vividhta Sanrakshan Main Janta Ki Bhagidari - III.* Booklet in Hindi by GBPIHED, Himachal Unit, Mohal-Kullu-175126, Himachal Pradesh. pp. 24-39.

Sharma, P., M.S. Rana and **S.S. Samant** (2010). Nargu Vanya Jeev Abhyaran ki pramukh chara aur endhan prajatiyain. In: S.S. Samant (Ed.) *Jaiv Vividhata Sanrakshan Main Janta Ki Bhagidari - III.* Booklet in Hindi by GBPIHED, Mohal-Kullu-175 126, Himachal Pradesh. pp. 40-43

Sharma, P., S. Vidyarthi and **S.S. Samant** (2010). Harnessing economic potential of Hemp (*Cannabis sativa* L.) in Himachal Pradesh. *Him-Paryavaran*, 22 (1): 18-20.

Sharma, R.K., Dhyani, P.P. and **Samant, S.S.** (2010). Pesticide residues in food chain: An issue of socio-economic development for the marginal farmers of Kullu, Himachal Pradesh. *ENVIS Newsletter on Himalayan Ecology*, 7: 8.

Sharma, R.K., Dhyani, P.P. and **Samant, S.S.** (2010). Toxic chemicals in fruits and vegetables-An overview. *Everyman's Science*, 45 (4) : 215 - 218.

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*, Vol. 18 (Accepted).

Wangjen K., K. Majumdar, **S.C. Arya** and **P.K. Samal** (2010). Traditional *Piper betel* farming: linking market and conservation by the Wancho community of Arunachal Pradesh. *Hima Paryavaran*, 22(1): 17-18.

2. PATENT

Pandey, A. and **L.M.S. Palni** (2010). 'A method of hardening of tissue culture raised tea plants'. Patent number: KE 303.

3. AWARDS AND HONOURS

Elected as Fellow of the National Academy of Sciences, India (F.N.A.Sc.), by the NASI in the year 2010 **(S.S. Samant)**.

A National level award was confered as 'SCHOLL Research Challenge Award – 2010' under '*Sustainable Development and Preservatoion of Ecosystem*' category organized by North East Development Foundation (NEDF), New Delhi and National Foundation for India in collaboration with Internation Development Research Center (IDRC) (Award value: 25000), February 11, 2011, Guwahati **(Lodhi, M.S.)**.

Member : Working Group for Preparing Roadmap for the Forestry Research, Education and Extension Sector in India, Ministry of Environment and Forests (MoEF), Govt. of India (Group 3 : Interface with State Governments; Coordinator – Secretary, ICFRE, Dehradun; Convener - Director, FRI, Dehradun), October 2010 **(P.P. Dhyani)**.

Participation of Institute Faculty/Project Staff in Different Events:

Events	HQs	Units				*Total*
		NE	Sikkim	Garhwal	HP	
National						
• Symposia / Conferences / Workshops	29	25	13	06	29	**102**
• Training Courses	14	05	25	08	06	**58**
• Meetings	41	06	16	03	09	**75**
• Participation as a Resource Person	26	10	60	06	66	**168**
• Any Other	06	01	16	00	25	**48**
International	12	00	04	06	03	**25**

ANSUL AGRAWAL & CO.
Chartered Accountants
Sela Khola, Chaughan Pata, Near P.W.D. Office, Almora – 263 601 (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, 2011. 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 it 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:

As per notes on accounts\observations

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, 2011.
ii) In the case of Income & Expenditure accounts of the INCOME of its accounting year ending 31st MARCH, 2011.

FOR ANSUL AGRAWAL & Company
CHARTERED ACCOUNTANTS

Sd/-

C.A. ANSUL AGRAWAL
(PARTNER)

SEAL

DATED: 12/09/2011
PLACE: ALMORA

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

BALANCE SHEET AS ON 31ST MARCH 2011

PARTICULARS	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
CORPUS / CAPITAL FUND	1	61481057.71	54154882.92
RESERVE AND SURPLUS	2	404028310.17	405665244.81
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	73850837.23	59013786.08
TOTAL		**539360205.11**	**518833913.81**
ASSETS			
FIXED ASSETS	8	404028310.17	405665244.81
INVEST. FROM EARMARKED/ENDOWMENT FUND	9	52622055.92	29396720.48
INVEST. OTHERS	10	0	0.00
CURRENT ASSETS, LOANS, ADVANCES ETC.	11	82709839.02	83771948.52
MISCELLANEOUS EXPENDITURE			
TOTAL		**539360205.11**	**518833913.81**
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

Sd/-
(CA. ANSUL AGRAWAL)
PARTNER
M No. 092048

DATED: 12/09/2011
PLACE: ALMORA

Sd/ -
(DR. L.M.S. PALNI)
DIRECTOR

Sd/-
(Dr. S.C.R. Vishvakarma)
D.D.O

Sd/-
(K.K. Pande)

Sd/
(K.K. Pande)
Finance Officer

SEAL

G.B.PANT INSTITUTE OF HIMALIYAN ENVIRONMENT & DEVELOPMENT
KATARMAL, KOSI (ALMORA) Uttarakhand

INCOME & EXPENDITURE A/C FOR THE YEAR ENDED 31ST MARCH 2011

PARTICULARS	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
INCOME			
Income from Sales/Services	12	254466.50	216376.00
Grants/Subsidies(net off exp)	13	120067716.94	115572356.8
Fees/Subscriptions	14	0.00	0.00
Income tfr from Fixed Assets fund (to the extent of depreciation & WDV of asset sold)	-	20101215.14	19023565.61
Income from Royalty,Income from Inv. Publication etc.	16	0.00	220.00
Interest Earned	17	2129872.41	1451676.00
Other Income	18	2324585.88	2481805.00
Increase (decrease) in stock of Finished goods and work in progress)	19	0.00	0.00
TOTAL (A)		**144877856.87**	**138745999.36**
EXPENDITURE			
Establishment Expenses: a) Institute	20	46600236.00	50503939.00
b) Projects		8602695.00	7974548.00
c) F.C (Projects)		1687892.00	875069.00
Administrative Expenses : a) Institute	21	35065277.94	34949584.75
b) Projects (As per Annexure)		16366781.00	12533084.00
c) F.C (Projects)(As per Annexure)		4989405.00	974782.00
Expenditure on Grants, Subsidies etc.	22	6755430.00	7761350.00
Interest			0.00
Depreciation (Net Total at the year-end-as per Sch. 8)		20101215.14	19023565.61
TOTAL (B)		**140168932.08**	**134595922.36**
Balance being excess of Income over Expenditure (A - B)			0.0
Transfer to special Reserve			**0.00**
Transfer to/ from General Reserve			**0.00**
BAL.BEING SURPLUS TRF.TO CORPUS/CAPITAL FUND		**4708924.79**	**4150077.00**
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

Sd/-
(CA. ANSUL AGRAWAL)
PARTNER
M No. 092048

DATED: 12/09/2011
PLACE: ALMORA

Sd/-
(DR. L.M.S. PALNI)
DIRECTOR

Sd/-
(Dr. S.C.R. Vishvakarma)
D.D.O

Sd/-
(K.K. Pande)
Finance Officer

SEAL

G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT, KATARMAL, KOSI (ALMORA) Uttarakhand
RECEIPTS & PAYMENTS A/C FOR THE YEAR ENDED 31ST MARCH 20 11

RECEIPTS	CURRENT YEAR	PREVIOUS YEAR	PAYMENTS	CURRENT YEAR	PREVIOUS YEAR
I. Opening Balances			**I. EXPENSES**		
a) Cash in hand	35553.49	175983.09	**a) Establishment Expenses**	44153200.91	39821523.00
			I) Institute		
b) Bank Balances			**b) Administrative expenses**		
			a)Institute	22303625.94	26693548.00
i) In current accounts	11502199.80	12207958.84	b)R&D(Rev) expenses	12606240.00	12474061.00
ii) In deposit accounts (Coppus Fund)	29396720.48	26920216.48	c) Payments for current liabilities (gratuity/leave)	795216.00	213199.00
iii) Savings accounts	37756130.41	17868236.48	**C. Capital expenditure**		
c) Advances & Others	56292508.77	50080885.65	a) Purchase of Fixed Assets	10992538.00	17901846.00
(As per annexure Attached)			b)Expenditure on Capital Work in Progress	0.00	3819700.00
F.C. ACCOUNT			c) Aquirement of land (Lease money)	0.00	0.00
A) Cash in hand	10321.33	6439.33	**II Payments made against funds for various proj.**		
b) Cash at bank	3299753.07	907187.67	**Expenditure State govt. projects**		
c)FC Advances	0.00	0.00	a) Capital	5677168.00	4642304.00
II. Grants Received			b) Revenue:		
a) From Government of India			Establishment exp	7774916.00	7659217.00
i) Institute	110000000.00	91470291.00	Administration exp	16355751.00	12499599.00
ii) IERP Projects	0.00	8500000.00	**Expenditure FC projects**		
b) From Other agencies	34390812.00	28621302.00	**a) Capital**	1794432.00	0.00
c) From other sources [from FC]	6230998.47	5475560.57	b) Revenue:		
III. Income on Investments from			Establishment exp	1684940.00	843980.00
			Administration exp	4989405.00	974782.00
a) Corpus Fund	2617250.00	2476504.00	**IERP grant released**	6755430.00	7761350.00
			III Investments and deposits made		
IV. Interest Received					
a) On Bank deposits savings a/c	1851593.41	1159524.00	a) Corpus Fund	2617250.00	631016.00
b)On term deposits a/c	25767.00	0.00			
b) Loans, Advances etc.	252512.00	289224.00	**IV Refund of Surplus money/Loans**		
			a) To the Government of India	1128864.00	241169.00
V. Other Income			b)To Others/ security/ caution money)	1000.00	367193.00
			V Other payments		
(As per annexure Attached)	2579052.38	2723957.00	Other Payment to Instt. FC Proj.	0.00	
VI. Amount Borrowed		0.00	Current liabilities	6412952.97	3324013.44
VII. Any other receipts.	0.00	286552.00	**VI Closing balances**		
b) Advance FC a/c	2036605.17	0.00	**a) Cash in hand**	128345.13	35553.49
c) receipts current liabilities	0.00	3334851.68	**b) Bank Balance**		
d) IERP grants refunded by grantee Org.	223125.50	805779.00	I) In Current account	7273271.40	11502199.80
e)Construction Fund		0.00	ii) In deposit accounts (Corpus Fund)	20931307.92	29396720.48
			III) In savings accounts	34235962.93	37756130.41
.....	0.00	24830235.00	**Cheque in transit:**	769171.00	0.00
g) Caution Money	1000.00	2500.00	**C) Advances and others**	88853165.03	56292508.77
h) Security Deposit	100000.00	18500.00	**FC Project**		
			a) Cash in hand	27798.33	10321.33
			b) Bank Balance	339951.72	3299753.07
TOTAL	**298601903.28**	**278161687.79**	**TOTAL**	**298601903.28**	**278161687.79**

AUDITOR'S REPORT
As per our separate report of even date annexed.
FOR: ANSUL AGRAWAL & CO.
CHARTERED ACCOUNTANTS
Sd/-
(CA. ANSUL AGRAWAL)
PARTNER
M No. 092048
DATED: 12/09/20113-07-2008
PLACE: ALMORA
Finance Officer

SEAL

Sd/-
(DR. L.M.S. PALNI)
DIRECTOR
Sd/-
(Dr. S.C.R. Vishvakarma)
D.D.O
Sd/-
(K.K. Pande)

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

ANNEXURE FORMING PART OF RECEIPT/PAYMENTS A/C AS ON 31 MARCH 201 1

STATEMENT OF OPENING & CLOSING BALANCES

PARTICULARS	OPENING AMOUNT	CLOSING AMOUNT
Cash & Bank Balances		
Cash In Hand :		
Srinagar	5299.85	4632.85
Sikkim	1429.00	6078.00
Kullu	60.36	12061.40
Itanagar	22378.16	24658.16
Grant in aid in transit (Biotech-XIII)	184000.00	184000.00
Cheque in transit: (Srinagar)	17607.00	769171.00
Cash at Bank Balances		
SBI Almora A/c No.10861378091 (Corpus)	56423.48	20931307.92
SBI Tadong A/c No 11226047758	1490154.17	416122.84
SBI Kullu A/c NO. 10792147561	1391636.82	920181.78
SBI Itanagar A/c No 10940060114	3966888.63	3487038.78
SBI Srinagar A/c No 10972182864	686006.53	1015119.53
Advances		
House Building Advance	2656443.00	2082467.00
Motor cycle/Car Advance	250903.00	182575.00
Festival Advance	21600.00	31500.00
C.P.F	36.00	71.00
Income tax deducted at source	191498.00	191498.00
Units of Institute:		
Sikkim Unit	-33518.23	-74894.23
HP Unit	-220840.00	-221110.00
Garhwal Unit	16123.00	25000.00
NE Unit	0.00	14300.00
FC Advances:		
ICIMOD RSR (LOA-I)Director, Wild Life Dehradun	0.00	729000.00
ICIMOD RSR (LOA-III)Director, Wild Life Dehradun	0.00	270250.00
ICIMOD RSR (LOA-I)M/S TATA Motars N. Delhi	0.00	941990.00
E.T.& T.N.DELHI(INDO -CANADIAN SUMMER)	2880.00	2880.00
NRSA HYDERABAD(PARDYP)	258720.00	32274.00
Kasar Jungle Resort (Kailash Workshop)	25000.00	0.00
Kalmatiya Sangam (Kailash Workshop)	50000.00	0.00
Fixed Deposit		
Corpus Fund FDR'S	24830235.00	26051545.00
Interest Accrued on Corpus fund FDR	4510062.00	5639203.00
FDR (Margin Money/LC A/C)		
Institute	251364.00	6364.00
BIOTECH -XI	577.00	577.00
ISRO-JCK-EO (HP Unit)	815000.00	625000.00
DST Rinu -K Project	450000.00	0.00
DST-JCK-HP Unit	3445000.00	0.00
TOTAL:	**45342966.77**	**64300862.03**

G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOP MENT
KATARMAL, KOSI (ALMORA) Uttarakhand

BROUGHT FORWARD	**45342966.77**	**64300862.03**
Due Staff/ other IC A/c		
Dr. Vineeta Jagtap	4000.00	0.00
Dr. L.M.S. Palni	0.00	120000.00
Ms. Sarita Bagdwal	0.00	50000.00
STUP Consultant	0.00	(7435.00)
LICOR INC USA	0.00	54460.00
Post Master G.P.O Tadong (Sikkim)	213.00	0.00
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	0.00	243702.00
Adv. to NIH Roorkee	0.00	100000.00
DST (LMS) ILTP NRSA Hyderabad		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	2912596.00
Security Deposit CET Sikkim Unit	11000.00	11000.00
Uttranchal Renewal (UREDA)	165000.00	0.00
Uttranchal Renewal (UREDA) LDA Project	0.00	50386.00
Dr. S.C. Joshi (TA)	0.00	0.00
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	2500.00
M/s CCU New Delhi	924898.00	11291753.00
Security Deposit NE Unit	1750.00	1750.00
M/s Delta T-Devicies, England	46881.00	0.00
NCADMS, Itanagar (MOE&F CC-II)	-82270.00	756098.00
N.E. Regional Institute, Itanagar (MOE&F CC-II)	611411.00	1449779.00
EE R.E.S. Almora (MOE&F (BG) RSR	2952000.00	3402000.00
EE R.E.S. Almora Insitute	1107855.00	1571000.00
MOE&F (S. Sharma) NRSA Hyderabad	147000.00	0.00
WWF New Delhi (UNDP-CEF-GOL) NE Unit	931823.00	1210829.00
Director State Forest Research Institute (UNDP-CEF-GOL) NE Unit	656711.00	656711.00
Dr. Hari Ballabh MoE&F Hydropower Project	0.00	12000.00
E E R.E.S. Almora (HRDI I.D.B. Project)	0.00	59000.00
T O T AL	**56292508.77**	**88853165.03**

G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT

KATARMAL, KOSI (ALMORA) Uttarakhand

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 20 11

SCHEDULE 8 - FIXED ASSETS
(DETAILS A S PER ANNEXURE ATTACHED)

SL. 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	4069026.00	0.00	0.00	4069026.00	0.00	135634.00	0.00	135634.00	3933392.00	4069026.00
2	BULDING:										
	a) On Freehold Land	214751988.00	0.00	0.00	214751988.00	26184259.41	3500457.40	0.00	29684716.81	185067271.19	188567728.59
3	PLANT MACHINERY & EQUIPMENT										
	a) Scientific Equipments	155444891.11	8439420.00	3000.00	163881311.11	65802683.91	7784362.28	142.50	73586903.69	90294407.42	89642207.18
4	VEHICLES	8548737.25	0.00	680778.00	8267959.25	5809451.35	831151.29	680778.00	5959824.64	2308134.61	3139285.91
5	FURNITURE FIXTURES	22482857.40	1182690.00	0.00	23665547.40	12756027.00	1498029.15	0.00	14254056.15	9411491.25	9726830.41
6	OFFICE EQUIPMENT	19420282.35	2386786.00	0.00	21807068.35	7642422.34	2071671.49	0.00	9714093.83	12092974.52	11777860.00
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	40539.75	2895.70	0.00	43435.45	17526.56	20422.25
9	LIBRARY BOOKS	79672605.50	6458242.00	0.00	86130847.50	30900835.58	4091215.26	0.00	34992050.84	51138796.66	48771769.93
10	TUBE WELLS & W. SUPPLY										
11	OTHER FIXED ASSETS										
	GLASS / NET HOUSE	3911549.00	0.00	0.00	3911549.00	2537199.69	135798.58	0.00	2722998.27	1188550.73	1374349.31
	TOTAL OF CURRENT YEAR	**508838537.84**	**18467138.00**	**683778.00**	**526621897.84**	**151673419.03**	**20101215.14**	**680920.50**	**171093713.67**	**355528184.17**	**357165118.81**
	PREVIOUS YEAR	**475476767.09**	**33379377.75**	**0.00**	**508856144.80**	**132667460.42**	**19023565.61**	**0.00**	**151691026.03**	**357165118.81**	**357165118.81**
	B CAPITAL W I P										
	Aquirement of land (Lease money)	0	0.00	0	0.00	0.00	0	0	0	0.00	0.00
	CCU Delhi	48500126.00	0.00		48500126.00	0.00	0.00	0.00	0.00	48500126.00	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	**557338663.84**	**18467138.00**	**683778.00**	**575122023.84**	**151673419.03**	**20101215.14**	**680920.50**	**171093713.67**	**404028310.17**	**405665244.81**

* An amount of Rs. 135634.00 towards rent of leased land value has been written off.

SEAL

INSTITUTE SUPPORTING STAFF

HEAD QUARTERS

K.K. Pande	Finance Officer
Surya Kant Langayan	Accounts Officer
L.M.S. Negi	Office Superintendent (Admn.)
Sanjeev Higgins	Technical Gr. – III(2)
Mritunjay Anand	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
D.K. Agrawal	Scientist-E	Soil & Water Conservation Engg; Impact Assessment
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
S.C. Joshi	Scientist-E	Plant Physiology; Stress Physiology
J.C. Kuniyal	Scientist-D	Development Geography; Waste Management
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
Varun Joshi	Scientist-C	Environmental Geology
Ranjan Joshi	Scientist-C	Ecology Economics; Resource Valuation
L.K. Rai	Tech. Grade IV (3)	Plant Taxonomy
Y.K. Rai	Tech. Grade IV (3)	Rural Ecosystems

GARHWAL UNIT

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Paromita Ghosh	Scientist-C	Plant Science; Soil Science
S. Tarafdar	Scientist-C	Weather & Climate Change; Glaciology; Hydrology

NORTH-EAST UNIT

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M.S. Lodhi	Scientist-C	Environmental Assessment
S.C. Arya	Scientist-B	High Altitude Ecology
S. Chaudhary	Tech. Grade IV (2)	Conservation; Biological Diversity