ANNUAL REPORT
2007-2008

G.B. Pant Institute of Himalayan Environment & Development
(An Autonomous Institute of Ministry of Environment & Forests, Govt. of India)
Kosi-Katarmal, Almora 263 643, Uttarakhand, India

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Foreword

As the Eleventh Five Year Plan started reverberating and the Institute completed its 18 years of existence we made concerted efforts to review and introspect through extensive consultation with a wide range of stakeholders. And it was through this exercise we came up with VISION-2015 that envisages bringing in interdisciplinary collaborative research up front so that stake holder driven research agenda becomes our guiding principle in all our activities.

Thus the reporting period (2007-08) was to test our ability to respond to this changing paradigm of working as a Developmental Research Institute. And we made it happen through focused action oriented research, institutional collaborations and stakeholder's involvement as key elements to strengthen our methodological approach and scale up outreach. The Institute has carved its own niche in the International arena too. An impressive foundation has been laid to build a successful future through timely beginning of all identified topical and need based research programmes. It is committed to deliver products that are applicable, benefit all stakeholders and ensure ecological and economic security of the region.

The Institute made considerable advancement in achieving its R&D objectives. Among others, establishment of 'Glacier Study Centre' to study glacier response to climate change; precision monitoring of glacier snouts using Kinematic GPS survey; strengthening of permanent GPS network by establishing three new stations at Srinagar -Garhwal (Uttarakhand), Kullu (Himachal Pradesh), and Nainital (Uttarakhand); establishment of participatory training and action research centre at high altitude village Triyuginarayan; designing and establishment of models for Integrated Fish Farming in hills, and successful completion of several R&D activities initiated during 10th plan period, were the notable achievements of the year.

Organization of on-site training programmes, orientation courses and exposure visits on environment-friendly rural technologies, biodiversity conservation, natural resource management, and disaster management remained major focus for improving Institute's outreach. Further, strengthening of location specific R&D activities in nine states of Indian Himalayan Region through Integrated Eco-development Research Programme (IERP) and ensuring synergy of IERP projects with Institute's thematic thrusts and regional priorities also deserve special mention.

The Institute seeks to sustain unique value of its R&D contribution through induction and retention of high quality research, technical and scientific staff along with the infrastructure and service facilities that are compatible with international standards. The apex bodies of the Institute provided enormous support in achieving all these. The Institute thanks all those who contributed in this direction.

As the Director of this Institute, this would be my last report. During my stay in the Institute for over 18 years and as the Director for the past five years I thoroughly enjoyed working with all my colleagues, distinguished Chairpersons and members of the Society, Governing Body and Scientific Advisory Committee and, of course, the officers of the Ministry of Environment and Forests, Government of India. I take this opportunity to thank all those who helped me to build this Institute through their critique and invaluable inputs.

(Uppeandra Dhar)
Director

Major Achivements (2007-08)

1. Geohydrological research on springs of western Himalaya revealed that the broadleaf forests, moderately sloping terraces with deep soil and phyllitic-quartzite rocks in the recharge zone are conducive for improved spring water yield.
2. Glacier Study Centre was established as a unit of GBPIHED to study glacier response to climate change. Precise monitoring of Glacier snout using Kinematic GPS survey was carried out in Gangotri glacier and Milam glacier valleys for the first time with the help of this Centre.
3. Installation of three new permanent GPS stations at Srinagar (Garhwal), Kullu (Himanchal Pradesh) and Nainital (Uttarakhand) has been done as part of National GPS network of MoES, Govt. of India.
4. Establishment of participatory training and action research centre at high altitude village Triyuginarayan (2200 m asl), Garhwal Himalaya on land provided by the village community for demonstration, skill development and capacity building of local communities and other stakeholders in the area.
5. Successful completion of: (i) social and environment impact assessment of river rafting and camping on Ganga; (ii) activity on Biosresource Inventory of the Himalaya including inventory of (a) temperate plant families (50); (b) Orchids of IHR (886 spp; 152 genera); (c) medicinal plants of Himachal Pradesh (626 spp; 47% endemics); and (d) avifauna of west (482 spp.) and North East Himalaya (770 spp.).
6. Promoted outreach through conservation education programme in schools: (i) important training on biodiversity conservation; (ii) strengthened school conservation models; and (iii) generated datasets on weather and biodiversity.
7. Generated datasets on floristic diversity for the Kais, Khohkan and Manali Wildlife Sanctuaries and Lahaul valley of the proposed Cold Desert Biosphere Reserve in Himachal Pradesh.
8. Establishment of a sacred forest with people's participation at Kolidhaik village of Champawat district (Uttarakhand) for eco-restoration and biodiversity conservation.
9. Successful mass scale in-vitro propagation of genetically uniform 'maggar' bamboo plants was carried out.
10. Established 3 models for Integrated Fish Farming (IFF) in Kumaun Himalaya (1100-1600 m amsl), which resulted in an annual net gain of 3-4 times of the investment made by the beneficiary families.
11. Imparted 3 days training programmes (24) to 576 males and 384 females through Rural Technology Centre of the Institute.
12. Strengthening and continuation of location specific R & D activities in 9 states of Indian Himalayan region under IERP program.

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 2007-08 is as follows:

Watershed Processes and Management (WPM)

The Institute has undertaken several research and development projects on land and water management in the past. During the eleventh Plan Period, it was decided to conduct activities focusing on "Watershed Processes and Management (WPM)" theme for Indian Himalayan regions based on systems approach. In house researches were undertaken optimizing hydrological responses in central and Sikkim Himalaya, energy use pattern in rural domestic sector, development of sacred landscape and rehabilitation of degraded land of central Himalayan region, Jhum land in NE Himalaya, nematode diversity studies for improved soil fertility, etc. External funding supported studies in Higher Himalaya particularly on glaciers include glacier retreat in Kumaun and Sikkim Himalaya, and discharge and sediment yield in Gangotri, Thelu, and Milam glaciers, Global Positioning System (GPS) geodesy with permanent and campaign mode surveys for quantification of tectonic deformation rate and landslide monitoring, etc. Special efforts were made for strengthening the Institute's capabilities for GPS data analysis for surface mapping and landslide monitoring. Under demonstration activities, a joint project with National Cadet Corp (NCC) namely, "Operation PARADE" based on Village Environment Action Plan (VEAP) was executed in village Railakot (Distt. Almora, Uttarakhand) in collaboration with other themes of the Institute. Dissemination of findings was carried out through field trainings on soil and water conservation, water recharge using catchment treatment approaches, nursery development and plantation under SWEET package, etc. Sensitization of District officials (9 depatrments) of Uttarakhand State was done through awareness cum exposure programme on use of remote sensing & geographical information systems for planning & development. Glacier Study Centre has been developed in the Institute

with support from Ministry of Environment and Forests (MoEF) and Department of Science and Technology (DST). The Institute's glacier database has been incorporated in the special report on Himalayan glaciers prepared by Technology Information Forecasting & Assessment Council (TIFAC) under climate change program.

Biodiversity Conservation and Management (BCM)

While concluding the previous year's activities, especially on Bioresource Inventory of the Himalaya and Biodiversity Studies in Selected Protected Areas, the thematic group Biodiversity Conservation and Management (BCM), based on the inputs received from diverse range of stakeholders, initiated two multi-location projects, namely: (i) response assessment and processing of knowledge base to serve long term management and use of biodiversity in the Himalaya; and (ii) up-scaling applicability of ex-situ mechanisms for conservation and utilization of high value plant species and one state specific project 'Conservation and sustainable utilization of medicinal plants in Himachal Pradesh'. The major aim of these projects is to provide authentic and reliable data sets to mainstream biodiversity in achieving sustainable development goals in the region. In addition, emphasis has been given to develop approaches and mechanisms to build capacity of diverse stakeholders for best management and optimal use of Himalayan bioresources. Besides in house projects, the group continues with addressing specific issues pertaining to biodiversity through externally funded projects. During the reporting period, through such projects, intensive information was generated on plant diversity patterns along the altitudinal gradient of Himachal Pradesh, population dynamics of selected high value medicinal plants in different parts of IHR, and biodiversity patterns and conservation priorities in proposed cold desert biosphere reserve, wildlife sanctuaries and watershed. Continuing as lead center for Himalayan Biosphere Reserves (BRs), the group organized National Consultation Workshop, which identified specific issues of R&D for Himalayan BRs. Moreover, using various R&D interventions, the existing *ex situ* conservation sites at HQs, Sikkim and Himachal Pradesh, were further strengthened. Among others, analysis of antioxidant properties of *Hedychium spicatum* and berberine concentration in different parts and populations of *Berberis asiatica* have potential for further commercial application.

Environmental Assessment and Management (EAM)

In the year 2007-08, the research activities under the EAM theme have been carried out under the following projects : (i) Forest ecosystem services in the central Himalayan mountains: The project aims to look at various ecosystem services of the two major forest types (Oak and Pine) in three locations. Household surveys were undertaken to quantify services. Soil & vegetation analysis of the two forest types was also carried out. (ii) Strategic Environmental Assessment and Environmental Impact Analysis of Hydropower Projects in Western Himalayan Region: The information generated from Environmental Impact Analysis (EIAs), Detailed Project Reports (DPRs), Project Feasiability Reports (PFRs) and Environmental Management Plans (EMPs) of various projects was compiled and extensive field surveys for a few identified Hydro Electric Projects (HEPs) were undertaken. Geographical Information Systems (GIS) based thematic layers have also been developed. (iii) Urbanization vis-à-vis solid waste management and air pollution in sprawling urban cities of Himachal and Uttarakhand: In order to generate datasets and develop

appropriate strategies for management in the sprawling towns of Himalaya, six towns each in Himachal Pradesh and Uttarakhand have been selected. Sources, quantity, nature and composition of solid waste were assessed. (iv) Aerosols climatology over the northwestern Indian Himalaya Region: Characterization optical properties of aerosol at Mohal since May 2006 onwards is being undertaken. The spectral Aerosol Optical Depths (AODs) averaged over the period indicates high values at shorter wavelengths suggesting large concentrations of small size aerosol particles. (v) Ecology of Reduced Tillage and Mulching in the Central Himalayan Cropfields: Under this activity nutrient release from decomposing litter, soil fertility, crop yield and soil and water conservation studies were conducted using different combinations of three mulch materials under two crop cycles. Results based on the data of two years showed that soil fertility and crop yield were significantly greater under the *Lantana* mulched plots.

Socio-Economic Development (SED)

During the reporting period, based on the stakeholders response, the following five new projects on priority areas were initiated for detailed investigation during XI plan period: (i) Smallholders farming systems: strategies for economic and environmental viability in the western Himalaya (at HQs), (ii) Scaling up innovative resource management practices for improved livelihoods in the mid hills of the central Himalaya (HQs), (iii) Assessing the eco-tourism potential (Garhwal & Sikkim Unit), (iv) Shifting Agriculture: issues and options (NE Unit), and (v) Indigenous Knowledge: traditional health care practices in rural areas of Uttarakhand. Also, multilocational approach on 'Capacity building for entrepreneurship development and self employment in the Himalayan region' has been adopted as major demonstration and dissemination strategy of the theme. In addition, the group continued to work on a few externally funded projects, such as - Participatory management of Bhimtal Lake Catchment; 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; Fallow Management Practices among the Tangkhuls of Manipur in Shifting Cultivation Systems; and Enhancement of Livelihood Security through Sustainable Farming Systems and Related Farm Enterprises in north-west Himalaya. The theme also generated funding for a few new projects covering aspects like Enhancement of Livelihood Security through Sustainable Farming Systems and Related Farm Enterprises; Participatory assessment of sustainable scenarios for Himalayan pastoralism; Prioritization and categorization of ailment-specific medicinal plants and their contribution in traditional health care system, and Cultural landscape: the basis for linking biodiversity conservation with sustainable development. Besides concluding in-house projects of the previous plan period, externally funded project entitled 'Augmenting economic security of rural people using indigenous Bamboo resources in the Indian Central Himalaya' (funded by DST under Women Scientist scheme) was completed in the reporting year. Following training in bamboo craftwork, village women organized themselves in the fom of a society and marketed bamboo products with an earning of Rs. 1000-1200 per month per person.

Biotechnological Applications (BTA)

During the reporting period, emphasis was given to logically conclude some of the R&D

activities, namely (1) Water relation studies and ecophysiological responses of selected plants of Himachal Pradesh, (2) Large scale multiplication of elite planting material of important species using *in vitro* methods, (3) Studies on rhizosphere microbiology of Himalayan plants, and (4) Field trials of technologies developed. In keeping with stakeholders need and leads obtained from abovementioned activities, the focus was on developing propagation packages for economically important plant species of central, western and eastern Himalaya; emphasis shall be given on field performance and conservation, along with looking for alternative sources of active ingredient content via callus and hairy root cultures. Successful mass scale *in vitro* propagatioin of genetically uniform 'maggar' bamboo plants was carried out with satisfactory field performance in mid hill elevations. Exploration of microbial diversity with special reference to plant growth promoting microorganisms and mycorrhizal associations constituted another crucial aspect and is being carried out in Himalayan soils, including that of north east India, particularly for formulation of carrier based bioinoculants to increase plant productivity under extreme climatic conditions of the Indian Himalayan Region (IHR). Field evaluation of microbial inoculants developed for use in mountains is given equal attention. Enhancement in efficiency of the Rhizobium-legume symbiosis due to *Bacillus subtilis* inoculation has been achieved under field trials. Data sets pertaining to on farm conservation and genetic characterization of diverse landraces of rice are being generated. A study on diversity and reproductive success on fish (Ichthyology) has been recently initiated mainly for Arunachal Pradesh. Capacity building for rural people has been given due emphasis and projects on pond based integrated farming system for economic upliftment of rural women and technology demonstration for higher income generation for farmers are underway during this period.

Knowledge Product and Capacity Building (KCB)

The Himalayan communities have acquired an immense knowledge of their natural environment through their reliance on and interaction with nature and natural resources. Utilization of this knowledge should be an integral part of a holistic and cost-effective approach to sustainable development in many ecological/ social situations. The KCB theme is using this concept to provide both a common framework for the research and as the basis for policy engagement. The knowledge accumulated, documented, produced or developed over a period of time is being transmitted or exchanged through capacity building efforts of the Institute. Major activities undertaken in 2007-08 were successful operation of Rural Technology Centres at Institute Headquarters and units with specifically designed training programs for different stakeholders. The technology adoption rate of about 40% is achieved through Rural Technology Complex (RTC) and several state development programs like Hariyali, watershed management, livelihood improvement schemes are benefited from the training facility. The Institute has enhanced its outreach in most of the Himalayan states through projects funded under the Integrated Eco-development Research Program (IERP). Disaster management faculty, Sikkim trained various officials at district level and under different sectors on disaster mitigation. Several demonstration and dissemination activities were conducted round the year under the theme.

1. INTRODUCTION

The year 2007-08 is nineteenth 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 XI 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 2007-2008 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

Annual Day Celebration & G.B. Pant Memorial Lecture

The Institute celebrated its Annual Day on 120th birthday (September 10th, 2007) of Bharat Ratna Pandit Govind Ballabh Pant, at its Headquarters Kosi-Katarmal, Almora and at all the four regional units. Chief guest Prof. V.K. Gaur, Distinguished Professor, Indian Institute of Astrophysics, Bangalore briefly mentioned about the physical, biological and socio-cultural peculiarities of the Himalayan mountain system and stressed upon the need to develop adequate understanding about the changes happening in this dynamic and geologically young mountain chain of the earth. Delivering the 13th G.B. Pant

Memorial Lecture entitled, "***Mystery of our Origin***", Prof. Lalji Singh, Director, Centre for Cellular and Molecular Biology, Hyderabad made a detailed power point presentation on various stages of human evolution on the earth. He traced back the history of human evolution on this planet earth dating back to about 60-65 million years till today, and showed that the present day man separated from his ancestor Chimpanzee about 5-7 million years ago. He unfolded an interesting information that Indian subcontinent has the maximum number of human populations (4635; including 532 tribes and 72 primitive populations). Besides, the Chief Guest released a training manual entitled "Natural Disasters – Preparedness, Mitigation and Management", prepared by the Disaster Management Faculty, Sikkim Unit of the Institute while Prof. Lalji Singh released the Institute Newsletter, Hima-Paryavaran.

Inception Workshop on "Community Awareness on Environmental Issues for the Tibetan Community"

A six day training workshop (October 8-13, 2007) on "Community Awareness on Environmental Issues for the Tibetan Community" was organized by the Himachal Unit at Rewalsar with the aim to sensitize the Tibetan community on various issues. Participants were exposed through lectures to various environmental issues related to Watershed Management; Traditional Beliefs, Water Recharge and Conservation; Solid Waste Management; Rehabilitation of Degraded Lands; Biodiversity Status and Conservation and Environmental Education with focus on Participatory Conservation; Status, Conservation and Agri-techniques of Medicinal Plant Cultivation; and Environment Friendly Cost Effective Technologies. Besides, field trainings were also organized for the participants on these aspects. About 45 participants representing the Tibetan Community participated in the workshop.

Brain Storming Session on "*Global Climate Change: Issues of Himalayan Concern*"

Realizing the impact of Climate Change on natural resources and the contemporary trend of global warming as highlighted in the Inter-governmental Panel on Climate Change (IPCC) report 2007, G. B. Pant Institute of Himalayan Environment and Development organized a one-day Brain Storming Session on "Global Climate Change: Issues of Himalayan Concern" at its Head Quarters, Kosi-Katarmal, Almora (Septemebr 8, 2007). Dr. R.S. Tolia, Chief Information Commissioner, Uttarakhand, Prof. V.K. Gaur, Distinguished Professor, Indian Institute of Astrophysics, Bangalore, Mrs. Vibha Puri Das, Principal Secretary & Commissioner, Forest & Rural Development, Govt. of Uttarakhand, Prof. Kanchan Chopra, Director, Institute of Economic Growth, Univ. of Delhi, Prof. Jyoti Parikh, Executive Director, Integrated Research and Action for Development (IRADe), New Delhi, Dr. Subodh K. Sharma, Ministry of Environment and Forests, New Delhi, and representatives of various other Institutions including the Institute faculty and research scholars attended the Session. Among others, the brain storming session focused on: *1. Mountain Agriculture, 2. Water, 3. Growing Aridification / Desertification, 4. Critical Ecosystems, Habitats, Species, and Sites, 5. Forests & Fodder Resources 6. Model based data generation and retrieval, comprehensive modeling, and 7. Community involvement in adaptation and mitigation.* Major recommendations include: (i) Development of work plan to address critical issues like water availability, mountain agriculture, fodder and forestry, (ii) Development of a comprehensive and validated dataset as the first and a critical requirement for any such analysis and (iii) Development of inter-institutional synergy for

effective implementation in a useful timeframe.

Consultation Meeting on Systems Approach

Realizing the need of employing multi-disciplinary approaches and keeping in view the Vision 2015, the Institute organized a Consultation Meeting for developing a systems approach based on collateral imperatives towards solution of problems related to Himalayan environment and development (September 9, 2007). Welcoming the experts Dr Uppeandra Dhar, Director GBPIHED, informed about the significance of the Systems Approach in the context of Vision 2015 document of the Institute and elaborated on the approved thematic areas and Rolling Plan of the Institute for next five years. Prof. Jyoti Parikh, highlighted the need for considering the Systems Approach by exemplifying the activities taken up under EERC program mainly in the subject areas related to Himalaya. She felt that proper application of Systems Approach in all multidisciplinary project activities of the Institute is critical for obtaining desirable results. Prof. Kanchan Chopra presented the methodologies adopted in Millennium Assessment (MA) framework and highlighted the need for considering both the ecosystem services and human well being. Prof. Vinod K.Gaur emphasized on the need for soft science to improve the life style of society. Thinking widely is the systems approach he said. Besides, presentation on the various projects representing different thematic areas namely, Watershed Processes and Management, Biodiversity Conservation, Environmental Assessment and Management, Biotechnological Applications and Socioeconomic Development, of the Institute was made by the respective PIs for obtaining specific inputs from the experts.

Governing Body Meeting (s)

The 30th Governing Body Meeting of G B Pant Institute of Himalayan Environment and Development, was held on April 16, 2007 at the Ministry of Environment & Forests, New Delhi, under the Chairmanship of Dr. Prodipto Ghosh, Secretary, Ministry of Environment & Forests, New Delhi. The meeting was attended by Prof. V. K. Gaur, Prof. J. S. Singh, Prof. Kanchan Chopra, Shri B. S. Parsheera, Additional Secretary, MoEF, Shri G. K. Prasad, Director General Forests, MoEF, Shri. S. Jagannathan (Representative of Additional Secretary & Financial Advisor) and Dr. Uppeandra Dhar, Director (Member Secretary) among others. The Governing Body approved the Vision 2015 document of the Institute and expressed satisfaction on the overall progress of the Institute.

The 31st Governing Body Meeting of G B Pant Institute of Himalayan Environment and Development, was held on August 10, 2007 at the Ministry of Environment & Forests, New Delhi. Mrs Meena Gupta, Secretary, Ministry of Environment & Forests, New Delhi, Chaired the meeting. Among members, Shri B. S. Parsheera, Additional Secretary, MoEF, Prof. J. S. Singh, Prof. V. K. Gaur, Prof. S. K. Sopory, Shri G. K. Prasad, Addl. Director General Forests, MoEF, Shri A. K. Goyal, Joint Secretary, MoEF, Dr. Uday Shanker, Dy. Secretary (nominee of Addl. Sec. FA), and Dr. Uppeandra Dhar, Director (Member Secretary) attended the meeting. The Governing Body approved the draft Annual Report and statements of the Accounts for the year 2006-07. The 5 year Rolling Plan of the Institute (2007-2012) was placed in the meeting.

SAC Meeting

The 15th Meeting of the SAC of the Institute was held (May 07-08, 2007) at Wadia Institute of Himalayan Geology, Dehradun under the

Chairmanship of Prof. Jayanta Bandyopadhyay. The committee members appreciated the Institute's effort and discussed the various thematic areas. Subsequently the committee approved the new thematic areas and projects of the Institute.

Society Meeting

The 14th meeting of the G.B. Pant Society of Himalayan Environment and Development (GBPSHED) was held under the chairmanship of Shri Namo Narain Meena, Hon'ble Minister of State, Environment and Forests, Government of India, on 15th November 2007. Among other members, Shri Harish Rawat, Hon'ble Member of Parliament (Rajya Sabha) and Shri K.C. Singh 'Baba', Hon'ble Member of Parliament (Lok Sabha) attended the meeting. Dr Uppeandra Dhar, G.B. Pant Institute of Himalayan Environment and Development and Member Secretary, welcomed all the dignitaries to the Society meeting.

3. RESEARCH AND DEVELOPMENT PROGRAMMES

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

The unique environmental setting of the Indian Himalayan Region (IHR) is varied owing to ecological, socio-economic and cultural diversity. Traditionally, the system is strongly rooted upon the concept of recycling of resources within; however, the system is undergoing rapid breakdown because of the population pressure and developmental needs. In view of 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.

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 United Nations 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 theme envisages to i) study the dynamics of the watershed processes and evaluation of ecosystem components on the 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 Mid Elevation Himalayan Watershed

(2007-2012, In-house)

The ecological and economical services provided by the watershed hydrology have largely been neglected in the past. With the established fact of severe water scarcity in the hills, the state governments have now realized the importance of recharging the water sources through source centered catchment area plans. But, the quantification of hydrological services and its optimization for integrated water management at watershed level is still not attempted in the region. This project therefore will focus on this interface of water demand & availability, major land uses (forest land, agriculture / waste land and urbanization) for water sustainability in the fragile Himalayan watersheds. The objectives of the project are i) to analyze policies and practices of land use, land transformation and related water use in selected watersheds, ii) to quantify hydrological processes and establish functional relationship of land use changes and hydrological responses and iii) development and demonstration of functional land use model using optimized hydrological response water allocations at sub-watershed level.

A. Central Himalaya

- The study is conducted in the northern part of the Kosi basin (upper Kosi watershed) spreading over the Lesser Himalayan domain and administratively within district Almora, Uttarakhand state. The upper Kosi watershed is further divided into ten fifth order sub-watersheds of area varying from 24 to 75 km^2. Monthly variation in discharge at three stations of Upper Kosi catchment is given in Table-1. A sharp decline in flow is observed after September in Kosi and Nanakosi river.
- Digitization of land use map is done with the help of 1962 toposheet. Out of total watershed area of 447.30 km^2, about 228.41 km^2 is under forest, 129.07 km^2 is under agriculture and 89.82 km^2 is under barren land category (Fig. 1). Domestic need and agriculture are the two main parameters used in the area.
- Village survey for water and land use has been completed in 30 representative villages falling under lower, middle and higher altitude of two sub-watersheds of the study area. Water consumption for household purpose is approximately 50 litres per capita per day in summer and 40 litres per capita per day in winter. The livestock water consumption is 75 litres per animal unit per day in summer and 45 litres per animal unit per day in winter. This trend is similar to the other mid elevational watersheds in the central Himalayan region.

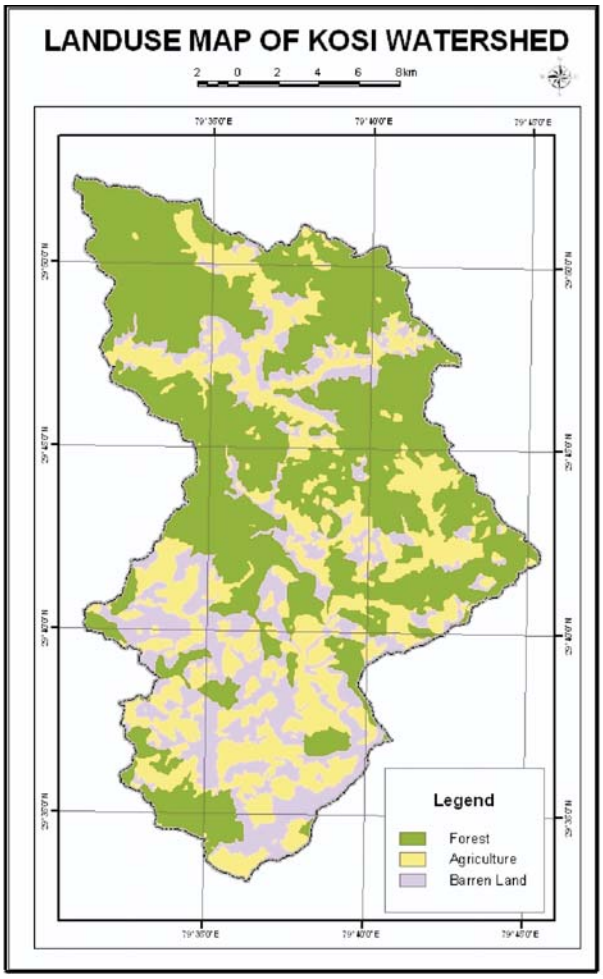


Fig. 1. Land use map of Kosi watershed.

Table 1. Monthly discharge (X 10^6 litre) at three station of Upper Kosi watershed.

Month	Main Kosi	Menol *Gad*	Nanakosi
Jul-07	8587.716	-	1001.713
Aug-07	34031.36	1909.6846	4256.711
Sep-07	73971.39	2230.5277	7101.829
Oct-07	10326.19	2095.4108	1513.688
Nov-07	4899.435	1331.6759	1006.342
Dec-07	4338.806	936.31767	987.4165
Jan-08	3821.325	1006.7845	942.0385
Feb-08	3485.272	791.23092	856.8456
Mar-08	3109.06	691.58358	846.3134

B. Sikkim Himalaya

- The study watershed of Taktsom chu is a tributary of Rani Khola in Teesta basin. It is situated at the south-eastern part of the state in the East district. It extends from 27^{0}15' to 27^{0}20' N and 88^{0}37'30" to 88^{0}42'30" E, embracing an area of 35.42 sq. km which is

about 0.49% of the total area of Sikkim. The watershed extends into three revenue blocks i.e. Naitam, Assam and Lingzey blocks. The elevation of the watershed varies from 932 m to 3172 m.

- Secondary data of Taktsom chu watershed for total households, populations, land use, etc. is collected. The area is dominated by scheduled tribe population (Table 2). Gairigaon village has been selected for the formulation of a Village Environmental Action Plan (VEAP). Stakeholders meeting was conducted to assess the village problems and possible solutions.
- Drainage and Settlement maps of the watershed were prepared (Fig.2). Site for Silt Observation Post (SOP) was selected in Balakhola-Gairigaon, East Sikkim. The manual measurement of daily discharge (runoff) was started in Balakhola-Gairigaon, East Sikkim indicating rising trend of discharge after February (Fig. 3).

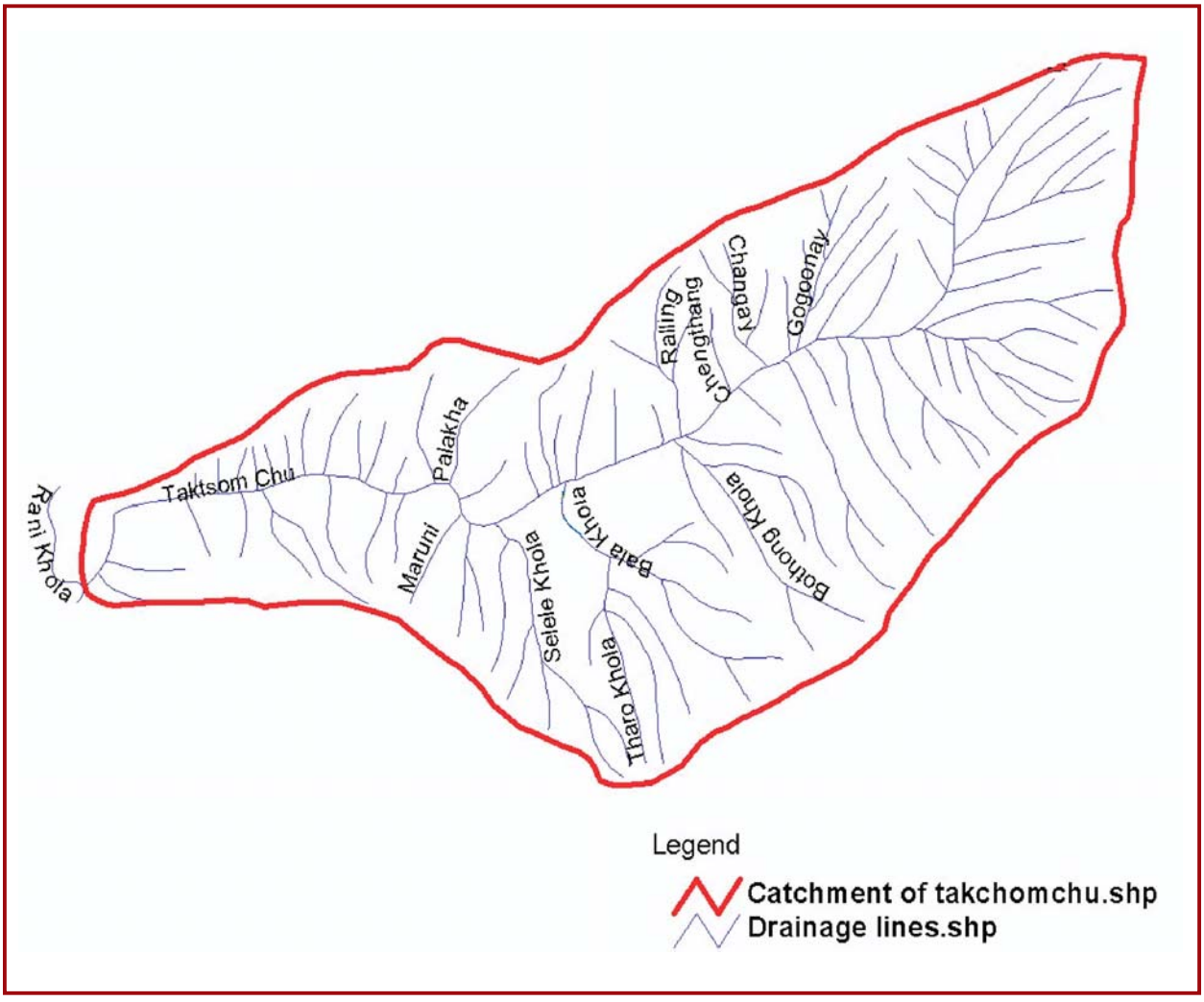


Fig. 2. Drainage map of Taktsom chu watershed.

Table 2. Community wise population of different villages of watershed.

VILLAGE	ST		SC		OBC		MBC		GEN		TOTAL
	M	F	M	F	M	F	M	F	M	F	
Saureni	111	108	90	78	99	99	57	68	30	8	744
Lingzey	172	153	20	29	20	21	201	189	7	6	818
Daragaon	113	87	0	0	51	48	133	119	3	4	558
Gairigaon	57	62	5	3	38	41	230	210	0	0	646
Pastanga	92	89	2	1	7	13	152	146	9	5	516
Nimthang	58	51	1	2	30	32	53	35	0	0	262
Pabyuk	129	134	0	0	50	54	101	83	0	0	551
Naitam	174	170	19	22	47	44	166	166	8	2	818

ST= Scheduled Caste, ST= Scheduled Tribe, OBC= Other Backward Class, MBC=Most Backward Class, GEN= General, M= Male, F= Female

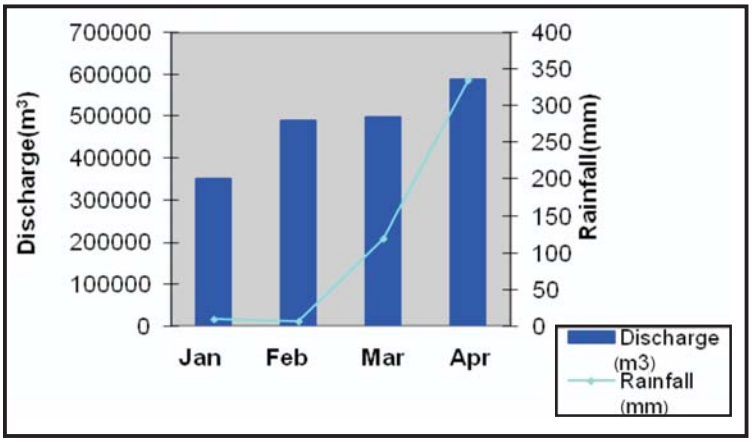


Fig. 3. Discharge and rainfall at proposed SOP site, Balakhola.

Developing Sacred Landscape Model for Eco-restoration and Biodiversity Conser-vation *(2007-2012, In-house)*

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 recognized as an inspiring model for rehabilitation of degraded lands and conservation of biodiversity based on the use of sacred/cultural values. As a follow-up of this programme, the Institute also 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, 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. The project objectives are i) creation of environmental awareness among the local people for eco-restoration and biodiversity conservation, ii) to screen/identify/recommend promising plants for rehabilitation of degraded lands based on their eco-physiological health and adaptability potential and develop a sacred landscape model (consisting of sacred forest – to value peoples' sentiments, multipurpose tree model and horticultural tree model – to meet peoples' requirements) using scientific and sacred values and iii) make policy recommendations for the development, management and protection of sacred forests/ landscapes.

- A degraded site with poor soil quality in terms of available nitrogen, phosphorous, potassium and sulphur was selected for the development of a sacred landscape model for eco-restoration and biodiversity conservation at Kolidhaik village (Lohaghat) of Champawat district of Uttarakhand. This area comprised of two small hills, namely 'Kail Bakriya Hill' and 'Daikhura Kattarkandi Hill'. The selected project site (total degraded area – 14.3 ha) was marked for the development of 3 models (i.e., Multipurpose Tree Model at 'Kail Bakriya Hill' in 5.6 ha degraded area, and Sacred Forest - Kalikavan Model in 7.7 ha degraded area and Horticultural Tree Model in 1 ha degraded area at 'Daikhura Kattarkandi Hill').
- A sacred forest of multipurpose trees, which was established earlier at 'Kail Bakriya Hill', has been maintained and strengthened during the year. Almost 200 saplings of plants, which could not survive at the site, were replaced by well-established saplings of Oak trees. Furthermore, 150 saplings of Oak trees were added to the site. The villagers obtained 3 tonnes of dry fodder during the months of October & November 2007 from this project site.
- Socio-economic survey for plantation of species at 'Daikhura Kattrakandi Hill' project site was carried out in June 2007, which indicated plantation of 5 multipurpose tree species (namely, *Deodar, Banj, Phalyant, Utis* and *Bedu*) for the development of Kalikavan. Almost 6,500 pits were dug for plantation purpose and 110 trenches and 3 water harvesting tanks were constructed for water conservation (Fig. 4). A plant nursery has been established at the headquarters of the Institute in 0.5 ha degraded area and almost 1,000 seedlings of 24 tree species were raised in the nursery. A Ritual Distribution of Tree Seedlings and Plantation Ceremony (RDTSPC) was organized in August 2007 for the development of 'Kalikavan' at 'Daikhua Kattarkandi Hill' project site, in which the villagers planted almost 200 saplings of Deodar in the name of their ancestors (Fig. 5). A Plant Distribution Ceremony (PDC) was also organized and almost 200 well-established saplings of Oak were distributed, free of cost, to the locals for plantation in and around their habitations.
- A Stakeholder Consultation Meeting on Sacred Landscape Model (SLM) development was organized and convened in December 2007. Another 2-day On-site Training Programme on 'Degraded land rehabilitation for livelihood enhancement' was also organized and convened in December 2007 at 'Daikhura Kattarkandi Hill' project site, in which capacity of 55 farmers/women of the Kolidhaik village was built.

Fig. 4. Daikhura Kattarkandi Hill project site at Kolidhaik village.

Fig. 5. Ritual plantation for Kalikavan establishment.

Energy Use Pattern in Rural Domestic Sector of Uttarakhand State *(2007-2012, In-house)*

Rural domestic energy requirements are mainly for cooking, lightning, 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 energy resources. Wide variety of energy resources and their highly site-specific and variable nature, coupled with different types and qualities of energy needs, pose a challenging problem in the designing of an integrated planning and management system. The objectives of this project are: i) to analyze patterns of domestic energy requirements with varying variables in rural settings for projection of future patterns and impact on resources and ii) to understand technical, institutional and financial mechanisms in rural energy demand, supply, and alternatives for planning and management.

- The concerns that emerged from formal communications and consultative meetings with the officials engaged in rural energy sector were (a) to meet the growing demand in rural energy sector (the shift from

traditional to modern energy use is visible and this process is governed by many drivers), (b) use of existing sources of energy which is equal to the carrying capacity of infrastructure/ resources thus leading to collapse/failure of system at many times, (c) A few decentralized energy production setups are working as good models to demonstrate rural public partnership in the programme and (d) pattern analysis of cooking and lighting source data from other organizations (primarily Census 2001, Fig 6)

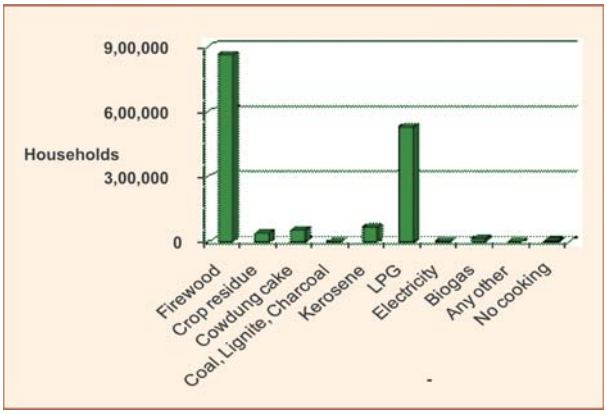


Fig. 6. Fuel Type-Uttarakhand.

Fig. 7. Fuel wood collection.

at household level indicates that the data set lacks information on composition and share of different sources used by each household and economical stratification associated with resource use pattern.

- Based on the field survey it is realized that the proximity of resource centre and physiographic variable (representing environmental variables) are also important in decision making by households in utilization of an energy source (Fig 7).

Nematode Diversity in the Traditional Agro Ecosystem of Central Himalaya

(2007-2012, In-house)

Nematodes are important soil mineralizers in nitrogen poor ecosystems. Developing an understanding of nematode diversity with respect to cropping pattern and nutrient transformation in the agro ecosystem is desirable to exploit nutrients supply through nematodes. This study is being conducted to understand and identify proper sets of cropping pattern and nematode diversity for maintaining soil fertility and enhancing crop productivity. A majority of the rural population is directly or indirectly related to agriculture and skilled in traditional agriculture practices. The second part of the project aims to tap this skill for economic viability of the Himalayan farming system for an agro-eco-tourism model development and harness opportunities for the development of market niches based on new food and nutrition experiences for the tourists. The objectives of the project are i) to examine the nematode diversity in the traditional agro ecosystem under different cropping combination, ii) demonstrations of agro ecotourism by growing different crop combinations under traditional cropping and farming practiced in central Himalaya.

- Soil nematodes have been isolated. Their population is being counted and classified according to five feeding categories. Physico-chemical properties of soil have been analysed (Table 3).
- Pipalkoti a small township (Altitude 1233m,

situated at 30° 25' N and 79° 25 E) is identified as a potential site for demonstration and promotion of agro-eco-tourism after +extensive survey. The Bhotiya communities of Pipalkoti and its adjoining villages have preserved their cultural heritage and also their food habits, agriculture and handicraft. An introductory workshop with stakeholders on agro ecotourism was held at Pipalkoti (Fig.8) for taking up agro-eco-tourism as another additional livelihood option.

Fig. 8. Agro-eco-tourism workshop at Pipalkoti.

Table 3. General soil characteristics of plots planted to sole and intercropped ratios of paddy and foxtail millet, cropping season averages ± 1SE, n = 18.

Parameters	Treatments				
	Paddy SC	Intercrop Ratios			Foxtail millet SC
		4:02	3:03	2:04	
Soil texture					
Sand (%)	65.3± .26	63.3± .72	63.5± .85	65.1± 1.09	61.6± 0.05
Silt (%)	30.1±1.10	27.5±2.56	24.5± .24	24.0± 0.85	22.5± 0.49
Clay (%)	4.6± .04	9.2± 5.18	11.6±3.59	11.8± 1.55	15.4±1.79
Soil moisture (%)	17.11 ± 2.80	19.44 ± 3.39	19.74 ± 3.10	18.75 ± 3.21	19.36 ± 1.89
Bulk density (g cm $^{-3}$)	0.90 ± 0.05	0.92 ± 0.03	0.93 ± 0.03	0.95 ± 0.20	0.98± 0.02
pH	6.5±0.08	7.0 ±0.09	6.9 ± 0.19	6.4 ± 0.16	6.6 ± 0.18
WHC (%)	36.8±0.78	30.7±1.46	33.2± .24	32.6± 1.88	31.2± 1.67
Total N (%)	0.07±0.02	0.07±0.01	0.08±0.09	0.08±0.01	0.09±0.01
Organic C (%)	0.79±0.04	1.05±0.10	0.97±0.10	1.01±0.20	0.95±0.05
Organic matter (%)	1.37±0.06	1.80±0.18	1.67±0.16	1.74±0.36	1.70±0.20

SC: Soil Characteristics

Glacier Study Centre

A. Geohydrological and Sediment Load Studies of Thelu glacier (Gangotri Glacier system) (2005-2008, DST Funded)

Climatic fluctuations cause variations in the mass balance of a glacier. Any change in glacier mass initiates a complex series of changes in the flow of the glacier that ultimately results in a change in the position of terminus. In the Himalaya, glaciers cover approximately 33000 km^2 area with one of the largest concentrations of glacier-stored water outside the Polar Regions. In addition, large areas of the Himalaya are covered by seasonal snow during winter. Melt water from snow and glacier ice forms an important source for the rivers originating from the Himalaya

during critical summer months. Discharge and sediment monitoring studies were conducted in Thelu, Raktverna and Gangotri glaciers for third successive year (2007-2008). The main objectives of the study are i) quantification of discharge and suspended sediment (SS) load of melt water stream of Thelu, Raktverna and Gangotri glacier, ii) monitoring the receding rate of tributary glaciers of Gangotri i.e. Raktavarn, Thelu and Chaturangi glacier and iii) To evaluate the sediments source area, production mechanism and transport pathways of the sediment load of the glacier.

- Melt water discharge of Thelu glacier in three consecutive years (2005, 2006, and 2007) showed almost similar variations on a seasonal scale. It started increasing from the month of June till mid-August. After that a decreasing trend followed in September (Fig. 9). In 2003, bright sunshine hours were minimum, which might have affected the overall flow pattern of the glacier.
- Good correlation between discharge and SS on seasonal scale in 2005, 2006 and 2007 suggests sufficient supply of sediments from source (Fig. 10). In a system of equilibrium conduits, the dominant sediment sources are mostly the beds of the conduits.
- On diurnal scale, the levels of melt water discharge that exceed previous flow value do not always have impact on sediment flux. As such there is no direct relationship between the quantity of sediment evacuated during an event and discharge magnitude of that event.

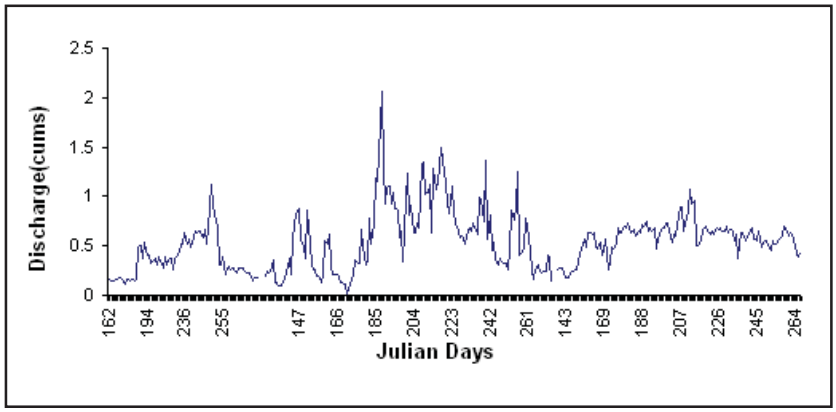


Fig. 9. Daily discharge of Thelu Glacier (year 2005-07).

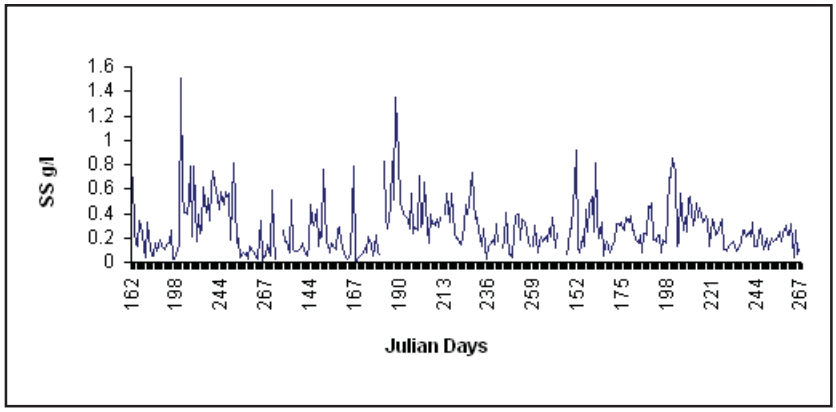


Fig. 10. Daily suspended sediments (SS) of Thelu Glacier (year 2005-07).

B. Glacier Retreat Studies in Kumaun Himalaya, Uttarakhand (2006-2009, Space Application Centre Funded)

Estimation of retreat of glaciers is of immense importance in Kumaun Himalaya as the glacier melt runoff feeds important rivers namely, Pinder, Ramganga, Goriganga and Dhauliganga. Considering the difficulty in determining the retreat of each glacier in the field using conventional methods, it is important to use methods based on remote sensing, which can quickly measure the retreat of several glaciers in a shorter time. In view of this, a remote sensing investigation is proposed to estimate glacial retreat in these river valleys. For estimation of retreat, glacial snouts are identified on the satellite images and their positions are compared with any known position in the past such as in the Survey of India topographical map or satellite images of the recent past. Based on this the total area evacuated can be estimated. The project aims at estimation of the retreat of glaciers of Pindar, Ramganga, Goriganga and Dhauliganga river basin using satellite data available in the last 10 years.

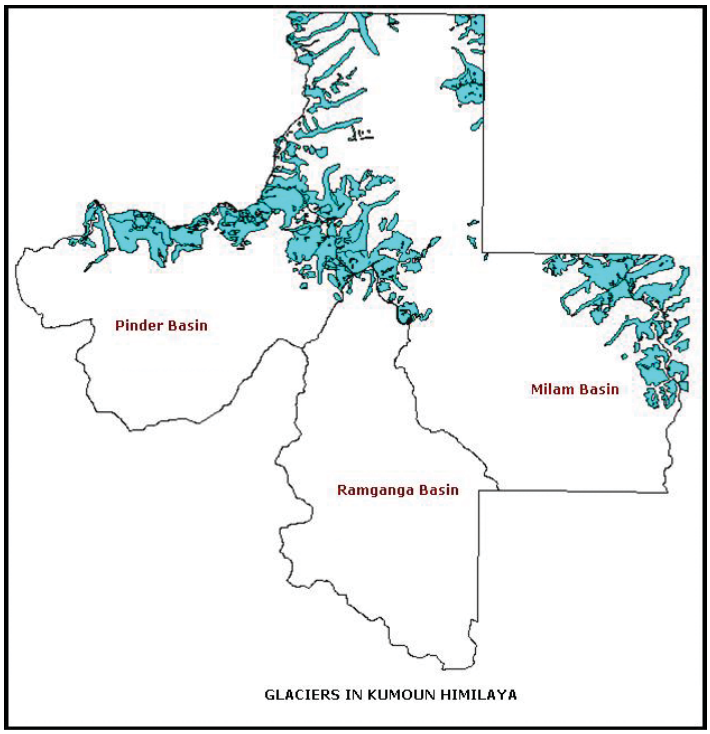


Fig. 11. Glaciers of Kumaun Himalaya.

- Digitization of glacier boundaries was completed for three river basins in Kumaun Himalaya, namely, Pindari river basin (encompassing Pindari, Mulkotha & Bidalgwar, Burh & Buria, Mrigthuni, Tal Chhanguj & Salchanguj, Mangtoli glaciers), Gori Ganga river basin (encompassing Mangron, Milam, Pacchmi Bamchhu, Syakaram, Kwalgang, Timphu, Burphu, Pachhu,Nandagungti, Lwa, Laspa & Jrambha, Poting, Balati, Panch Chuli, Balnti-Rula, Jimba, Kulka glaciers) and Ramganga river basin (encompassing Ramganga glacier) (Fig. 11).
- The Glacier area varied from < 1 km^2 to >200 km^2 in these basins with Gori ganga basin having the largest glaciated area (Fig 11).

C. Snow and Glacier Studies in Sikkim Himalaya (2006-2009, Space Application Centre Funded)

Glacier (both continental and valley types) are the largest water reservoir on the earth surface. Glaciated regime is very sensitive to global and local climatic regime on the one hand and human interference on the other. It is therefore, very essential to have a reliable database on glaciated regime in terms of its numbers, size, shape, volume, behaviour in geologic, historical and recent times. The Sikkim Himalaya covers an area of about 12,540 km^2 with major and minor glaciers spread in various sub-basins of Tista viz., Goma Chu, Sebuzong Chu, Zemu Chu, Umram Chu, Rangyong Chu, Rilli Chu, Prek Chu and Tsakchurong Chu, Lachung Chu, respectively. The present study focuses on i) monitoring snow cover using AWiFS data using NDSI algorithm and ii) to determine the retreat of glaciers of Teesta basin using high resolution satellite data available in the last 10 years.

- Various map layers using Survey of India (SOI) toposheets and geocoded data have been generated for Tista basin, i.e., drainage, contours, glacial boundaries and glacial lakes, etc.

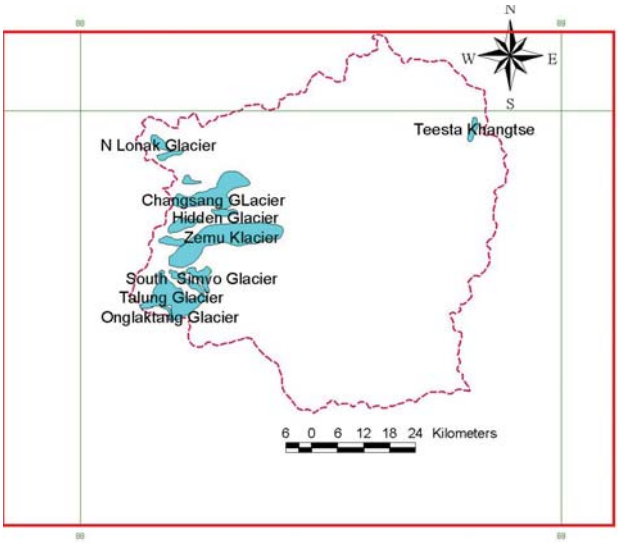


Fig. 12. Glacial Boundary map of North Sikkim.

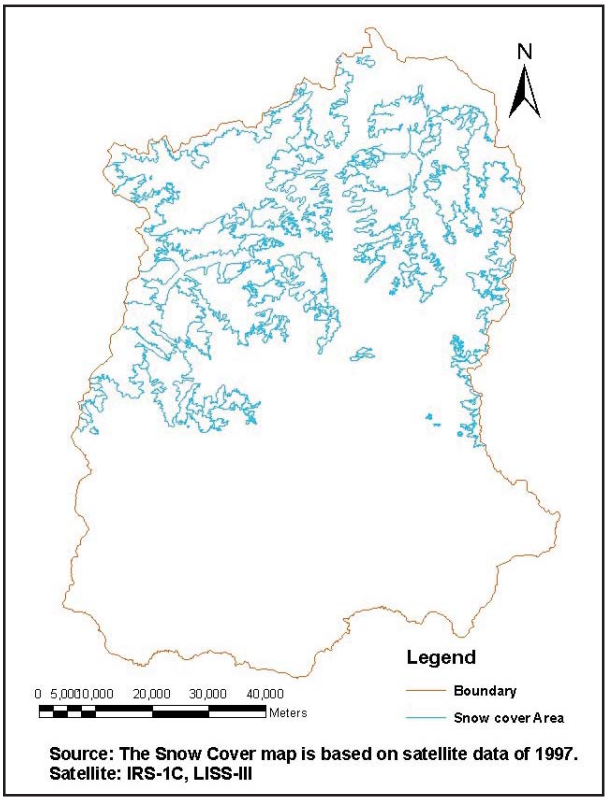


Fig. 13. Snow cover map of Sikkim.

- Glacial boundary maps prepared from available satellite data for the year 1997 (Fig.12). Snow cover map was also generated using available satellite data of the year 1997 (Fig.13).

Tectonic Deformation and Assessment of Stability of Himalayan Town using GPS *(2005-2010, MoEF Funded)*

The proposed experiment envisages establishment of a network of permanent Global Positioning System (GPS) stations near the selected urban centres to quantify the slip rate along reported faults. It will also attempt at quantification of the strain suffered by the region from NW to NE along the Himalayan arc. The selection of these sites is dictated by the disposition of anticipated active faults and experiences the intimate knowledge of the terrain gained by extensive field work in the area. Repeated measurement of above mentioned sites provide information on rate of strain accumulation in the Himalaya and of co-seismic strain distribution following moderate and large earthquakes. Permanent GPS stations will be the reference station for the future campaigns for the study of Himalayan deformation rate and will fill the gap in DST network of permanent stations in unrepresented areas. The project objectives are i) quantification of tectonic deformation field by experimentally determining the displacements of fixed sites using GPS Geodesy with high resolution and ii) to measure slip rates across reported faults in the area towards improving assessments of the stability of different parts of the mountain urban centers.

- Installation of new GPS Receiver with meteorological system for three new permanent GPS stations (Nainital (Uttarakhand), Srinagar (Uttarakhand), and Kullu (Himachal Pradesh)) was completed in this year. The preliminary field

observations show that the areas around all the five stations are tectonically active. Series of landslides and neo-tectonic indicators suggested that the terrain is unstable and accumulating continuous strain.

- The GPS derived velocity of Almora (GBPK) and Sikkim (GBSK) stations is of same magnitude as of Bangalore (IISC) (~ 41 mm/year). However, velocity of Tibtian plateau is more than the velocity of Indian Plate (Fig 14).
- Results of baseline changes for year 2005-2007 show that there is no significant baseline change between IISC and GBPK (Table 4). However, there is a convergence of ~ 30-40 mm/year between GBPK - KIT3 and GBPK – POL2. Results also indicate that, the LHAS is moving toward east with a baseline extension of ~16 mm/year relative to GBPK. The baseline changes between GBPK and GBSK is ~20 mm /year, as GBSK is moving towards East in comparison to GBPK.

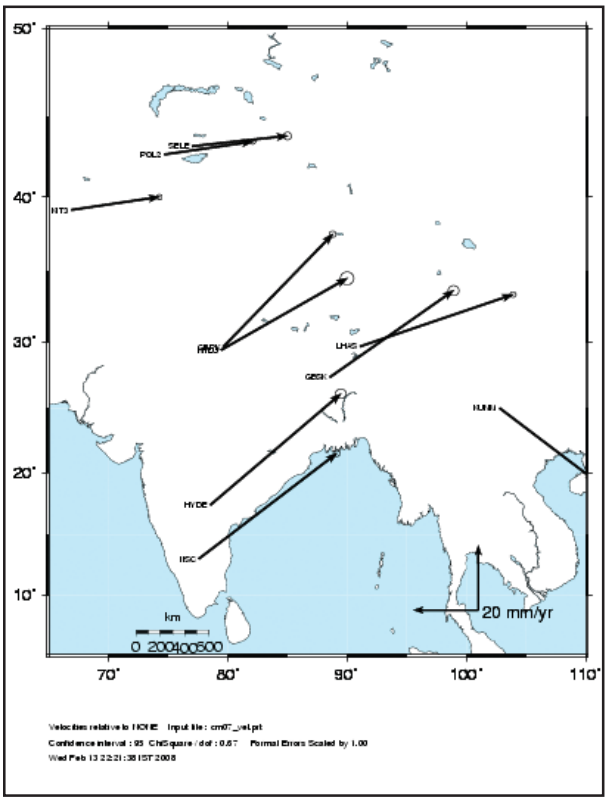


Fig. 14. Velocity of permanent GPS stations.

Table 4. Velocity of Permanent and IGS stations for year 2004-2007.

Station Name	Velocity (mm/year) (2006-2007)	Error (mm/year)	Velocity (mm/year) (2005-2006)	Error (mm/ year)	Velocity (http://itrf.ensg.ign.fr)	Error (mm/ year)
LHAS_GPS	49.62	0.36	48.84	3.24	48.08	0.24
KIT3_GPS	27.35	0.48	25.41	3.28	28.3	1
POL2_GPS	27.45	0.47	32.32	3.4	27.92	1.36
SELE_GPS	29.47	0.69	34.3	3.63	28.26	0.3
GBPK_GPS	48.33	0.58	32.69	4.27	-	-
GBSK_GPS	46.43	0.92	52.99	4.3	-	-
IISC_GPS	53.12	0.57	40.73	4.32	52.96	1.24
HYDE_GPS	52.68	0.91	37.39	4.39	53.95	1.93
KUNM_GPS	37.27	0.581	30.48	5.67	35.11	0.61
NTLU_GPS	44.58	1.16	38.97	8.2	-	-

Three Dimensional Imaging of the Lithosphere and Active Deformation Across Sikkim-Darjeeling Himalaya *(2007-2010, DST Funded)*

The Himalaya, built by the continent-continent collision of the Indian and the Eurasian plates over the past 50-70 Ma, is the youngest and arguably the most dominant features on the surface of the Earth. A 3-Dimensional image of the crust and upper mantle beneath the Himalaya combined with focal mechanisms and depths of moderate-to-large earthquakes is essential to understand the dynamics of the ongoing continental collision and assess the hazard associated with future earthquakes in the region. In order to understand the lithospheric structure and deformation across the Himalayan collision zone the present study proposes i) to investigate the seismic velocity variation, structural fabric and active mountain building over the entire thickness of the lithosphere in Sikkim-Darjeeling Himalaya using an array of closely spaced network of broadband seismographs, ii) compute focal mechanisms (hypocentral depth and fault plane solutions) of local earthquakes to delineate active faults and map the stress field across the region and iii) combine 3-D velocity variations, Poison's ratio, geometry of Crust and upper Mantle discontinuities, active faults, and petrological models to understand the regional geodynamics of NE Himalaya.

- Detailed survey of Sikkim-Darjeeling Himalaya for identification of location for setting of closely spaced network of broadband seismographs has been completed.
- Installation of 6 broadband seismographs at Ravangla, Namchi, Mangan, Chugthang, Lachung and Lachen has been completed and data is being archived (Fig 15).

Fig. 15. Seismometer in the vault.

Active Tectonics of the Darjeeling-Sikkim Himalayas Using GPS based Geodesy *(2004-2008, DST Funded)*

The study aims at understanding the kinematics of active deformation in the Darjeeling-Sikkim area. Strike-slip earthquakes of magnitude around 6.0 have dominated the earthquakes recorded in the region, so there is a need to look at the nature and the mechanism of active tectonics in the region. This area has also not experienced any high magnitude earthquake and that makes the earthquake potential in the region extremely high. The work will build on the data from the fixed GPS station at Pangthang, Sikkim as reference station. Investigations are on

Table 5. GPS derived base line length of different campaign sites in Sikkim Himalaya.

Baselines	Baseline (m)	Errors (mm)
LHAS_GPS-GBSK_GPS	355188.3014	0.17
LHAS_GPS-IISC_GPS	2299529.156	0.8
LHAS_GPS-POL2_GPS	2050580.064	0.17
LHAS_GPS-KIT3_GPS	2438017.468	0.2
LHAS_GPS-TIGE_GPS	404975.3126	0.19
LHAS_GPS-NAMC_GPS	388813.7679	0.27
LHAS_GPS-PELI_GPS	384838.1377	0.46
GBSK_GPS-IISC_GPS	1950581.797	0.16
GBSK_GPS-POL2_GPS	2103685.68	0.17
GBSK_GPS-KIT3_GPS	2382081.161	0.21
GBSK_GPS-TIGE_GPS	50206.8136	0.15
GBSK_GPS-NAMC_GPS	33695.432	0.29
GBSK_GPS-PELI_GPS	35178.0236	0.56
GBSK_GPS-KUPU_GPS	26799.2393	0.24
IISC_GPS-POL2_GPS	3262461.049	0.19
IISC_GPS-KIT3_GPS	3049218.133	0.19
IISC_GPS-TIGE_GPS	1901068.432	0.24
IISC_GPS-NAMC_GPS	1917600.296	0.42
IISC_GPS-PELI_GPS	1924008.08	0.51
IISC_GPS-KUPU_GPS	1964041.822	0.6
POL2_GPS-KIT3_GPS	765905.7414	0.14
POL2_GPS-TIGE_GPS	2122187.289	0.26
POL2_GPS-NAMC_GPS	2109813.282	0.41
POL2_GPS-PELI_GPS	2091710.813	0.45
KIT3_GPS-TIGE_GPS	2384940.526	0.32
KIT3_GPS-NAMC_GPS	2377455.514	0.51
KIT3_GPS-PELI_GPS	2360383.395	0.59

whether there is lateral variation in the shortening across the Himalayan region or not. The specific objectives of the study are i) to set up about 20 GPS stations in the Darjeeling-Sikkim Himalaya and to determine the rate of deformation of the Darjeeling-Sikkim Himalayan region and ii) modeling of the surface deformation by simulating slip on one or more major Himalayan thrusts and strike slip faults.

- A network of campaign-mode stations have been set up in the region to identify the possible location of the active deformations in the region and comparisons are being made with the active deformation in other parts of the Himalaya.
- GPS field campaign is being conducted in selected sites in Sikkim and Darjeeling Himalaya and data is being analyzed (Table 5). Monitoring and maintenance of permanent GPS station at Pangthang was accomplished.

Summary of Completed Project / Activity

Tectonic Deformation and Landslide Modeling using GPS Surveys Kumaun Himalaya *(2002-07, DST Funded)*

The study area lies in Gori valley transact (GVT) and Kali valley transact (KVT) of the NE part of Kumaun Himalaya in Uttarakhand. The section encompasses four well-defined physiographic divisions – The Shivalik, the Lesser Himalaya, the Great Himalaya and the Tethys Himalaya. These lithotectonic domains are separated from one another by thrusts/faults. For this stretch the GPS data of annual campaigns in the last three to five years is available. The study was conducted with specific objectives of i) determining the annual strain rate field in Kumaun Himalaya from Dung (north of Milam) to Almora and Malpa to Pithoragarh and ii) monitoring the temporal evolution of some potentially damaging landslides using Kinematic GPS survey. Salient findings of the study are as below.

- The magnitude and direction of velocity vector varies from south to north and from one thrust zone to other. The Trans Himalayan GPS sites velocity range was estimated maximum for Kalapani (42.08±1.37mm/yr) and minimum for Dung (28.34±3.13 mm/yr). The Great Himalayan GPS point's velocities indicate that tectonic movements are of similar magnitude and direction. Change in direction in Trans-Himalaya is observed towards east in case of Dung. The velocity ranges from 36.11±3.44 mm/yr at Khalia Top to 43.40±3.46 mm/yr at Bugdiar. The velocity of foot wall of Main Central Thrust (MCT) is also in a similar range (32.56±3.13 mm/yr for Munsyari) as compares to that of the velocity of hanging wall of MCT (31.52±15.13 mm/yr for Khaliya Top).
- Although the GPS derived velocities for the sites located within the fault zones are not significantly different (at $p<0.05$) in magnitude in comparison to other sites, the area is experiencing horizontal movements of the order of 30 - 40 mm/ year. However, there is not much differential movement along MCT.
- The GPS survey results are found useful for modeling and verifying the Digital terrain models (DTM) with sub meter level accuracy. However, the accuracy of the reconstructed surface depends on the precision of GPS survey, processing and the surface interpolation method. The present study discusses the surface approximation using the RBF neural network with the help of MATLAB. The cm level accurate point coordinates obtained through GPS survey are used to design and test the RBF network. The RBF network has shown a significant gain in terms of accuracy as compared using RMSE.
- The main advantage of the proposed technique is its capability of producing high-resolution DTMs of small terrain surfaces with a fast measurement campaign as it takes less resources and time to collect and analyze the data and model the surface very accurately. The application of the terrain mapping is proposed to be used in landslide modeling in hill areas.

Summary of Completed Project/Activity

Traditional Soil and Water Management Practices *(2004-2008, In-house)*

A. North East region

The present study documented traditional soil and water conservation (TSWC) practices by Nyishi tribe in Senkhi watershed of Papum Pare district situated in the central eastern region of Arunachal Pradesh, India. The study area, Senkhi watershed covers a total geographical area of 300.30 km^2, of which 86.62 % and 6.77 % are under forest cover and agricultural land use, respectively, while the rest is under household settlement, water bodies, etc. There is a limited altitudinal variation across the study site, which ranges between 296-668 m msl. The livelihood sustaining *jhum* cultivation, locally known as *Rongo* covers nearly an area of 4.25% where experimental plots had been setup to estimate the most debated soil erosion, surface runoff and nutrient leaching. The landholdings across the study site vary from 0.2 to 2.45 hectares per household. Soils are clay loam to sandy loam.

- Phai, an indigenous SWC practice has been identified for detailed analysis of its effectiveness. In this, tree trunk, branches, bamboo and stones are used as barrier across the slope and weeds are put alongside (Fig. 16)
- Nine plots (10m x 5m), 3 each for jhum fallow (Nyibi), TSWC practice and Jhum TSWC are taken into consideration for detailed analysis of sediment and surface runoff in each treatment. Soil moisture, organic carbon, phosphorus and nitrogen are significantly ($P<0.05$) less in fallow compared to SWC and WSWC. However, potassium is significantly ($P<0.05$) less in SWC compared to jhum fallow and WSWC.

Fig. 16. Traditional soil and water conservation practice (just after burning).

- Interestingly total soil loss (11.04 th a^{-1}) in the TSWC practice is significantly less than that of the shifting cultivation WSWC practice ($P<0.05$). Meanwhile soil loss from jhum fallow is also significantly less ($P<0.001$) than that of WSWC. Surface runoff (1467.39 m^3ha^{-1}) in shifting cultivation WSWC practice is significantly ($P<0.001$) higher compared to that of TSWC and jhum fallow.
- The energy input by males is significantly higher at $P<0.001$ in jungle clearing (134.55 ±19.45 Mj $ha^{-1}a^{-1}$ in SWC and 118.59 ±12.20 Mj $ha^{-1}a^{-1}$ in WSWC) and fencing (77.25 ±17.47 Mj $ha^{-1}a^{-1}$ in SWC and 55.85 ±10.78 Mj $ha^{-1}a^{-1}$ in WSWC) while that of females it is high in field preparation (59.35 ±9.36 Mj $ha^{-1}a^{-1}$ in SWC and 54.36 ±5.98 Mj $ha^{-1}a^{-1}$ in WSWC), sowing, weeding and harvesting. The total energy input in SWC (1180.63 ±99.25 Mj $ha^{-1}a^{-1}$) and WSWC (1075.18 ±40.11 Mj $ha^{-1}a^{-1}$) is significantly different at Pd" 0.01. The energy output in shifting agro-ecosystem is significantly higher at $P<0.001$ in SWC compared to jhum WSWC practice.

Summary of Completed Project/Activity

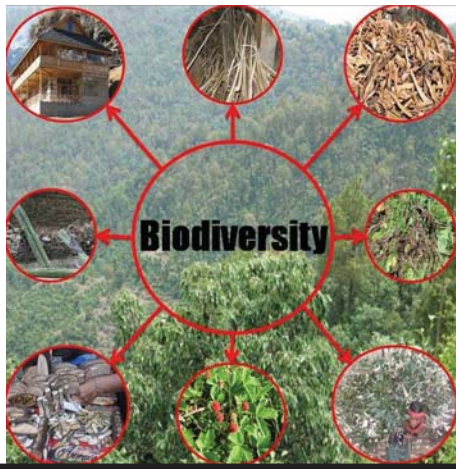
Creating Sacred Forest for Eco-restoration and Biodiversity Conservation in the New Millennium *(2004-2007, In-house)*

This project was initially a follow-up of a completed in-house project (i.e. Badrivan restoration programme) of the Institute. It was executed in August 2004 with 3 main objectives - i) to create environmental awareness among the local people for eco-restoration and biodiversity conservation, ii) to screen/identify promising plants for rehabilitation of degraded lands, and iii) to develop a model for eco-restoration and biodiversity conservation (with peoples' participation) by creating/establishing a sacred forest in the Kumaon Himalaya. The project was concluded in May 2007 in view of the R&D shift of the Institute. The major highlights of this project are summarized below.

- During the project period, a degraded site [namely, 'Kail Bakriya Hill' in Kolidhaik village (Lohaghat) of Champawat district of Uttarakhand] was rehabilitated with peoples' participation by the establishment of a 'sacred forest in 5.6 ha degraded area. At present, 6200 well-established saplings of 24 multipurpose plant species (mainly of sacred, horticultural, multipurpose and fodder trees) are surviving well at the site. The local villagers have now started on getting their fodder needs fulfilled from this project site partially.
- Environmental awareness was created among the locals, from time to time, by organising four (4) Ritual Distribution of Tree Seedlings and Plantation Ceremonies (RDTSPCs) and four (4) Plant Distribution Ceremonies (PDCs) at the project site; these ceremonies were attended by more than 1250 persons and significantly inspired the locals for afforestation, degraded land rehabilitation, and biodiversity conservation.
- Observations on eco-physiological characteristics (namely, diffusive resistance, rate of transpiration and total leaf energy absorption) of various multipurpose tree species were recorded and subsequently the data were analysed and computed, which clearly revealed greater suitability of 5 tree species, namely Utis (*Alnus nepalensis),* Banj *(Quercus leaucotrichophora),* Phalyant *(Q. glauca),* Bhimal *(Grewia optiva),* and Kharik *(Celtis australis)* for rehabilitation of degraded lands.
- The R&D efforts carried out during the project period have emerged in the form of a sacred forest, which is an inspiring model for eco-restoration and biodiversity conservation in the central Himalayan region. This model will not only respect the religious sentiments of the locals but will also supplement their fodder, fuel, food and religious needs in due course of time. Based on the overall R& D interventions, it is concluded that creation/ establishment of the scared forests for eco-restoration and biodiversity conservation in the central Himalayan region is possible only if the fodder, fuel and food requirements of the local people are met out.

Theme

BIODIVERSITY CONSERVATION AND MANAGEMENT (BCM)



Accelerating rates of biodiversity loss and signing of international agreements such as the Convention on Biological Diversity have called for the inventorying and monitoring of the global biodiversity at gene, species and ecosystem levels. The United Nations WEHAB (Water, Energy, Health, Agriculture and Biodiversity) initiative and the Millennium Development Goals (MDGs) also recognize biodiversity as an integral component of any mechanism linked with global sustainable development agenda. The human induced activities have been identified as the critical factors for the biodiversity loss and global climate change. This has necessitated preparation of inventory and monitoring of biodiversity at different levels and climatic regimes. The theme envisages to i) assess, valuate, prioritize, map and monitor biodiversity of the protected and unprotected areas at gene, species and ecosystem levels across the Indian Himalayan region (IHR) for understanding the status, availability, potential and patterns, ii) develop packages of practices for maintenance and optimal use of sensitive biodiversity components and improvement of bio-resource based livelihood options for indigenous communities, iii) establish and maintain live repositories (Arboreta, Herbal Gardens, Nurseries, etc.) in different agro climatic zones across the IHR for ensuring availability of quality planting material, and iv) 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 *(2007-2012, In-house)*

Considering that the world's mountain ecosystems are undergoing rapid environmental changes thereby affecting their overall integrity and life support values, the need for better understanding the response patterns and implementation of multidisciplinary approach to address the issues is globally realized. While considering approach for effective implementation of such strategy, the Mountain Protected Areas (MPAs) have emerged as global priority sites and are being used as an 'early warning' system. In this context, this project seeks to define appropriate mid to long term management regimes that maintain the multiple functions of MPAs as a major challenge to the management of integrity and diversity of representative ecosystems. Investigations will focus on ecosystem integrity profiles using different attributes of ecosystem (i.e., biological, physical and social) in an integrated manner. The specific objectives include: (i) synthesis and use of information on biodiversity components of

selected areas; (ii) investigations on recruitment trends and compositional patterns of forest communities along altitudinal gradient; (iii) understanding use patterns of resources by the inhabitants; (iv) identify and prioritize human wildlife conflicts; (v) study the grazing competition among livestock and wild ungulates; (vi) determine the livestock depredation and retaliatory killing of wild carnivores; (vii) identify threat categories of the biodiversity; (viii) suggesting policy interventions with a view of general applicability; and (ix) drawing comprehensive biodiversity management plan(s) for alternative scenarios. Preliminary outcome of the project are as follows:

Nargu Wildlife Sanctuary, Himachal Pradesh

- Consultation Meeting (March 15, 2008) of the stakeholders was organized to identify the issues and gaps of the protected areas. Survey resulted in identification of 305 species of vascular plants (Angiosperms: 279; Gymnosperms: 6 and Pteridophytes: 20) belonging to 89 families and 166 genera. Out of total, 45 species were trees, 50 shrubs and 210 herbs. Altitudinal distribution revealed maximum number of species (197) in 1801-2800m zone.
- A total of 15 forest communities were delineated (Table 6). Soil of each community was analyzed for pH, moisture content, organic carbon and nitrogen. Maximum sites (12) were represented by *Quercus semecarpifolia* community. Maximum habitats and aspects were represented by *Rhododendron arboreum* and *Quercus leucotrichophora* communities.
- Village survey revealed that 79 species were used as Fuel, Fodder, Edible, Agricultural Tools, Timber and Medicinal purposes by the inhabitants. Village wise utilization pattern showed that maximum species (22, each) were extracted for fuel in Madh and Thaltukhod villages and total collection ranged from 5598-7812 kg/hh/yr. Maximum collection (7812 kg/hh/yr) was reported from Boching Village, followed by Galu (7680 kg/hh/yr) and Rulang (7500 kg/hh/yr) Villages (Fig.17).

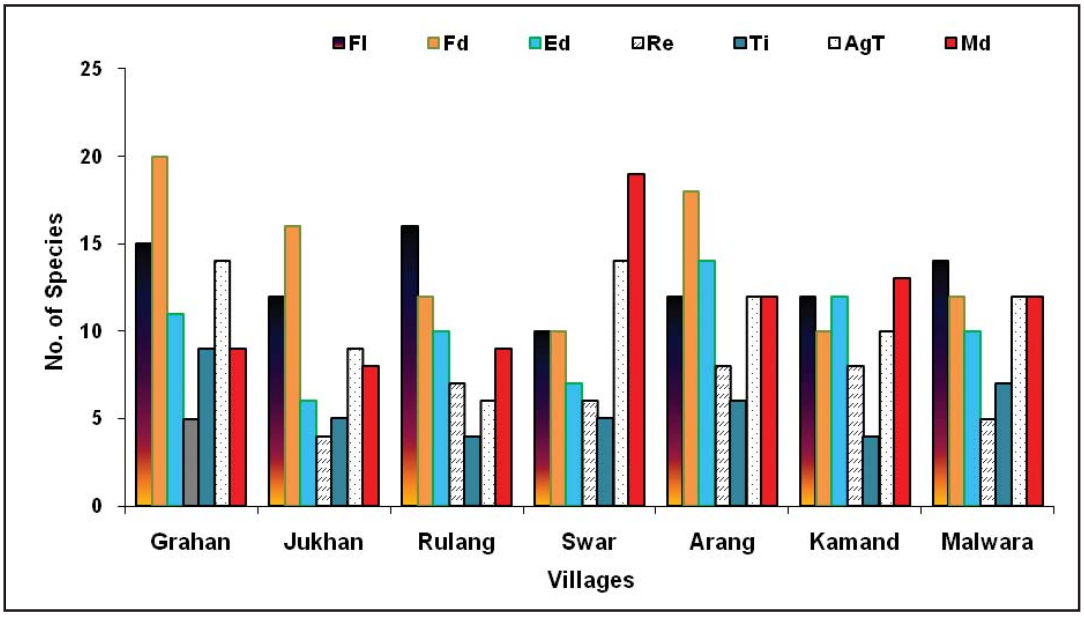


Fig. 17. Utilization pattern of floristic diversity by the inhabitants in Nargu Wildlife Sanctuary.
Abbreviations Used: Fl=Fuel, Fd= Fodder, Ed=Edible, Re= Religious, Ti=Timber, AgT= Agricultural Tools and Md=Medicinal

Table 6. Community Diversity, Total Basal Area, Total Density and Species Diversity Index of the forest communities in Nargu Wildlife Sanctuary.

Community Type	SR	Altitudinal Range (m)	TBA (m^2/ha)	Total Density (Ind/ha)		Species Diversity (H^1)			
				Trees	Shrubs	Trees	Saplings	Seedlings	Shrubs
Abies pindrow	1	2822	56.18	450.0	730.0	0.52	0.00	1.16	1.61
Cedrus deodara	5	1333-2104	22.38	405.8	2280.0	1.61	1.52	1.78	1.97
Myrica esculenta	1	1393	21.74	370.0	4970.0	1.09	0.89	1.04	1.92
Neolitsea pallens	1	1818	10.04	540.0	3350.0	0.99	0.48	0.79	1.74
Pinus roxburghii	3	1203-1393	27.38	353.3	1096.7	0.59	1.14	1.82	1.41
Pinus wallichiana	2	1855-1872	26.67	370.0	1655.0	1.43	1.91	1.81	1.86
Quercus floribunda	1	2281	31.46	300.0	3060.0	1.37	1.12	1.32	1.83
Quercus leucotrichophora	8	1548-2497	23.08	345.3	2315.0	1.62	2.00	2.11	1.75
Quercus semecarpifolia	12	2820-3188	31.30	425.0	2100.0	0.48	0.86	0.17	1.07
Quercus semecarpifolia-Abies pindrow mixed	1	2840	60.75	460.0	1005.8	1.135	1.17	1.33	1.25
Rhododendron arboreum	6	1902-2803	24.21	563.0	1023.3	1.12	1.57	1.67	1.95
Rhododendron arboreum-Alnus nitida mixed	1	1821	4.43	310.0	2340.0	1.92	1.55	1.47	1.79
Sapindus mukorossi-Mallotus philippensis mixed	1	1003	12.34	440.0	2770.0	1.55	0.00	1.38	1.91
Sapium insigne	1	1087	7.22	350.0	2790.0	1.4	1.07	0.00	0.85
Toona serrata	1	2057	26.52	270.0	3680.0	1.18	1.37	0.88	1.95

Abbreviations Used: SR=Site Representation, m=meter, Ind/ha=Individuals per hectare and TBA=Total Basal Area

Nanda Devi Biosphere Reseve, Uttarakhand

- Synthesis of available information was conducted and information was classified in different groups (Fig. 18). The grouped information was analyzed for priority assessment and gap identification. Consultation on priorities and gaps was held with the BR resource persons (29) and the inhabitants (32) of the reserve (October 30-31, 2007, Joshimath, Chamoli).
- Demographic and socio-economic status of selected villages (Lata and Reni) were analyzed and data generated on fuel wood collection patterns. Over 60% of households in these villages are largely dependent on fuel wood. Average requirement (kg/house hold/day) varied from 10.7 (Reni) to 14.1(Lata). Among preferred species *Berberis aristata*, an established medicinal plant, figured high.

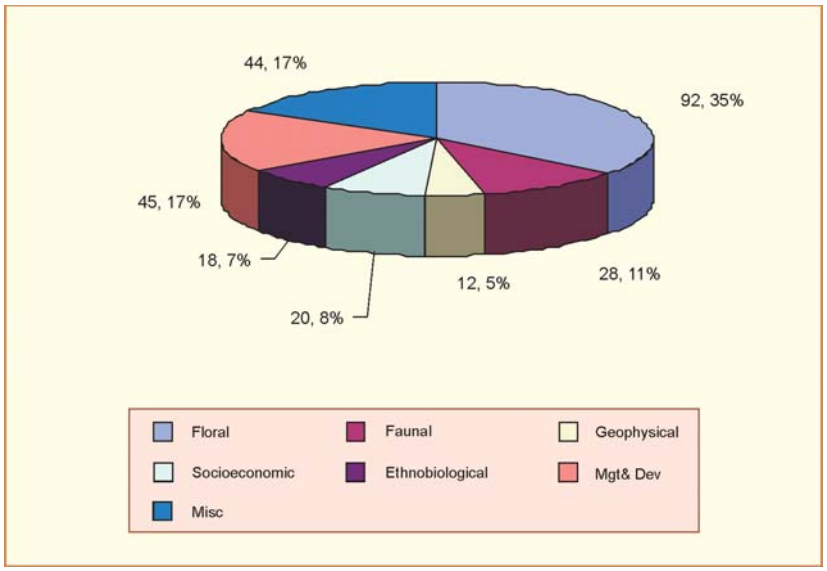


Fig. 18. Analysis of available information on NDBR (n = 259).

Khangchendzonga Biosphere Reserve (KBR), Sikkim

- Surveys resulted in additional record of 277 species of Angiosperms. In order to investigate compositional pattern/ communities, 18 sites were identified and 180 plots along 2400 to 4200m altitudinal transacts laid in western part of the KBR. The plots exhibited over 40 woody taxa, including 15 *Rhododendron* species. Altitude, 2400 to 2600m and 2600 to 2800m were richest for inhabiting over 37% species, each (Fig. 19).
- Surveys in the buffer zone/fringe villages in north and west parts of KBR targeted use pattern of ethno medicinal plants. For north KBR, 118 species curing 66 ailments under 14 broad categories, covering 71 families and 108 genera were recorded. Zingiberaceae appeared as the most used family (8 species and 5 genera). Administration of medicine orally is recorded in 75% cases.

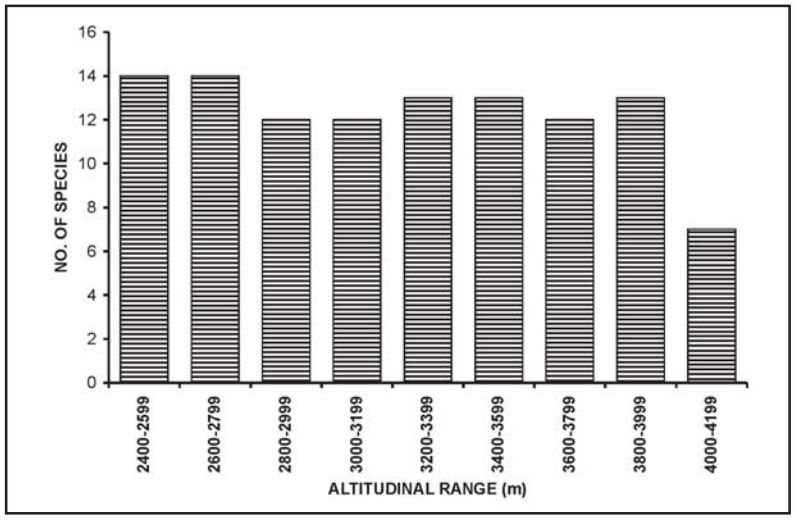


Fig. 19. Species richness in different altitude zones of west KBR.

Tawang –West Kameng Biosphere Reserve (Proposed), Arunachal Pradesh

- Considering incidence of man-animal conflicts, 6 villages (3 each in West Kameng & Tawang districts) were selected (Fig. 20). Senge village was the largest having 147 households, followed by Jang (72), while lowest in Lubrang (21 households).
- Survey revealed occurrence of 40 species of mammals (34 genera, 18 families and 8 orders). Of these 22 (55%) species fall in the Low Risk category (LR), 5 (12.5%) Endangered (EN), 7 (17.5%) Vulnerable (VU), 3 (7.5%) Least Concerned (LC), 1(2.5%) near threatened, 2 (5%) species were however not found in the IUCN listings.
- About 13 animal species have been recorded, having indirect conflict with man. Out of these two (*Bandicota indica* and *Canis familiaris*) live in close association with man, while the other 11 species were found in the wild. Crop raiders and livestock depredators had equal share being seven in numbers. *Ursus thibetanus* was reported for having its unique distinction ability to raid crop and depredate livestock.
- Conflict intensity as per the local perception has been shown (Table 7).

Table 7. List of the animal species reported to have conflicts with man.

Species	Conflict		Conflict intensity
	Livestock depredation	Crop raiding	
Macaca mulatta	–	√	++
Trachypithecus pileatus	–	√	+
Felis marmota	√	–	+
Uncia uncia	√	–	+++
Cuon alpinus	√	–	+++
Hystrix indica	–	√	+++
Bandicota indica	–	√	+
Macaca munzala	–	√	+++
Sus scrofa	–	√	+++
Martes flavigula	√	–	++
Panthera pardus	√	–	+
Canis familiaris	√	–	++
Ursus thibetanus	√	√	++

Fig. 20. Evidences of hunting in selected area - Wild dog (*Cuon alpinus)* skin; blue sheep *(Pseudois nayaur)* horns.

Up-scaling Applicability of *Ex Situ* Mechanisms for Conservation and Utilization of High Value Plant Species – Focusing on Promotion of Conservation Education and Capacity Building *(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 highly required. The project attempts to: (i) apply *ex situ* conservation techniques for developing appropriate technologies for mass multiplication and storage of germplasm; (ii) upscale the applicability of existing protocols in selected sites; (iii) ensure quality planting material through phytochemical and genetic investigations; (iv) understand growth responses of the species in wild and cultivated land; (v) develop a center for on-site training and extension programmes; and (vi) inculcate among students excitement about biodiversity conservation. The results of the study are as follows.

Headquarters, Uttarakhand

- In order to apply the *ex situ* conservation techniques for mass propagation, seed germination protocol for *Hedychium spicatum* was developed. The results revealed significant improvement in seed germination (95%) in GA_3 treated seeds.
- Phytochemical investigation of different parts of *Berberis asiatica* collected from diverse altitudinal range showed that lower elevation has significantly ($P<0.01$) more berberine content than higher altitude (Fig. 21). When compared to the different parts, the root parts possess significantly ($p<0.01$) more berberine content than the stem bark.
- Towards demonstration of proven technologies in the field, establishment of demonstration models at three school campuses was promoted (Fig. 22) - GIC Kunelakhet, GIC Kamleshwar and GIC Mahhatgaon in district Almora.
- In order to disseminate the technology to various stakeholders and to promote outreach through Conservation Education, a three day training workshop was conducted at G.I.C. Hawalbagh in Training of Trainers (ToT) mode. A total of 34 school children and teachers from 16 schools participated.

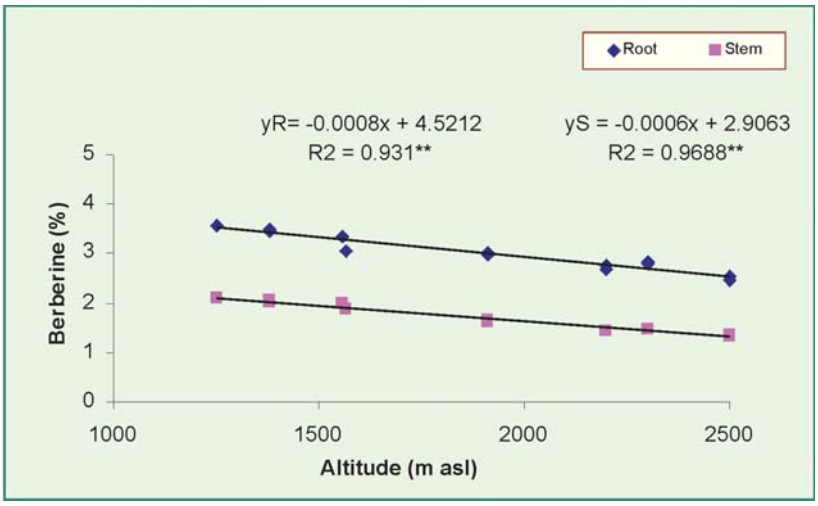


Fig. 21. Variation in Berberine content across altitude and plant parts in *Berberis asiatica*.

Himachal Unit

- At Himachal Unit ecologically and economically important 650 seedlings of 27 species were planted in the arboretum sites and survival was monitored. The seedling survival was <15% for naked seedlings and >60% for polybag seedlings.
- Seed germination protocols for *Carpinus viminea* a multipurpose tree showed maximum germination in KNO_3 and GA_3 treated seeds (Fig. 23).

Fig. 22. Participatory establishment of conservation model at schools.

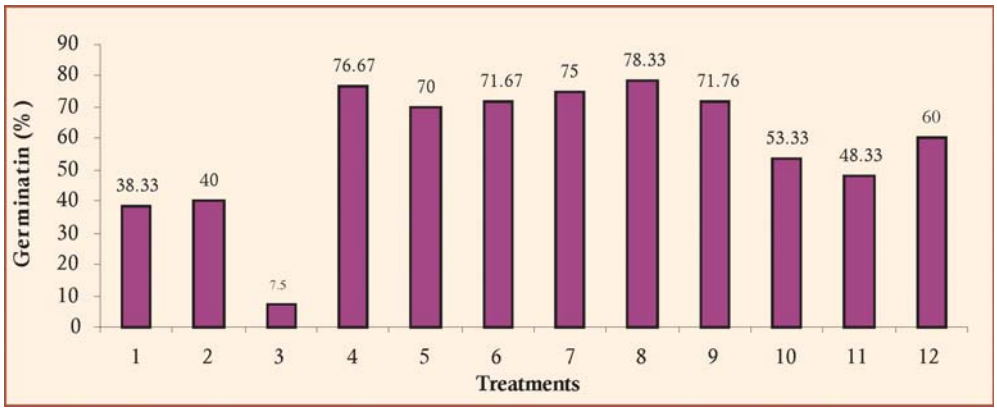


Fig. 23. Seed germination of *Carpinus viminea* in different conditions.

(Abbreviations used: 1=Control Direct; 2=Control Distilled Water Soaking 24 hrs; 3=Control Polybags in shade net; 4=KNO_3 50mM; 5=KNO_3 100mM; 6=KNO_3 200mM; 7=GA_3 50µm; 8=$GA_3$100µm; and 9=GA_3)

- One day training programme on "Peoples Participation in Biodiversity Conservation" was organized (March 18, 2008) for the field level staff of Forest Department and NGOs. Over 1500 people representing different stakeholders i.e., Line Departments, students, teachers, farmers, NGOs and others were educated on biodiversity issues through organization of exposure visits on various occasions.

Sikkim Unit

- Seedling emergence of MPTs was monitored and *Eryobotrya petiolata* (71%), *Bischofia javanica* (79%), *Spondias pinnata* (97%), *Juglans regia* (79%), *Machilus edulis* (36%), *Michelia excelsa* (10%) and *Toona ciliata* (47%) showed encouraging results.
- Experimental seed sowing for seed size basis made for *Machilus* sp., and *S. pinnata*; and monitored for growth. Propagules of 12 useful species were collected. Over 10 accessions of *Hedychium spicatum* were collected and introduced in the herbal garden/nurseries. Seeds of 4 populations tested for over 90% germination at fresh.
- Two training workshops for capacity building of each for over 30 representatives of Farmer clubs, SHGs and NGOs of Sikkim (in October 2007) and for over 20 farmers' clubs (February 2008) were organized, focusing on biodiversity conservation & nursery and farm based technologies. Also a training workshop for students and teachers from 14 schools of east and north Sikkim was organized (Fig. 24).

Fig. 24. Participation in capacity building programmes on use and conservation of biodiversity.

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

The State of Himachal is being seen as a herbal state and its medicinal plants a major sources 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 plants cultivation and their 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. It is

envisaged to: (i) assess, monitor and map the medicinal plant diversity; (ii) valuate medicinal plant diversity; (iii) assess threat categories; (iv) prioritize potential medicinal plants for conservation and socio-economic development of the inhabitants; (v) develop strategies and promote ex-situ and in-situ conservation of medicinal plants; and (vi) impart training to different stakeholders on conservation and sustainable utilization of medicinal plants. The results of the study are as follows.

- Consultation Meeting (March 15, 2008) of the stakeholders (59) was organized to identify the issues and gaps on medicinal plants sector in Himachal Pradesh. Surveys for the Medicinal plants of in different sites revealed that the Chandra Valley has the maximum species at 2801-3800m, while in Upper Beas Valley, Mohal Khad Watershed, Parbati Watershed and Upper Banjar Valley, the maximum species were found between 1801-2800m (Fig.25).
- The analysis showed 23 species were used in fever, 22 species in cold & cough, 11 species in diarrhoea, 3 species in sores, 21 species in skin disease, 21 species in wounds, 10 species in headache, 11 species in swelling, 5 species in bone fracture, 13 species in boils, 6 species in vomiting, 12 species in toothache and 5 species in indigestion by the inhabitants.
- Twenty two sites representing 07 aspects and 8 habitats were sampled for the assessment of populations of threatened medicinal plants. Site representation, altitude/ altitudinal range, habitat/s, aspect/s and relative density of some threatened species are given (Table 8).
- About 4,200 seedlings of 25 medicinal plants were developed and established in the herbal gardens and medicinal plants nurseries. Over 1500 stakeholders were educated on medicinal plants in various occasions.

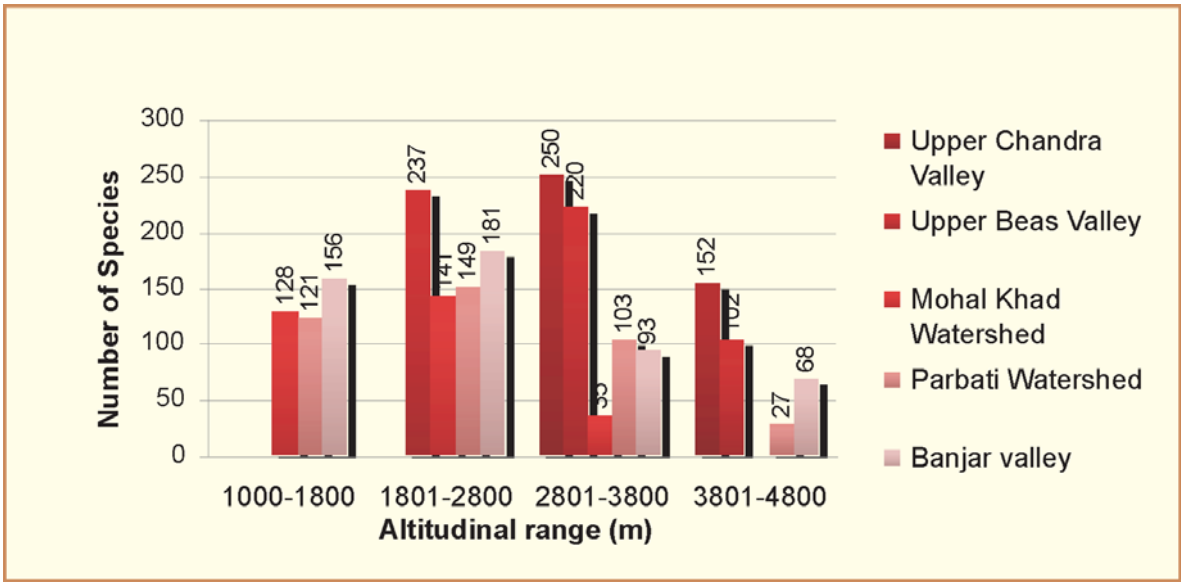


Fig. 25. Altitudinal distribution of medicinal plant richness in different sites of HP.

Table 8. Distribution and relative density of some important threatened medicinal plants in Chandra Valley of Lahaul and Spiti District.

Taxa	Altitudinal Range (m)	SR	Aspects	Habitat/s	LF	Relative Density (%)
Aconitum heterophyllum	3178-3910	6	SE, SW, NW, S, E	AS, Ro, Gr	H	0.44
Aconitum violaceum	3304-4219	6	SE, NW, NE, S, E	Ro, AS, Bo	H	0.8
Allium carolinianum	3304-3532	2	NW	Ro	H	1
Angelica glauca	3178	1	NW	MS	H	0.5
Arnebia euchroma	3325	1	SE	Ro	H	0.38
Bergenia stracheyi	3083-4219	10	E, NE, NW, SE	AS, Bo, OS, Ro	H	6.68
Bergenia ciliata	3304	1	NW	Ro	H	0.33
Betula utilis	3304-3537	2	SE, NW	Ro	T	100
Dactylorhiza hatagirea	3140-3537	5	SE, NW, SW	Ro, Gr, MS	H	0.99
Ephedra gerardiana	3325	1	SE	Ro	Sh	82.35
Hypericum perforatum	3171	1	S	Dry Slope	H	0.4
Meconopsis aculeata	3083	9	E, NE, NW, SE	AS, Bo, Ro,	H	0.54
Picrorhiza kurrooa	3083-4219	8	E, NE, NW, SE	AS, Bo, OS, Ro	H	2.05
Podophyllum hexandrum	3083-3695	9	E, NW, S, SE, SW	Ro, Gr, MS, Bo, AS	H	0.42
Polygonatum multiflorum	3400-3537	2	SE, NW	Ro	H	0.54
Polygonatum verticillatum	3083-3304	3	NW, SW, E	Ro, Gr, AS	H	0.93
Rheum australe	3083-3095	5	E, NW, SE	Ro, Bo, AS	H	0.81
Rheum moorcroftiana	3537-4016	2	SE, NE	Ro, AS	H	0.14
Rheum webbianum	3325-3753	5	SE, NW	Ro, AS	H	0.31
Rhodiola heterodonta	3530-4149	5	SE, E, NE	Ro, OS, Bo	H	1.81
Rhododendron anthopogon	3083-4149	8	E, NE, NW, SE	Ro, OS, AS,	Sh	53.69
Rhododendron campanulatum	3304-3530	2	NW, E	Ro	Sh	9.28

Abbreviations Used: SR=Site representation; LF=Life form; S=South; SW=South West; NE= North East; NW=North West; SE=South East; Ro=Rocky; OS=Open slope; Gr=Grassland; AS=Alpine scrub; Bo=Bouldary; NH= Near habitation; MS=Moist slope; H=Herb, Sh=Shrub; and T= Tree

Study on the Assessment and Conservation Prioritization of Plant Diversity Along an Altitudinal Gradient in Himachal Pradesh, Northwest Himalaya *(2006-2009, DST Funded)*

The State of Himachal Pradesh supports representative, natural, unique and socio-economically important biodiversity. Although, the State has been explored by many workers for floral, faunal and ethnobotanical diversity, but, very few studies have been carried out on quantitative analysis of vegetation. Further, an integrated study to: assess plant diversity and study status and distribution pattern of the native and endemic species in relation to climate and altitude; study utilization pattern of plant diversity including indigenous knowledge and

practices; identify rarity of the species; and prioritize potential sites for conservation of biodiversity; and species for socio-economic development of the local communities has not been carried out so far. This has necessitated initiating biodiversity studies on the above lines. Project focuses on: (i) Assessment of the plant diversity in relation to climate and altitude; (ii) Assessment of status and distribution pattern of native and endemic species within the communities and habitats along an altitudinal gradient; (iii) Assessment of utilization pattern of plant diversity and documentation of indigenous knowledge and practices; (iv) Identify the rarity and prioritize potential sites for conservation and high value potential species for socio-economic development of the local communities. The results of the study are as follows :

- The present study identified 19 forest communities from Chailchowk-Rohanda-Kamrunag Area (CRKA), 13 forest communities from Ghanahatti-Shimla forest and 06 forest communities from Mandi-Pandoh area. The structural attributes of these communities are given (Table 9). Soil of each community was analyzed for pH, moisture content, organic carbon, nitrogen, phosphorus and potassium.
- Species diversity (H') for trees in the CRKA ranged from 0.304-1.986, saplings 0.13-1.51, seedlings 0.68-1.82 and shrubs 1.014-2.449 and in Ghanahatti-Shimla forests, species diversity for trees ranged from 0.445-1.830, saplings 0.462-1.733, seedlings 0.451-2.423 and shrubs 1.495-3.041. Concentration of Dominance (Cd) for trees in CRKA ranged from 0.146-0.71, saplings 0.27-0.59, seedlings 0.31-0.669 and in Ghanahatti-Shimla forests Concentration of dominance for trees ranged from 0.217-0.704, saplings 0.253-1.00, seedlings 0.117-1.00 and shrubs 0.057-0.260.
- A total of 439 species from HSCs, 328 species from CRKA, 213 species from Ghanahatti-Shimla and 137 species from Mandi-Pandoh area were recorded as economically important (Fig. 26).

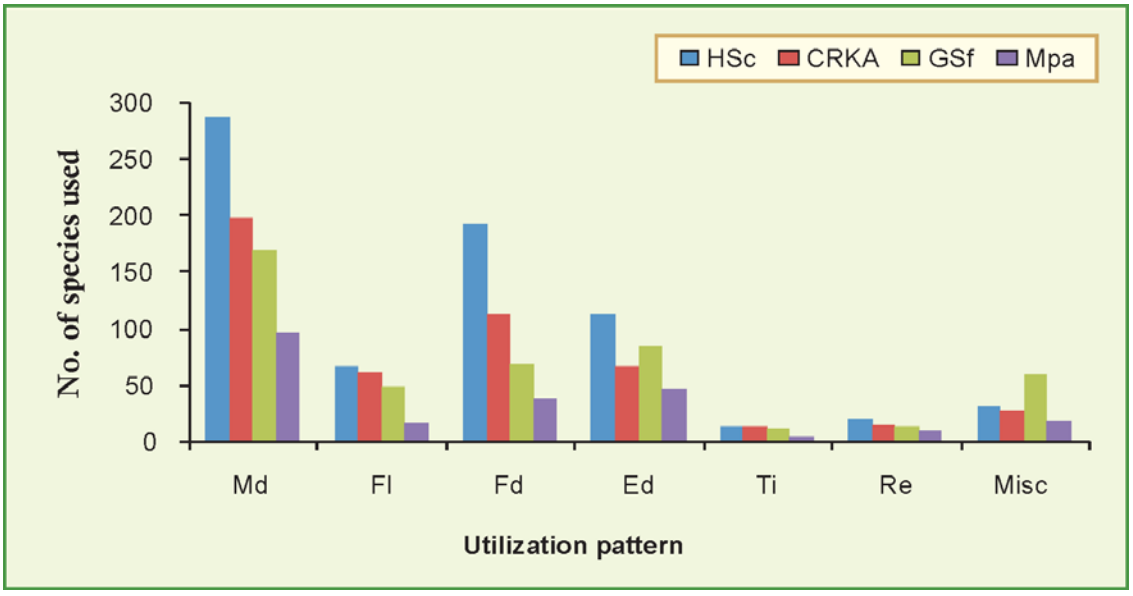


Fig. 26. Use of floristic diversity in different parts of HP
Abbreviations Used: HSc=Hirb & Shoja catchments; CRKA=Chailchowk-Rohanda-Kamrunag Area; GSf=Ghanahatti-Shimla forests; Mpa=Mandi-Pandoh Area; Md=Medicinal; Fl=Fuel; Fd=Fodder; Ed=Edible; Ti=Timber; Re=Religious; and Misc.=Miscellaneous

Table 9. Structural attributes of forests in study sites, Himachal Pradesh.

Study Sites	TTD (Ind/ ha)	TBA (m^2/ha)	TSD (Ind/ ha)	Species Diversity (H^1)			
				Trees	Saplings	Seedlings	Shrubs
HSCs	60.0-1060	0.20-83.99	330-2470	0-1.78	0-1.85	0.53-1.72	1.06-2.58
CRKA	40-1226	0.01-49.53	380-2365	0.3-1.99	0.13-1.51	.68-1.82	1.01-2.45
GSF	130.0-507.27	16.51-106.0	509.1-3530.0	0.45-1.83	0.46-1.73	0.45-2.42	1.5-3.04
MPA	110.0-360.0	5.2-66.5	730.0-1610.0	0.03-1.2	0.08-0.78	0.23-0.48	0.89-1.35

Abbreviations Used: HSCs=Hirb & Shoja Catchments; CRKA=Chailchowk-Ruhanda-Kamrunag Area; GSF=Ghannahatti-Shimla Forests; MPA=Mandi-Pandoh Area TTD=Total Tree density; TSD=Total shrub density; and TBA=Total Basal Area

Studies on the Diversity and Conservation Status of Plants in a Proposed Cold Desert Biosphere Reserve of Himachal Pradesh in North Western Himalaya *(2005-2008, MoEF Funded)*

The Cold Desert Biosphere Reserve (CDBR) is one of the proposed Biosphere Reserves of Indian Himalayan Region and covers the whole area (13,835 Km^2) of Lahaul and Spiti District. The CDBR is a unique socio-physical unit of Himachal Pradesh. The two different mountains tracts i.e., Lahaul and Spiti sub-divisions are physically, biologically and culturally distinct from each other. The area represents unique vegetation and remains snow covered for almost six months. The review of literature indicates that studies on the diversity and conservation status of plants in Cold Desert Biosphere Reserve have not been carried out so far. Therefore, the present study has been carried out to integrate different components of floristic

Fig. 27. Chandra Valley in Cold Desert BR.

diversity and prioritize habitats, species and communities for conservation. Objectives include; (i) to assess plant diversity of the Cold Desert Biosphere Reserve; (ii) to assess the distribution pattern and status of native and endemic species; (iii) to identify the ecologically and economically important species and assess the populations of selected species; and (iv) to prioritize habitats, species and communities for conservation, and economically important species for the socio-economic development of the Tribal communities. The results of the study are as follows.

- A total of 28 sites representing 08 habitats and 06 aspects between 3,083-4,609 m were surveyed and sampled from Chandra valley (Fig. 27) of the proposed Cold Desert Biosphere Reserve.
- 316 species of vascular plants belonging to 65 families and 163 genera were recorded. Of these, 277 species were herbs, 20 shrubs, 9 trees and 10 ferns. 17 plant communities i.e., 04 trees; 06 shrubs and 07 herbs were identified. Structural attributes of these communities are presented (Table 10).

Table 10. Distribution, Diversity (H^1) and Concentration of dominance (Cd) of some of the major communities in CDBR.

Community types	Altitudinal Range (m)	Habitat (S)	Species Diversity (H^1)			Conc. of dominance (Cd)		
			Trees	Shrubs	Herbs	Trees	Shrubs	Herbs
a). Tree communities								
Betula utilis	3304-3537	A	0	2.14	4.07	1	0.12	0.02
Juniperus polycarpos	3325	A	0	0.47	1.02	1	0.71	0.05
b). Shrub communities								
Ephedra gerardiana	4130-4335	B, C	-	0	3.45	-	1	0.04
Rhododendron anthopogon	3537-4149	A,D,E,F	-	1.42	4.12	-	0.32	0.03
Juniperus indica	3695	E	-	0	3.15	-	1	0.06
Rosa webbiana	3178-3270	G, E	-	0.66	3.79	-	0.53	0.03
c). Herb communities								
Agrostis munroana-A. grifthiana-Calamagrostis holciformis-Calamagrostis emodensis mixed	3270	G	-	-	3.47	-	-	0.04
Bergenia stracheyi-Puccinellia himalaica-Bromus tectorum mixed	3437	E	-	-	2.45	-	-	0.2
Potentilla atrosanguinea-Sibbaldia parviflora-Poa alpina-Oxytropus tatarica-Bistorta affinis mixed	4609	A	-	-	2.51	-	-	0.09
Bistorta affinis-Poa alpina-Sibbaldia parviflora-Oxytropis tatarica mixed	4590	B	-	-	2.28	-	-	0.12

Evaluation and Propagation of Two Vitality Strengthening Astavarga Plants of West Himalaya *(2006-2009, NMPB Funded)*

Indiscriminate collection and destructive harvesting of the medicinal plants from the wild have put many valuable plant species in the category of critically endangered, endangered, vulnerable and even extinct. Conservation of such plants has emerged as a common agenda. However, along with the various approaches towards conservation, which include banning of extraction and trade, some indirect approach needs to be developed, which deals with the sustainable utilization of the resources. Development of such approaches need involvement of technology based innovations with high quality research and development investments. In this context, development of suitable propagation packages for mass production of planting materials, analysis of phytochemical properties for quality control and growth response in wild and cultivation are some areas where one can achieve conservation as well sustainable utilization goals. The focus of study is to; (i) analyze the phytochemical properties within and among population of selected species; (ii) develop propagation and storage protocols using conventional as well as biotechnological tools for conservation and sustainable utilization; (iii) maintain the accessions of each individual collected from different localities in gene bank; (iv) compare the phytochemical properties of wild with cultivated planting material; and (v) maximize the field transfer of plantlets obtained from elite stock. The results of the study are as follows.

- Asymbiotic *in vitro* seed germination of *Habenaria edgeworthii* revealed the variation in seed germination percentage among the different mediums tried. MS medium was found best for asymbiotic seed germination and 94% seed germination was achieved (Fig. 28).
- Propagules collected from different localities (*Habenaria intermedia* – 11; *H. edgeworhii* - 9 localities) were planted in Surya Kunj. Survival and growth performance monitoring is under progress.

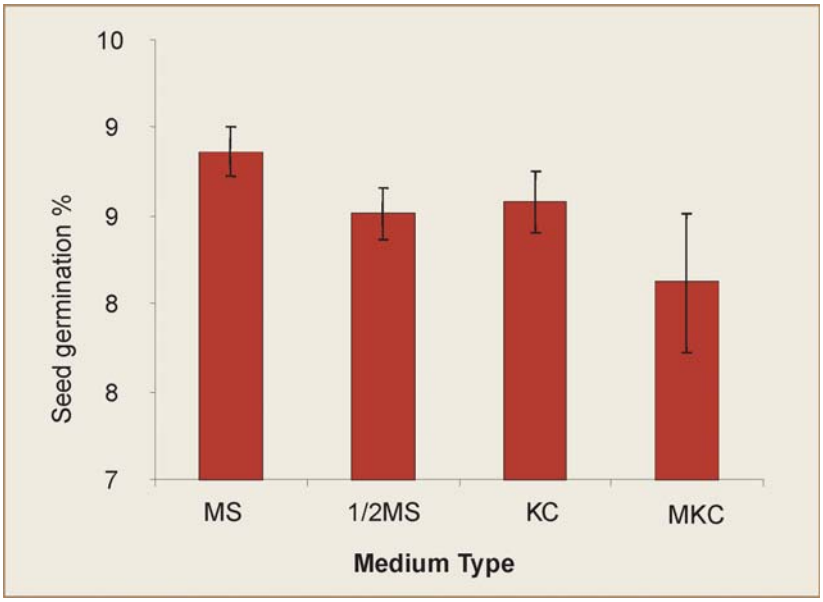


Fig. 28. Effect of various medium on asymbiotic seed germination of *Habenaria edgeworthii*.
MS-Murishige & Skorg, KC-Knudson C, MKC-Modified Knudson C

Population Status Assessment and Screening of Active Constituents of Selected Medicinal Plants in Uttarakhand Himalaya *(2006-2009, UCOST Funded)*

Medicinal plants are of particular interest because they contain variety of phytochemicals and bio-chemicals which could be potential source of new and novel natural antioxidants. It is more important in the context of Himalayan medicinal plants where no or little information is available on the natural source of antioxidants. The project thus envisages; (i) screening of selected plants of Uttaranchal for natural source of antioxidants; (ii) determining the potential of bioactive ingredients using bioassay methods; and (iii) addressing the issues related to conservation and sustainable utilization of these plants in the state. The outcome of the project will be helpful in identifying novel biomolecules/ natural source of antioxidants, identification of new natural sources of antioxidants and determining the viable population on the basis of chemical fingerprinting. The results of the study are as follows.

- Gas chromatography analysis of linalool content in essential oil of *Hedychium spicatum* showed variation across populations and ranged between 0.86% (P3) to 7.84% (P4).
- Total antioxidant activity of the *Hedychium spicatum* rhizome by multiple screening assay methods i.e., Azinobis (Ethylbenzothizoline 6-Sulphonic acid) radical & caranging (ABTS), Diphenyl-2-picryl-hydrazyl (DPPH) and Ferric Reducing Antioxidant Power (FRAP) revealed the variation in antioxidant potential of the species. The ascorbic acid equivalent antioxidant activity was specific to each assay and ranged between 0.84 ±0.06 (DPPH) to 2.18 ±0.16 mM /100 gram dry weight of rhizome (ABTS) (Fig. 29).
- Propagules collected from different localities (*Hedychium spicatum* - 18; *Roscoea procera* - 16) were planted in Surya Kunj. Survival and growth monitoring is under progress.

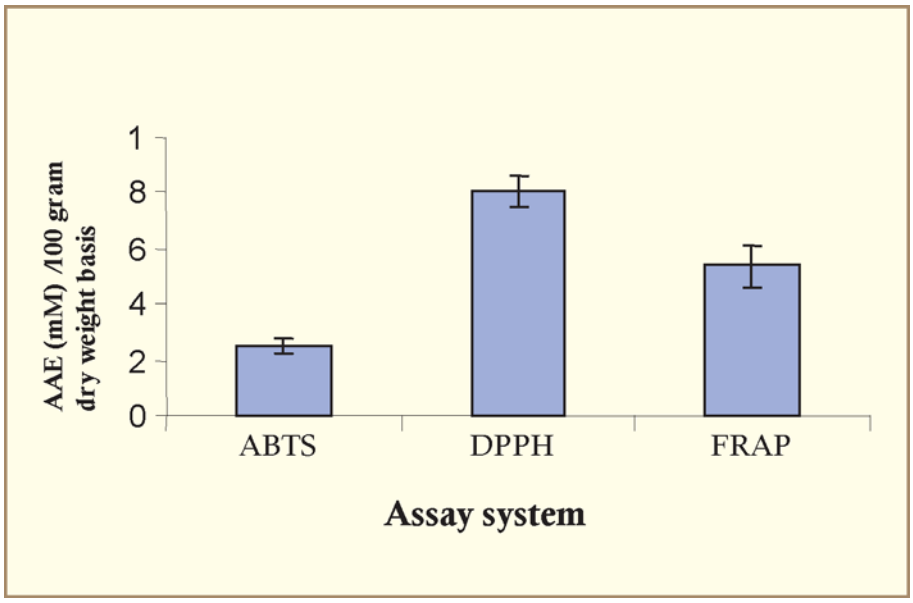


Fig. 29. Antioxidant activity of *Hedychium spicatum* in different bioassay system.
ABTS-Azinobis (Ethylbenzothizoline 6-Sulphonic acid) radical & caranging , DPPH-Diphenyl-2-picryl-hydrazyl, FRAP- Ferric Reducing Antioxidant Power, AAE-Ascorbic Acid and Quiralent

Summary of Completed Project / Activity

Bioresource Inventory of the Himalaya *(2004-2007, In-house)*

The activity focused on developing adequate baseline information on bioresources of the Indian Himalaya with a specific attention for a database on native and endemic species. The achievements under different groups included the following:

Floral inventory

- Database was developed for 50 temperate families of vascular plants (3333 species, 532 genera) in Indian Himalayan Region (IHR) and analysis revealed: (i) richness of endemics (1934 spp; 57.7%), and increasing prevalence of endemics from subtropical (30.8%) to high alpine (75.2%) zones; (ii) Significantly higher endemism than expected in families like Apiaceae (index of endemicity, Ie-2.3), Berberidaceae (Ie 3.4), Caryophyllaceae (Ie 1.6), Gentianaceae (Ie-2.1), Ranunculaceae (Ie-1.8) and Rosaceae (Ie-1.9). Endemic richness was more in barren habitat, followed by forests and Moraines. Considering various attributes (taxonomic richness, endemic richness, restricted taxa, weighted endemism index, corrected weighted endemism index) of studied temperate families, 15 grids (localities) have been prioritized.
- Inventory of Orchids (886 spp.; 152 genera) of IHR were prepared and analysed for species diversity and distribution pattern. The species rich genera include of *Bulbophyllum* (80), *Dendrobium* (76), *Eria* (45), *Liparis* (34), *Oberonia* (33), *Cymbidium* (25), *Habenaria* (23), *Peristylis* (22), and *Calanthe* (21 spp.). Maximum orchids (92.78%) are distributed in the zone <1800 m amsl and minimum (2.6%) the alpine zone. Nearly 50% species are Himalayan natives and 41 species are recorded in the Red Data Book of Indian plants.
- Inventory was prepared for Medicinal Plants of Himachal Pradesh (626 species; trees 102; shrubs 119; herbs 405) which included 41% as Himalayan natives, 27% endemic and 20% near endemic. 68 species were reported under different threat categories.

Faunal inventory

- Database was developed for avian fauna of West (482 species; 20 orders, 52 families and 212 genera) and north east Himalaya (770 species; 19 orders, 68 families). Information was analyzed for threat status assessment of identified species.
- An inventory of 99 species of reptiles belonging to 14 families and 3 orders was prepared across the Himalayan Biosphere Reserves (HBRs). The total of 82 species fall under different threat categories (Critically Endangered – 3; Endangered – 6; Vulnerable 22; Low Risk Near Threatened – 24; Low Risk Least Concern – 14 and Data Deficient – 13).
- Study completed on ichthyo-faunal population and diversity in Senki stream of Papum Pare district, Itanagar (AP), revealed presence of 47 species, 16 families, 32 genera of fishes and 2 species of crustaceans.

Summary of Completed Project/Activity

Studies on Biodiversity *(2004-2007, In-house)*

1. Biodiversity Rich Areas – PAs

A. Wildlife Sanctuaries

- The study, conducted in three protected areas [i.e., Manali Wildlife Sanctuary (MWLS), Kais Wildlife Sanctuary (KWLS) and Khokhan Wildlife Sanctaury (KhWLS) in Himachal Pradesh] revealed – (i) a total 637 species of vascular plants in MWLS, 376 species in KhWLS and 607 species in KWLS.
- Total 26 plant communities in KWLS, 17 in KhWLS and 23 forest and 24 alpine communities in MWLS were identified. Total trees, shrubs and herbs densities ranged from 170.0-1190.0 Ind ha^{-1}, 190.0-3890.0 Ind $ha^{-1}$and 43-276 Ind m^{-2}, respectively, in MWLS and 160.00-860.00 Ind ha^{-1}; 396.00-4025.00 Ind ha^{-1}; and 47.35-164.00 Ind m^{-2}, respectively in KWLS. Whereas total tree density in KhWLS ranged from 460.0-1468.5 Ind m^{-2}. Total basal area ranged from 0.76-103.9 m^2ha^{-1} in MWLS and 2.75-253.0 m^2 ha^{-1} in KWLS and 77.45-369.07 m^2 ha^{-1} in KhWLS.
- Species diversity (H^1) for trees, shrubs and herbs ranged from 0.27-2.17, 0.70-2.87 and 2.88-4.26, respectively in KWLS and 0.393-2.060, 0.638-2.737 and 2.313-4.138, respectively in MWLS whereas tree diversity ranged from 0.74-2.66 in KhWLS.
- Presence of 56.3% and 52.9% species were natives, 30.8% and 31.6% endemics in MWLS and KWLS, respectively, which signifies the importance of conservation of these areas. Maximum number of non-natives were in the altitudinal zone of 2000-2800m in both Sanctuaries pointing towards habitat degradation due to human inhabitation.
- 390 species in MWLS, 67 in KhWLS and 437 species KWLS are used by the local inhabitants. The high value medicinal species such as *Picrorhiza kurrooa, Aconitum heterophyllum, Dactylorhiza hatagirea, Jurinella macrocephala, Angelica glauca, Podophyllum hexandrum,* and *Arnebia benthamii;* communities *Betula utilis, Cedrus deodara, Picea smithiana, Rhododendron campanulatum* and *R. anthopogon*, in shady moist forests, bouldary, dry forest and alpine moist slope samong the habitats were prioritized for conservation.

B. Biosphere Reserves (Proposed Cold Desert Biosphere Reserve)

The study was conducted in the forest zone of the Lahaul valley and focused on the assessment of forest vegetation, status and distribution pattern of native and endemic species, resource use pattern and indigenous uses, threat assessment of the species and conservation prioritization of habitats, species and communities.

- 633 species of vascular plants (287 genera and 90 families) were recorded. Of the total, 40.1% were natives and 30.1% endemics. Families, Asteraceae, Poaceae, Rosaceae and Fabaceae were dominant.

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- 96 sites representing 15 habitats and 8 aspects were surveyed and 14 forest communities identified. *Juniperus polycarpos* community represented maximum sites (43), followed by *Pinus wallichiana* (13), *Cedrus deodara* (11), Picea smithiana (8 sites), *Abies pindrow* (6 sites) and Betula utilis (5 sites).
- Among the communities, richness of trees ranged from 1-9, shrubs 3-23, herbs 9-213, seedlings 0-5, and saplings 0-4. Total tree density within the communities ranged from 170.54-1850.00 Ind ha^{-1}; total basal area 13.65-124.89 m^2 ha^{-1}; total shrub density 480.00-2611.7 Ind ha^{-1}; total herb density 7.83-95.10 Ind m^{-2}; total sapling density 162.15-816.42 Ind ha^{-1} and total seedling density 0-1300.00 Ind ha^{-1}. Species diversity (H^1) for trees ranged from 0.00-1.88, seedlings 0.00-1.15, saplings 0.00-1.28, shrubs 0.05-2.74 and herbs 0.01-4.30 and Concentration of dominance (Cd) of trees ranged from 0.19-1.00, seedlings, 0.08-1.00, saplings 0.30-1.00, shrubs 0.08-0.98 and herbs 0.02-0.21.
- Threat assessment of the species was done and 40.13% species were identified under different threat categories.
- Habitats (forest and shady moist); and Communities (*Abies pindrow-Pinus wallichiana mixed, Fraxinus xanthoxyloides, Picea smithiana-Pinus wallichiana* mixed and *Cedrus deodara-Acer cappadocicum* mixed) were prioritized for conservation based on the conservation priority index.

2. Sensitive and High Value Species

- Population and habitat studies of *Aconitum ferox*, *Rheum acuminatum*, *Dactylorhiza hatagirea*, *Panax pseudogingseng, Swertia chirayita*, *Angelica glauca* and *Podophyllum hexandrum* in different parts of East and West Himalaya showed that plant density m^{-2} ranged between 1-13 (*A. ferox*), 1-25 (*R. acuminatum*), 1-17 (*P. pseudogingseng*), 1-11 (*D. hatagirea*), 1.65 to 2.35 (*S. chirayita*), 0.95-1.8 (*A. glauca*), 0.1-1.9 (*P. hexandrum*), etc. In case of *Swertia chirayita* non-significant correlation ($r=0.1997$; $p<0.05$) obtained between altitude and plant density. Stem height ($r=-0.464$; $P<0.01$) and collar diameter ($r=0.272$; $P<0.01$) significantly correlated with altitude.
- Genetic diversity analysis in the natural populations of *Hedychium spicatum* represented total 32 alleles in 13 loci. Remarkable levels of variation were observed in all the loci except MDH (Malatedehyetrogenase). The observed mean hetorozygosity for all allozyme loci ranged from 0.328 in H_1 population to 0.641 in H_8. The mean expected heterozygosity (genetic diversity) for all allozymes ranged from 0.328 in H_{10} to 0.451 in H_7. The mean number of alleles for population 1.77 in H_3, H_9, H_{11}, H_{12} to 1.92 in H_4. Population H_{10} showed the lowest percentage of polymorphic loci (61.54%), whereas the population H_1 showed highest percentage of polymorphic loci suggested the mass multiplication of the population with higher polymorphism.

Summary of Completed Project/Activity

Inventorying and Monitoring of Natural Resources for the Socioeconomic Development of Local Communities in Mohal Khad Watershed of the Himachal Pradesh *(2003-2007, In-house)*

The study was conducted in the Mohal Khad Watershed of the Kullu district (HP) to: (i) assess and map natural resources (biological, land and water, etc.); (ii) study socioeconomic status of the local communities; (iii) assess floristic diversity including community delineation and regeneration pattern; (iv) assess dependence of local communities on natural resources and document indigenous knowledge and practices; (v) monitor changes of the landscapes and overall impact of local communities on the natural resources; (vi) prioritize natural resources for the socioeconomic development of the local communities. (vi) establish and maintain conservation models; and (vii) develop conservation and management strategy. The outcome of study is as follows:

- In the watershed, most of the population (91%) depends on agriculture, followed by Government jobs (6%) and business (3%), which indicated peoples preference for agriculture and horticulture for sustenance.
- Rainfall, runoff and soil were monitored for 5 land use types (i.e., deodar forest, mix forest, broad leaf forest, barren land and agriculture land). Average rainfall was highest for the agricultural land (2.07 cm), followed by barren land (1.70 cm), mix forest and deodar forest (1.68 cm, each) and broad leaved forest (1.37 cm). The highest run off was recorded under mixed forest (18.57%), followed by barren land (18.41 %), broad leaved forest (12.59 %), deodar forest (7.62 %) and agricultural land (2.22 %).
- 87 economically important species (43 trees, 11 shrubs and 33 herbs) were recorded. These species were used as medicine (27), wild edible/food (22), fuel (31), fodder (25), timber (10), religious (15), making agricultural tools (5) and miscellaneous purpose (15 spp.).
- Total 13 forest communities were identified and total tree density ranged from 710.00-1468.49 Ind ha^{-1}; total basal area 81.57-369.07 m^2 ha^{-1}; total sapling density 180.00-1171.87 Ind $ha^{-1}$and total seedling density 145.00-1289.67 Ind ha^{-1}. *Abies pindrow* community had maximum tree density (1468.49 Ind ha^{-1}), followed by *Persea odoratissima* (1232.50 Ind ha-1) and *Quercus floribunda* (1218.33 Ind ha^{-1}).
- Soil pH ranged from 5.09-6.47, moisture content 11.53-30.63%, total nitrogen 0.13-0.68 %, total organic carbon 2.19-3.65%, and total organic matter 3.92-6.27%.
- The watershed supports diverse habitats, species, communities and ecosystems. These are one of the major sources of livelihood of the inhabitants. Therefore, development of appropriate strategy for the conservation and management of these resources is suggested.

Summary of Completed Project / Activity

Conservation and Sustainable Utilization of Sensitive Biodiversity Elements of the Trans, North West Himalaya *(2004-2007, In-house)*

The study was conducted in three protected areas i.e., Manali Wildlife Sanctuary (MWLS), Kais Wildlife Sanctuary (KWLS) and Khokhan Wildlife Sanctaury (KhWLS) in Kullu district. Total 637 species of vascular plants in MWLS, 376 species in KhWLS and 607 species in KWLS were recorded. Maximum species occurred in between 2000-2800m and decreased with the increasing altitude in all three Sanctuaries. 26 plant communities in KWLS, 17 in KhWLS and 23 forest and 24 alpine communities in MWLS were identified. Total tree, shrub and herb densities ranged from 170.0-1190.0 Ind ha^{-1}, 190.0-3890.0 Ind ha^{-1} and 43-276 Ind m^{-2}, respectively, in MWLS and 160.00-860.00 Ind ha^{-1}; 396.00-4025.00 Ind ha^{-1}; and 47.35-164.00 Ind m^{-2}, respectively in KWLS. Whereas total tree desity in KhWLS ranged from 460.0-1468.5 Ind m^{-2}. Total basal area ranged from 0.76-103.9 m^2 ha^{-1} in MWLS and 2.75-253.0 m^2 ha^{-1} in KWLS and 77.45-369.07 m^2 ha^{-1} in KhWLS. Among communities, *Picea smithiana* and among habitats, bouldary habitat had highest species richness in both Sanctauries. Species diversity (H2) for trees, shrubs and herbs ranged from 0.27-2.17, 0.70-2.87 and 2.88-4.26 respectively in KWLS and 0.393-2.060, 0.638-2.737 and 2.313-4.138, respectively in MWLS whereas tree diversity ranged from 0.74-2.66 in KhWLS. pH ranged from acidic to neutral and nitrogen, organic matter and carbon ranged from 0.06-1.26%, 1.30-12.29 % 1.16-6.51%, respectively in MWLS and 0.14-1.47%, 2.14-13.23%, and 1.24-7.67 %, respectively, in KWLS. 56.3% and 52.88% species were natives, 30.81 % and 31.6 % endemics in MWLS and KWLS, respectively, signifies the conservation importance of the areas. Maximum number of non-natives were in the altitudinal zone 2000-2800m in both Sanctuaries pointing towards habitat degradation due to human inhabitation. 390 species in MWLS, 67 in KhWLS and 437 species KWLS used by the local inhabitants as medicinal, wild edible, fodder, fuel, timber, religous and various other purposes. The high value medicinal species such as *Picrorhiza kurrooa, Aconitum heterophyllum, Dactylorhiza hatagirea, Jurinella macrocephala, Angelica glauca, Podophyllum hexandrum, Arnebia benthamii; communities Betula utilis, Cedrus deodara, Picea smithiana, Rhododendron campanulatum and R. anthopogon*, and shady moist forest, bouldary, dry forest and alpine moist slope among the habitats were prioritized for conservation. Monitoring of habitats, species and communities supporting useful, native, endemic, and threatened species, and in-situ and ex-situ conservation measures are suggested.

Summary of Completed Project / Activity

Studies on The Diversity and Conservation Status of Plants in a Proposed Cold Desert Biosphere Reserve of the Himachal Pradesh in North Western Himalaya

(2004-2007, In-house)

- The study was conducted in the forest zone of the Lahaul valley from 2004 to July 2007 and focused on the assessment of forest vegetation, status and distribution pattern of native and endemic species, resource use pattern and indigenous uses, threat assessment of the species and conservation prioritization of habitats, species and communities.
- 633 species of vascular plants belonging to 287 genera and 90 families were recorded from the forest zone between 2400-4000m. Of the total species, 40.13% were natives and 30.13% endemics. Families, Asteraceae, Poaceae, Rosaceae and Fabaceae respectively were dominant.
- 96 sites representing 15 habitats and 8 aspects between 320 22.517' - 320 48.564'N Latitudes and 76025.017' - 77016.636'E Longitudes were surveyed and sampled and 14 forest communities were identified. *Juniperus polycarpos* community represented maximum sites (43 sites), followed by *Pinus wallichiana* (13 sites), *Cedrus deodara* (11 sites), *Picea smithiana* (8 sites), *Abies pindrow* (6 sites) and *Betula utilis* (5 sites). 90.48% trees, 94.00% shrubs and 99.18% herbs showed regular distribution; 4.76% trees, 6.00% shrubs, 0.82% herbs random distribution; 4.76% trees contagious distribution among the communities.
- Among the communities, richness of trees ranged from 1-9, shrubs 3-23, herbs 9-213, seedlings 0-5, and saplings 0-4. Total tree density within the communities ranged from 170.54-1850.00 Ind ha^{-1}; total basal area 13.65-124.89 m^2 ha^{-1}; total shrub density 480.00-2611.7 Ind ha^{-1}; total herb density 7.83-95.10 Ind m^2; total sapling density 162.15-816.42 Ind ha^{-1} and total seedling density 0-1300.00 Ind ha^{-1}. Species diversity (H^1) for trees ranged from 0.00-1.88, seedlings 0.00-1.15, saplings 0.00-1.28, shrubs 0.05-2.74 and herbs 0.01-4.30 and Concentration of dominance (Cd) of trees ranged from 0.19-1.00, seedlings, 0.08-1.00, saplings 0.30-1.00, shrubs 0.08-0.98 and herbs 0.02-0.21.
- Threat assessment of the species was done and 40.13% species were identified under Critically Endangered, Endangered, Vulnerable and Near Threatened categories. Species falling under Critically Endangered, Endangered and Vulnerable categories were Prioritized for Conservation.
- Habitats (forest and shady moist); and Communities (*Abies pindrow-Pinus wallichiana mixed, Fraxinus xanthoxyloides, Picea smithiana-Pinus wallichiana mixed* and *Cedrus deodara-Acer cappadocicum* mixed) were prioritized for conservation based on the conservation priority index.
- Regular monitoring of the prioritized species, habitats and communities has been suggested.

Theme

ENVIRONMENTAL ASSESSMENT AND MANAGEMENT (EAM)

The economic development especially in the industrial age has led to depletion and marginalisation of natural and human resources. Keeping this in view, all programmes of conservation and development need to be evaluated in terms of comprehensive Environmental Impact Analysis (EIA) framework, a basic tool for decision making at national, regional and local levels. In view of the above, EAM theme focuses on assessment and monitoring of environmental attributes (physical, biological and socio-economic) related to various kinds of developmental interventions/policies/plans in the Indian Himalayan Region (IHR). Baseline status assessment, impact assessment, valuation of ecosystem services, database development and formulation of environmental management plans are also covered under the theme. Global warming, climate change related issues, and macro level studies on impact assessment of developmental interventions including land use/land cover change for planning and management solutions are also the core areas of R&D activities. The theme envisages to i) make comprehensive assessment and monitor environment with respect to various kinds of developmental interventions/policies/plans in the IHR, and ii) develop/formulate/suggest appropriate management plan(s) for ensuring ecological and economic security of the IHR.

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

Ecosystem services (ES) are the conditions and processes through which natural ecosystems and the species that make them up and fulfil supply of goods and services, sustain human life. Ecosystem services are generated due to the interaction and exchange between biotic and abiotic components of an ecosystem. Ecosystem services include 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, scenic beauty and aesthetics etc. The harvest and trade of these goods represent an important and familiar part of the human economy. This study was initiated to compare the various ES of the two major forest ecosystems of central Himalaya (viz., Oak and Pine) at three sites (Lohaganj in Chamoli Distt.; Kausani in Bageshwar Distt.; and Dharonj in Champawat Distt.) to better understand these forests for conservation and management implications. The objectives of the study are i) to quantify and evaluate various ecosystem goods and services accrued from major forest types of central Himalayan region, ii) To investigate the impact of these forests on cropfield fertility, pollinators, crop yield and crop

diversity, iii) development of methodologies and approaches for quantification and valuation of forest ecosystem services and iv) to find out suitable mechanism to incorporate the findings in the EIA framework.

- Soil moisture across the soil depth during winter was found significantly different (LSD significant at $p<0.05$) in the Oak forest of Kausani and in the Pine forests of Kausani and Dharonj (Fig.30). A definite trend for soil moisture across the soil depths was not discernible. In general, Water Holding Capacity (WHC) declined with increasing soil depth. Soil Organic Carbon (SOC) during winter was found ranging from (0.21 - 2.52%) across different soil depths in Oak (0.1-0.76%) in Pine forests. SOC was not found significantly different across the soil depths. SOC declined with increasing soil depth for all the forest sites in both the forest types.
- During the rainy season in the undisturbed Oak forest a total of 154 spp. of different plants were recorded as compared to only 68 spp. in Pine forest of Lohajang (Chamoli)

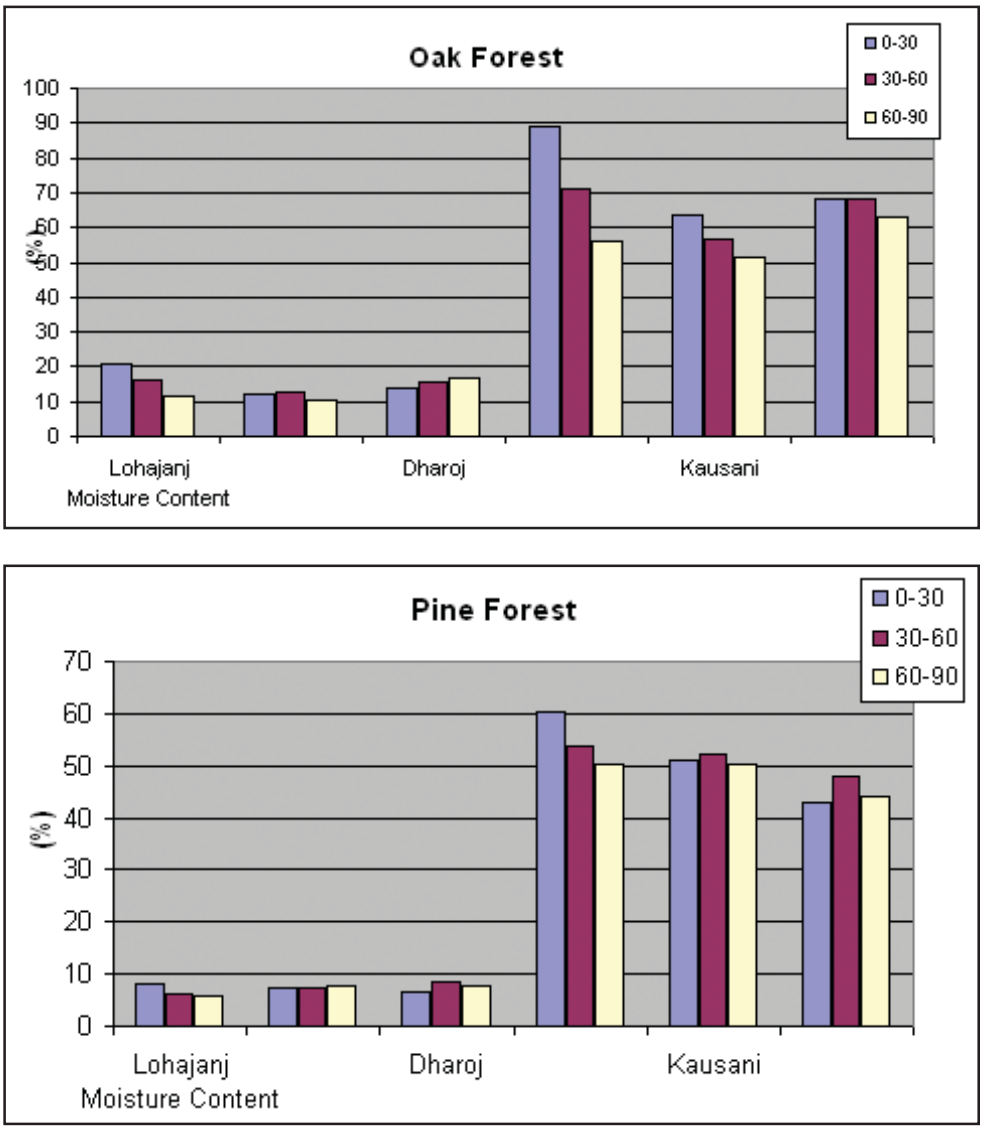


Fig. 30. Soil moisture and Water holding capacity during winter in different forests.

site (Fig. 31 & 32). In the undisturbed Pine forest of Gwaldom (Chamoli) a total of 109 plant spp. were recorded and in the Pine forest of Kausani 36 spp. of different plants were reorded. In the Oak forest of Kausani 76 spp. of plants were recorded.

- A stakeholders' consultation meeting was organized with the rural people in village cluster of Dewal Block (Lohaganj; Chamoli) in which over 150 people participated and listed various ES of these forests.

Fig. 31. A Pine forest surrounded by cropfields and human settlements.

Fig. 32. A close view of canopy of Oak forest.

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

India currently generates only about 14% electricity from hydroelectric plants (HEP) mainly located in Himachal Pradesh, Uttarakhand, and the Northeastern states. The major portion of the future potential to be developed lies in IHR only. Review of current policies reveals that in the context of Himalayan region; no specific provisions for environmental conservation are made except for provisions laid down through the acts in terms of protected areas; rare/threatened/endangered species; noise/air/water pollution, etc. The Himalayan region constitutes a fragile and unique ecosystem that requires special consideration. In this background it is necessary that while undertaking EIA studies in IHR greater emphasis should be placed on understanding inter linkages and inter relationships of the fragile ecosystem. Strategic Environmental Assessment (SEA) is one such decision making tool which can help in sustainable development of hydropower projects. This work is an attempt to provide a representative overview of SEA to provide suitable clues for necessary policy framework. The specific objectives are i) to overcome the challenges associated with project level EIA process and try to conduct cumulative impact assessment (-ve/+ve) of various hydropower projects (existing/proposed) initially for a river basin in Western Himalaya and subsequently for entire Western Himalayan region as a whole, ii) 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, iii) to suggest the optimal number and type of hydropower projects such that the development is environmentally viable, iv) to incorporate ecological economic based prospecting for compensation of eco-system services.

- Uniform database about number of hydropower projects in operation, construction and planning stages has been developed along with relevant details on precise location (dam site and power house site), capacity, developer, EIA/EMPs status, dam/barrage

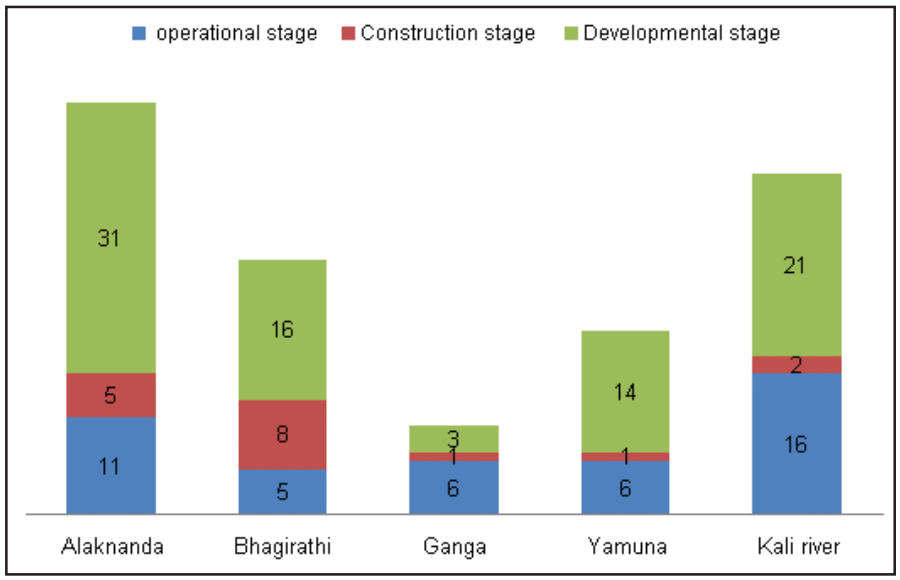


Fig. 33. Major river basins in Uttarakhand and the number of HEP within them at different stages.

height, submergence area, catchment area, no.'s and lengths of tunnel, etc.

- In Uttarakhand, the maximum numbers of HEPs are proposed in Alaknanda river basin (Fig 33). Based on compiled database so far, out of 123 hydropower projects; there are 40 hydropower projects under operation in Himachal state which would have 5490.57 MW capacity under centre/joint sector, 466.95 MW under state sector and another 412.6 MW under private sector (Fig. 34 & 35).
- GIS based thematic layers on aspect, Protected area, village boundary, drainage pattern, Digital elevation model, settlement, road, slope have been developed for Uttarakhand and Himachal Pradesh states of the Western Himalaya. A comprehensive review of the prevalent policy framework for the hydropower projects has also been made.

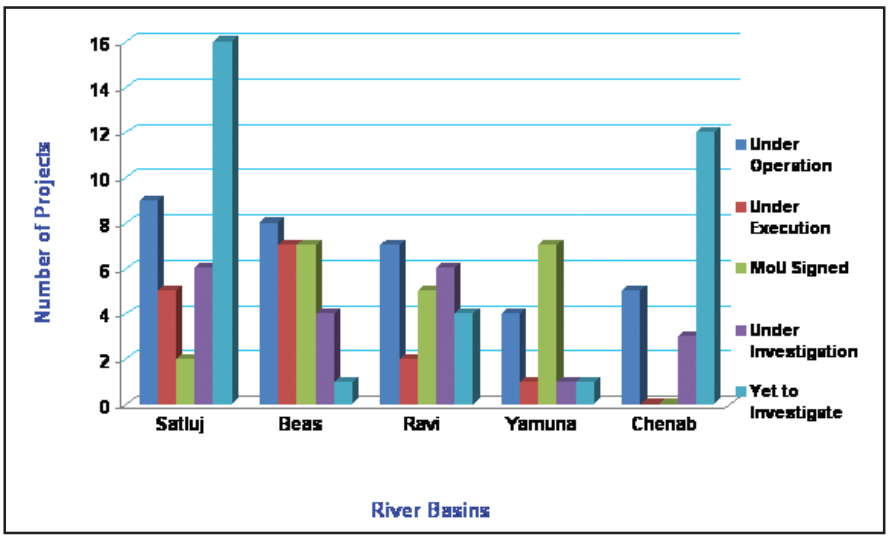


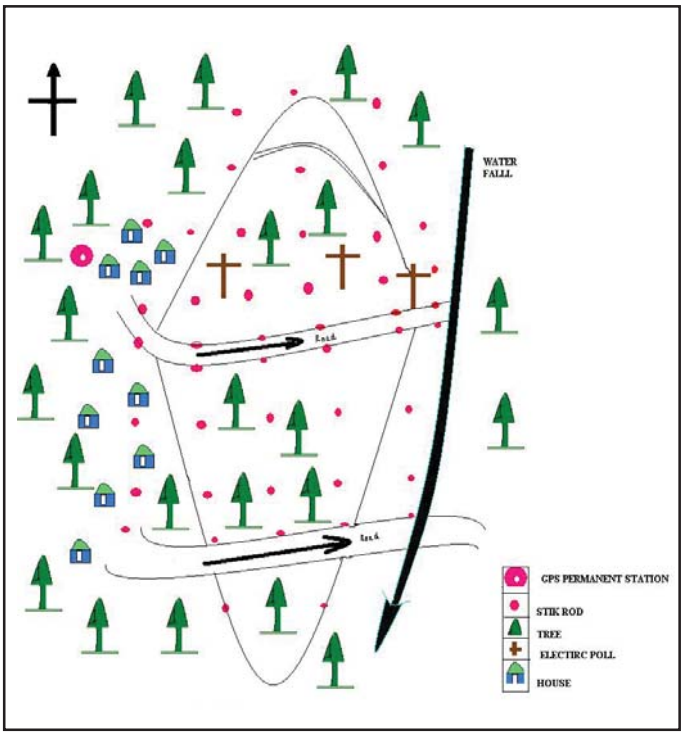
Fig. 34. Hydropower Projects under various stages of development in Himachal Pradesh.

Fig. 35. A view of Koldam (800 MW) hydropower project under construction in the Sutlej basin depicting few of the environmental impacts of hydropower development.

Stabilization of Landslide Through Bioengineering Measures in Sikkim
(2007-2012, In-house)

Landslide and other mass movement are serious geo-environmental hazards in the Sikkim Himalayas. This is due to a combination of several factors such as geological formation with fragile rock and unconsolidated soil materials coupled with high intensity annual precipitation and steep slopes. Massive landslides have killed tens of thousands people with catastrophic damage. This investigation is carried out with emphasis on understanding triggering mechanism that has contributed to the release and creep of natural slope. An attempt is made to design and demonstrate bioengineering measures for stabilization of slopes. The study focues on i) identification of hazard zones, mapping and habitat assessment, ii) stabilization of landslide through engineering and bioengineering measures and iii) performance/monitoring of engineering and bioengineering measures in different landslides and their comparison.

- Field survey in 60 landslides from different parts of Sikkim was carried out for collecting details such as location and size of slide, rock type, soil type, slope condition, history of slide and failure mechanism, etc.
- A meeting was organized with stakeholders on sharing of experiences in mitigation of landslide and for selection of one slide for implementation of engineering and bioengineering measures. The two landslides identified are Malbasey slide (Singtam) and Bojeck slide. Based on the feasibility assessment one slide will be selected for implementation of engineering and bioengineering measures.
- Monitoring of Bakthang landslide/ subsidence has been initiated using GPS survey (Fig. 36 & 37). 50 stakes has been fixed in the slide/subsidence area for measurement of movement.



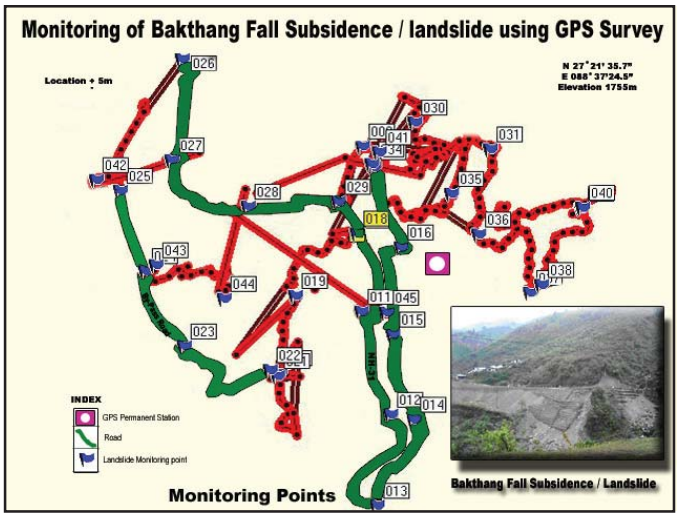


Fig. 36. Sketch for Bakthang slide/subsidence showing the locations of stakes.

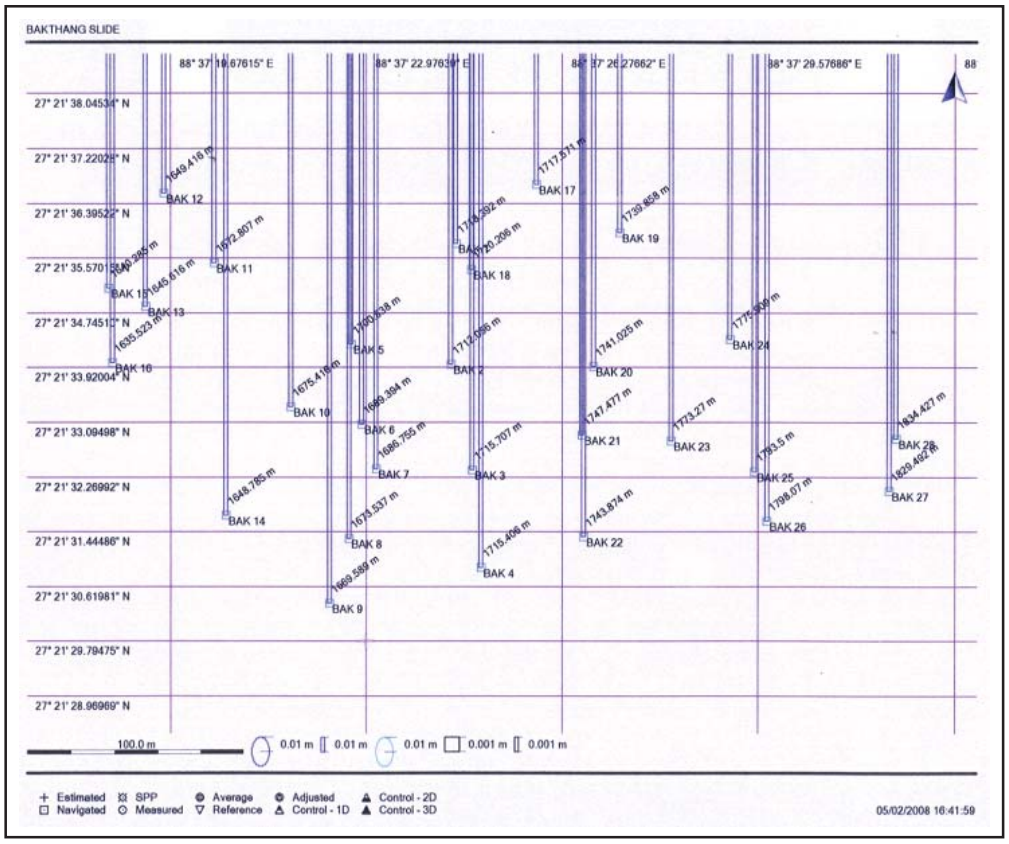


Fig. 37. GPS measurement point showing error.

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

With the continuous expansion of urban settlements in the Himalayan region, the townships are getting continuously degraded due to ever growing population and their activities in terms of disposal of waste. The situation is getting worsened when most of the townships have sprawled in the outer fringes of the municipal limits due to saturation within the main township area. In the absence of proper and inadequate infrastructural services, some of the human induced pollution such as solid waste and air pollution have been continuously increasing in the urban towns of Himachal Pradesh and Uttarakhand. Unscientifically managed solid waste has become a major 'nuisance' in hilly urban areas, which needs to be converted into reusable resource whenever possible. For rationale planning to manage solid waste in the hilly urban areas, it is essential to gather the information on nature and extent of solid waste generated and existing system of waste disposal. The study is therefore envisaged with the specific objectives of i) identifying sources, quantity, and nature of solid waste for its source-wise characterization, ii) surveying the treatment and disposal facilities available including their adequacy, and iii) monitoring particulate and gaseous pollutants in ambient air to establish background values close to hill towns for policy implications. The salient findings are as below.

- Based on reconnaissance survey for solid waste study, the municipal councils from five towns; Bilaspur, Kangra, Mandi, Hamirpur, Chamba and one village Panchayat; Keylong (also district headquarters of Lahaul & Spiti district), have been selected. Population details of these towns are presented in Fig. 38.
- Solid waste sampling was carried out in the selected locations in both the states (Fig. 39). In Himachal, per day total generation of household waste was recorded highest at Mandi and lowest at Kangra for both the Autumn and Winter seasons. The per day waste generation values were highest with 7 tonnes in autumn and 6.2 tonnes in winter at Mandi and 1.5 tonnes in autumn and 2.1 tonnes in winter season at Kangra (Fig. 38). Generation of solid waste in different towns of Uttarakhand is analyzed as presented in Table 11. In Almora and Srinagar town of Uttarakhand, per capita per day solid waste generation worked out to be 125 and 367 gm, respectively.

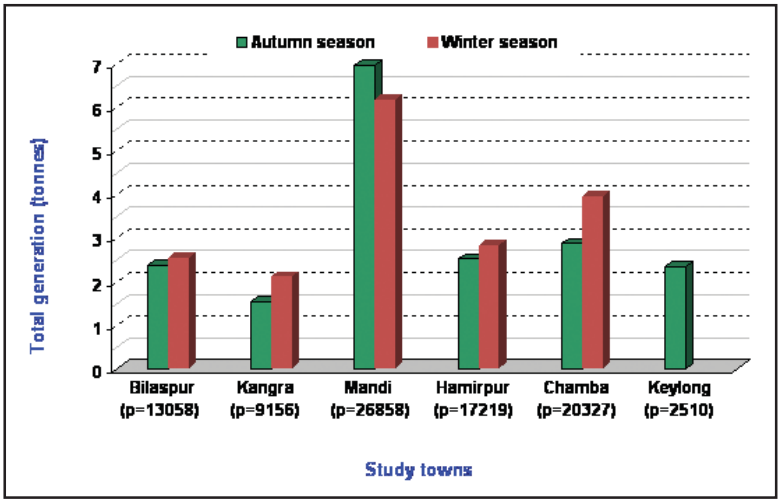


Fig. 38. Total generation of household waste in the study towns of Himachal Pradesh during Autumn and Winter seasons, 2007-08 ('p' indicates population of a town).

Fig. 39. Solid waste practices, problems and management waste characterization to obtain its composition at Keylong and Kangra.

Table 11. Total waste generated/day and dumped quantity/day (Ton).

Sampling Town	Population as per 2001 census	Waste Generation (ton/day)	Municipal Area (sq. km)	Population Density (per sq. km)	Per capita Waste Generation (kg)
Almora	30153	15	11.04	2731.25	2.01
Pithoragarh	41157	20	9	4573.00	2.06
Ranikhet	19055	7	1690	11.28	2.72
Srinagar	19861	12	7.77	2556.11	1.66
Chamoli	19855	5	15.02	1321.90	3.97
Joshimath	13202	3	11.19	1179.80	4.40

Impact of *Lantana* Mulching on Soil Fertility *(2005-2008, DST Funded)*

In the Central Himalayan mountains about 90% of agriculture is carried out on sloping rainfed terraces characterized by low soil fertility, low soil moisture and high soil erosion. Due to low soil moisture and lack of irrigation facilities the use of inorganic fertilizers is limited and the agricultural productivity is very low (0.1 – 1.3 t ha^{-1} a^{-1}). Therefore, increasing the agronomic production under these conditions in an environmentally sustainable manner is of crucial importance to feed the growing population. Continued removal of leaf litter from the forests for traditional farm yard manure (FYM) leaves the forest floor nutrient poor and vulnerable to invasion by weeds, such as Lantana camara (a shrub). In addition, Lantana due to its fast spreading nature also invades the rainfed and marginal cropfields, particularly in the warm valleys (below 1500 m elevation). Attempts are therefore required to restore soil fertility and soil moisture and find out sustainable use of Lantana. The objectives of this study are i) to investigate the impact of oak, pine and lantana mulch application and frequency of tilling on soil physico-chemical properties, crop yield, weed infestation and nutrient release pattern, ii) to assess the allelopathic impact of the above mulch application on soil microorganisms (microbial pool size and mineralization processes), and iii) to determine suitable practices of crop cultivation favorable for conservation of soil, water, nutrients as compared to traditional practices of crop cultivation.

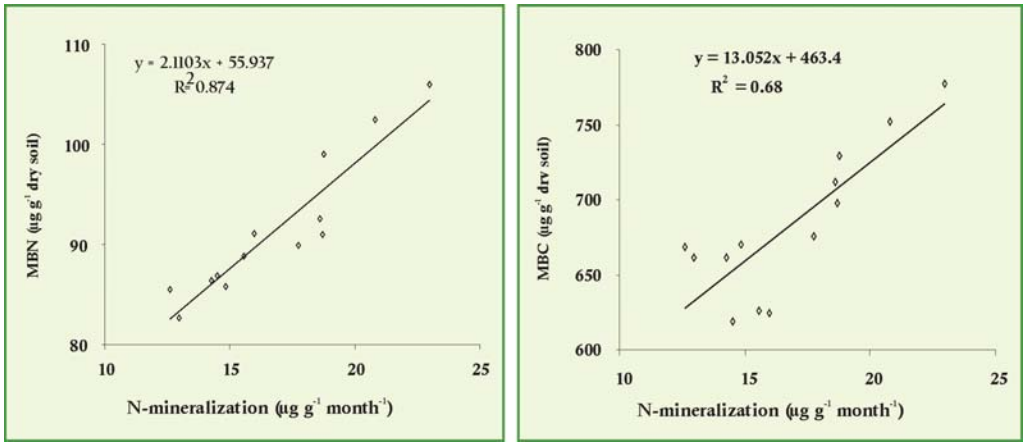


Fig. 40. Relationship between (a) N–mineralization and MBN; and (b) N-mineralization and MBC across all treatments and sampling periods.
MBN-Microbial Biomass Nitrogen, MBC-Microbal Biomass Carbon

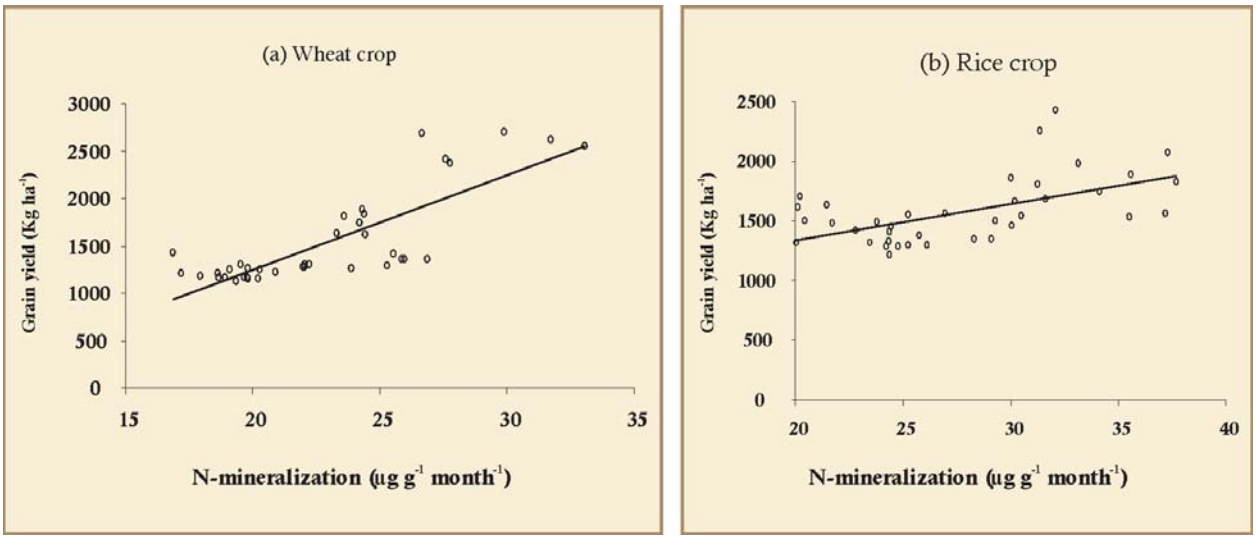


Fig. 41. Relationship between N-mineralization and grain yield (a) wheat cropfield (y= -746.99 +99.61x); and (b) rice cropfield (y=730.73+30.51x).

- Mixing Lantana leaves with Oak and Pine leaf litter enhanced the rate of nutrient release (N by 20% and P by >70%) from the decomposing litter. In the 75% and 100% Lantana mulched plots soil N and P availability and N-mineralization was recorded significantly greater ($P < 0.000$) that supported the high yield of both wheat and rice crops as compared to the plots mulched with a greater proportion of Oak and Pine leaf litter.
- The results support the view that temporal variability in specific N-transformation rates is partially related to changes in microbial biomass and they vary due to different mulch treatments. The Lantana (75% and 100%) mulched plots recorded significantly higher total nutrient pools and microbial biomass and C and N mineralization as compared to Oak and Pine mulched plots and traditional practice of crop cultivation.
- A strong positive relationship between microbial biomass nitrogen (MBN) and N-mineralization ($p< 0.01$) and between microbial bioamss carbon (MBC) and N-mineralization ($p<0.05$) (Fig.40 a&b) was observed. Microbial biomass in the nutrient poor crop fields acts as a sink (summer and rainy season) and a source (winter) of nutrients. A significant positive relationship between the crop yield and N-mineralization was found for both wheat ($r=0.65$; $P<0.001$) and rice crops ($r= 0.34$; $P<0.05$) (Fig.41 a&b).

Aerosols Climatology Over The Northwestern Indian Himalaya Region, Himachal Pradesh *(2005-2008, ISRO-GBP Funded)*

With the increasing human populations, continuously upcoming economic activities and ever expanding urbanization in and around the existing towns and the hill spots of the mountains, long-term impacts on climate change in these regions are required to be monitored through the measurements of columnar aerosols. The studies of ambient aerosols so far indicate that the particulate ambient air pollution as well as gaseous pollutants has much role to play in affecting climate change in a region. The particulate pollution has a cooling effect close to the earth surface whereas gaseous pollutants

have green house effect along with risks to humans and plant life. The results so far obtained indicate that human interferences in the region are continuously increasing and affecting the regional climate. Under the series of aerosol studies in the Kullu valley, columnar aerosol studies are being taken up for the last one and a half years to know the aerosol concentration under fine-accumulation and coarse modes. Specific objectives of the study are i) to obtain aerosols optical depth (AODs) with respect to spectral variations at ultra violet (<390 nm), visible (390-770 nm) and near infra-red (>770 nm) using Multi-wavelength Radiometer (MWR) and ii) to analyse aerosol size distribution and atmospheric turbidity using Angstrom parameters, α (alpha) and β (beta).

- The AODs averaged over the months plotted in Fig.42 indicate its high values at shorter wavelengths compared at longer wavelengths. This indicates that human interferences are continuously increasing in the region and as a result the regional climate is also being affected adversely. Significant variations in AODs are observed at representative wavelengths; 380 nm (0.50 ±0.03), 500nm (0.37±0.02) and 1025 nm (0.20±0.01). The highest value in the month of July 2007 is on account of the fact that these observations are for pre-monsoon period. Higher values in subsequent months even during rainy season indicate the effect of rain shadow zone. As a result, this location is showing different results compared to other regional parts of the country.
- The minimum AODs were noted in the month of February 2008 showing 0.24±0.01 at 380 nm, 0.18±0.01 at 500 nm and 0.09±0.00 at 1025 nm. On an average, very high AODs were noticed during the summer months especially in May and very low in the winter months. During autumn and winter months of the year, the AODs started to decrease rapidly at higher wavelengths indicating a general reduction in the number of large size particles.

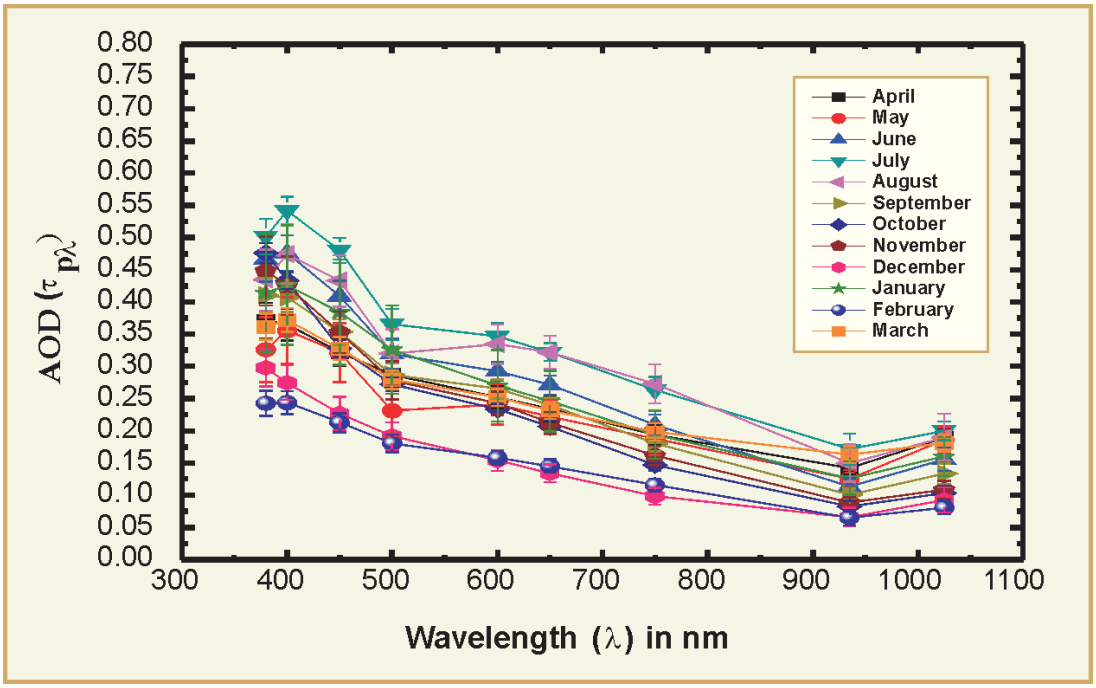


Fig. 42. Mean AOD variations during clear sky day conditions from April 2007 to March 2008.

- Fig.43 shows α (alpha) and β (beta), with inverse relationships indicating higher values in fine-accumulation mode compared to coarse mode. Increase in 'α' and decrease in 'β' means low values of coarse size particles.

and cloud condensation nuclei (CCN) for cloud formation above the surface affecting local weather phenomena for shorter period and climatic conditions for longer period. The objectives of the study are i) to measure important concentration of ultrafine and gaseous

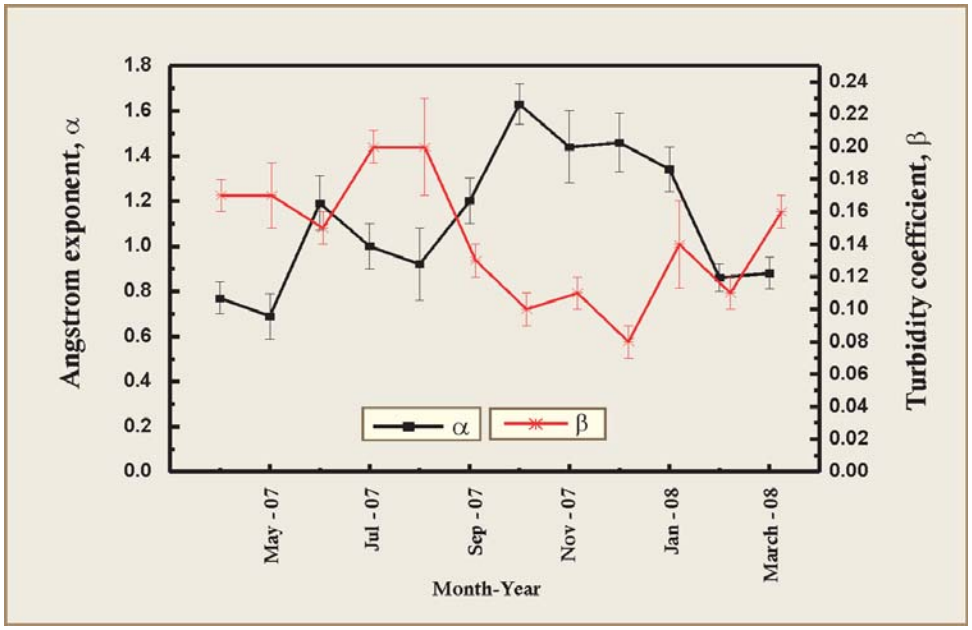


Fig. 43. Monthly mean variations in Angstrom exponent (α) and Turbidity coefficient (β) during clear sky day conditions.

Gaseous Air Pollution in the Background Site of Urban Environment of Himachal Pradesh *(2008-2011, ISRO ENV-OBSR Funded)*

The air pollutants remaining in suspended conditions in the form of gaseous, liquid and solid are termed as 'aerosols'. The ultrafine aerosols act as carriers of chemical and biological species in the atmosphere which have the potential to cause many adverse health impacts. They also inhibit plant growth and ultimately affect the local weather and climatic conditions. But all this depends on the size of particles that vary from 10 Å to 200 Å (0.001 µm to 0.02 µm). These aerosols specifically are termed as 'aitken nuclei' or 'ultrafine aerosols', which work as a nuclei for fog formation close to the surface

pollutants due to natural cum anthropogenic activities to establish background values in the Himalayan region ii) to observe local meteorological conditions and long range transport to relate with the gaseous pollutants, and iii) to suggest some feasible mitigating measures for implementation at the policy level.

- The Particle Counter (PEM-PC 2, Polletech make) was used to measure ultrafine aerosols in different three cut-offs (200 Å, 30 Å (0.003 µm) & 10 Å) at two different altitudes, Mohal (1,154 m) and Kothi (2,478 m). The daily mean variation of ultra fine aerosols at 200 Å (0.02 µm) mode at Mohal differed from 4067 N Cm^{-3} in March to 10040 N Cm^{-3} in February, 2008. But their number concentrations at 30 Å were from 3133 N Cm^{-3} in March to 7093 N Cm^{-3} in

February, 2008. However, these concentrations at 10 Å ranged from 516 N Cm^{-3} in March to 3967 N Cm^{-3} in February (Fig. 44).

- The daily mean variation of ultrafine aerosols at Kothi was highest in March with 7489 N Cm^{-3}, 5407 N Cm^{-3}, 1020 N Cm^{-3} at 200 Å, 30 Å and 10 Å modes of particle sizes, respectively (Fig.44). Diurnal variations in ultrafine aerosols at Mohal show bimodal distribution at different two size cut-offs, that is, 200 Å and 30 Å. While the remaining ultrafine particle mode measurement at 10 Å shows almost a constant diurnal pattern in concentrations except a slight increase during traffic peak hours.
- The particle number concentrations have shown close correlation with a degree of traffic congestion. The reason for this higher concentration of aerosols at low and high altitudes is due to collective impact of forest fires, burning of fire wood, coal and vehicular influx from winter tourists.

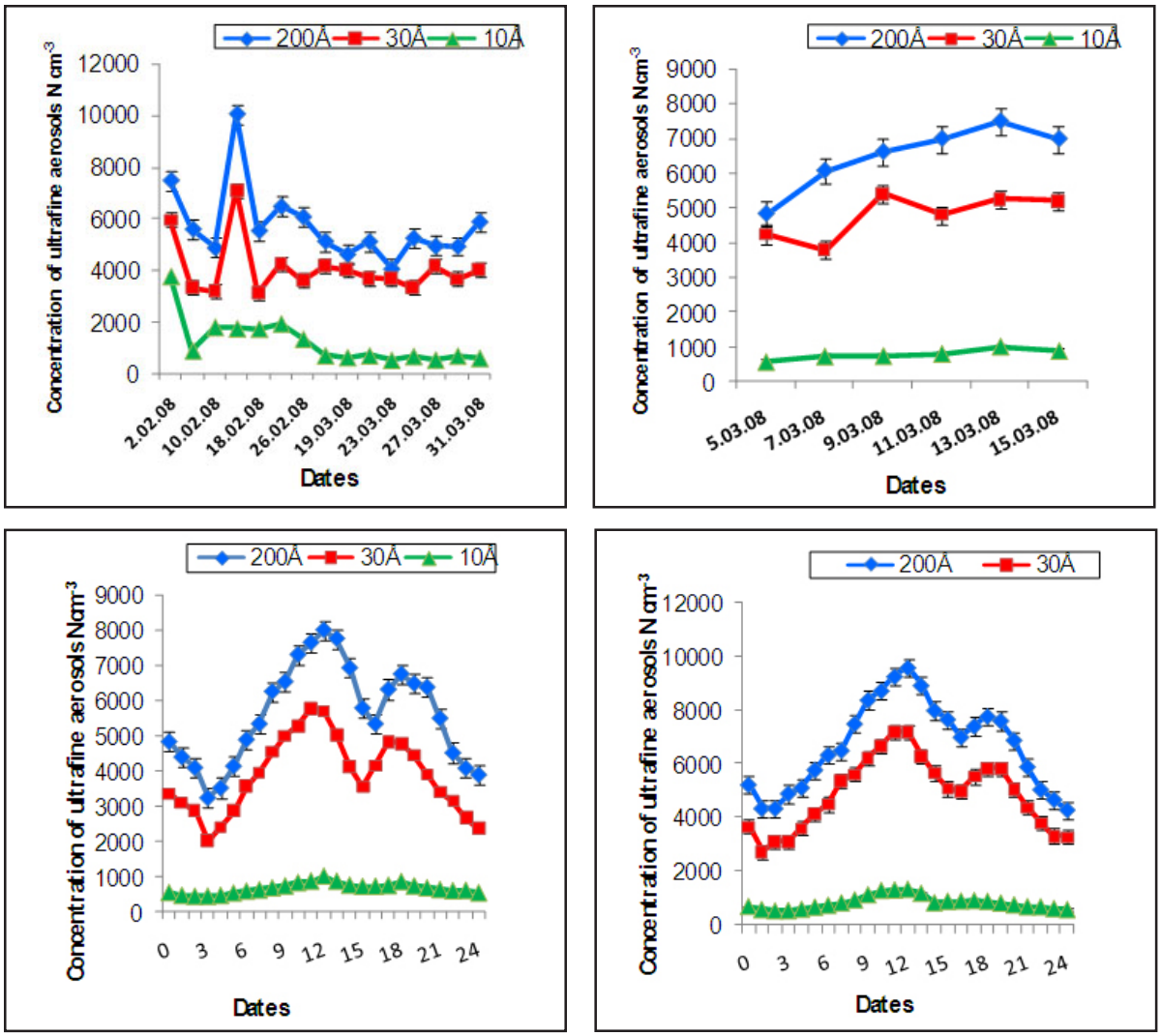


Fig. 44. Daily mean variations and diurnal pattern of ultrafine aerosols in the Kullu valley: (a&c) Mohal (1,154 m) and (b&d) Kothi (2,478 m)

Summary of Completed Project/Activity

Environmental Assessment of Hydropower Projects in the Beas Valley of Himachal Pradesh *(2003-2007, In-house)*

Himachal Pradesh in a recent decade experienced a rapid increase in the number of hydroelectric power projects. India as such is endowed with 84,000 MW hydropower potential out of which Himachal Pradesh accounts for 20,647 MW from its major five river basins. The Beas catchment stands as a major sub-basin of the Indus drainage system with 4,797 MW potential. Keeping this in mind two hydropower projects, Parbati Stage II and III that would generate 800 MW (200×4) and 520 MW (130×4) were taken up for construction. These developmental projects while in the construction phase have a lot of social, economic and environmental impacts. The local communities realise that such development of hydropower projects could probably be the possible way for their socio-economic upliftment apart from serving the purpose of state and national development in spite of having realized the negative environmental impacts in their surroundings. To identify and analyze these impacts during the construction stage, the study was carried out in and around the Parbati Stage II and III hydropower projects in the northwestern Indian Himalaya. The brief findings are as under:

- Residents of thirty six villages surrounding these two hydropower projects were interviewed at household level with a structured questionnaire. Road construction, monetary compensation in lieu of land, possibilities of future tourism development and other economic benefits were among the positive impacts. The perception study unfolds that more than 75% of the respondents perceived water crisis, tree felling, air pollution, crop damage, noise pollution, and natural hazards as the major negative impacts of these ongoing projects.
- Air quality in the form of Total suspended particulate (TSP) matter concentration on average measured at 67.8 μg m^{-3} which was within national permissible limit ranging from 11.01 μg m^{-3} (October 16, 2006) to 191.72 μg m^{-3} (April 25, 2006). Out of total 90 exposed 24 hourly samples, more than twenty two samples were found beyond permissible limit of 75 μg m^{-3}. Ambient noise levels as per norms from Central Pollution Control Board (CPCB) from different activity sources within a distance of 50 m to 300 m of noise exceeded threshold limit of 55 dB during day time (6 a.m.-1 p.m. IST) and 45 dB during night time (10 p.m.- 6 a.m. IST). The major adverse impacts of noise pollution as perceived by the local communities were disturbance in sleep at night, wildlife disturbance, annoyances due to lack of peace among tourists, and shifting of children's schools.

Summary of Completed Project / Activity

Changing Behaviour of Ambient Air Quality in the Kullu Valley

(2003-2007, In-house)

The changing behavior of ambient air quality was monitored at two stations in the Kullu valley; an important destination of tourists. The monitoring was carried out at Mohal (1,154 m) and Kothi (2,478 m). The no. of annual visitors is estimated to be over 15 lakhs, whereas the visitors influx in peak summer season is estimated at about 24,000 per day at Mohal (Kullu) and about 9,000 at Kothi (Rohtang Pass). The number of plying vehicles was about 3,000 at Mohal and 1,300 at Kothi. Due to high traffic volume, besides other environmental problems, air pollution is increasing day by day. The findings of the air quality monitoring are as under.

- The 24 hourly average concentrations of total suspended particulate matter (TSP) indicate that during summer their values exceeded the permissible limit. TSP concentrations at Mohal were observed as much as 267 μg m^{-3} and at Kothi 259.9 μg m^{-3}.
- Particulate matter below 10 μ in size (PM_{10}) at Mohal was measured as high as 97 μg m^{-3} with a mean value of 77±5.6 μg m^{-3}, while at high altitude experimental site- Kothi it was as high as 102 μg m^{-3} with highest mean value of 45±5.7 μg m^{-3} in May 2004.
- Sulphur dioxide (SO_2) concentration was as much as 46 μg m^{-3} during observation with the highest monthly mean concentration of 26±2.8 μg m^{-3} at Mohal (January 2006). This highest value at high altitude site- Kothi was 49 μg m^{-3} (July 8, 2003) with the highest monthly mean concentration of 29±3.5 μg m^{-3} (January 2006).
- Nitrogen oxide (NO_2) at Mohal indicated highest concentration with 22 μg m^{-3} (April 7, 2004). while at Kothi, this value remained highest with 20 μg m^{-3} (January 24, 2004). Surface ozone (O_3) concentrations at low altitude experimental site- Mohal was with 87 ppb (April 26, 2004) with the monthly mean highest value of 38±5.8 ppb.
- Vehicular emissions from a large number of plying vehicles belonging to winter and summer visitors and biomass burning (forest fires, heating and cooking) during electricity failures in winter (January-March & December) are the major local sources contributing to the concentrations of particulate and trace gas species in this region. However, the influence of long-range transport may also not be neglected as this too is a contributing factor from outside.
- In essence, air environment, considered relatively pristine in this ecologically sensitive and topographically fragile part of the country, is going to be degraded in summer as well as in winter months. Developing a green belt around the hill spots would be among the viable options to reduce the concentration of air pollutants in the region.

Summary of Completed Project/Activity

Land Use Changes and its Environmental Impacts in Cold Desert Environment: A Case of Lahaul Valley, Northwestern Himalaya *(2002-2007, In-house)*

The study mainly focussed on four typical villages; Kuthar (2,006 m), Hinsa (2,007 m), Jahlma (3,000 m) and Khoksar (3,200 m) including 'Jahlmanal watershed', to represent the Lahaul valley of the cold desert in Himachal Pradesh. It mainly incorporated a detailed study of land use types, land utilisation, land capability and different forms of cropping patterns and productivity. The 'Jahlmanal watershed' is mainly taken to see micro level variations in crop combinations, crop concentration and diversification, crop efficiency in terms of per unit area performance as well as monetary and energy analysis. The findings are:

- The study depicts that in an age-old traditional crop cultivars, cash crops (pea, potato and hop) have been introduced within a limited growth period of crop season (April-May to September-October). As a result, dietary pattern and dietary essentials (protein, minerals, carbohydrates, calcium, iron, etc.) of the local communities have also been drastically changed.
- The whole region is suffering from food security point of view, however, the farmers have strengthened their economy with the high yielding variety (HYVs) of cash crops. So, there is an urgency to establish a balance between introduced crops and traditional crops to strengthen the food security as well as income of the farmers. Moreover crop farming is recommended along with other ecosystem components such as agroforestry, tree cropping, medicinal plants, bushes (seabuckthorn, wild roses, etc.), and grasses to make village agroecosystem as well as the watershed economically profitable and ecologically sound for sustainable growth of people and environment in the cold desert areas of the northwestern Himalaya.

Summary of Completed Project/Activity

Environmental Impact Assessment Studies & Environmental Management Plans Formulation in Respect of Tamak-Lata and Nandprayag-Langasu Hydro-Electric Projects *(2005-2007, UJVNL, Dehradun)*

In the newly created Uttarakhand State vast potential of hydropower is seen as major source of electricity generation and earning of revenue for the State. In this context, Nandparayag-Langasu (141 MW) and Tamak-Lata (280 MW) HEP are proposed to be constructed on river Alaknanda and Dhauliganga, respectively by the Uttarakhand Jal Vidyut Nigam Ltd. The Institute had undertaken the assignment to prepare comprehensive EIA and EMP study of these projects. Considering the objectives of the study, primary and secondary data was collected and synthesized for Land, Water, Air, Noise, Flora and Fauna and Socio Economic environment. Study for all the other components was completed except for Socio-Economic environment as the land details of the project affected families could not be made available by the project proponents. Thus, the final EIA/EMP report is yet to be prepared. The main findings of the study are as follows:

- The floral survey conducted in the influence zone of both the project sites following stratified random sampling method (Fig.45). Data syntheses revealed that in Nandprayag-Langasu HEP project site, a total of 373 species of plants (i.e. Angiosperms, Gymnosperms, Pteridophytes, Bryophytes, Lichen and Algae) belonging to 258 genera and 119 families were present. Whereas at the Tamak-Lata HEP site, a total of 376 plant species belonging to 264 genera and 116 families were recorded in the peak growing season (Table 12).

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- The faunal survey revealed that at the Nandprayag Langasu HEP area, a total 76 species of birds,16 species of mammals, 15 species of insects and 4 species of reptiles were present. Whereas at the Tamak-Lata HEP project area, a total 41 species of birds, 16 species of mammals, 42 species of insects 4 species of reptiles were reported.
- Air quality data were collected in both the project areas and the air quality index (AQI) was calculated to represent the overall air quality of the project sites. Maximum AQI (93) was calculated for Chamoli sampling site of Nandparayag Langasu HEP site and 106 for Tamak-Lata HEP sampling site Suraithota.
- Water quality study was conducted across 8 sampling locations of Nandprayag –Langasu project site and results of various water quality parameters in terms of average value are as follows: Temperature-18.4 ^{0}C, pH-7.79, Dissolve oxygen 9.6 mg/l, Total solids 510.6 mg/l, EC 156.7 mho/cm, Hardness 38.8 mg/l, Calcium 24.1mg/l, Chloride 3.62 mg/l, Sulphates 3.02 mg/l, Nitrates 0.38mg/l, Total Nitrogen 1.19 mg/l. Similarly, for Tamak Lata HEP, the study was conducted across 7 locations and results are as follows: Temperature-12.4 ^{0}C, pH-7.8, Dissolve oxygen 8.2 mg/l, Total solids 297.5 mg/l, EC 99.4 mho/cm, Hardness 33.5 (mg/l), Calcium 25.4 mg/l, Chloride 2.04 mg/l, Sulphates 2.4 mg/l, Nitrates 0.10 mg/l.
- The required RS/GIS layers and database has been created for both the projects independently and demarcation of sub-catchments, drainage network, transport (road, bridge path, footpath etc); settlements and boundaries of reserved forests and protected areas has also been completed.

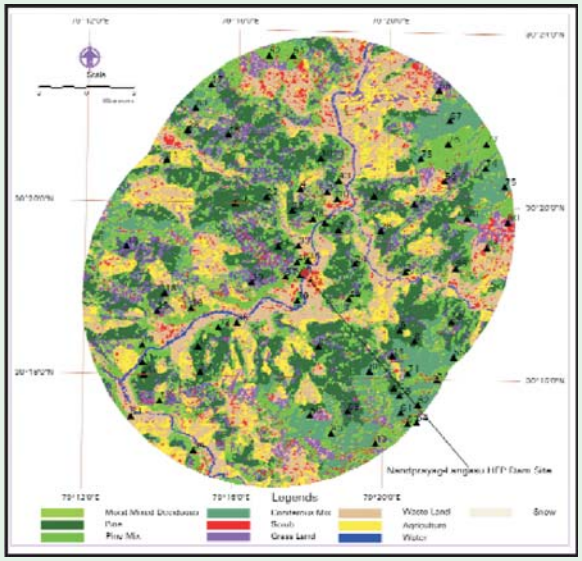

Fig.45. Influence zone map with quadrate points of Nandprayag Langasu HEP.

Table 12. Enumeration of the plant species present in the catchment of the two HEP sites.

Taxonomic Groups	Nandprayag Langasu HEP			Tamak Lata HEP		
	Family	Genera	Species	Family	Genera	Species
Angiosperms	85	217	315	87	225	322
Gymnosperms	2	3	4	4	8	10
Pteridophytes	8	12	18	14	16	22
Bryophytes	10	10	17	3	3	9
Lichens	5	5	7	3	4	5
Algae	9	11	12	5	8	8
Total	**119**	**258**	**373**	**116**	**264**	**376**

Summary of Completed Project / Activity

Impact Assessment Studies on Tea Cultivation in Uttarakhand Hills

(2004-2007, In-house)

In Uttarakhand the history of tea cultivation and its processing is quite old. Its cultivation in India started about 150 years ago. In 1835 the first consignment of 20,000 tea seedlings from Calcutta reached Kumaun and Garhwal regions and tea production started in this region in 1837-38 and simultaneously small tea factories were established. Till 1880, there were a total of 63 small and big tea gardens in Uttarakhand measuring about 10937 acre areas. Inspite of the glorious beginning of tea industry in this region, it could not continue for long and degenerated due to several socio-economic and political reasons. As a result, the tea production declined from 1710000 pounds in 1897 to 105000 pounds in 1908. The old abandoned tea gardens still continue to attract tourists and planners. In some localities of Uttarakhand, tea from the old gardens is still produced and consumed locally. Tea was again introduced in Uttarakhand hills in 1987 by the state government. Mostly abandoned rainfed cropland and culturable wasteland of local inhabitants has been acquired on lease basis and put under tea plantations (approx. 500 ha). It has now come up as an important land management activity for income and employment generation in some areas (Fig. 46). To understand the socio-economic and ecological impacts of this alternative land use practice a study was conducted and the findings are summarized below:

Fig. 46. A mature tea garden established by Uttarakhand Govt.

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(i) Socio-economic studies indicated that tea farming has provided employment to some of the women and weaker sections in their own otherwise wasteland. However, the reduction in livestock population (due to the shortage of fodder that was otherwise provided by the land under tea gardens) and increased work load on women may be seen as the negative aspect; (ii) Soil nutrients (OC, N) were found low in tea gardens compared to adjacent non-tea area; thus implied that tea farming requires regular input of fertilizers to support the tea crop; (iii) Mean values for chloride and nitrite were found higher in the water draining tea gardens, whereas other water quality parameters were almost the same as control, and well within the permissible limit of BIS and WHO (Table 13); (iv) Floral survey of 11 tea gardens revealed that a few weed species (viz., *Azeratum conyzoides, Chrysocephalum crepeoidis, Chrysanthellum americanum, Galinsoga parviflora, Lepidium sativum*) were found growing abundantly in tea gardens that were uncommon as native flora. Abundance of these weeds will have ramifications on pollinators population, soil fauna and crop yield of the adjacent land use practices (agriculture/horticulture) in future; and (v) Phenological studies show that production of leaves per bush once attains a peak in April- May and then drops until mid- July and then again attains peaks till September. The extreme drought during summer calls for irrigation to maintain the yield levels in tea during May-June.

Table 13. Mean annual concentration of different water quality parameters in selected tea gardens of Kausani (Uttarakhand hills). Values in parentheses presents the range of the values.

Parameters (ppm)	Tea Garden	Parameters (ppm) (Except pH)	Adjacent Non-Tea Garden Area (Control)	Level of Significance
pH (n=37)	7.52±0.08 (6.21-8.23)	pH (n=38)	7.57±0.09 (6.22-8.37)	t=0.42 <NS>
Chloride (n=14)	6.87±0.70 (2.4-11.1)	Chloride (n=14)	5.94±0.85 (1.5-12.6)	t=0.84 <NS>
Nitrate (n=31)	1.67±0.15 (0.02-3.9)	Nitrate (n=33)	1.87±0.21 (0.2-6.7)	t=0.77 <NS>
Nitrite (n=37)	0.08±0.04 (0.02–1.08)	Nitrite (n=38)	0.045±0.02 (0.02–0.8)	t= 2.18 P <0.05
Phosphate (n=37)	1.25±0.04 (0.9– 1.6)	Phosphate (n=38)	1.28±0.04 (1.0–1.7)	t=0.6 <NS>
Sulphate (n=10)	89.50±12.69 (40-164)	Sulphate (n=12)	92.42±13.74 (42-196)	t=0.156 <NS>
Total hardness (n=15)	30.53±2.93 (14-62)	Total hardness (n=14)	30.86±2.66 (12-42)	t=0.084 <NS>

Summary of Completed Project / Activity

Geohydrological Studies for Augmentation of Spring Discharge in the Western Himalaya *(2004-2007, Ministry of Water Resources Funded)*

In the western Himalayan mountains springs are the main source of fresh water for drinking and other household consumption. The water sources of such springs, in most cases are unconfined aquifers where the water flows under gravity. Spring water discharge fluctuations owe primarily to rainfall pattern in the recharge area or more precisely stated, to variation in the amount of rainwater that is able to infiltrate the ground and recharges the ground water and the recharge zone characteristics. Impact of the recharge zone characteristics and land use land cover changes on spring water quality has also been reported. The present study was carried out to understand the effect of rainfall, physiography, lithology, slope and aspect, land use practices, vegetation, altitude, soil type and anthropogenic interference (e.g., road construction and settlement etc.) and other characteristics in the spring recharge zone on the water yield and water quality of the 12 selected springs in the western Himalaya.

The selected springs represented a wide variety of topography, slope (up to 70°) altitude (550 -2800 m asl), geology, rock types (metasedimentary and sedimentary rocks with phyllite, quartzite, mica-schist, slate and dolomitic limestone), catchment area, land use and land cover and anthropogenic influence in the spring recharge zone. The land use varies from agriculture, forests, grazing land and wasteland to land under urban and rural settlements. The land cover consisted of sparse to dense forests of broadleaf (Oak) and conifer (Pine) tree species. Detailed lithological, slope, land use and soil profile maps for the recharge zones of these springs were prepared. Rainfall data adjoining the studied springs were procured from secondary sources. Spring discharge was measured at monthly intervals in the first year and at fortnightly intervals in the second year. Seasonal water quality tests were also conducted. The findings are summarized as: (i) In the spring recharge area the soil depth was found ranging from 45 - 90 cm. The proportion of sand was found ranging from 16.6-57.2%, silt (13.2-43.7%) and clay (9-60%). Soil moisture ranged from 6-62% and water holding capacity from 33-66% across the springs; (ii) Water yield of the springs revealed that some springs (viz., Bhaktiyana, Batula, Karas) were characterized by high (205 – 293 x 10^5 l/yr) to moderate (132 – 187 x 10^5 l/yr) water yield (viz., Kothar, Gulabrai, Chatwapipal) and the rest of the springs recorded a low water yield (40 – 90 x 10^5 l/yr). The mean daily water yield across the springs was found ranging from 5205 – 110765 l/d. The decline in water discharge (relative to the peak discharge) was found in the range of 10 - > 90% across the springs; (iii) Among the water quality parameters pH (range= 6.7–7.4), electrical conductivity (62-568 µS/cm), total dissolved solids (40–364 mg/l), alkalinity (36–170 mg/l), total hardness (76- 276 mg/l), calcium (11–71 mg/l), magnesium (9–24 mg/l) were recorded. Nitrate (range= 0- 21 mg/l) was absent in most of the springs. Similarly, chloride was detected only in four springs (range= 0-18 mg/l). Among the trace elements, the concentration of Fe (range = 0.753–9.218 ug/l), Cu (0.119–0.995 ug/l), Pb (0.0016–0.138 ug/l) and As (0.061 – 1.166) were recorded. Bacteria were found in all the water samples. Coliform was not found in Bidakot, Gulabrai, Kamera and Joshimath springs. *Escherichia coli* was not found in any of the water samples of these springs. (iv) Geology, land use / land cover and level of biotic interference emerged as one of the controlling factors for the spring discharge. It can be pointed out that oak forest (broadleaf), terraced land, moderately grazed pasture land and low biotic interference in the spring recharge areas are conducive for water recharge. The topography with moderate slope, south-west aspect of the recharge zone and deep soil promoted the water infiltration and recharge of ground water. Geologically phyllite with quartzite bands, quartzite and limestone favoured the water holding capacity of rocks and thus produced high water yield.

Theme

SOCIO-ECONOMIC DEVELOPMENT (SED)

A majority of our population continues to live within a biomass-based subsistence economy. This fundamental way of life has woven itself into numerous ecological and cultural tapestries, each in consonance with the ecological niche that it occupies. No process of development and eradication of poverty can be conceived without focusing on environmental management and sustainable development. To address the issue of poverty alleviation, it is also vital to optimize the natural resource exploitation and farming systems productivity. In view of above, the theme addresses issues of sustainable development of the rural areas through identifying developmental bottlenecks, formulation of strategies for location-specific problem solving, demonstrating NRM and livelihood strategies and by providing inputs for policy formulation. The theme envisages to i) develop resource planning and management strategies based on sound ecological, economic and cultural database and policy analysis, ii) strengthen livelihood promotion strategies (on- and off-farm) through identification of innovative livelihood options, strengthening indigenous livelihood practices and value addition, technology backstopping, and capacity enhancement, iii) minimize negative natural resource use effects by adopting/adapting/ replicating best-management practices to see the efficacy of various developmental and R&D interventions for policy implications, and iv) develop 'Rural Enterprise Services' for socio-economic upliftment of Himalayan communities.

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

The small farms are integral to Indian Himalayan Region (IHR) with over 60-80% households compring landholdings <1 ha to support considerable human and livestock population. Moreover most of the agriculture (70-80%) in IHR is rainfed that has been bypassed by policy backing and green revolution. Therefore, working on smallholders is an important priority for the IHR. Improvement of the status of such lands desires simultaneous handling of issues of arable land degradation, rural income diversification and rehabilitation of common property resources with respect to farmers' aspirations, characteristics, constraints, and futuristic viewpoints. The possible development pathway could be the need-based intensification with a people centered approach by increasing community access and participation in natural resource management, and diversifying livelihood resources in village itself. The objectives of this study include: (i) to undertake in depth assessment of farming systems and its

economic growth in the western Himalayan region; (ii) to identify issues and options for rural income diversification (on farm and off farm); (iii) to restore the village commons and degraded areas by strengthening introduction of energy, fodder and commercial plant species; (iv) strengthen village institutions for natural resource management, and (v) to develop pathways and policies for rural livelihood. The results of study are summarized below:

Achievements

- The work initially focused on Uttarakhand, which comprises 34650.6 km^2 area under forest. The control of forested area is with Forest Department 70.46%, Revenue Department 13.76%, Land community 15.73% control that is maintained by the village forest councils (Van Panchayats - VPs). Of the total 13 districts, 11 have Van Panchayats (total number 12,089). Pauri district followed by Almora and Pithoragarh comprised maxium Van Panchayats. Area wise distribution of VPs in the State is given (Fig. 47).
- The information on land holdings in the Indian Himalayan region were reviewed which indicates a total of over 346 lakhs landholdings. Distribution of holdings in different cases indicate: 75% - marginal (land <1 ha), 15.16% small (1-2 ha), 6.93% semi-medium (2-4 ha), 2.19% medium (4-10 ha) and < 1% large (>10 ha).
- As a specific case, Patharkot village (area 163.62 ha, elevation 1400 m) in Hawalbagh Block, District Almora, (Uttarakhand), has been selected to demonstrate impact of selected interventions as per community perception.
- The people's perception for development was grouped into five major categories viz: (a) conservation and sustainable utilization of natural resources; (b) development of agriculture, wasteland and livestock sectors; (c) promotion of livelihood resources and human resource development; (d) promotion of health, cleanliness and education; and (e) development of village institutions. A work plan has been prepared to initiate selected activities in the village.
- As per the desire of the community, initially 8 ha land has been earmarked for horticulture model development. A community training (beneficiaries-54) on horticultural promotion was conducted to strengthen farmers' capacity in this sector (Fig. 48).

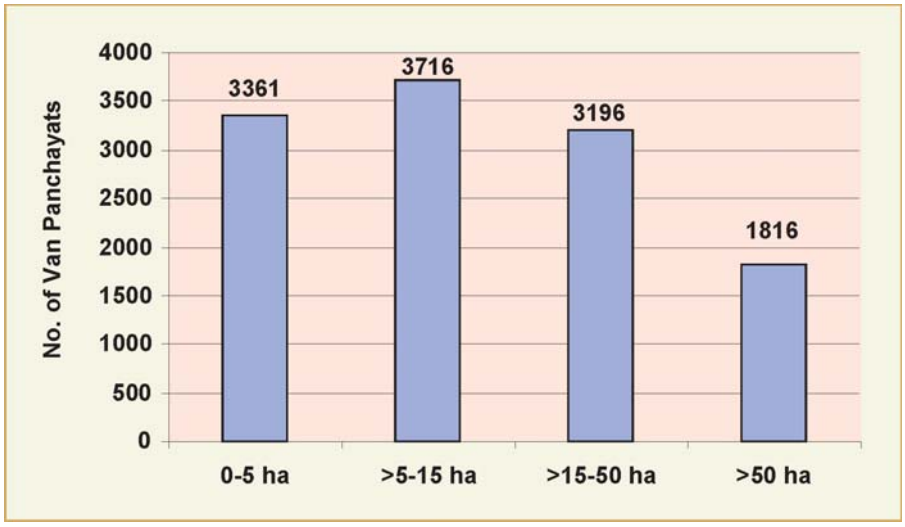


Fig. 47. Area wise distribution of VPs in Uttarakhand.


Fig. 48. Community capacity building on horticulture plantation and participatory planning.

Scaling Up Innovative Resource Management Practices For Improved Livelihoods *(2007-2012, In-house)*

The natural resource degradation in the Himalayan region is often linked to increase in population, open grazing, deforestation and biomass removal, and intensive use of biodiversity that ultimately affects ecological sustainability of the region. The efforts made to check these problems are not well planned, therefore, the resource degradation process is continuing. Building on the lessons learned from different studies, innovations and improved livelihoods devised by the farmers, technical backstopping, and material support needs to be provided to the villagers, particularly to the marginal farmers in the adoption/ adaptation process. Realizing this, the present study attempts to: (i) analyze adoption/adaptation scenario of tested/ innovative resource management practices; (ii) develop strategies for adoption/ adaptation of innovations for improved economic and ecological viability; (iii) scale up viable practices through participatory action research involving community institutions, local stakeholders and resource farmers; (iv) sharing of knowledge and information through improved networking of the stakeholders. The specific focus of study is Garurganga Watershed, Bageshwar District (Uttarakhand).

- Organized two meetings with the stakeholders for situation appraisal, questionnaire developed for survey to assess scenario of innovations/ options provided by different programmes to the villagers for improved livelihood and management of the natural resources. Survey of 120 families revealed that the farming system is under threat due to sectoral approach of the developmental projects and absence of structured monitoring system.
- The agriculture sector requires to be supported in terms of material, technical back stopping and market linkages. Decreasing interest of the people, weak Van-Panchayat institutions, ownership conflicts, etc. have led to depletion of the natural resources. Introduction of hybrid/ improved livestock has not had an impact livelihood due to adverse climatic conditions, improper management and scarcity of quality feed.
- Up scaling of a few options has been initiated at remote locations aiming to demonstrate improved management of the resources and associated livelihoods of the people.

Shifting Agriculture: Issues and Options for Ecological, Economical and Social Viability *(2007-2012, In-house)*

In the North-East Himalaya, shifting agriculture (jhum), once considered to be an efficient system of cultivation being sustainable both ecologically and economically, is gradually becoming untenable under pressure from a number of factors and besieged with conflicting views with regard to the degradation/ conservation of ecosystem and the way of life for the upland people. This situation led to a number of dialogues; one section perceives the practice as ecologically destructive, uneconomical and, therefore undesirable, hence advocates to ban or replace the practice by other alternative land use practices such as agroforestry based farming system. The other section, in view of the social and economic dependency of the ethnic communities on this practice, considers it as a way of life that integrates both material and non-material culture. They emphasize on the unique resource ownership and utilization pattern of the shifting cultivators, which according to them, makes the system ecologically and economically sustainable. Paradoxically, efforts of the government to find solutions through settled agricultural practices have not succeeded. 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. This necessitates the present study with a focus on: (i) review the state and central policies and laws in the forest and agriculture sectors dealing with shifting cultivation and ongoing schemes and programmes of state and central Governments for control and regulation of shifting cultivation; (ii) to study the land tenure and customary laws of selected ethnic communities relating to shifting cultivation; (iii) documenting TEK on soil conservation, water resources & forest resource management and validation of indigenous soil and water conservation practices; (iv) documenting processes and patterns of ecological recovery with special emphasis on impact of shifting agriculture on faunal diversity; (v) need based assessment and identification of potential interventions and their applications.

- Three districts of Arunachal Pradesh, namely: East Siang, West Siang and Papum-Pare were selected for extensive research work. Three villages were selected for in-depth study. A document on review of existing shifting cultivation development techniques has been submitted to the Sub-Group on "Database, Technology Development and Extension" of the "National Taskforce on Rehabilitation of Shifting Cultivation Lands" constituted by MoEF, GoI.
- Land tenure and customary laws of Adi tribe in three villages of East and West Siang districts in Arunachal Pradesh are being studied. Role of traditional village institutions such as Kebang (village council) and other village institutions who manage the natural resources have been analysed. As a customary norm, no villager whether from his owned forest patch or from others' patch, can harvest forest products for selling. Any body found to violate their customary practices of resource use will be imposed penalty, which later on is used for the welfare of the community.
- The forest /shifting cultivation land is sub-divided into patches, called as "Patat". In Rumgong village, the entire land is divided into 25 patats. Of which, 15 patats are used for shifting cultivation at present. Only a single patat is used for shifting cultivation in a year and re-use of a patat is possible only when all the patats are used once. Each patat has a specific name and sequence of re-cultivating these patats follows an unique pattern and reflects the jhum cycle of each patat.

- *Pan-eng*, an indigenous soil conservation practice by the Adis community has been documented. In such practice, logs are being placed across the slope to check soil and nutrient loss in shifting agricultural field. Also means for maintaining soil fertility in shifting agro-ecosystem have been documented.

Sustainable Tourism- Assessing the Potential *(2007-2012, In-house)*

Tourism is a fast growing industry worldwide and over the past three decades it has developed considerably in India. It has made rapid strides in earning high revenue. It is an age old practice in Uttarakhand state because it offers variety of attractions to domestic as well as foreign tourists. The state is replete with religious and mythological sites that are a rich legacy of the cultural past. The Garhwal region has unique socio-cultural diversity, places of religious pilgrimage, and sacred areas that are visited by thousands of tourists annually. The main occupation of people in the Kedar valley is tourism based. Likewise in the Sikkim, tourism is being viewed as a priority sector and the government is encouraging it through creating infrastructure, developing new sites, and by organizing shows, festivals, and trekking programmes. The common urban commercial (Leisure) tourism, village tourism, adventure tourism, monastic tourism, and cultural tourism are some of forms that exist in the state. With the opening of trade with China through "Nathula Pass' a new form of tourism i.e. trade tourism is also beginning to develop here. In order to link the rural people with tourism, this project was formulated to assess potential of eco-tourism promotion in selected areas of Garhwal Himalaya (Uttarakhand and Sikkim), along with the value addition of the local products that could be associated likewise in the state. The envisaged activities include: (i) assessment of eco-tourism potential; (ii) promote bioresource based (medicinal and aromatic plants, wild edibles, etc.) value addition; (iii) study impacts and economics of tourism; (iv) appraisal of various management options and policy issues for sustainability of tourism.

A. Garhwal Himalaya

- Based on the analysis of data collected on tourists' flow in the Kedar valley on annual basis income generated by various stakeholders in the Kedarnath valley was calculated (Fig. 49 and 50).

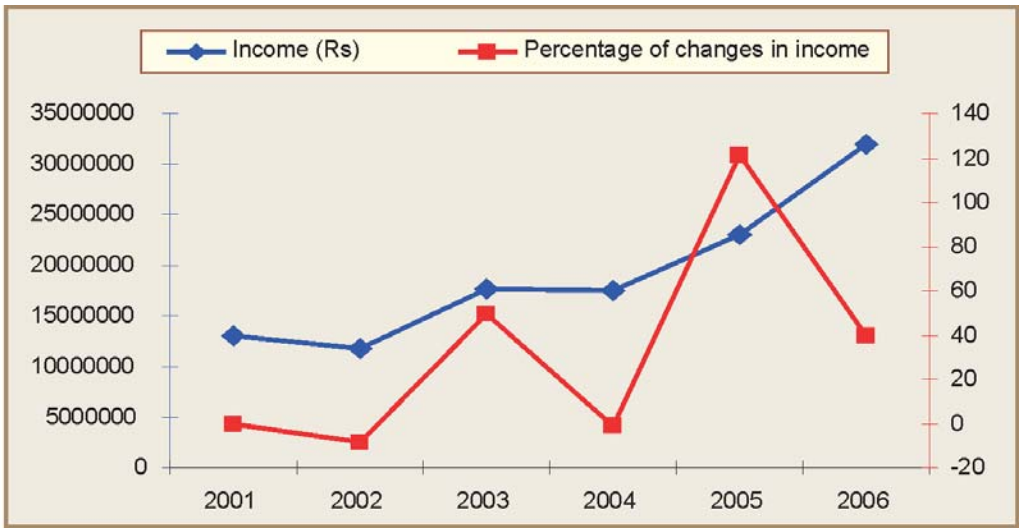


Fig. 49. Income and change in income through tourism in Kedar valley (source: Kedarnath Mandir Samiti).

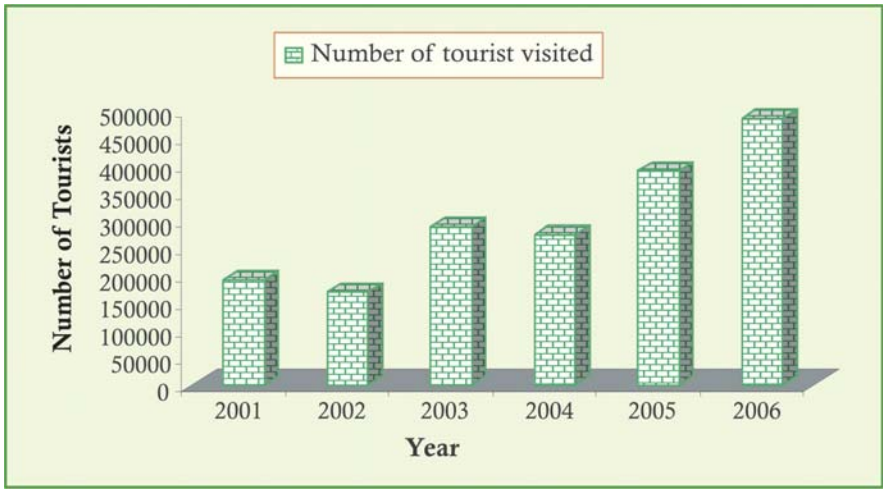
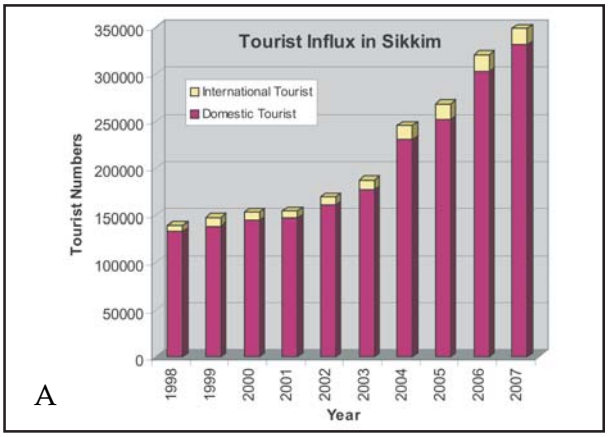


Fig. 50. Tourists flow in Kedar valley *(Source: Kedarnath Mandir Samiti).*

- A workshop organized to identify the potential areas for promoting eco-tourism and share experiences, ideas and constraints of experts, scientists, officials, and stakeholders resulted in the formation of various committees to develop coordination among different stakeholders for promoting eco-tourism in the valley. A joint declaration on People's Participation on Sustainable Eco-Tourism in Kedar Valley was also achieved. The final outcome was the formation of an association named, 'KEDAR' (Kedarghati Ecotourism Development Action and Research).

B. Sikkim Himalaya

- Analysis of tourist data trends, Fig.51A&B, revealed increasing annual influx trends suggesting a growing state of tourism in Sikkim.
- Both domestic and international tourist visit the state, the international tourist comprise only 5-6% of annual tourist rush to the state. Study of past 10 years of data suggests an average influx of 201698 (sd= 72657) domestic tourists and 11805 (sd=4572) foreign tourist per annum.
- The total tourist arrival for the last 2 years was noted to be above 3 lakhs. March-May and Oct-Nov are tourist rush months; the maximum tourist rush for sommers was noted in May and for autumn in Oct.



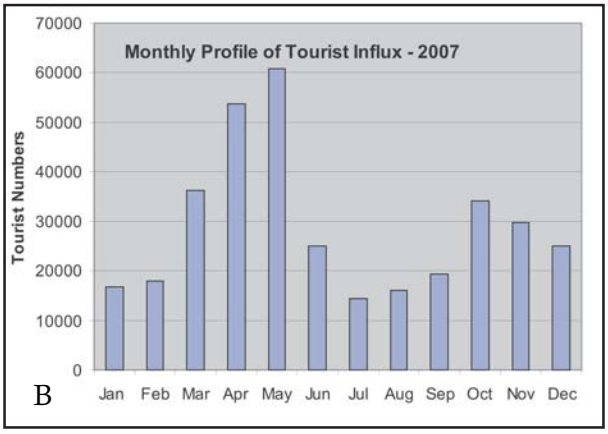


Fig. 51A&B. Annual influx trends of Tourists in Sikkim Himalaya.

Indigenous Knowledge: Traditional Health Care Practices in Rural Areas of Uttarakhand *(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 in strengthening the practices and creating 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 times immemorial. Such practices still continue in rural areas as they are inexpensive, culturally familiar and readily available. However, due to excessive removal of herbs from wild for commercial use and rapid forest degradation in the recent past the number and quantity of herb species has declined in the wild. In Uttarakhand a majority of traditional health care practiceners (*vaidyas*) are found in remote rural areas and are of great utility to the community in the absence of modern health services. The vaidyas largely use medicinal herbs for preparation of formulations and treatments. This study targets this system and aims at: (i) documentation of traditional health care practices; (ii) documentation of plant species used in traditional health care practices; (iii) documentation of IK of practices, processes, knowledge and resources used in traditional health care practices; (iv) assessment of status of herbs used by the traditional herbal healers in the wild; (v) evaluation of the present status of traditional health care practiceners for identification of possible IPR value.

- Extensive interaction and interviews of 23 traditional health care practioners (vaidya) in the Badrinath valley revealed that most of them (43.8.1) were in age group 61-85 years, followed by age group 41-61 year (34.8%). The younger generation does not find the profession interesting and as a result the profession is on the decline.
- Majority of vaidyas (65.2%) inherited knowledge of healing within family, 21.9% learnt it by self education and only 13.04% acquired expertise through training (Table 14).
- Analysis of people's perception (n = 525) revealed than traditional vaidyas and traditional health care practices traditional herbal healing (vaidya system), natural therapy, herbal healing with chanting holy incantations (mantra) and allopathy were practised in the area. Among them the vaidya system was most prominent in all the villages (Fig.52). Villages located at high altitude and far away from the road heads were more dependent on vaidya system and herbal healing with chanting holy hymn.
- It was found that majority of *vaidyas* had expertise in curing children (22.61%), followed by expertise in curing cattle, women and serious diseases. Experts for mental sickness, bone setting and common disease were more or less equal for each group about 10% of the total. Experts for curing snake bites/scorpion and spider bites were about 2.93%.

Table 14. Mode of acquiring professional knowledge of Traditional Health care practiceners in Badrinath valley.

S.N.	Professional knowledge	Number of THH	%
1	Inherited within family	15	65.2
	a. One generation	1	4.4
	b. Two generations	5	21.7
	c. Three generations	9	39.1
2	Self education	5	21.7
3	Training	3	13.1
	THH	**38**	

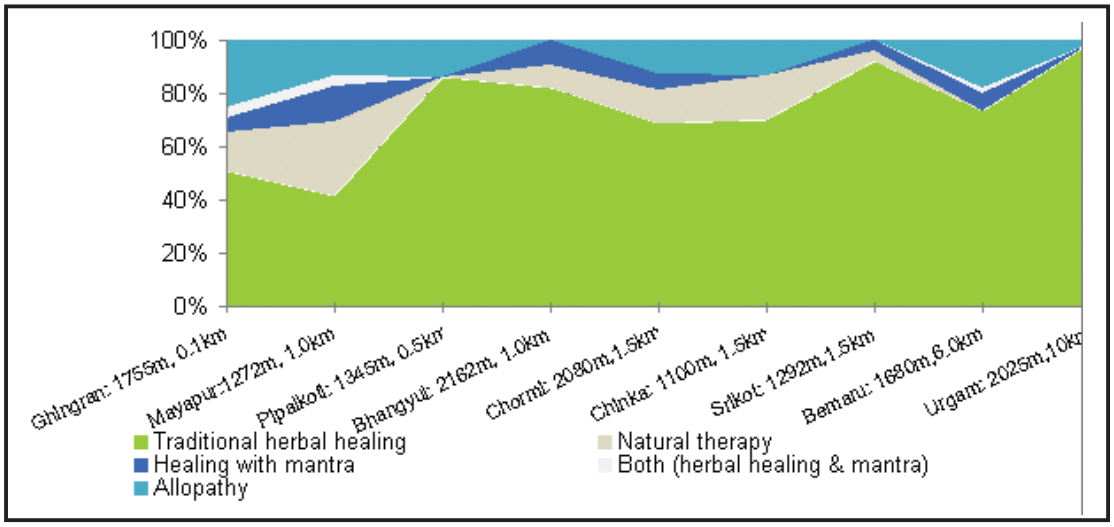


Fig. 52 (a). Traditional therapies (%) found in villages of Badrinath vally.

Fig. 52 (b). Collection of *garudpanja* (*Roscoea purpurea*) by a traditional vaidya for its medicinal use; in inset root of the same herb.

Participatory Assessment of Sustainable Scenarios for Himalayan Pastoralism *(2007- 2009, SIDA Funded)*

Pastoral grazing in the Himalayan alpine pastures is as old as the hills and it is well understood that without the support of the pastoral people and their traditional resource management systems, the biodiversity of alpine Himalaya will not be able to survive long. The rangelands used by pastoralists are often land that cannot be used by conventional agriculture. Pastoralists make substantial contributions to the economy of developing countries, both in terms of supporting their households and in supplying protein to villages and towns. Their economic system is

constantly threatened by the market forces and process of globalization of trade in livestock products. On the contrary, the issue of livestock grazing in the Himalaya is seldom discussed with a holistic perspective considering it as a livelihood fact of various local communities. Present study seeks to understand and quantify the potential of pastoralism through an empirical application of inter- and trans-disciplinary approaches. The region, due to the presence of transhumant pastoral grazing of sheep and goats and nomadic grazing of buffalos has diverse traditional strategies, resource use pattern and survival approaches and rich bio-cultural diversity. The specific issues to be addressed include: (i) improve scientific understanding of participatory and trans-disciplinary approaches to identify the issues related to carrying capacity of pastoralism through the use of innovative methodologies; (ii) understand and analyze the linkages with numerous other stakeholders (agro-pastoral, tourism, forestry, etc.) of bio-resources in these altitudinal zones; (iii) seek viable scenarios for continuation of pastoralism in the region, and suggest development of few economic activities directly related to pastoralism, and those are culturally appropriate, ecologically sound, economically viable and socially equitable; (iv) integrate results within a broader theoretical understanding of the interrelations between society and nature, and to bridge social and natural sciences; (v) provide reliable socioeconomic and environmental information on the pastoral systems.

- Data analysis revealed that there is a substantial change in the Bhotiya pastoralists of Johar valley of Munsyari region of Kumaun region. Due to regular functioning of the public distribution systems (PDS) which ensures rations at nominal rates to all the villages. Land under crops is now only 20% of the total land available. A predominantly female occupation is losing its economic importance due to the adoption of medicinal and aromatic plant cultivation by the local people who were earlier pastoral glaziers. Now only a small percentage of these people maintain sheep and goats. The pastures have been leased out to the traditional shepherds of Garhwal and Himachal Pradesh called as *anwals* and *gaddis* to graze their flocks.
- Due to education and employment amongst the traditional Bhotiya pastoralist families of Kumaun and Garhwal region, no longer live together as the employed members have to go wherever the jobs take them. Surplus female labor is no longer available due to distribution of nuclear families to their place of job and out migration. The reduction in the size of available forage and unwillingness of younger generation in pastoral activities, hence families have given up maintaining livestock or have reduced their numbers and there skills related to wool work is losing its value.

Prioritization and Categorization of Ailments Specific Medicinal Plants of High Altitude Region, Alaknanda Catchment, Uttarakhand *(2007-2009, NMPB Funded)*

Traditional system of medicine is deeply rooted in the culture and depends on availability of natural resources. Throughout the human history it has saved the lives of poor people around the globe and still continues to do so. Ayurveda is arguably the oldest medical system in Indian sub-continent, and is reportedly based on medicines derived from about 2000 plant species. The other form of traditional medicinal systems of India where large numbers of plant species are utilized include Siddha (1121 species), Unani (751 species) and Tibetan (337 species). In the evolution of Ayurveda, the Himalayan region has played an important role by contributing restricted and unique habitats of many valuable

medicinal plant species. This system of medicine has played a crucial role in the health care of traditional societies, but it could not develop at par with other popular forms of medicare systems. And one of the main causes of this crisis is the loss of knowledge base relating to raw drugs. The magnitude of knowledge erosion is even faster than the rate of resource erosion. In the absence of required raw materials in the right quantity and quality at the right time, this ancient system of healing is slithering into oblivion. The present study therefore attempts to: (i) identify and list the prominent diseases prevalent in the high altitude region and also prepare the list of plants used by local healers in the traditional health care systems; (ii) document indigenous knowledge related to composition of medicinal plants in various drugs and method of prescribing these drugs by local healers/ Vaidhyas; (iii) study the dependence of tribal and non-tribal communities on herbal and allopathic treatment for curing some important ailments; (iv) create awareness among the local communities through workshops/seminars about the role of medicinal plants and local healers.

- The study highlighted that the tribal and non-tribal communities of Niti, Bhilangana and Mandakni valley of Alaknanda catchment possess immense knowledge, they use over 225 plants belonging to 98 families for curing 100 major ailments. So far, a total of 35 major diseases have been reported from these three valleys.
- About 91 Vaidyas of Alaknanda catchment were consulted in order to understand their perceptions on deterioration of traditional health care system (THCS) in the regions. About 82% respondent expressed that easy availability of modern medicines and their quick relief is one of the major cause of declining THCS. On the other hand about 90% respondent emphasized that unavailability of MAPs for THCS, 89% reveal that it is not a lucrative systems like other system of health care etc.
- A Workshop on the "Role of Vaidyas in Traditional Health Care System" was organized at Srinagar, Garhwal. More than 110 participants actively participated in the workshop, of which 75 participants were traditional medical practitioners (vaidyas, local healers, villagers and peoples related to traditional health care system and Ayurveda) Fig.53 & 54.

Fig. 53. Proceedings of Workshop on THCs

Fig. 54. A Traditional Vaidya

Cultural Landscape-Linking Biodiversity Conservation with Sustainable Development of Arunachal Pradesh, *(2008-2011, UNESCO- McArthur Foundation Funded)*

This study aims to address biodiversity conservation with concerns for sustainable livelihood development of traditional societies living in the mega-cultural landscape along an altitudinal transect of the West Kameng hill areas with forest centered land use practices in Arunachal Pradesh. The communities living in this region have always been closely linked with the landscape around them, being dependant upon both natural and human-managed biodiversity contained therein. Whilst using and indeed manipulating biodiversity to meet with a range of their livelihood needs, they have not only conserved the available biodiversity and even enhanced the same. Being dependant upon this biodiversity, the cultural landscape that each ethnic group has created around themselves have a distinct imprint of its own, which is the product of the given socio-ecological system, and the traditional ecological knowledge (TEK) that the given ethnic group possesses. Realizing that conserving and sustainably managing the given 'cultural landscape' is important for conserving biodiversity with concerns for socio-cultural integrity of the given ethnic group. The project envisages: (i) landscape system analysis, figuring out the linkages between natural and human-managed ecosystems; (ii) trying to evaluate the manner in which traditional societies perceive management of biomass, soil fertility and water resources within the landscape; (iii) A detail analysis of the culture-based non-codified institutional arrangements; (iv) issues related to competition vs coexistence of different ethnic groups within and outside the identified boundaries of a given cultural landscape and

Table 15. Land use-cover of Dirang and Bomdila circles in West Kameng district, Arunachal Pradesh (Area in sq km).

Description	Dirang	Bomdila
Evergreen/Semi Evergreen Forest (Dense)	927.87 (67.76)	7.37 (43.65)
Evergreen/Semi Evergreen Forest (open)	143.97 (10.51)	6.44 (38.13)
Degraded/scrub Forest	21.36 (1.56)	-
Land with Scrub	112.14 (8.19)	-
Land without Scrub	0.24 (0.02)	-
Alpine Grass	22.67 (1.66)	-
Current Shifting Cultivation	13.16 (0.96)	0.06 (0.33)
Abandoned Shifting Cultivation	10.54 (0.77)	1.19 (7.04)
Settled Cultivation	14.28 (1.04)	-
Village settlement	3.22 (0.24)	0.14 (0.85)
Town settlement	-	1.52 (9.02)
Barren Rocky/Stony Waste/sheet Rock Area	14.73 (1.08)	-
Snow Covered/Glacial Area	75.69 (5.53)	-
Lake/Pond	1.27 (0.09)	-
River	8.30 (0.61)	0.16 (0.96)
Sum total	**1369.41**	**16.89**

Parentheses are percentage sharing in each category; Source: State Remote Sensing Agency, Government of Arunachal Pradesh.

their implications; (v) the role of institutional arrangements for effective management of natural resources with emphasis upon the traditional institutional arrangements.

- Eight villages have been selected for detail investigation, of which 6 villages are situated in Dirang circle while two in Bomdila circle in the West Kameng district of Arunachal Pradesh.
- Land use-cover data of Dirang (75%) and Bomdila circles (82%) reveals high forest cover, which is higher compared to the state and the district. The land area under shifting cultivation is higher in Bomdila (7.4%) compared to Dirang (1.7%) indicating intensity of shifting cultivation in Bomdila circle, seeking immediate attention (Table 15).
- Comparative demographic profile of study circles revealed low sex ratio and literacy rate in both the circles in comparison to the national figures. However, the literacy rate is higher in Bomdila circle against that of the district and the state.
- Occupational structure reveals low percentages of work participation in both the circles. Agriculture is the main livelihood sustenance in Dirang circle (75 % of the total workers) compared to low percentage in Bomdila (7.5%).

Conservation and Sustainable Management of Belowground Biodiversity (BGBD) in two Altitudinal Windows of Garhwal Himalayas *(2007-2008, TSBF/GEF/UNEP Funded)*

During the past 20 years, the recognition of the importance of soil fauna in the functioning of soils has been continuously growing, resulting in some important application in agriculture. Inspite of the general agreement about the ecological importance of soil fauna and its economic consequences, the absence of concern about this group from conservationists in their studies is conspicuous. The multiple values of soil fauna discussed in body of literature provides good arguments to justify concerns about decreasing soil biodiversity. Hence, soil biodiversity ensures the multiplicity of the ecological, environmental and instrumental function of soil fauna in a wide variety of environmental conditions. Even if the functional importance of soil biodiversity still lacks sufficient studies to be clearly understood, its conservation is vital as an insurance against unpredictable or expected environmental changes that may impair ecosystem functioning in the future. Recognizing this fact the study attempts to (i) continuously sample, preserve and identify the macro faunal diversity in major landuses of Nanda Devi Biosphere Reserve (NDBR) and Kedarnath valley of Garhwal Himalaya, (ii) initiate interlinking of forest and agriculture above-and below-ground biodiversity and community participation for identifying key areas of conservation and management were also proposed.

- The numerical abundance and biomass of different macro-fauna such as Hymenoptera, Isoptera, Coleoptera, Myriapods, Dictyoptera, Diptera, Hemiptera and Orthoptera were studied under different land uses at two elevations (high and low altitude) during monsoon and post monsoon season. At lower elevation oak forest showed lower population of Hymenoptera during both the seasons whereas there were no significant differences in population size in different forests and agro-ecosystems during post monsoon.
- Home-garden and rain-fed agriculture showed significantly higher biomass of Hymenoptera as compared to oak and pine forests at lower elevation, though these sites did not differ significantly in terms of numerical abundance.

- Studies on traditional grain legume crops of the Central Himalaya with regard to changes in temporal and spatial diversity were conducted. Beside, studies on status, changing scenario, cropping and yield pattern, factors and process responsible for loss of legume diversity etc. were undertaken in detail.
- Participatory action research and demonstration centre for capacity building and educational awareness in the area of conservation and management of below ground biodiversity were established in Triyuginarayan Distt. Rudraprayag of Garhwal Region.

Summary of Completed Project/Activity

Fallow Management Practices among the Tangkhuls of Ukhrul District, Manipur in their Two Year Plus Shifting Cultivation Systems *(2004-2007, In house)*

The project attempted to identify efforts to enhance soil fertility replenishment processes within shortened fallow periods. In the light of this, the research investigation was carried out to identify the fallow species managed during the slashing and cropping phase of shifting cultivation as practiced by the Tangkhuls of Ukhrul district, Manipur and the perceived values of the species for which the farmers assigned. In order to analyse the effect of their fallow management practices, soil and yield parameters of the system were also collected and results are summarized as bellow:

- In an area of about 30.38 acres, 1018 plants of 34 species were retained after thinning/lopping the branches during slashing the fields whereas 2419 stubs/trunks of 61 species were also retained after cutting at about 1.5 meters height. In the same area of land, 149 root sprout plants of 9 species mostly of *Albizia* spp. and *Quercus* spp. were nurtured by the farmers. Moreover, 353 plants of 6 species mostly *of Toona ciliata, Melia azadirach* and *Alnus nepalensis* were introduced during the cultivation phase (Fig. 55).

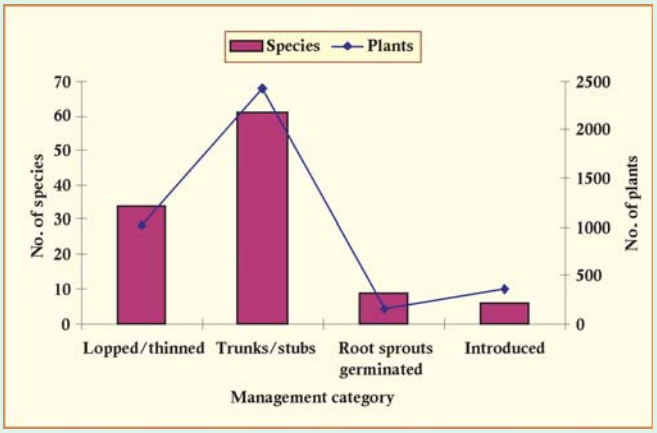


Fig. 55. Cultivation phase of different species of plants.

- Farmers were of the opinion that the nurtured species have values to their fields as well as their livelihood.
- During 1st and 2nd year of continuous cropping, the soil remains loam in nature whereas 3rd and 4th year it exhibits sandy loam character.
- Organic carbon and nitrogen reduces marginally with increasing year of cropping (upto 3rd year) but slightly improved during 4th year.
- While maize yield was constant throughout the cropping year, rice bean yield increases with increasing year of cropping.

Summary of Completed Project/Activity

Augmenting Economic Security of Rural People Using Indigenous Bamboo Resources in the Indian Central Himalaya

(2005-2007, DST, Women Scientist Project)

This study was focused to document indigenous knowledge on bamboo resource use and its management, assessing structure and propagation practices of selected species, and capacity building of bamboo artisans for developing new products and resource conservation in Uttarakhand state. The main findings include:

- An inventory of bamboo species for entire Indian Himalayan states (12 states) was prepared (79 species in 22 genera). For Uttarakhand state only 8 bamboo species (5 genera) were recorded that grow naturally (*Dendrocalamus strictus, D. Somdevii, D. Parellaris, Bambusa bamboos, Arundinaria falcata*, *Thamnocalamus falconeri, Thamnocalamus spathiflorus* and *Thamnocalamus jaunsarensis* (all ringal bamboo species).
- Survey of 132 bamboo artisan (Baruries) and 560 ringal artisan (Rudias) household in 20 villages of Almora, Bageshwar, Uttarkashi and Nainital districts was conducted.
- At mid hills the bamboo culms were recorded to be collected from private lands that are sporadically distributed in village lands. Such bamboo clumps are leased to '*Baruries*' for a certain period, the prices are fixed on per number of culms/clump. The cost of raw material has gone up significantly due to limited bamboo resources in recent times. An analysis of past 20 years record of bamboo harvests in Uttarakhand state revealed that the maximum bamboo production and revenue was generated in 1987-88 and over the years it has decreased.

Fig. 56. A ringal-bamboo plant and skill development of the traditional ringal artisans.

Contd.....

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- Line transect survey in Uttarkashi district (25x20 m) revealed density of ringal as 5.3, 4.8 and 5.7 clumps per 25 m2 respectively in three stands. The major associated tree species in the stands were *Quercus leucotrichophora, Alnus nepalensis, Cedrus deodara, Abies pindrow, Fraxinus micrantha, Juglans regia, Betula alnoides, Quercus semecarpifolia, Q. floribunda, Aesculus indica, Lyonia ovalifolia, Taxus buccata, Ilex deparine,* and *Silex sp.*
- Vegetative propagation of 5 species (*D. strictus*, *B. burmanica*, *B. nina*, *D. calostachys* and *B. tulda* were tested. The data revealed that *D. strictus* and *Bambusa burmanica* had maximum response while *Bambusa nina* exhibited minimum.
- Two courses of capacity building were organized. The Ist batch comprised 20 women entrepreneur to develop their basic skill for bamboo based trade development. These women have organized themselves and started marketing of the bamboo products and earning Rs.800-1200/month. the IInd batch comprised 18 artisans who were trained for developing new and market oriented products of bamboo. It was recorded that new products making is promising in terms of less use of raw material, high output price and less time spent on their making.

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 *(2004-2007, DST Funded)*

Agricultural development in the northeast uplands requires a concerted technology backstopping as access to technology in the region is grossly inadequate given the constraints of terrain and the limits of concerned line departments. Demonstration, dissemination, technology backstopping, and capacity building need to be institutionalized closely to the demand areas to reach to the weakest section of the society. Considering that the present project addresses: (i) to institutionalize a process mechanism for technology backstopping & capacity building of rural upland farmers in simple, low-cost, appropriate technologies, (ii) to set up a network of credible NGOs to showcase simple, low-cost, appropriate technologies, (iii) to hand-hold the selected NGOs to set up Demonstration Centres and On-farm demonstrations and facilitate a process mechanism for capacity enhancement of upland tribal farmers, particularly shifting cultivators, (iv) to build up the capacity of Partner NGOs (PNGOs), (v) to facilitate a process mechanism for identifying technology input needs in remote marginalized areas and built a community-driven process mechanism for addressing technology gaps, (vi) to establish a process mechanism for capacity building in on-farm technologies and enhance technology dissemination through on-farm demonstration and trainings, (vii) to technically validate technology modifications/ adaptations for further technology upgradations, (viii) develop technology dissemination material (ICT- printed, audio-visual and other material) and ensure wider dissemination in local languages through Partner NGOs, and (ix) encourage entrepreneurship development among rural youth, especially women, based on simple low cost, appropriate technologies.

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- The project has seven regional partner-NGOs (PNGOs) in five North Eastern States. The blocks and villages covered by the PNGOs are given in Table 16. 22 technologies demonstrated along with the technical back-up support. The PNGOs are trained GBPIHED, Northeast Unit, who subsequently train lead farmers and farmers at grass root level in their respective states. The project is ensuring institutionalized network, where the institute serves as a 'Single Window' Technology Dissemination and Upgradation Centre, or a 'Technology Hub'. This is linked at the next level to localized NGOs, who have established Demonstration Centres, which could gradually graduate to become 'Rural Technology Colleges'.
- The activities of the PNGOs are being continuously monitored. The results indicated that farmers are adopting technologies through PNGOs (Table 17). The manual related to these technologies are translated in local languages.
- NEC, Shillong is involved in the monitoring aspect of the project. Linkages have been made with line departments and other related institutes in the operating states, e.g. in Arunachal Pradesh state with Rajiv Gandhi University (RGU), North Eastern Regional Institute of Science & Technology (NERIST), State Institute of Rural Development (SIRD), State Forest Research Institute, and Arunachal Pradesh Seva Sangh; in Meghalaya with IFAD-MRDS, Shillong. Similar efforts are under progress for other states.

Table 16. Name of the PNGOs along with states, blocks and villages covered.

Name of the NGO	State	Block(s)	Villages
Institute of Integrated Resource Management (IIRM)	Assam	Balipara, Dhekiajuli	Chapaguri, Batabari, Ulubari, Dhekidol, Adabari, Barpatgoan
North Cachar Hills Hmar Cultural Organization (NCHHCO)	Assam	Harangajao, Mahur	Retzawl, Doiheng, Boro-Muolkoi, D. Huonveng, Buolmuol Bagan
Centre For Environment Protection (CEP)	Mizoram	Tlagnuam	Muthi, Sihphir vengthar, Nausel, Lungdai, Mualkhang
Society for Sustainable Rural Development (SSRD)	Manipur	Ukhrul	Kalhang, Luireishimphung, Kuirei, Ngahui, N. Khullen
Northern Integrated Development Association	Manipur	Phungyra, Chingai	Pudunamei, Punanamei, Rabunamei, Kalinamei, Song song, Thonglang
St. Vincent's Welfare Society (St.VWS)	Tripura	Manu	Kathalcherra, Kanchancherra, Nalkata
Nurture and Motivation-Rural Human Empowerment Network Association (NAM-RHEN Association)	Meghalaya	Chokpot, Amlaren, Mylliem	Pamtabuh, Jaralod, Amtasam, Amladthkur, Lurniang

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Table 17. Technology adoption by lead farmers under PNGOs in different NE states.

PNGOs	Villages Selected	Lead Selected	Farmers	Technology Selected	Technology Adoption by Farmers
IIRM	6	12	60	9	-
NCHHCO	5	10	170	7	108
CEP	5	20	150	8	15
SSRD	5	22	56	7	15
NIDA	6	120	300	6	125
St. VWS	4	30	20	9	12
NAM-RHEN	5	18	31	9	8

Theme

BIOTECHNOLOGICAL APPLICATIONS (BTA)

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 the current concern about the global climatic change. A thorough understanding of the mechanism of plant adaptation to stress, be it physiological, biochemical or molecular, is extremely relevant for increasing the productivity of plants. Besides this, exploration of microbial diversity with special reference to plant growth promoting microorganisms and mycorrhizal associations is also considered crucial, particularly for the formulation of carrier based bioinoculants for increasing plant productivity, under extreme climatic conditions of the Indian Himalayan region (IHR). This theme focuses on plant propagation and adaptation, quantification of active ingredients of medicinal and aromatic plants, documentation of microbial diversity with special reference to plant growth promoting microorganisms and mycorrhizal associations, etc. 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 resource.

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, due to over exploitation, has also resulted in decreasing the availability of many economically important plant species including non-timber forest products. With ever increasing human population and consequentially the growing demand for plants and plant based products, there has been a tremendous anthropogenic pressure on these primary producers. In order to cope with such challenges, large scale plantations need to be taken up. Therefore, large scale multiplication of quality planting material would be required. Besides conventional methods of propagation, in vitro propagation techniques have the recognized potential for rapid multiplication of elite clones to provide the much needed planting material for cultivation, and also to achieve the objectives of conservation. Keeping these goals in mind, studies have been taken up with the following objectives: a) Germplasm collection and maintenance in nursery, b) Development of propagation protocols by conventional (by cuttings and seeds) and *in vitro* methods, and c) Large scale multiplication.

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.

- Extensive field surveys were conducted in and around the respective places to collect plant samples (seeds, cuttings, etc) for germplasm collection and obtaining plant material for various experiments.
- In order to influence germination, seeds of *Olea ferruginea* were given different physical and chemical treatments. Among various treatments, soaking in conc. H_2SO_4 (8 h) and scarification improved the per cent seed germination; the positive effect was more pronounced in mechanical scarification treatment (Fig.57).

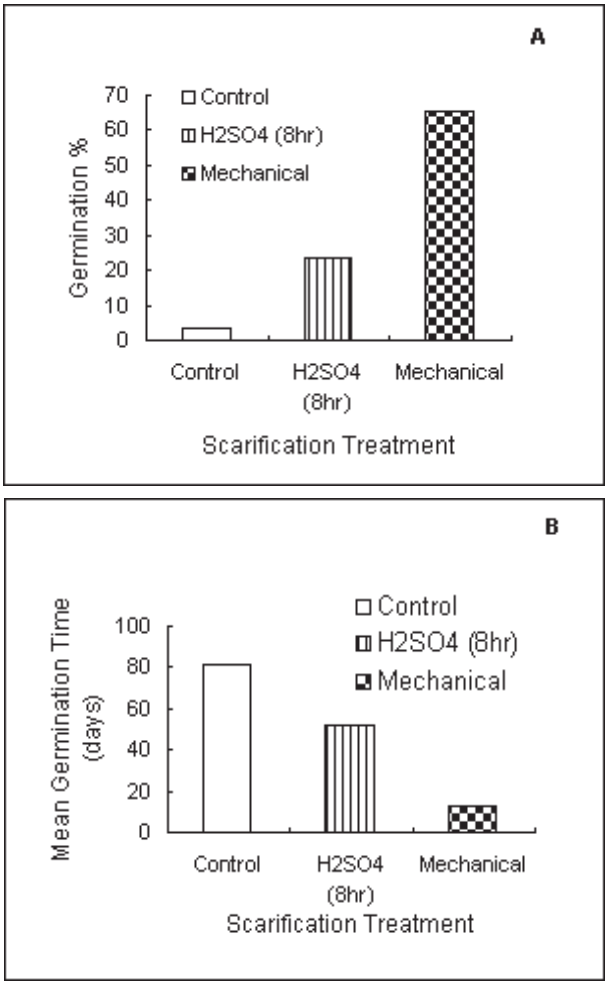

Fig. 57. Effect of chemical and mechanical scarifications in germination % (A) and mean germination time (days; B) in *Olea ferruginea*.

Fig. 58. Use of chemical treatments for inducing rooting in stem cuttings of *Quercus lamellosa* and *Zanthoxylum armatum*.

- Stem cuttings (15-20 cm) of *Quercus* spp. were treated with solutions of different chemicals including plant growth regulators (IBA, NAA, Phloroglucinol, GA_3, ABA, IAA) and a systemic fungicide (Bavistin) to influence rooting; results are awaited. Similar treatments were provided for stem cuttings of *O. ferruginea* and *Zanthoxylum*

armatum, however, success was not achieved (Fig.58).

- Efforts are being of *Zanthoxylum armatum* using explants collected from plants growing in Kasardevi (1800 m), Basoli (1500 m) both in Distt. Almora, and from Munsyari area (1500 m), Distt. Pithoragarh, and for *Amomum subulatum* collected from Ukhimath (1900 m), Distt. Chamoli. The explants were cultured in MS media containing different concentrations of plant growth regulators; some contamination free cultures have been obtained and are being used for differentiation. Efforts are being continued to establish *in vitro* cultures of oaks using seeds of *Q. pachyphlora* & *Q lamellose.*
- Efforts continued for *in vitro* mass scale multiplication of *Rhododendron maddeni* for conservation; more than 1000 hardened plants are ready for field transfer while 300 plants are being hardened under green house/ net house conditions.
- A method was developed for plant regeneration from alginate-encapsulated shoot tips of *R. maddeni*. Encapsulated shoot tips exhibited successful regeneration after different periods of cold storage at 5°C. Among the four different storage conditions (0°C, 5°C, 17°C & 25°C), the beads stored for 30 days at 5°C showed maximum frequency (68%) of shoot proliferation when placed back into regeneration medium (Fig.59).
- The standardization of *in vitro* propagation protocol of another Sikkim Himalayan rhododendron, *R. dalhousiae* Hook. f. (Lahare Chimal as known in Sikkim) continued. The rooted plantlets were hardened and successfully established in greenhouse; survival of these plantlets was found to be 93%.

Fig. 59. Encapsulation of shoot tips (A) and plant regeneration from these beads of *Rhododendron maddeni* grown on Anderson's medium.

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

- Thirteen thermophilic strains originally isolated from hot spring sites have been investigated for their morphological, biochemical, physiological and molecular characters. The bacterial strains could tolerate a temperature range between 40-45°C to 85-90°C (optimum 65°C-70°C) and pH between 4-11 (optimum 6-8). Based on the oxygen requirement, the strains can be defined as facultative anaerobes. The cell morphology varied from short to long rods arranged in single, diplobacilli or short or long spiral chains with coiling. The bacterial strains varied in respect of their biochemical

tests conducted for various enzymes, fermentation of sugars, tolerance to antibiotics and salt. Based on the 16S rRNA analysis, 11 strains showed maximum similarity with *Geobacillus stereothermophilus*, one strain with *G. kaustophilus* and one with *Geobacillus* sp. Characterization of ten cold and pH tolerant species of *Aspergillus* has been carried out with special reference to their P solubilization potential (Fig.60). The important parameters considered for this study were the production of organic acids and phosphates.

- Study sites were selected in NE region and soil samples were collected to investigate the microbial diversity under shifting cultivation areas. These samples were collected immediately after completion of the 'fire process'. Pure cultures of bacteria, actinomycetes and fungi have been obtained for detailed investigations.

Identifying Environmental Correlates of Reproductive Success of Fishes for Enterprise Development of Lotic Stream Fishery *(2008-2012, In-house)*

Based on the leads from the on going activities on Iccthyology a new project has been initiated in NE unit, Itanagar, with the objectives on population estimation, behaviour and reproductive success of fishes. Twenty nine species belonging to 24 genera spread over 16 families and two species of economically important crustaceans, Barytelphusa (Maydelliathel phusa) laugbris laugubris (crab) and Macrobrachium lammarei (Shrimp), have been recorded. Detailed studies are in progress.

On - Farm Conservation and Molecular Characterization of Different Landraces of Rice in Kumaun Region of the Indian Central Himalaya *(2007-2010, DST-YS Funded)*

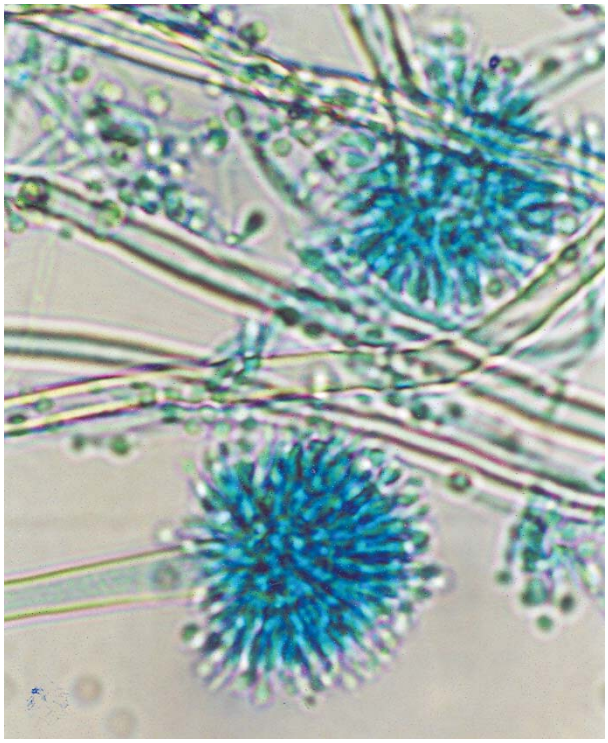

Fig. 60. Cold and pH tolerant *Aspergillus* sp.

In spite of many virtues of traditional agriculture, the country is still losing precious genetic diversity in the form of landraces. If a serious view of the existing situation is not taken, the Himalayan region will become a food-importing region and lose ecological and economical security. In recent decades, the Green Revolution has gradually eroded/displaced the mosaic of traditional crop varieties/landraces. Despite such a trend, many "heirloom" varieties are still being maintained by gardeners, farmers and tribals, particularly in isolated remote areas. In view of the importance of different landraces of rice, which are needed for strengthening the national and regional 'gene banks' for future breeding programmes, the present investigation has been undertaken with the following objectives: (a) Exploration of various landraces in the entire Kumaun region particularly in remote villages located at higher elevations and estimation of biomass and productivity, on farmers' field and in experimental plots, and (b) Traditional uses of these landraces and their conservational importance.

1. Extensive surveys were made in each landform of the Kumaun Himalaya to identify different practices and landraces cultivated on farmers' field with a particular view to explore diversity within the rice crop (in the form of landraces or varieties). A questionnaire was prepared and used in these surveys. Seeds of various landraces were collected, and various agronomic characteristics viz, sowing and harvesting time, specific morphological features, and traditional importance of different landraces were also recorded. So far 11 landraces have been collected and the survey work is still going on (Fig.61).

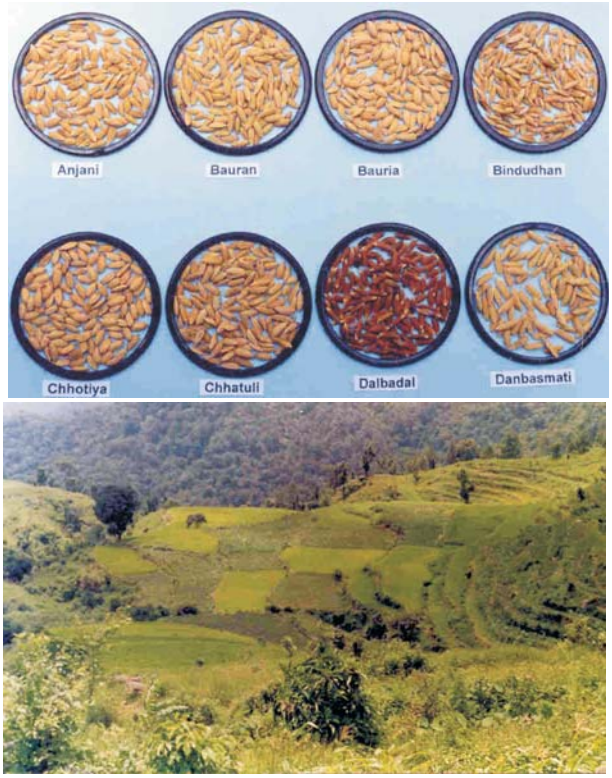

Fig. 61. On farm cultivation of different landraces of rice in Kumaun Himalaya.

Development of Callus and Hairy Root Cultures for the Production of Active Compounds from two Himalayan Plants *(2006-2009, UCOST Funded).*

Several plant species of the IHR are sources of high value drugs, and due to increasing global demand for the "naturals", they are being subjected to reckless, often illegal harvesting, well beyond their natural regeneration capacity. Although *in vitro* methods have proven to be promising methods for multiplication and subsequent cultivation of plant species, use of callus cultures and genetically transformed hairy roots for production of active ingredients of medicinal value in *Picrorhiza kurrooa* and *Aconitum heterophyllum* would be an attractive alternative. Genetically transformed hairy roots produced by gram negative soil bacterium *Agrobacterium tumefaciens*, appear to be promising for secondary metabolite production. The study envisages establishment of callus and hairy root cultures, analysis of chemical constituents, and scaling up cultures for the production of active ingredients.

- Callus of *P. kurrooa* was developed from leaf and nodal segments taken from already established *in vitro* cultures using different combinations of plant growth regulators in MS media. Best response of callus formation was obtained from nodal segments in a medium containing Thidiazuron and Benzylaminopurine.
- Three types of explants (shoot tip, leaves and nodal segment; taken from already established aseptically grown multiple shoots of *P. kurrooa*) were used to initiate hairy roots. Nodal segments produced hairy roots when cultured on MS basal medium after infection with 8 different types of *Agrobacterium tumefaciens* (Fig.62).
- The transformed roots, following infection with above strains were confirmed by PCR analysis. Efforts are now underway to analyze the production of picrosides in callus and hairy root culture and to characterize hairy roots using molecular tools.

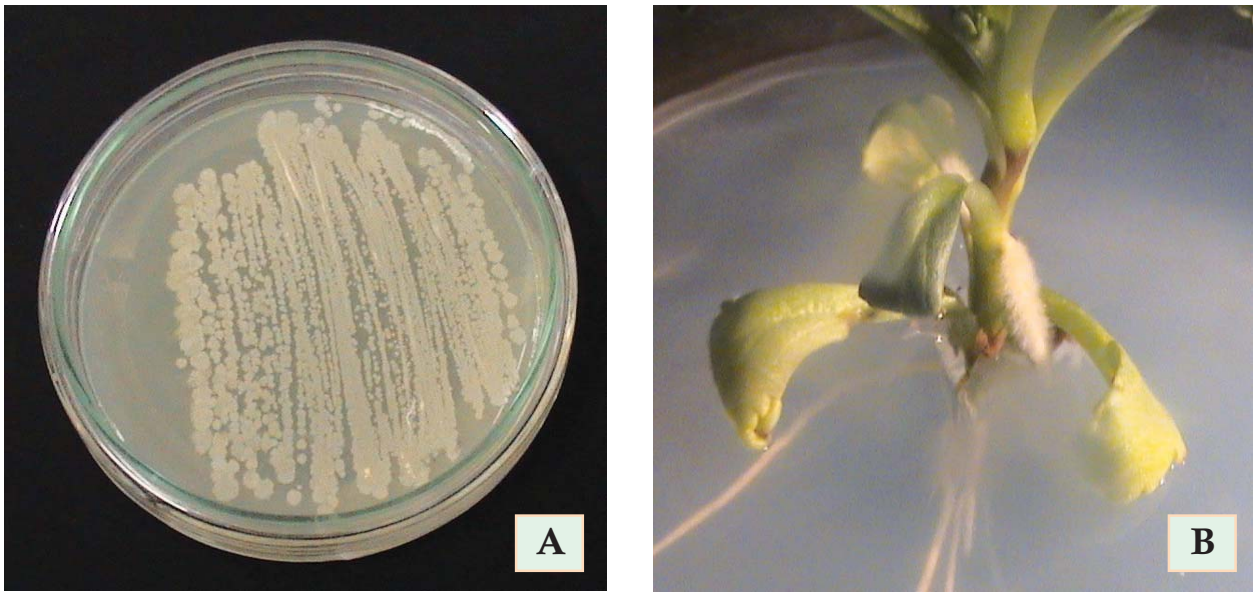

Fig. 62. Strains of bacteria, *Agrobacterium rhizogenes* growing in Luria Broth media (A) and induction of hairy roots in *P. kurrooa* using *A. rhizogenes* strain A4 (B).

Summary of Completed Project / Activity

Network Programme for the Establishment of Bamboo Plantation in Uttarakhand

(2004-07, DBT Funded)

There is a great demand of bamboo for commercial purposes particularly as its long fibre is required for the pulp and paper industry. It is thus known as one of the most sought after raw materials in the tropics. Apart from industrial use, bamboo is utilized in making rayon, mat boards, roofing, construction work, furniture, agricultural implements, baskets and has numerous other traditional uses. In view of the decreasing forest reserves in the country and its great relevance to the hilly areas of Uttarakhand, this demonstration project on *Dendrocalamus hamiltonii* ('Maggar' Bamboo), a multipurpose bamboo, also known for good quality winter fodder, was initiated with the following objectives: a) large scale multiplication by conventional and in vitro methods, and b) setting up demonstration plots.

- A nursery, exclusively for bamboo, was developed with fenced area and two polyhouses were constructed in it for raising and hardening of plants. Seed germination of this species was poor with only 10% germination; treatment with chemicals was not useful. Vegetative propagation (clonal propagation) using culm cuttings (2-2.5 m length containing 6-7 nodes) was carried out. Two auxins (IBA and NAA) and a systemic fungicide (Bavistin) were found to be effective for root induction in it (about 60% compared to 5% in control) and were used for its multiplication.
- Tissue culture method was used for large scale clonal multiplication. Single node cuttings, taken from the lateral branches of a mature 20- year-old bush were used for developing cultures. In this project, by modification of culture media composition (in Murashige & Skoog medium) for shoot multiplication (developed earlier in the laboratory), and also that of rooting medium,

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higher than the reported number of plantlets could be generated. The plantlets thus produced were found to develop a satisfactory root system and were subsequently transferred to cups/bags containing soil. Following proper hardening (a month each in green house and in shaded net house) the plants were transported and subsequently field planted by the Uttarakhand Bamboo & Fibre Development Board Dehradun in the plains with a satisfactory survival rate. The in vitro raised plants planted in the lower hill elevation (Kosi-Katarmal; 1150 m) exhibited about 70% survival rate with excellent growth performance even after one year (Fig.63).

Fig. 63. Healthy in vitro raised plants of *D. hamiltonii* one year after field plantation; in vitro plant multiplication (inset).

- The total number of plants supplied to UBFDB was: *Dendrocalamus hamiltonii* (6,500 tissue culture raised, 500 seed raised), *D. strictus* (11,000 seed raised) and *Bambusa arundinaceae* (2400 seed raised).

Summary of Completed Project/Activity

Rhizosphere microbiology of Himalayan plants *(2004-2007, In-house)*

The Himalayan region (IHR) represents great variation with respect to environmental conditions; this in turn is responsible for the occurrence of a wide variety of habitats and climates. It provides varied ecological niches and microclimates not only for the higher plants and animals but for the microorganisms as well. Various research projects were carried out on (1) diversity of various groups of microorganisms, and (2) their possible biotechnological applications with reference to IHR. While the temperate and alpine locations were explored for enumerating the diversity of free-living bacterial, actinomycetes and fungal communities, symbiotic associations between selected trees and the AM (arbuscular mycorrhizal) fungi were also investigated. Studies related to rhizosphere of Himalayan plant species including rhizosphere effect were carried out. A couple of hot spring sites, located in the Garhwal region of IHR, were studied for the isolation and characterization of thermophiles.

With a view to develop microbial inoculants for field applications in the colder mountainous regions, suitable bacterial and fungal species including arbuscular mycorrhizae have been selected. Efficient strains of plant growth promoting rhizobacteria belonging to the species of *Bacillus* and *Pseudomonas* have been evaluated for their growth promotion and biocontrol potential. In view of the necessity to develop "easy to use agents" for field applications and commercialization, the bacterial inoculants were further developed in suitable formulations.

Summary of Completed Project/Activity

Large Scale Propagation of Location Specific Elite Plants Using Conventional and Biotechnological Methods *(2004-2007, In-house)*

Quality planting material in large quantities is required for afforestation, conservation and rehabilitation programmes and for commercial purposes. In order to achieve this, conventional (involving seeds and cuttings) as well as tissue culture methods have been quite successfully adopted under this activity for developing protocols for large-scale multiplication. Particular emphasis was given to field transfer and subsequent growth monitoring of these plants. Field plantation of tissue culture raised plants of *Dendrocalamus hamiltonii*, a multipurpose bamboo, following 2 months of hardening (Fig.64), exhibited 3 fold increments in height within the 1st year along with satisfactory survival (70%). Concomitant increases in chlorophyll content (1.6 to 1.82 mg/g fr wt for Chl a and 0.70 to 1.23 mg/g of fr wt for Chl b) and leaf area (21.7 cm^2 to 36 cm^2) were also observed; net photosynthesis rate improved from 3.55 to 5.44µmol/m^2/s while transpiration rate increased from 1.12 to1.70 mmol/m^2/s. Assessment of genetic fidelity of these plants was carried out (Fig.64). The pattern of RAPD fragments produced by the random primers showed that all amplification products in the mother clone were found to be monomorphic across the tissue cultured plants. The primers OPA3, OPA4, OPA5, OPA9 and OPA15 did not reveal any variation in the mother and tissue cultured plants, indicating genetic fidelity among the regenerants of the mother plants.

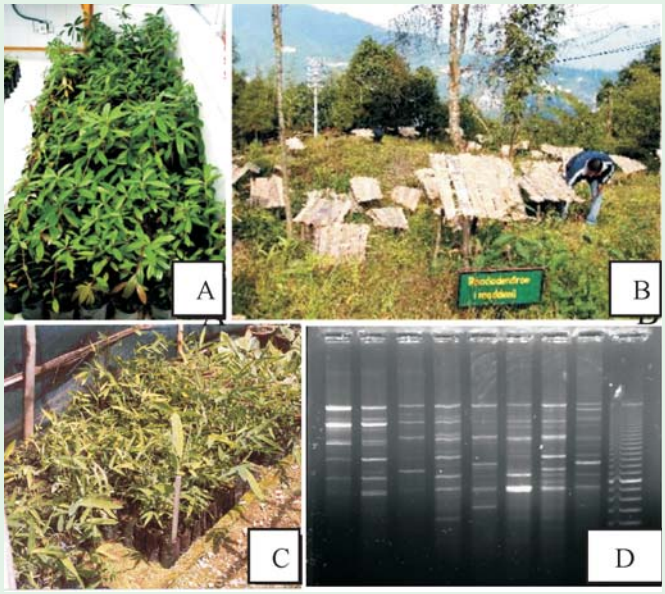


Fig. 64. Mass multiplication and field plantation of *R. maddeni* (A & B), tissue cultured plants and genetic fidelity assessment of *D. hamiltonii* (C & D).

More than 3000 tissue cultured plants of *Rhododendron maddeni*, an endangered rhododendron species produced using previously developed propagation protocols, were hardened under green house conditions (Fig.64A). The growth parameters of tissue cultured plants after plantation in arboretum were monitored at three-month intervals in terms of plant height, stem diameter, no. of leaves, largest leaf length and largest leaf width; all the plants attained significant size within nine months and exhibited over 90% survival. *In vitro* shoot multiplication was achieved in *R. dalhousiae.* Moreover, hundred tissue culture raised plants of *R. maddeni* and 200 conventionally propagated plants of six different rhododendron species (*R. griffithianum R. baileyii, R. maddeni, R. dalhousiae, R. grande,* and *R. ciliatum*) were planted in the Rare & Threatened Plant Conservation Park' of the Zoological Park at Gangtok where they are growing satisfactorily (Fig.64B). The antioxidant potential of 21 species/subspecies of rhododendrons was studied for their total phenolic contents (TPC), flavonoids, antioxidant activity (AOA) and free radical scavenging capacity. Amongst them *R. baileyii, R. camelliiflorum, R. campanulatum, R. ciliatum* and *R. cinnabarinum* were found to possess high TPC, high AOA and efficient free radical scavenging property.

Summary of Completed Project/Activity

Water Relation Study of Some Multipurpose Tree Species of Himachal Pradesh, North West Himalaya *(2006-2007, In-house)*

The main aim of this study was to identify multipurpose tree species with the potential to be used for afforestation of degraded lands in North West Himalaya using water relations and morphophysiological traits as selection criteria. Several indices of water relations (water potential, relative water content, succulence and water content at saturation), leaf sclerophylly (leaf mass per unit area and density of foliar tissue) and growth were determined in eight multipurpose tree species (*Olea ferruginea, Grewia optiva, Robinia pseudoacacia, Ulmus wallichiana, U. villosa, Cedrus deodara, Pinus roxburghii and P. wallichiana)* of Kullu district in Himachal Pradesh during their active growth period in the rainfed field conditions. The major findings of the study are:

Differential responses for the studied parameters were observed amongst the species studied. Of the eight species studied, *O. ferruginea* and *R. pseudoacacia* showed considerably low water potential throughout their active growth period. Further, when the water potential values of individual species were averaged across the growing season, *O. ferruginea* (-4.45 MPa) followed by *R. pseudoacacia* (-4.02 MPa) species exhibited the lowest water potential while *U. villosa* (-2.14 MPa) exhibited the highest. The data suggest that *O. ferruginea* and *R. pseudoacacia* could tolerate maximum water deficit to remain physiologically active.

The chlorophyll content measured in terms of SPAD values did not differ significantly among the 4 broad leaved species when compared across the growing season. However, chlorophyll content was found significantly higher in *O. ferruginea* as compared to other plant species, which was probably responsible for its better growth and productivity in degraded lands.

O. ferruginea also showed low RWC throughout the active growth period. Both water potential and RWC data indicate that this species has a dehydration tolerance capacity regarded as a very efficient drought tolerance mechanism since it allows plants to function even under low water potential. This species also possesses higher leaf mass per unit area and higher density of foliar tissue compared to other plant species. The leaf mass per unit area and density of foliar tissue also suggest that *O. ferruginea* has the potential to survive drought stress and thus could be suitable for afforestation of degraded lands.

Summary of Completed Project / Activity

Ecophysiological Responses of Different Populations of Selected High Altitude Medicinal Plant Species Subjected to Natural Temperature and Water Deficit Stress *(2006- 2007, In-house)*

Many high value medicinal plant species of Himachal Pradesh have entered into the red data book. This has been mainly attributed to over and reckless - exploitation. However, ecophysiological responses of different populations of high altitude medicinal species subjected to natural temperature and water deficit stress within their natural habitats are poorly known. Such studies are of fundamental importance for the conservation of these species. Therefore, this project was initiated with the objectives to : i) compare the physiological and biochemical responses of different populations of selected medicinal plant species subjected to natural temperature and water defict stress, and ii) understand the underlying mechanisms used by different populations of the selected plants for their survival and growth. The species selected for the present investigation were *Aconitum heterophyllum, Picrorhiza kurrooa, Podophyllum hexandrum* and *Rheum moorcroftianum*. The significant findings are:

Water potential, relative water content (RWC) and chlorophyll content measured in terms of SPAD values in the leaves of *P. kurrooa, P. hexandrum* and *R. moorcroftianum* plants growing on the exposed slopes in the alpine habitat during vegetative and reproductive stages were determined (Table 18). In general, alpine species exhibited high water potential as well as RWC. Of the three species, *R. moocroftianum* maintained relatively higher water potential than *P.kurrooa* and *P. hexandrum*. The latter species also showed lower RWC compared to other species.

There was no significant decrease in chlorophyll content in terms of SPAD values in *P. hexandrum* at reproductive stage; however, the decrease was significant in *P. kurrooa* and *R. moorcroftianum*.

Table 18. Water potential, relative water content (RWC) and chlorophyll content (SPAD values) of alpine plant species (exposed ones) during vegetative and reproductive stage.

Plant Species	Vegetative Stage			Reproductive Stage		
	Water Potential (MPa)	SPAD Values	RWC (%)	Water Potential (MPa)	SPAD Values	RWC (%)
P. kurrooa	-1.17±0.05	44.55±2.76	97.37±3.89	-1.12±0.06-	35.30±2.87	97.40±4.11
P. hexandrum	-1.19±0.08	35.55±1.42	83.22±4.99	-1.34±0.06	39.13±4.30	86.27±6.07
R. moorcroftianum	-0.70±0.04	47.44±2.32	90.34±3.67	0.84±0.04	36.32±4.35	92.71±4.67

Theme

KNOWLEDGE PRODUCTS AND CAPACITY BUILDING (KCB)

The mountain communities have acquired an immense knowledge of their natural environment. Yet this accumulated knowledge is rapidly disappearing as the traditional communities are steadily becoming more & more culturally and biologically advanced. With greater realization of the value of this knowledge base, it is considered that the knowledge should 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 related to human well being and natural resource management, is required to be transmitted or exchanged through capacity building efforts in empowering all the stakeholders. Knowledge base of the different traditional societies and knowledge developed through science and technology interventions, if successfully adopted/implemented through capacity building programmes, would certainly generate ecologically sound, economically viable, socially acceptable and institutionally enforceable outputs. The theme envisages to i) undertake in-depth studies on documentation and validation of knowledge (traditional/indigenous/rural) system including their cultural, biological, material, spatial, landscape as well as intellectual components and their on-going interactions as the basis for protecting and safeguarding of knowledge base, ii) utilize natural resources for income generation using local knowledge and capacities through S&T interventions, iii) translate existing knowledge related to bio and natural resources into products, iv) enhance rural capacities and skill in harnessing the potential of knowledge systems for socio-economic development, and v) provide opportunity for stakeholders to interact with each other and with institutions working on knowledge products system together to address research, action, and policy needs and help to develop appropriate strategies and guidelines for sustainable mountain development.

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

The Himalayan region is rich in bio-resources but it is strongly felt that the potential of science and technology has not been adequately and appropriately harnessed in realizing the potential of these resources. The absence of basic infrastructural facilities is a major constraint to the promotion of entrepreneurial ventures in the region. Further, the phenomenon of rural-urban drift is often stimulated by the depressed level of living conditions prevailing in the rural sector. In this context, it is of utmost importance to recognize the need for providing support to local communities. This would serve to mobilize the

innovative capacity of rural people as well as to diversify and enhance the productivity of resources as also the skills available with them. This essentially requires capacity building of people and organizations to enable them to adapt themselves to new circumstances. Moreover, integrating human skills, organizational development and information networks is the key to effective technology transfer and self employment. Realizing this the project intends to: (i) enhance mechanisms for capacity building and self employment generation through introduction and promotion of hill specific cost-effective potential technologies; (ii) select, on farm and off- farm technology packages/ interventions for improving livelihood options; (iii) improve income of the rural people through implementation and replication of simple and cost-effective technologies. The progress of the project at different locations is as follows:

A. Head Quarters

Rural Technology Complex (RTC)

- Information on about 35 approaches/ technologies/ activities for sustainable development was collected, documented, tested, modified and demonstrated/ maintained at the Rural Technology Complex (RTC). RTC acted as central facility for imparting training on diverse options. A total of thirty two training/ awareness programmes were organized (Table 19) for different stakeholders.
- A total of 10,000 seedlings/saplings of different plant species valuable for the region were raised of which 1200 saplings were distributed amongst stakeholders for plantation.
- Based on the tested and modified technology, training manuals on various technology packages were prepared and distributed to the different stakeholders.
- Towards becoming a self sustaining unit, RTC generated Rs 6, 91, 620/- (Rs 6, 76,100 through training and awareness programmes and Rs 15,520 through sale of planting material).

Table 19. Training organized for different stakeholders (April 2007-March 2008).

Users	Training Programmes			
	One day	Two day	Three day	Total
Members & Farmers selected by NGOs	4	-	-	4
Farmers/officals selected by Govt. Organizations	1	1	24	26
Students	1	1	-	2
Total training	6	2	24	32

Table 20. Capacity building through training (April 2007-March 2008).

Users	Total	Male	Female
Farmers selected by NGOs	226	25	201
Farmers/officals selected by Govt. organizations	688	515	173
Students	46	36	10
Total	960	576	384

B. Regional Units

Garhwal Unit

- Rural Technology Centers established at various locations played a catalytic role in the capacity building of the user groups on various rural technologies. Interested stakeholders consisted of 90 high school students of Kendriya Vidyalaya, Srinagar Garhwal, 30 Representatives and officers from Livelihood programme, farmers, NGOs, Govt. officials and officials of NABARD (GM/DGM/DM) of Uttarakhand.
- About 130 women farmers of Triyuginarayan and adjoining villages and other stakeholders were provided on-site training on organic farming and off-season vegetable cultivation through the use protected cultivation.
- Potential bioresources were identified with respect to household level small scale enterprises such as development of: fiber based products from *Hibiscus sabdarifa* (threatened resource of the region) and Medicinal and aromatic plants (MAPs) based herbal spices and value addition of selected wild edibles.
- The farmers were provided necessary technical skills on protected cultivation through hands-on training and field demonstration. The capacity building programme has made a significant contribution, which is reflected in the rate of adoption of these technologies into farm. Over 20 progressive farmers in Sirsi and Triyuginarayan villages have adopted low cost polyhouse technologies for nursery raising and vegetable cultivation (Figure 65).

Fig. 65. Stakeholders engaged in various bioresource based technologies.

North East Unit

- The Multi Technology Demonstration Centre of the Institute at Midpu, Arunachal Pradesh has been continuously providing training on low cost rural technologies to diverse stakeholders including farmers, NGOs and Government officials, etc., from across the North Eastern region. All the technologies that have been housed in the Centre have been suitably tested and modified according to the demand of the region.
- Among others, one technology (i.e. trellies for home gardens) which has wide acceptance across the region, was modified towards giving a new meaning to the art of home gardening. A nursery has been developed to grow locally available medicinal plants, etc., which can cater as a seed bank to propagate medicinal plants of importance in the state of Arunachal Pradesh.
- During 2007-08, seven trainings / exposure visits were conducted. A consultancy for Meghalaya Rural Development Society (MRDS) Shillong, Meghalaya was also undertaken to impart training to villagers on Trellises. Five cluster villages in the Ri Bhoi district of Meghalaya were covered during the consultancy (Table 21).

Disaster Management Faculty, Sikkim

(2004-2012, Ministry of Home Affairs, Govt. of India Funded)

Disaster not only poses a threat to the lives of the people but affects them in several ways. Besides, damaging the economy and physical infrastructure built over the years, it also causes severe strain on the Government resources. Natural disasters have been taking place since the origin of the universe, but their impact on the human beings has increased due to increase

Table 21. Details of cluster villages and number of participant farmers in the demonstration during consultancy programme with MRDS Meghalaya.

Date	Name of Village	Block	No. of Participants	
			Male	Female
Sept 7-8, 2007	Ranibari	Jirang	15	35
	Balakhowa	do	-	3
	Bernongsai	do	1	-
	Ranibari	do	6	9
Sept 10-11, 2007	Bakhlapara	do	13	4
	Jimirigaon	do	11	3
	Lungkhung	do	9	4
Sept 12-13, 2007	Nongrim	do	4	-
	Jaribasi	do	6	7
	Nongrim	do	12	5
	Umkrembykhong	do		5
	Jaribasi	do		
Sept 18-19, 2007	Umsen	do	10	6
	Umlathu	do	2	1
	Pynkea-C	do	1	3
	Pahamjula	do	2	2
	Pynker-A	do	3	-
Sept 20, 2007	Mawdem	do	11	13
	Belahori	do	2	6

in the population. This has forced people to inhabit hazardous and vulnerable areas on the one hand and has increased pressure on the resources, leading to erosion of natural ecological balance, on the other. Almost 85 % area of India is vulnerable to single or multiple disasters and about 57 % of its area, including Sikkim state, lies in a high seismic zone. All four districts of Sikkim i.e. East, West, North and South districts are prone to one or the other disaster. Natural disasters can not be prevented, but their impact on the lives and socio-economic aspects of the people can be reduced to a considerable extent. In this context, a paradigm shift in the approach to disaster management took place with United National International Decade of Natural Disaster Reduction (IDNDR). The focus increasingly shifted towards prevention and mitigation of disaster. Looking at this type of strategy the Disaster Management Faculty under the Central Sector Scheme on Natural Disaster Management by Ministry of Home affairs was proposed in the state with Land Revenue Department, Govt of Sikkim in January 2003. The objectives include: (i) organization of training programme for various stakeholders in the state; (ii) conducting research studies on hazards in the state; (iii) documentation of past records of various hazards in the state; and (iv) development of a data base. The major achievements during the reporting period are as follows:

- Publication of training modules part II, documentation of information from various departments and update of existing database.
- Demonstration on importance of Disaster Mitigation to college students who visited the Sikkim Unit of the Institute.
- Training to Sikkim Armed Police, Govt. Officials, Sashastra Seema Bal (S.S.B.) and masons and exposure to students on disaster management (Fig. 66).
- Detailed studies of landslides and earthquakes triggered in and around Gangtok (Fig. 67).

Fig. 66. Training to Sikkim Armed Police and Sashastra Seema Bal (SSB) and exposure to students on Disaster Management.

Fig. 67. Massive rock fall at Amdo Golai, Tadong, Gangtok buildings evacuated.

R&D HIGHLIGHT OF THE REGIONAL UNITS

The Institute executes its R&D activities through four regional Units, namely, Himachal Unit (Kullu), Garhwal Unit (Srinagar-Garhwal), Sikkim Unit (Pangthang) and NE Unit (Itanagar). These regional units have been adequately equipped with basic facilities and laboratory instruments to conduct R&D work according to the Institute's mandate. In the following pages the major highlights of the R&D work carried out at these Units is presented. However, details of the R&D projects executed by the Scientists of these Units appear in the main text of this Annual Report.

Himachal Unit

- Database on floristic inventory, community diversity, distribution and utilization patterns and soil characteristics of the forest communities of Nargu Wildlife Sanctuary and Lahaul valley of the proposed Cold Desert Biosphere Reserve was developed. Besides, diversity of medicinal plants in Chandra Valley, Upper Beas Valley, Mohal Khad Watershed, Parbati Watershed and Upper Banjar Valley was assessed. The analysis revealed 23 species used in fever, 22 species in cold & cough, 11 species in diarrhoea, 3 species in sores, 21 species in skin disease, 21 species in wounds, 10 species in headache, 11 species in swelling, 5 species in bone fracture, 13 species in boils, 6 species in vomiting, 12 species in toothache and 5 species in indigestion by the inhabitants.

- The study was conducted along an altitudinal gradient in Hirb and Shoja Catchments (HSCs) between 2,000-3,600m, Chailchowk-Rohanda-Kamrunag Area (CRKA) between 1,300-3,050m, Mandi-Pandoh Area (MPA) 700-1000m and Ghanahatti-Shimla Area (GHA) between 1500-2400m. A total of 645 species of vascular plants were reported from HSCs, 423 CSKA, 254 from GSA and 160 from MPA. 439 species in HSCs, 328 species in CRKA, 213 species in GSA and 137 species in MPA were economically important, being mainly used for medicinal, fuel, wild edible/food, fodder, timber, religious, making agricultural tools and various other purposes.
- Floristic diversity of the Manali Wildlife Sanctuary (MWLS), Kais Wildlife Sanctuary (KWLS) and Khokhan Wildlife

Sanctuary (KhWLS) and proposed Cold Desert Biosphere Reserve was assessed for the species inventory, community patterns, regeneration pattern of the trees, species diversity index, concentration of dominance, similarity, physical and chemical properties of the soil, native, endemic, economically important (including indigenous knowledge and extraction trends) and threatened species and prioritization of habitats, species and communities.

- Training Programmes and Consultation Meetings were organized and over 1500 people representing different stakeholders i.e., Line Departments, students, teachers, farmers, NGOs and others were educated on biodiversity issues through the organization of exposure visits on various occasions. Conventional propagation protocols for *Carpinus viminea* and *Olea ferruginea* were developed. Arboretum, herbal gardens and medicinal and multipurpose trees nurseries were strengthened through plantations of over 5,000 seedlings.
- For generating adequate datasets and to develop appropriate strategies for solid waste management (SWM) in the sprawling five urban towns; Bilaspur, Kangra, Mandi, Hamirpur, Chamba and one village Panchayat; Keylong (also district headquarters of Lahaul & Spiti district), have been selected in Himachal Pradesh. The existing waste management options in all the experimental sites are open dumping and burning. However, bio-composting is also in practice in three towns; Hamirpur, Kangra and Chamba but these require further scientific strengthening.
- Characterization of aerosol optical properties is a nationwide ongoing programme supported by ISRO, Bangalore under Aerosols Radioactive Forcing in India (ARFI) since May 2006 at Mohal. The Multi-Wavelength Radiometer (MWR) measures columnar aerosols work in different wavelengths, i.e., 380 nm, 400 nm, 450 nm, 500 nm, 600 nm, 650 nm, 750 nm, 850 nm, 935 nm, and 1025 nm.

Garhwal Unit

- A rural technology centre has also been set up at Triyuginarayan in high altitude for imparting knowledge and technological skill for rural communities in particular and unemployed and educated youth in general for development of small scale enterprises.

- A joint declaration on people's participation on sustainable ecotourism in Kedar valley was formulated. GBPIHED, Garhwal Unit initiated the deliberations among stakeholders to highlight the importance of mutual collaboration assistance which resulted in the formation of an association named KEDAR (Kedarghati Ecotourism Development Action & Research).
- A change in calendar for pastoral migration from alpine to foothill forests has been recorded. The attributes for this change has been identified. The pastoralists also are now changing their occupation and are being observed to be more inclined towards medicinal and aromatic plant cultivation. Pastoralism is now being perceived as a less favoured occupation.
- Numerical abundance and biomass of micro and macro-fauna were studied under different land uses in two different climatic

conditions at high (Nanda Devi Biosphere Reserve) and low altitude regions. However, at higher elevation, uncultivated lands had significantly lower density as compared to the cultivated ones. Effect of land use was more marked in terms of numerical abundance of different groups compared to density of all soil fauna pooled together.

- A demonstration model for agro-ecotourism, a potential form of tourism, in which farmer's agronomic skills can be harnessed for their economic upliftment is underway at Pipalkoti. The tribal (the Bhotiya) community has been observed to be more responsive and keen to adopt the new technologies. The Bhotias have also preserved their traditional culture, agriculture and food habits which is a potential tourist attraction.

Sikkim Unit

- A method was developed for plant regeneration from alginated-encapsulated shoot tips of *R. maddeni*. Encapsulated shoot tips demonstrated successful regeneration after different periods of cold storage at 5°C. Among the four different storage conditions (0°C, 5°C, 17°C and 25°C), the buds stored for 30 days at 5°C showed maximum frequency (68%) of shoot proliferation when placed back into the regeneration medium.
- Intensive data was collected along 2400 to 4200m altitude transect in KBR core zone (west part) for investigating recruitment trends and forest community patterns. Eighteen sites were identified for 180 plots, which exhibited over 40 woody taxa. Two field based stakeholders' consultations were organized: (i) Consultation meet, in west part (Yuksom) for about 50 stakeholders, (ii) Consultation Workshop, in northern part (Dzongu), for over 60 stakeholders. Ethnomedicinal study in north KBR (Dzongu) was made. Over 118 species curing 66 ailments under 14 broad categories, covering 71 families and 108 genera were recorded.

- A two days training cum workshop, 'Conservation of Biodiversity' was organized (45 students/teachers; 14 schools). Participants perceived necessity of immdediate conservation of Red Panda (78), Musk Deer (28), Himalayan Bear (50), Snow Leopard (45) and Blue Sheep (50). 'Memo of Agreement' was signed with NABARD (Gangtok); consequently two training workshops (biodiversity conservation, nursery/farm technologies) were organized for >30 Farmer clubs, SHGs and >20 farmers' clubs.
- Improved cultivation technology along with specialized training and demonstration to the farmers for vegetable crops and their seed production was performed at Chhamgaon village, South Sikkim. Planting materials of fruit plants which were not available locally around Cham Gaon were procured and distributed to the beneficiary farmers.
- Meeting with stakeholders and villagers on sharing of experiences in watershed was held on March 18, 2008 at Garirgaon village in Taktsom chu watershed. This meeting was attended by 65 people covering state line departments and villagers.
- Seven training programmes/lectures were delivered on disaster management in Sikkim. These programme was attended by more than 1700 participants of various levels.

North East Unit

- Up scaling of technology dissemination and backstopping has been carried out in five states of the NE region with the help of seven PNGOs. A number of demonstration centres have been established by the PNGOs in the respective states. So far, technology demonstration activities have been carried out in 35 villages spread over 12 Development Blocks in 5 states.
- Major task force/commission study reports on shifting cultivation were reviewed and analyzed. Success stories and best practices/ examples such as Nagaland Environment Protection and Economic Development (NEPED) and North East Region Community Resource Management Project (NERCRMP) in shifting agriculture were also documented.
- A document prepared to review the existing shifting cultivation development techniques has been submitted to the Sub-Group on "Database, Technology Development and Extension" of the "National Taskforce on Rehabilitation of Shifting Cultivation Lands" constituted by MoEF, GoI.
- Crop profile of Shifting agro-ecosystem in various villages in two districts in Arunachal Pradesh has been documented. Two traditional soil and water conservation practices are documented. Those are *Phai* among the Nishyie tribe of Papumpare district and *Panpeng* or *Pan-eng* among Adi tribe of East Siang and West Siang districts of Arunchal Pradesh. As many as 55 numbers of weed species under 28 families have been documented from shifting agroecosystem.

- Ecological recovery following shifting cultivation is documented in various successional stages in and around the Mouling National Park in Arunachal Pradesh. A detailed checklist of faunal groups with special reference to mammals, birds and butterflies has been prepared. Study has revealed high rates of hunting of birds and mammals which is being currently quantified to clearly understand the process and patterns of recovery following shifting cultivation.
- Human Wildlife conflicts were identified and prioritized in the proposed Tawang West Kameng Biosphere Reserve, in the high altitudes of Western Arunachal Pradesh. High intensity of livestock predation, crop raiding and retaliatory killing of carnivores is being foreseen as a major threat to the coexistence of the human and wildlife.
- The NE Unit has been implementing a consultancy based on a ToR signed with Meghalaya Rural Development Society (MRDS) for setting up demonstrations for agriculture, with special focus on the trellis, modified jhum and pitcher irrigation (Haandi irrigation) system in Meghalaya. During the financial year 2007-08 on the field trainings and demonstrations had been imparted to farmers in 5 cluster villages and 14 villages in Ri Bhoi district of Meghalaya.

APPLICATION OF R & D OUTPUTS IN DEMONSTRATION AND DISSEMINATION

Participatory Management of Bhimtal Lake Catchment *(2006-2008, LDA, Govt. of Uttarakhand Funded)*

The Institute has been implementing this project since June 2005 with an aim to promote strategies and measures for land reclamation of degraded lands involving local communities and stakeholders. The project comprises vegetative and bioengineering restoration measures for 65 ha degraded land within Bhimtal lake catchment in two phases; Phase I comprised of a model development in 20 ha land depicting a few land use types in the Van Panchayat areas of Sanguri and Son gaun during 2005-2007, and Phase II focused to replicate the identified land use models in the remaining 45 ha land area through community participation from 2007 onwards. The project has successfully completed its Phase I stage. The project has been strengthening community linkages for lake conservation and providing suitable options for livelihood to the local people. Much emphasis was laid on local community planning alongwith their capacity building for area treatment and economic upliftment. During 2007-08 the following work was accomplished:

- Due to low soil depth, high boulder content, and lack of water to irrigate planted species at Karkotak, high mortality (60-80%) of saplings was registered in the previous two years. Therefore, replacement/ gap filling of the dead plants were done in this year. 1520 seedlings were replaced. To increase survival the species were planted in earthen pots, jute bags, and open pits, after carrying out soil amendments. The experiment has shown increase in species survival.

Table 22. Performance of plantations with different treatments.

Planting Treatment	Soil : FYM	No. of Saplings Planted	Sapling Survival (%)
Earthen pots	80 : 20	484	89.8
Cotton bags	80 : 20	700	75.0
Pits with amended soil	100 : 0	75	66.6
Pits with resident soil	80 : 20	1614	32.9

- In Silvi-pasture model 15 q Napier grass was planted along 54 contour trenches. Besides, saplings of *Kanol* (700 in nos.) and *Bhimal* (100 in nos.) were also planted. The seedling survival was 45% for Napier and 50-61% for different planted species. It was observed that the Napier and broom grass are frequently cut by the villagers for fodder. Also, there was damage by the wild animals. The steep slope, low moisture level, drier conditions during summer and severe frost in winter hampered the plant growth.
- In the Aromatic plant model (area 5 ha) nearly 40000 slips of lemon grass were planted for gap filling (mostly on the south-west slope). Nearly 900 kg of lemon grass was harvested for oil extraction. The oil content varied 0.62-0.90% during different months. 890 fruit tree seedlings were planted at Agro-horticulture model site.
- As Phase II activities, 13 ha additional van-panchayat land was identified by the LDA for plantations covering Songaun (5 ha), Mehragaun (4 ha), and Bhagtura (4 ha). The activity was completed by planting 3625 (11 species), 1562 (19 species), and 2475 (21 species) saplings at respective sites. 20 poly-houses were constructed in Karkotak (6 nos), Jipti (5 nos), Bhankar (5 nos), Songaon (1), Bhatura (1), and Meharagaon (2). The farmers' response to the vegetable growing was encouraging.

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

The impact of development initiatives in agriculture for sustaining the small and marginal farmers has generally fallen short of expectations. Therefore, up gradation of natural resource base coupled with sustainable agriculture and requisite training of target groups are important aspects requiring attention in the hilly region. Considering this a project has been initiated with the support of NAIP-ICAR in the Champawat and Tehri Garhwal districts of Uttarakhand state to improve the status of village commons, comprising degraded community forests, wastelands, pastures, etc., The project focuses on strengthening of livelihood based approach for resource conservation and land rehabilitation model in selected village clusters. The specific objectives are i) enhancement in the agricultural productivity through proven technological interventions, ii) rehabilitation of wastelands and upgradation of natural resource base, iii) agro-processing, value addition and improved marketing for enhancing profitability and 4) empowerment through capacity building and skill development in agricultural and allied sectors.

- Memorandum of Understanding (MoU) has been signed with stakeholders for setting up demonstration models. At Champawat district, the land preparation and fencing for various proposed prototypes was initiated. Baseline survey on energy use pattern and resource dependency was also initiated. Plantation of selected medicinal and aromatic plants, i.e. *Valeriana wallichii, Salvia lanata, Cinnamomum tamala, Origanum vulgare*, large cardamom, has been done in the selected areas.
- In Tehri district, baseline survey of three selected village clusters, community mobilization meetings and priority surveys was completed and village common land for plantation has been identified. Medicinal-plant cultivation, mushroom cultivation, apiculture, floriculture, firewood and fodder plantation have been identified as the major areas of intervention. Various species were identified and prioritized on the basis of location, climatic conditions, altitude, market availability and need of villagers for all three village clusters.

Meteorological Data Collection, Monitoring, Processing and Analysis to Evaluate Climate Variability in the State of Uttarakhand *(2003-2008, DST Funded)*

Participation of youth in Real time/field Observations to Benefit the Education in Uttaranchal state (U-PROBE) is the programme initiated by Department of Science and Technology, New Delhi with an aim to make science education interesting. U-PROBE, a model project, is being implemented at multiple locations of Uttarakhand and aims at bringing together students, teachers and the scientific community to inculcate multidisciplinary understanding through the multi-location meteorological observations. It is envisaged that the process of participative data collection and observation by school children as a means of scientific learning will help students to understand their environment. The Institute, as Technical Resource Center (TRC) is responsible for facilitating establishment and regular monitoring of weather observatories at 21 schools and linking the weather datasets with ongoing researches on different aspects of Himalayan environment.

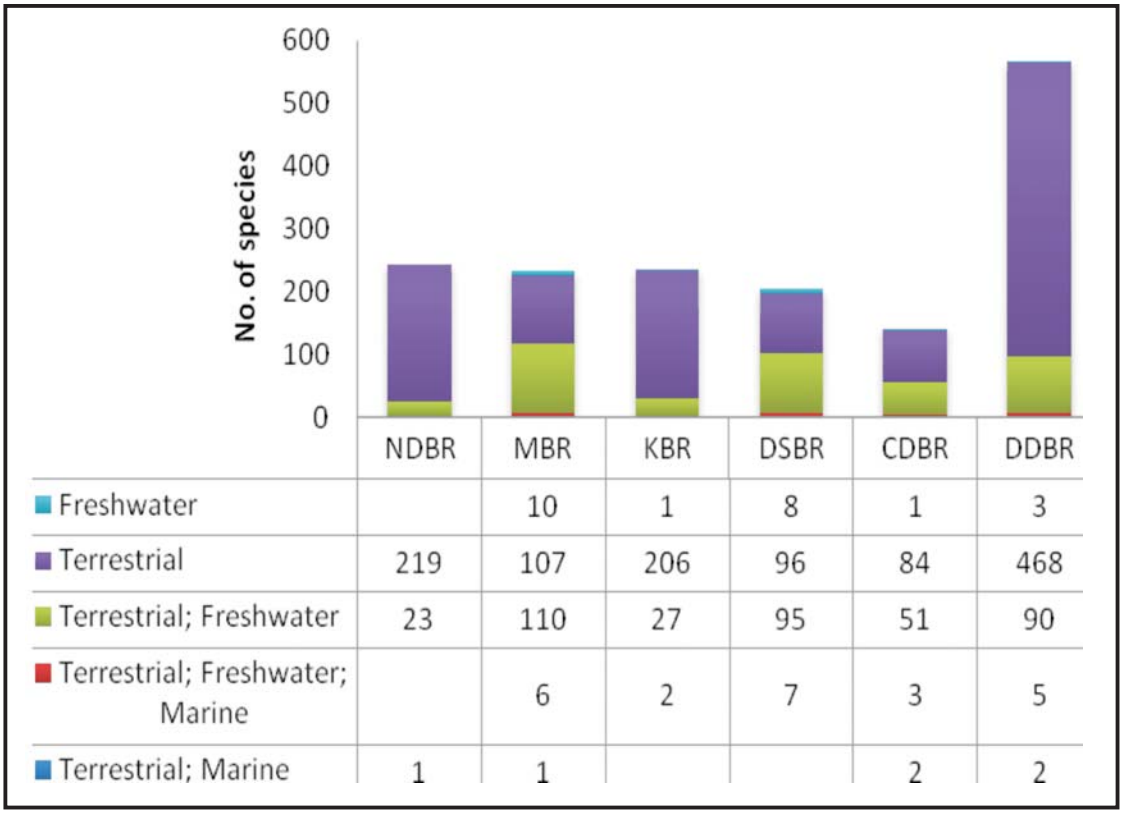
- A total of 18 weather observatories have been established in identified schools [i.e. GIC, Pithoragarh (district – Pithoragarh); GIC, Almora; Barechina; Hawalbagh; Danya; Lamgara; Kheti; Ranikhet; Deowlikhet; Chaunaliya; Binta; Manila; Syalde (district – Almora); GIC Kausani; Bhatkhola; Bageshwar; Garur and Dwarahat (district – Bageshwar)].
- A 3 days U-PROBE Teachers Training Workshop (8-10 December, 07) was organized at GIC, Hawalbagh (Almora). Representatives of 17 U-PROBE schools participated in the workshop. Four identified school teachers along with the TRC-GBPIHED representative acted as resource persons during the programme. The workshop largely focused on inculcating multidisciplinary understanding among the U-PROBE teachers through the multi-location meteorological observations and other related scientific activities.
- For wider dissemination, TRC, GBPIHED, Almora launched a U-PROBE Website (http://gbpihed.gov.in/uprobe/uprobewebsite.html) which includes information about the U-PROBE project and the instruments. Besides, it provides information on the recent events/ achievements under the Environmental Education Programme.
- To motivate the U-PROBE family, the third issue of U-PROBE Newsletter was published and distributed amongst students and teachers across the region.

Lead Coordinating Institution for Himalayan Biosphere Reserves *(2006-2009, MoEF Funded)*

The Ministry of Environment and Forests, Government of India, has designated the Institute as a Lead/Coordinating Institution for Himalayan Biosphere Reserves (including Nanda Devi, Manas, Dibru-Saikhowa, Dehang-Debang and Kangchendzonga Biosphere Reserves) to serve as a focal point for formulation of research projects and collection and dissemination of research based information for better management of Biosphere Reserves. The project focuses on: (i) collection, synthesis and dissemination of research based information for respective Biosphere Reserves; (ii) interaction with regional Research Organizations for development of suitable research projects; (iii) interaction with biosphere reserve managers to assess the research needs and crucial issues requiring research efforts; (iv) preparation of UNESCO-MAB Net documents for respective BRs for UNESCO- World MAB Network; (v) preparation of Electronic Biological Diversity Database of HBRs; and (vi) prepare feasibility documents for proposed Cold Desert (J&K and H.P.) and Tawang-West Kameng (Arunachal

Pradesh) Biosphere Reserves. The results of the study are as follows.

- Electronic database of 851 species of birds (18 orders, 72 families and 341 genera) was prepared for Himalayan BRs. Dehang-Debang BR in East Himalaya is most species rich (568 spp.). The target BRs are representative of 3 EBAs (Endemic Bird Areas) which suggests their uniqueness value. They also represent populations of > 44.4% restricted ranged species of these EBAs.
- Considering taxonomic groups; order Passiformes (501 spp: 58.9%; represented in 29 families and 163 genera) is the most diversely represented group in HBRs. Among families Muscicapidae (228:26.7%); Accipitridae (47:5.5%); Fringillidae (40:4.7%); Phasinidae (32:3.7%) are species rich. Whereas, *Garrulax* (20); *Phylloscopus* (18); *Carpodacus* (14); *Paradoxornis* (11) and *Falco*, *Emberiza*, *Ficedula* (10 each) are the most diversely represented genera.
- Of the total, 651 (76.5%) species prefer exclusive terrestrial habitat; and 10 species (1.1%) are freshwater dependent. Whereas, 178 species (20.9%) share, terrestrial-freshwater system and 9 species (1.1%) terrestrial-freshwater-marine systems, only 3 species viz., *Falco peregrinus, Sterna hirundo, Larus ichthyaetus* shared terrestrial-marine habitats. Habitat preference wise richness of birds in different BRs is given (Fig. 68).
- In order to address the various issues on HBRs, two days Consultation Workshop "Himalayan Biosphere Reserves - defining role under global change scenarios of climate and human economies" was organized (6-7 July 2007).



	NDBR	MBR	KBR	DSBR	CDBR	DDBR
Freshwater		10	1	8	1	3
Terrestrial	219	107	206	96	84	468
Terrestrial; Freshwater	23	110	27	95	51	90
Terrestrial; Freshwater; Marine		6	2	7	3	5
Terrestrial; Marine	1	1			2	2

Fig. 68. Distribution of species in different habitat/system types.

Capacity Development and Economic Upliftment of Rural Women through Integrated Farming System Approach *(2007-2010, DST-WS Funded)*

There are a number of technology packages, which can be useful for the hilly areas. Among these, pond-based Integrated Farming System (IFS) concentrated on location and area specific integration(s) has great potential for socio-economic development of rural women of Uttarakhand hills. Based on encouraging leads obtained from the recently concluded project on IFF, this study proposes to incorporate several other components such as, composite carp culture, poultry/duckery, livestock, off-season vegetable and mushroom cultivation, green fodder production and vermi-composting/bio-composting to develop model(s) This project envisages i) to optimize utilization of water, under used land resources and farm waste (biomass) through integration of fishery with poultry/duckery livestock, vegetable and mushroom cultivation, green fodder production and bio-composting/vermi-composting, ii) motivation and capacity building to provide employment, income generation opportunities and nutritional security to rural folk.

- Surveys have been conducted in several villages in Kumaun region to ascertain the available resources and farmers response; two villages in Almora district namely, Sunaulla (1200 m; Hawalbagh block) and Basoli (1500 m; Takula block) have been selected. Creation of the first model has been started at Sunaulla with active participation of women folk and old models have been maintained.
- Fingerlings of Chinese carp species, viz., silver carp (*Hypophthalmicthys molitrix* Valenciennes), grass carp (*Ctenopharyngodon idella* Valenciennes) and common carp (*Cyprinus carpio* Linnalus) have been stocked into the ponds at Manan village (for maintenance of one of the earlier sites in concluded project).

Technology Demonstration for Higher Income Generation for Farmers of Sikkim *(2003-2009, TIFAC-DST Funded)*

Under the broad objectives of Technology Vision 2020 Mission Mode Project on Agriculture, this project in Sikkim supports the overall upliftment of the socio-economic condition of hill farming communities with the following objectives 1) direct interventions in the farmers field to increase the productivity potential of the existing upland on-farm practices, and 2) Hands-on training to the farmers/village youth for motivation towards increased agricultural potential and assessment of impacts on their socio-economics.

- Improved cultivation technology along with specialized training of the farmers for vegetable crops and their seed production was continued at Chhamgaon villages in South Sikkim district.
- Good yield of vegetables was obtained at Chhamgaon, South Sikkim, utilizing polyhouse and other technology interventions alongwith the knowledge gained under various training programmes. Planting material of fruit plants which were not available locally around Chhamgaon area were procured and distributed to the beneficiary farmers.

Fig. 69. Cultivation of vegetables inside a poly house using meter plots technique.

Field Evaluation of Microbial Inoculants Developed for Use in Mountains *(2006-2009, UCOST Funded)*

The major objectives of this project are (i) the field testing of the carrier based microbial inoculants using important agricultural and forest species of mountains, and (ii) to set on farm demonstrations to bring awareness to the local farmers about this microbe-based technology. The selected plant species belong to agricultural (cereals and legume crops), and forest (Cedrus, Taxus and Ginkgo species). The inoculations are being conducted after seed or cutting treatments using broth based or solid formulations. Growth monitoring is being carried out at various intervals depending on the plant species.

- Interesting observations related to rhizosphere changes in terms of mycorrhizal vs endophytic colonization have been recorded. For example, in case of lentil, enhancement in the symbiotic efficiency between *Rhizobium*- legume associations due to bacterial inoculation was recorded. It was demonstrated in terms of increment in number, and leghaemoglobin and protein content of nodules. One of the remarkable observations due to bacterial inoculation was the increase in colonization of endophytic fungi and a simultaneous decrease in colonization of mycorrhizal fungi in roots.
- The general microflora (bacteria, actinomycetes and fungi) in the rhizosphere and their corresponding non-rhizosphere soil samples of *Ginkgo biloba* L. of two age groups growing under a temperate location of IHR have been determined. Observations were also made for the diversity, distribution and colonization of arbuscular mycorrhizal (AM) fungi and occurrence of endophytes in roots of *G. biloba*.

Demonstration and Dissemination of Appropriate, Cost effective Hill specific Technologies in Garhwal region of Uttarakhand *(2004-2007, DST Funded)*

Technology change is an important element in the process of development, and lack of it is the main cause of poverty, which is common in the rural sector of the central Himalaya. The worsening economic and environmental conditions emphasizes the need for a critical re-examination of prevailing hill areas developmental planning and approaches. The 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 Himalayan environment. Therefore, advancement of technologies and the requisite training of target groups/users are two important aspects required in the transfer of technology in areas where it is needed. The project aims at i) identifying suitable site for introducing, designing/developing, demonstration and dissemination of few selected potential hill specific technologies that are simple, cost effective and appropriate, ii) capacity building through onsite training and establishment of effective linkages between farmers/users, NGOs, Researchers and Extension workers and 3) to develop potential technology packages.

- For successful demonstration and transfer of rural technologies among local farmers and other user groups, a field demonstration and training center was established at village Maletha, in district Tehri Garhwal of Uttarakhand.
- At this centre fifteen (15) appropriate and hill specific rural technologies such as rehabilitation of degraded land through slopping watershed environmental engineering technology (SWEET), low-cost rain water harvesting tank technology, bio prospecting and value addition of wild edibles and traditional agro biodiversity, farm

produce particularly vegetables storage technique, protected cultivation, yield increasing, drip irrigation, biobrequetting, apiculture and mushroom cultivation, were successfully introduced. About 35 on site trainings were organized in which about a total of 2329 participants were trained.

- A total of 30 plant species of wild origin, 2-semi-domesticated and 5 agro-forestry plant species were identified as a promising species for bio-prospecting. Among the rural technologies, organic compost and bio-fertilizers was adopted by 185 families, off-farm income generating options and technologies by 177 families, other supporting technologies by 71 families and 57 families adopted protected cultivation.

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

The 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. Subsequently, two broad thrust areas, namely Technology Development and Research (TDR) for Integrated Eco-development, and Technology Demonstration and Extension (TDE), were identified by the Institute under its IERP scheme. In the current financial year, 6 R&D themes and 16 policy problems were identified by the Scientific Advisory Committee (SAC) of the Institute for execution of its R&D activities in the Indian Himalayan region. The main objectives are i) 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), ii) to develop scientific capabilities in the IHR and strengthen infrastructure for environmental research, and iii) to develop and execute coordinated programmes on the recommendations of the completed projects/ special theme(s)/R&D need(s) in the IHR with the help of identified network partners.

- Based on the recommendations of the Project Evaluation Committee (PEC), 27 projects (10 to the Universities, 14 to the NGOs and 3 to the Govt. Institutions), under 5 identified R&D themes of the Institute, were sanctioned and funded during the financial year 2007-2008.
- During the year, funds for seventy eight (78) ongoing/completed projects were released to different organizations by the Institute after careful examination of the Utilization Certificates and Statement of Expenditures. Annual Progress Reports (APRs) of 36 on-going projects were processed and Final Technical Reports (FTRs) of 15 completed projects were sent to the various Govt. Agencies, etc., for follow-up action on the recommendations.
- Coordinated programme entitled "Sacred values, eco-restoration and conservation initiatives in the Indian Himalayan region" was strengthened in 4 States (namely, Uttarakhand, Himachal Pradesh, Assam and Arunachal Pradesh).

Operation PARADE' (Participatory Action for Rural Area Environment & Development *(2005-2008, In-house)*

This programme is a joint venture of National Cadet Corps (NCC) of India and GBPIHED. The programme envisages implementing Village Environment Action Plan (VEAP) and strengthening rural livelihood technologies in adopted villages with the technical support of GBPIHED and involvement of the workforce of National Cadet Corps. This programme has been launched to address the aspirations of local inhabitants and national compulsions of

environmental protection and development. Initially the target area is Kumaun in Uttarakhand; subsequently it will be expanded to other areas of the region. The objectives are 1) to train the NCC cadets and officials of the region in training of trainers (ToT) mode on VEAP, 2) extension and awareness camps organization by NCC cadets/officials in respective rural areas for training the farmers/ villagers to foster this programme through VEAP and 3) Implementation of VEAP demonstration models in adopted villages across the region.

- In Railakot village of Kumaun Himalaya 700 plants of 9 multipurpose tree species were replaced in this year. One water harvesting tank was dug at site with the help of N.C.C. cadets for supplying water for irrigation to plantation works. Different species of fruit plants are distributed among farmers in different parts of village. 2 qt. of fodder grass also planted in rainy season.
- Gairigaon village has been selected for the formulation of a Village Environmental Action Plan (VEAP) in Sikkim.

Library Facility of the Institute

The Central Library of the Institute at its headquarters has 13,962 books at the end of financial year 2007-2008. Library also subscribed to 105 periodicals (66 Foreign and 39 Indian) in the areas of environment and development. For management of Library and Information Centre, a network version of the software (PALMS) 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, and Web Services (Online Journals), etc. The Library of the Institute is accessible through the Institute's web site (http://gbpihed.gov.in). During the reporting year, 314 new book titles were added to the Library. R & D achievements of the Institute were disseminated through its regular in-house publications, namely Himа-Paryavaran – a biannual newsletter, Institute Annual Report, Progress Brief and Folders/ Leaflets to various academic and scientific institutions, Government departments, NGOs, policymakers, planners and individuals working on various aspects of mountain environment and development.

Strengthening and Management of ENVIS Centre in the Institute *(1992 – Long Term activity, MoEF, Govt. of India Funded)*

The Environmental Information System (ENVIS) Centre on Himalayan ecology was set up in the Institute in 1992 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 to collate all the information from all the Centres to provide national scenarios to the international set up INFOTERRA Programme of the UNEP. The project objectives are 1) to collect, collate, compile and build qualitative and quantitative databases of information related to various aspects of Himalayan ecology, 2) to disseminate all available information, free of cost, to various stakeholders/users through print and electronic media, 3) to develop, up-grade and maintain ENVIS website at the headquarters of the Institute. Information on different aspects (abstracts/articles/technical reports and news clippings, etc.) of Himalayan ecology from various District Information Centres, Universities/University Campuses, Research Centers, NGOs, Experts, and Institutions working in the Indian Himalayan region (IHR) was collected and compiled for publication in the 'Selected Abstracts' and 'News and Views' section of the ENVIS Bulletins. About 190 abstracts/research papers/technical reports, related to the various aspects of Himalayan ecology, were added on the ENVIS Bibliographic Database, which is maintained by the ENVIS Centre of the Institute.

Main page/home page of the ENVIS website <http://gbpihed.gov.in/envis/envis.html> was modified by the amendment of pop-up menu for accessing classified information and re-modeling of some web-links to the home page of the website. About 280 queries, related to the various aspects of Himalayan environment and development, were received by the Centre and responded through e-mails and print media during the year. ENVIS Bulletins, Vol. 6 (1-2) to Vol. 14 (1-2); Monographs, No. 1 to 3; and Newsletters, Vol. 1 to 3, were made online for effective dissemination of information on various aspects of Himalayan ecology.

Strengthening & Management of IT Infrastructure in the Institute

The Institute's HQs and its Units are using the VSAT service from NICNET and getting shared bandwidth speed of 128 kbps through VSAT over NICNET. This 128 Kbps bandwidth is distributed within the Institute HQ through Local Area Network (LAN) & the same kind of bandwidth is available with each Unit of the institute to access Internet applications. The Institute website has been developed and hosted at the Internet Data Centre (IDC) server 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 our end. The website of the institute is updated at frequent intervals. Strengthening of Wide Area Network (WAN) for Video Conferencing & Internet facility in the Institute was also initiated. BSNL, Bangalore Hub is in the process of setting up Wide Area Network between GBPIHED-HQ, its Units and MoEF-HQ and this WAN would be used for on-line video conferencing and internet applications. Through this WAN the Institute will get the shared bandwidth speed of 512 Kbps for Internet access and Video-Conferencing.

Central Laboratory Facility

The Institute has established a central laboratory at its headquarters to enhance the analytical capabilities in the region. The Laboratory not only fulfils the needs of the research work of the Institute, but also provides its services to other organisations such as different state government organizations and NGOs working on various aspects of the Himalayan Mountain environment and development. The Central Laboratory is equipped with sophisticated instruments like Gas chromatograph [Chemito-CERE 800 make]; CHNSO analyzer [Elementar make]; Atomic Adsorption Spectrophotometer [Varian GTA120] besides other analytical instruments. The laboratory also provides training and technical support to different laboratories and organisations.

Dissemination through interactive forums

Forum/Events	Venue/Date	Target Groups
Awareness Workshop on Desertification and Climate Change - One Global Challenge	Chimi village, Papumpare District, Arunachal Pradesh. June 17, 2008	Villagers / Farmers
Role of Vaidyas in Traditional Healthcare Systems	Srinagar Garhwal, 25-26 March 2008	Traditional Vaidyas
Meeting with stakeholders on "Sharing of experiences in mitigation of landslides"	GBPIHED, Sikkim Unit, Pangthang. March 25, 2008	Line departments of State and Central Govt
Meeting on sharing of experiences in watershed	Garirgaon village in Taktsom Chu Watershed. March 18, 2008	State line departments and villagers
Training on Viable Options of Livelihood Improvement	Maletha, Garhwal, 17 March 2008	Self Help Groups & NGOs
A meeting on "Biodiversity Conservation and Management for Implementation of R & D Outcomes in Himachal Pradesh"	Himachal Unit, Mohal-Kullu, March 15, 2008	Govt. departments, NGOs, Panchayat members and farmers
Capacity Building in Organic Farming and Rural Technologies for Livelihood Improvement	Triyuginarayan, Rudrapryag, Garhwal, 28-29 February 2008	Local Farmers and User groups
Training to farmers "Capacity Building for Adoption of Technology" (including medicinal plants cultivation and nursery technology)	GBPIHED, Sikkim Unit, Pangthang (21-22 February 2008).	Farmers and representatives of NGOs
Exposure Visit on Demonstration and Dissemination of Rural Technologies	Maletha, Garhwal, 24 January 2008	NABARD Officials
Exposure Visit on BGBD & Eco-Technologies	Srinagar-Garhwal, 15 January 2008	Students of Kendriya Vidyalaya, Srinagar
A meeting on "Cultivation of Seabuckthorn and Other Multipurpose Plant Species in cold Desert areas in North Western Himalaya"	Himachal Unit, Mohal-Kullu, January 08, 2008	Experts, Central and state govt. officials and Farmers
Building construction and retrofitting of buildings	Community Hall, Namchi, South Sikkim (November 29, 2007)	Masons, Officers and of Govt. of Sikkim Engineers
Organized Exposure Visit for Natwarlal Maniklal Dalal Mahavidyalaya of Arts, Commerce, Law and Managemnt, Gondia, Maharashtra	Himachal Unit, Mohal-Kullu, November 27, 2007	Students and Teachers
Building construction and retrofitting of buildings	Forest Secretariat, Gangtok (November 25, 2007)	Masons, Officers and Engineers of Govt. of Sikkim
Organised Exposure Visits for Mother Touch School	Himachal Unit, Mohal-Kullu, November 14, 2007	Students and teachers
Organised and Exposure Visits for NABARD Trainees	Himachal Unit, Mohal-Kullu, November 14, 2007	Farmers and NGO.s

Stakeholders Technology Need Assessment Workshop	Demonstration Centre, Midpu, Doimukh, Arunachal Pradesh November 07, 2007	Villagers / Farmers / Women
Assessment-cum-Monitoring Workshop for NGOs of NE States	NE Unit Complex, Itanagar October 31, 2007	NGOs
Sustainable Ecotourism: Possibilities and Peoples Participation	Sitapur, Rudraprayag, Garhwal, 11-12 October 2007	Stakeholders
Training to farmers, "Capacity building through training and workshops on Farm based simple technologies"	GBPIHED, Sikkim Unit, Pangthang (9-10 October, 2007)	Farmers, Self Help Groups (SHGs) and NGOs
Workshop on "Community awareness on environmental issues"	Rewalsar, Himachal Pradesh, 8-13 October, 2007	Teachers and students of Tibetan community
Organized Exposure Visit for students of Ch. Devi Lal University Sirsa	Himachal Unit, Mohal-Kullu, October 03, 2007	Students and Teachers
Disaster Management in Sikkim and Forest Fire	Sikkim Armed Police, Pangthang (September 21, 2007)	Forest Department's R.O.s, B.O and Excise Department, Govt. of Sikkim
Annual Day	Sikkim Unit, GBPIHED, Pangthang	Over 30 school children
Brainstorming on Shifting Agriculture: A Good or Bad Practice	NE Unit Complex, Itanagar September 10, 2007	School teachers, students
Demonstration for Trellis in Home-gardens for Meghalaya Rural Development Society (MRDS) in the project villages of Meghalaya	Ri Bhoi District, Meghalaya September 6-20, 2007	Villagers / Farmers / Women
Disaster Management in Sikkim	Sikkim Armed Police, Pangthang, Sikkim, (August 23, 2007)	Officials of Sikkim Armed Police
Disaster Management in Sikkim and mitigation of landslides	Singtam and Ramphoo (August 10-11, 2007)	Cyclists and officials of Sashastra Seema Bal (SSB)
Disaster Management in Sikkim	Sikkim Armed Police, Pangthang (June 21, 2007)	Officials of Sikkim Armed Police
Brainstorming on World Day for Combatting Desertification	HQ, Kosi-Katarmal, Almora, 17 June 2007	Scientists, Researchers
Organized a Meeting on "Climate change" on World Day	Himachal Unit, Mohal-Kullu, June 17, 2007	Panchyat Pradhans, Members, Van Samiti, B.D.C. Pradhans, Mahila Mandal & Yuvak Mandal
Capacity Building in the Field of Rural Technologies	Triyuginarayan, Rudraprayag, 5-7 June 2007	NGOs of Western Himalayan Region
World Environmental Day	Sikkim Unit, GBPIHED, Pangthang, (June 5, 2007)	School children, teachers and progressive farmers

Celebration of World Environment Day	Himachal Unit, Mohal-Kullu, June 5, 2007	Students, Teachers, NCC cadets, ITBPF officials, Panchayat Members, Fruit Grower Association, NGOs, Farmers and Gos
Organized Exposure Visit for the trainees of the Mid Himalayan Watershed project	Himachal Unit, Mohal-Kullu, May 23, 2007	Trainees of the Mid Himalayan Watershed Project
Exposure Visit for students & teachers of Y S Parmar University of Horticulture and Forestry, Solan	Himachal Unit, Mohal-Kullu, May 1, 2007	Students and Teachers
Training programme on " Nature science Activity Camp-Youth Involvement in Ecorestoration and Environmental Awareness"	Himachal Unit, Mohal-Kullu, April 26- 27, 2007	Students and Teachers
Disaster Management in Sikkim	Sikkim Armed Police, Pangthang (April 5, 2007)	Officials of Sikkim Armed Police

MISCELLANEOUS ITEMS

1. SCIENTIFIC PUBLICATIONS

(I) Scientific Journals

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Participation of Institute Faculty/Project Staff in Different Events.

Events	HQs	Units				*Total*
		NE	Sikkim	Garhwal	HP	
National						
• ***Symposia / Conferences / Workshops***	14	25	07	13	10	**69**
• Training Courses	05	02	01	05	12	**25**
• Meetings	10	03	08	08	13	**42**
• Participation as a Resource Person	13	06	24	04	31	**78**
• Any Other	02	03	15	07	11	**38**
International	01	01	00	01	00	**03**

ANSUL AGRAWAL & CO.
Chartered Accountants
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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, 2008. 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, 2008 and

ii) In the case of Income & Expenditure accounts of the INCOME of its accounting year ending 31st MARCH, 2008.

FOR ANSUL AGRAWAL & Company
CHARTERED ACCOUNTANTS

Sd/-

C.A. ANSUL AGRAWAL **SEAL**
(PARTNER)

DATED: 23-07-2008

PLACE: ALMORA

ANSUL AGRAWAL & CO.
Chartered Accountants
Sela Khola, Chaughan Pata, Near P.W.D. Office,
Almora – 263 601 (Uttarakhand)
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G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT

KATARMAL, KOSI (ALMORA) Uttarakhand

BALANCE SHEET AS ON 31ST MARCH 2008

PARTICULARS	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
CORPUS / CAPITAL FUND	1	32304568.85	27843878.66
RESERVE AND SURPLUS	2	378479980.63	363628399.51
EARMARKED / ENDOWMENT FUNDS	3	8768985.48	8256780.48
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	43173510.58	32701255.86
T O T A L		**462727045.54**	**432430314.51**
ASSETS			
FIXED ASSETS	8	379329006.82	361616089.53
INVEST. FROM EARMARKED/ENDOWMENT FUND	9	8768985.48	8256780.48
INVEST. OTHERS	10	0	0.00
CURRENT ASSETS , LOANS, ADVANCES ETC.	11	74629053.24	62557444.50
MISCELLANEOUS EXPENDITURE			
T O T A L		**462727045.54**	**432430314.51**

0.00

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: 23-07-2008
PLACE: ALMORA

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

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

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

SEAL

ANSUL AGRAWAL & CO.
Chartered Accountants
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G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT

KATARMAL, KOSI (ALMORA) Uttarakhand

INCOME & EXPENDITURE A/C FOR THE YEAR ENDED 31ST MARCH 2008

PARTICULARS	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
INCOME			
Income from Sales/Services	**12**	273571.00	71860.00
Grants/Subsidies(net off exp)	**13**	83011898.12	72179450.19
Fees/Subscriptions	**14**	0.00	0.00
Income tfr from Fixed Assets fund		15935537.88	14531151.46
(to the extent of depreciation & WDV of asset sold)			0.00
Income from Royalty,Income from Ins. Publication etc.	**16**	320.00	0.00
Interest Earned	**17**	2184411.19	1771720.07
Other Income	**18**	2002388.00	1323473.00
Increase (decrease) in stock of Finished goods and work in progress)	**19**	0.00	0.00
T O T A L (A)		**103408126.19**	**89877654.72**
EXPENDITURE			
Establishment Expenses: a) Institute	**20**	24530234.00	19400235.00
b) Projects		6243554.00	8348665.00
c) F.C (Projects)		352235.00	703409.00
Administrative Expenses : a) Institute	**21**	31130191.12	27560306.23
b) Projects (As per Annexure)		8786758.00	8335892.00
c) F.C (Projects)(As per Annexure)		846978.00	466722.00
Expenditure on Grants, Subsidies etc.	**22**	11121948.00	7364220.96
Interest			0.00
Depreciation (Net Total at the year-end-as per Sch. 8)		15935537.88	14531151.46
T O T A L (B)		**98947436.00**	**86710601.65**
Balance being excess of Income over Expenditure (A - B)		4460690.19	3167053.07
Transfer to special Reserve		0.00	**0.00**
Transfer to/ from General Reserve		0.00	**0.00**
BAL.BEING SURPLUS TRF.TO CORPUS/CAPITAL FUND		**4460690.19**	**3167053.07**
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: 23-07-2008
PLACE: ALMORA

SEAL

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

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

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

G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT

KATARMAL, KOSI (ALMORA) Uttarakhand

RECEIPTS & PAYMENTS A/C FOR THE YEAR ENDED 31ST MARCH 2008

RECEIPTS	CURRENT YEAR	PREVIOUS YEAR	PAYMENTS	CURRENT YEAR	PREVIOUS YEAR
I. Opening Balances			**I. EXPENSES**		
a) Cash in hand	12238.90	45195.55	**a) Establishment Expenses**	19103666.76	17783119.00
			i) Institute		
b) Bank Balances			**b) Administrative expenses**		
			i) Institute	16987636.00	17282622.76
i) In current accounts	3263658.93	24520525.90	ii) R&D(Rev) expenses	13866573.12	10277683.47
ii) In deposit accounts	15894994.00	15668574.00	iii) Payments for current liabilities		
iii) Savings accounts	26408166.87	4516591.56	**C. Capital expenditure**		
c) Advances & Others	16263220.11	12037236.14	i) Purchase of Fixed Assets	18133153.00	11540788.00
(As per annexure Attached)			ii) Expenditure on Capital Work in Progress	10000000.00	7487690.00
F.C. ACCOUNT			iii) Aquirement of land (Lease money)	3849026.00	0.00
a) Cash in hand	13364.33	5818.33	**II. Payments made against funds for various proj.**	0.00	
b) Cash at bank	701801.36	654577.36	**Expenditure State govt. projects**		
c) FC Advances	0.00		a) Capital	1584983.00	1437202.00
II. Grants Received			b) Revenue;		
a) From Government of India			Establishment exp	5901932.00	8348665.00
i) Institute	74313343.00	58000000.00	Administration exp	8779624.00	8335892.00
ii) IERP Projects	11286010.00	7500000.00	**Expenditure FC projects**		
b) From Other agencies	22081346.00	16977661.00	a) Capital	79088.00	2800.00
c) From other sources [from FC]	1422255.00	1116146.00	b) Revenue:		
III. Income on Investments from			Establishment exp	352235.00	703409.00
a) Earmarked/ Endow.Funds	512205.00	597771.10	Administration exp	846978.00	466722.00
b) Loans, Advances etc.	0.00	0.00	**IERP grant released**	11121948.00	7635305.00
			III. Investments and deposits made		
IV. Interest Received			a) Out of Earmarked/ Endowment funds	512205.00	597771.10
a) On Bank deposits savings a/c	654184.73	152156.07	b) Out of own funds (Investments Others)		0.00
b) On term deposits a/c	831406.46	1324392.00	c) General Fund		
c) Loans, Advances etc.	698820.00	295172.00	**IV. Refund of Surplus money/Loans**		
			a) To the Government of India	442451.00	
V. Other Income			b) To Others/ security/ caution money)	728922.00	0.00
			c) Grant refund F.C	58781.69	
(As per annexure Attached)	2276279.00	1395333.00	**V. Other payments**		
VI. Amount Borrowed		0.00	Current liabilities	23024650.80	19274836.08
VII. Any other receipts.			**VI. Closing balances**		
a) Advance FC a/c		0.00	**a) Cash in hand**	60228.90	12238.90
b) Receipts current liabilities	23562128.48	19153715.86	**b) Bank Balance**		
c) IERP grants refunded by granteeOrg.	0.00	271084.04	i) In Current account	5106946.12	3263658.93
d) Construction Fund	10000000.00	9500000.00	ii) In deposit accounts	14301869.00	15894994.00
			iii) In savings accounts	24929601.18	26408166.87
			C) Advances and others	29950992.60	16263220.11
			FC Project		
			a) Cash in hand	6439.33	13364.33
			b) Bank Balance	465491.67	701801.36
TOTAL	**210195422.17**	**173731949.91**	**TOTAL**	**210195422.17**	**173731949.91**

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: 23-07-2008
PLACE: ALMORA

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

G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT

KATARMAL, KOSI (ALMORA) Uttarakhand

ANNEXURE FORMING PART OF RECEIPT/PAYMENTS A/C AS ON 31 MARCH 2008

STATEMENT OF OPENING & CLOSING BALANCES

PARTICULARS	OPENING AMOUNT	CLOSING AMOUNT
Cash & Bank Balances		
Cash In Hand :		
Srinagar	0.85	4.85
Sikkim	242.00	17014.00
Kullu	279.36	1191.36
Itanagar	9934.97	26790.97
Grant in aid in transit Biotech-xiii	184000.00	184000.00
Cash at Bank Balances		
SBI Almora A/c No.01170003256 (Endo)	50846.48	52641.48
SBI Tadong A/c No 01000050044	287607.59	1209790.59
SBI Kullu A/c NO.01100076038	533217.82	5835712.82
SBI Itanagar A/c No 01100050337	215064.82	643699.82
SBI Srinagar A/c No 01100030433	1080630.53	1531690.53
Advances		
House Building Advance	3092835.00	2962463.00
Motor cycle/Car Advance	518914.00	419002.00
Festival Advance	15150.00	17250.00
C.P.F	36.00	36.00
Income tax deducted at source	119998.00	191498.00
Units of Institute:		
Sikkim Unit	-330159.82	-56125.82
HP Unit	-36674.00	-219085.00
Garhwal Unit	-14695.00	-55686.00
NE Unit	25645.73	-24179.00
FC Advances:		
ET & NT Delhi(INDO SUMMER)	2880.00	2880.00
NRSA Hyderabad (PARADYP)	258720.00	258720.00
Pant Nagar UNIV.(PDF GEF)	40000.00	40000.00
Fixed Deposit		
With SBI Endowment Fund	7884942.00	7884942.00
Interest Accrued on FDR(Endowment Fund)	320992.00	831402.00
Interest Accrued on FDR(General Fund)	67939.78	1665929.00
Asset under installation	0.00	0.00
FDR (Margin Money/LC A/C)		
Institute	553412.00	2511364.00
BIOTECH -XI	577.00	577.00
DST -KK-IV	176015.00	0.00
TOTAL	**15058352.11**	**25933523.60**

SEAL

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

Brought forward	15058352.11	25933523.60
Due Staff/ other IC A/c		
Post Master G.P.O Tadong (Sikkim)	0.00	2154.00
Post Master G.P.O Almora	20601.00	20625.00
Employment News	48287.00	48287.00
Sigma Aldrich Chemicals	10590.00	10590.00
Siltap Chemicals Ltd (Biotech -III)	408.00	408.00
NRSA Hyderabad	29300.00	35300.00
R.K.Nanda & Sons	28517.00	28517.00
NICSI New Delhi	35106.00	35106.00
B S N L Banglore	0.00	2912596.00
Security Deposit CET Sikkim Unit	11000.00	11000.00
M/s OTT Messachute	0.00	8500.00
Uttranchal Renewal (UREDA)	0.00	165000.00
NIC New Delhi	67147.00	0.00
Dr. Varun Joshi (TTA)	65000.00	0.00
NRSA Hyderabad (ISRO GBP SSS)	350000.00	350000.00
NRSA Hydrabad (DST-KK-I)	7400.00	7400.00
M/s S.D. fine New Delhi	0.00	7220.00
F.C.Inter A/C	2500.00	2500.00
M/s CCU New Delhi	70898.00	70898.00
M/s Hind Motors Dehradun	1921.00	0.00
M/sAnton Par GMBH Australia	0.00	293000.00
Security Deposit NE Unit	1750.00	1750.00
Sh. B.S. Mehra	10000.00	0.00
Sh Somai Kant Joshi	70000.00	0.00
Ms. Sneh Joshi	700.00	0.00
Sh. Khailandra Singh Kanwal (UJVNL)	0.00	6618.00
EMD DST YS (M Nadeem)	4200.00	0.00
M/s Elementar Analysis Sys. Germany	194145.00	0.00
M/s Varian B.V. Netherland	165398.00	0.00
INSA New Delhi	10000.00	0.00
T O T A L	**16263220.11**	**29950992.60**

SEAL

G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT

KATARMAL, KOSI (ALMORA) Uttarakhand

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2008

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

S NO.	DESCRIPTION	GROSS BLOCK				DEPRECIATION				NET BLOCK	
		Cost as at beginning of the year	Additions during the year	adj/deduction during the year	Cost at the end of the year	depreciation for prior periods	depreciation for current year	adj/deduction for previous years	Total up to the end of the year	As at the current Year end	As at the previous year-end
	A. FIXED ASSETS:										
1	**LAND:**										
	a) Freehold	75639.23	0.00	0.00	75639.23	0.00	0.00	0.00	0.00	75639.23	75639.23
	b) Leasehold	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	**BULDING:**										
	a) On Freehold Land	214751988.00	0.00	0.00	214751988.00	15682887.21	3500457.40	0.00	19183344.61	195568643.39	199069100.79
3	**PLANT MACHINERY & EQUIPMENT**										
	a) Scientific Equipments	130492172.11	8833354.00	1692877.00	137632649.11	46490461.08	6537550.83	1692877.00	51335134.91	86297514.20	84001710.85
4	**VEHICLES**	5035961.25	935370.00	491698.00	5479633.25	4242239.66	528764.36	491698.00	4279306.02	1200327.23	793721.59
5	**FURNITURE FIXTURES**	16871076.40	1856069.00	0.00	18727145.40	8883645.97	1185428.30	0.00	10069074.27	8658071.13	7987430.44
6	**OFFICE EQUIPMENT**	7194255.35	2787905.00	1419183.00	8562977.35	5249914.35	813482.85	1419183.00	4644214.20	3918763.15	1944341.00
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	31852.65	2895.70	0.00	34748.35	26213.66	29109.36
9	**LIBRARY BOOKS**	60597365.50	6374421.00	0.00	66971786.50	20482190.27	3181159.86	0.00	23663350.13	43308436.37	40115175.23
10	**TUBE WELLS & W. SUPPLY**										
11	**OTHER FIXED ASSETS**										
	GLASS / NET HOUSE	3911549.00	0.00	0.00	3911549.00	1979803.95	185798.58	0.00	2165602.53	1745946.47	1931745.05
	TOTAL OF CURRENT YEAR	**438990968.84**	**20787119.00**	**3603758.00**	**456174329.84**	**103042995.14**	**15935537.88**	**(3603758.00)**	**115374775.02**	**340799554.82**	**335947973.54**
	PREVIOUS YEAR	**424773939.84**	**14217029.00**	**0.00**	**438990968.84**	**88511843.85**	**14531151.45**	**0.00**	**103042995.30**	**335947973.54**	**355678760.97**
	B CAPITAL WIP										
	Aquirement of land (Lease money)	0	3849026.00		3849026.00					3849026.00	0.00
	CCU Delhi	24680426.00	10000000.00		34680426.00	0.00	0.00	0.00	0.00	34680426.00	24680426.00
	ASSET UNDER INSTAL /TRANSIT	987690.00	2205.00	(989895.00)	0.00	0.00	0.00	0.00	0.00	0.00	987690.00
	TOTAL	**464659084.84**	**34638350.00**	**2613863.00**	**494703781.84**	**103042995.14**	**15935537.88**	**(3603758.00)**	**115374775.02**	**379329006.82**	**361616089.54**

SEAL

INSTITUTE SUPPORTING STAFF

HEAD QUARTERS

K.K. Joshi	Administrative Officer
K.K. Pande	Finance Officer
Surya Kant Langayan	Accounts Officer
L.M.S. Negi	Office Superintendent (A)
Sanjeev Higgins	Estate Manager
Mritunjay Anand	Library Assistant
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	L.D.C.
R.C. Bhatt	Driver
Chandra Lal	Driver
K.N. Pathak	H.K./Att.
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
Sabita Krishna	L.D.C.
Musafir Rai	Peon
Shyambir	Peon
Jagnnath Dhakal	Field Assistant
P.K. Tamang	Peon

ABBREVIATIONS USED

CDBR	Cold Desert Biosphere Reserve
CPCB	Central Pollution Control Board
CRKA	Chailchowk-Rohanda-Kamrunag Area
DST	Department of Science & Technology
GPS	Global Positioning Systems
HYVs	High Yielding Varieties
IHR	Indian Himalayan Region
KhWLS	Khokhan Wild Life Sanctuary
KWLS	Kais Wild Life Sanctuary
MDGs	Millennium Development Goals
MPAs	Mountain Protected Areas
MWLS	Manali Wild Life Sanctuary
PNGOs	Partner NGOs
RDTSPC	Ritual Distribution of Tree Seedlings and Plantation Ceremony
SIRD	State Institute of Rural Development
SOC	Soil Organic Carbon
SOI	Survey of India
SSRD	Society for Sustainable Rural Development
SWC	Soil and Water Conservation
TBA	Total Basal Area
TEK	Traditional Ecological Knowledge
THCS	Traditional Health Care System
TSD	Total Shrub Density
TSPM	Total Suspended Particulate Matter
TTD	Total Tree Density
WHC	Water Holding Capacity

INSTITUTE FACULTY

HEAD QUARTERS

U. Dhar	Director	Plant Taxonomy; Conservation Biology
L.M.S Palni	Scientist-G	Plant Physiology; Biochemistry; Biotechnology
P.P. Dhyani	Scientist-F	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 and 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
R.G. Singh	Technician-B	Applied Arts; Photography, Social Science
B.S. Majila	Technician-B	Forest Ecology; Restoration Ecology
Subodh Airi	Technician-B	Forest Ecology; Seed Biology

HIMACHAL UNIT

S.S. Samant	Scientist-E & In-charge	Plant Taxonomy; Conservation Biology
S.C. Joshi	Scientist-D	Plant Physiology; Stress Physiology
J.C. Kuniyal	Scientist-D	Development Geography; Waste Management

SIKKIM UNIT

H.K. Badola	Scientist-E & In-charge	Morphoanatomy; Conservation Biology
K.K. Singh	Scientist-D	Plant Physiology; Stress Physiology
Varun Joshi	Scientist-C	Environmental Geology
Ranjan Joshi	Scientist-C	Ecology Economics; Resource Valuation
L.K. Rai	Technician-B	Plant Taxonomy
Y.K. Rai	Technician-B	Rural Ecosystems

GARHWAL UNIT

R.K. Maikhuri	Scientist-E & In-charge	Plant Ecology; Rural Ecosystems
N.A. Farooquee	Scientist-D	Social Science; Indigenous Knowledge Systems
Paromita Ghosh	Scientist-C	Plant Science; Soil Science

NORTH-EAST UNIT

P.K. Samal	Scientist-E & In-charge	Social Science; Anthropology
Gopi G.V.	Scientist-C	Wildlife Biology
S.C. Arya	Scientist-B	High Altitude Ecology
S. Chaudhary	Technician-B	Conservation; Biological Diversity

(Arranged alphabetically within Positions)

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