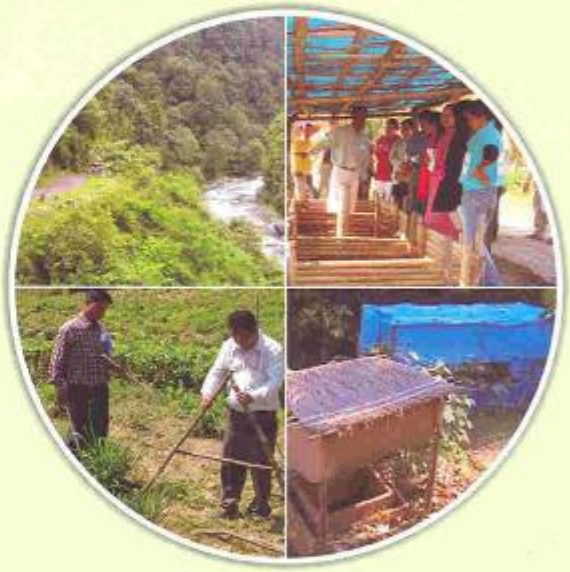
ANNUAL REPORT
2008-2009



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

SOCIETY

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Government of India, New Delhi

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(Nominee of the Director, GBPIHED)
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Scientist 'G'/Scientist-in-Charge
IERP, GBPIHED

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Contents

Foreword

The Institute, during two decades of its existence, has made significant strides to fulfill its mandate and created a special niche amongst National and International Research and Development oriented community. The progression has been multidirectional and Institute's scope of the Institute has expanded from a largely research based Institution to a Development focused Research Institute which caters to the needs of multiple stakeholder groups ranging from indigenous communities to policy planners. The programmes and activities, designed for the 11th plan period, are focused on applied action oriented research, and strive for greater institutional collaborations and stakeholders involvement to scale up its outreach. The Institute is committed to ensure time bound delivery of envisaged products of its programmes and activities.

During the reporting period (2008-09), the second year of implementation of the 11th plan, Institute has made significant progress in achieving R&D targets. Among others, strengthening of datasets on: i) water resources - following researches on optimization of hydrological responses; ii) land resources-using engineering and bioengineering measures for stabilization of landslides, and in-depth studies on glacier retreat phenomena; iii) biological resources - through multi-location response assessment studies, large scale multiplication of selected taxa following *in vitro* protocols and field transfer of seedlings, and exploration of microbial biodiversity of the Himalayan soils, were stressed. Also, the Institute continued to further strengthen activities related to environmental assessment and management in relation to selected hydropower projects, field demonstration trials on wasteland rehabilitation, strategies for economic development and environmental conservation in the region following alternate livelihood options. Towards promoting its outreach, Institute has focused on capacity building of a range of stakeholders on Training of Trainers (ToTs) mode on environment-friendly rural technologies through the Rural Technology Complex of the Institute at HQs, and its extension centres. On-site training programmes, orientation courses and exposure visits on biodiversity conservation, Natural Resource Management, and disaster management were major activities aimed at diverse range of stakeholders.

Augmentation of infrastructure in terms of state-of-the-art instrumentation and other facilities was also taken-up. Among others, establishment of the Nature Interpretation and Learning Centre, a facility for on-site training on Himalayan bioresource conservation, was initiated at 'Surya-kunj' *ex situ* conservation site of the Institute.

Realizing the importance of collaborative efforts, the Institute entered into Memorandum of Understandings with national and international organizations including International Centre for Integrated Mountain Development (ICIMOD), Nepal; Centre for Mathematical Modeling and Computer Simulation (C-MMACS), Bangalore; and Kumaun University Nainital. Institute also attempted to address critical issues such as hunting, shifting agriculture, community welfare and alternative livelihoods in the state of Arunachal Pradesh through GOI-UNDP project (Biodiversity conservation through CBNRM in Arunachal Pradesh), which is being implemented in collaboration with four identified partners. Extramural support for location specific R&D activities in different states of Indian Himalayan Region, through Integrated Eco-development Research Programme (IERP), continued to play key role in promoting Institute's outreach.

At the National level, Institute was identified for preparation of two base papers: one for the Task Force of the Planning Commission, GOI, to look into problems of hill states and hill areas; and second for the Ministry of Environment and Forests on "Conservation of Himalayan Eco-systems and Adaptation/ Regulation Measures" as an input to the document being prepared for implementation of the National Mission on Sustaining the Himalayan Ecosystem. The later subsequently provided base material for development of a combined report of MoEF and GBPIHED 'Governance for Sustaining Himalayan Ecosystem (G-SHE): Guidelines and Best Practices'. The report is likely to form a part of India's broader climate change adaptation strategy towards governance and management of the Himalayan Ecosystem.

Acceptance of Institute's outcome by way of the publications of research articles in peer reviewed scientific journals of high repute and increasing funding support from different funding agencies to conduct project based research on priority issues is a living testimony of increasing recognition of Institute's R&D capability. The Apex bodies of the Institute continued to provide desired encouragement and guidance to the Institute to maintain the quality and quantum of the out-put and to achieve its mandate. This help is gratefully acknowledged.

As Director of this premier Institute, it is my endeavour to strengthen the existing programmes and formulate new ones to realize the goals envisaged in Institute's Vision document. I am sure, with the help of colleagues in the Institute HQs and units, as well as its and well wishers out side, the Institute shall succeed in this endeavour. Your inputs and positive critique are always welcome.

L.M.S. Palni
Director

Major Achivements (2008-09)

- Development of landslide location map for Sikkim state through integration of SOI toposheets (1962), RS data (1997) and field surveys (2007-09).
- Organization of field expeditions for identification of glaciers in Dhauliganga basin. Onscreen digitization of glacier boundaries in Goriganga (26) and Dhauliganga (106) basins of Uttarakhand.
- Establishment of weather laboratories at 22 schools of Himachal Pradesh (Kullu, Mandi, Bilaspur and Hamirpur districts); quantification of hydrological responses in Kosi watershed (Uttarakhand) and Takatsum Chu watershed (Sikkim).
- Discovery of one cat-fish *Erethistoides senkkhiensis* (Senkhi stream, Papumpare district, Arunachal Pradesh) and one plan species *Arnebia nandadeviensis* (Pindari area, Nanda Devi Biosphere Reserve, Uttarakhand).
- Assessment and characterization of solid waste generated from six tourist towns of Himachal Pradesh. Study revealed 74.1% of segregated waste is useful for compost generation, 8.2% for direct or indirect reuse, 9.2% for decorative reuse, and 7.8% for recycling and 0.7% medical waste for safe disposal.
- Detailed biodiversity studies along Tholung-Kishong trek of Kanchndzonga Biosphere Reserve (Sikkim) and development of comprehensive information brochure for this eco trek in Dzongu landscape of the reserve.
- Initiating activities to address critical issues of hunting, shifting agriculture, community welfare and alternative livelihood in the proposed Tawang-West Kameng Biosphere Reserve and Apatani Plateau in Arunachal Pradesh in collaboration with identified partner institutions and NGOs in Arunachal Pradesh.
- Detailed documentation of Indigenous Knowledge of 400 medicinal plants and thrir application in traditional healthcare systems practiced by local herbal healers (Vaidhyas) in Uttarakhand.
- Promotion of the outreach activities through strengthening of: (i) multi-location capacity building activities of Rural Technology Center (Uttarakhand); (ii) disaster management faculty (Sikkim); (iii) conservation education trainings and exposure visits (Himachal Pradesh; Sikkim; Uttarakhand); (iv) eco-restoration and rehabilitation models; and (v) people's participation in sustainable eco-tourism (Kedar valley, Uttarakhand).

Publications:

Peer Reviewed Journals	National	-	32
	International	-	29
Book Chapters		-	21
Popular Articles		-	39
Fund Generation (externally funded projects):		-	291 lakh (Rs)

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 2008-09 is as follows:

Watershed Processes and Management (WPM)

During the eleventh Plan Period, "Watershed Processes and Management (WPM)" theme has focused its activities on systems approach to meet the recently accepted UN Millennium Development Goal targeted to reduce by half the proportion of people without sustainable access to safe drinking water and reduce hunger. In-house researches were optimizing hydrological responses in central and Sikkim Himalaya, stabilization of landslide through engineering and bio-engineering measures in Sikkim, energy use pattern in rural domestic sector, development of sacred landscape and rehabilitation of degraded land of central Himalayan region, and nematode diversity in the traditional agro ecosystem of central Himalaya and their impact on soil health and crop growth. External funding supported studies, 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 exploration, diversity, and mapping of vegetation in the urban forests of Kumaun Himalayan towns using remote sensing & GIS, soil nitrogen dynamics in relation to quality and decomposability of plant litter traditionally used as manure in the central Himalaya, etc. 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. Glacier mapping was initiated in Kumaun and Sikkim Himalaya using RS&GIS.

Biodiversity Conservation and Management (BCM)

During the reporting year, thematic group Biodiversity Conservation and Management (BCM), largely focused on achieving the targets slated under two multi-location projects:

(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'. Extensive field surveys, following the standard and compatible methodologies, were conducted to generate authentic and reliable data sets. While repeat surveys (after about two decades of forest stands yielded information for detecting changes in structure and composition of forests in Nanda Devi Biosphere Reserve (Uttarakhand), extensive information on floristic diversity patterns was generated from 52 sites and 12 habitats of Nargu Wildlife Sanctuary of (Himachal Pradesh). Resource surveys in buffer zone villages and geo-referenced data generation on vegetation diversity trends along 6 major sites remained target of study in Kanchendzonga Biosphere Reserve (Sikkim). Towards up scaling mechanisms for conservation and utilization of high value species, micro-propagation of *Hedychium spicatum* and chemical investigations on *Berberis asiatica* provided useful leads. Likewise, interesting data sets were generated on germination of multipurpose species from Himacahal Pradesh and Sikkim. Particular focus of studies on conservation and sustainable utilization of medicinal plants of Himachal Pradesh resulted in detailed quantitative data generation on status of medicinal plants from 27 surveyed sites between 1900-2900 m altitude in the upper Banjar Valley. Population assessment of selected threatened plants (e.g., *Podophyllum hexandrum, Polygonatum verticillatum, Valeriana jatamansi, Taxus baccata* subsp. *wallichiana, Angelica glauca, Bergenia stracheyi, Paris pollyphylla,* etc.) yielded first hand information on their status in natural conditions. In addition, emphasis was given to develop approaches and mechanisms to build capacity of diverse stakeholders for best management and optimal use of Himalayan bioresources. Over 1000 persons, belonging to diverse stakeholder groups, were educated through exposure visits and on-site trainings. Besides in house projects, the group continued 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 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. As lead center for Himalayan Biosphere Reserves (BRs), the group organized stakeholder's consultation meetings in different BRs and a field training workshop 'Biodiversity Conservation and Livelihood Options in Kanchendzonga Biosphere Reserve'. In order to promote outreach, on-site training workshop (2-3 days) and orientation course (7 days) on Conservation Education were organized at HQs and different units. As Technical Resource Center for U-PROBE programme of Department of Science & Technology, the group facilitated and strengthened activities of 21 U-PROBE schools in Uttarakhand and 20 schools in Himacahal Pradesh.

Environmental Assessment and Management (EAM)

In the year 2008-09, the research activities under the EAM theme largely focused on reviews of EIAs, DPRs, PFRs and EMPs relating to hydropower projects in Himachal Pradesh, and issues like dense allocation, overlapping of the influence zone boundary, crisis of potable water from a group of small hydropower projects, environmental pollution like ambient air quality degradation, solid waste problem and deforestation were identified. Socio-economic survey of four projects from the Sutlej basin; two

under construction (Shyang 3MW and Kashang 243 MW), one proposed (Tangling 5 MW) and one under operation (Chaba 1.7 MW) was completed. The socio-economic survey concluded that the hydropower projects under constructions denoted socio-economic and solid waste problems, changing land use pattern and decreasing size of land holdings. Solid waste characterization survey in six sprawling urban towns, Bilaspur, Kangra, Mandi, Hamirpur, Chamba and Keylong were conducted and solid waste sources, quantity, nature and composition of solid waste were assessed. The main sources of waste were households, shops, dhabas-restaurants, vendors, medical centers and buildings under constructions. The study reveals that all the towns are facing the problem of biodegradable waste (BW) in a majority (>70%) as compared to non-biodegradable waste (NBW). Whereas there is wide variations in waste generation from one hill town to another according to the population figures and living standards of the locality. Open dumping of waste and washout effect would continuously be increasing the pollution load in down slope regions. Bio-composting is one of the best means to manage the biodegradable waste. The Multi Wavelength Radiometer (MWR) measures columnar aerosols in 380 nm, 400 nm, 450 nm, 500 nm, 600 nm, 650 nm, 750 nm, 850 nm, 935 nm, and 1025 nm wavelengths. It measures continuous spectral extinction measurement of solar irradiance reaching to earth surface. The high value of AODs at shorter wavelengths compared to longer wavelengths indicated large concentrations of small size aerosol particles due to continuous increase in biotic interferences. A significant variation at 380 nm, 500 nm and 1025 nm noticed very high AODs during the summer months (pre-monsoon period) and very low AODs during the winter months which were directly related to the degree of human interferences. During autumn and winter months, the AOD values were found to decrease remarkably at longer wavelengths indicating a general reduction in the number of large size particles. The variations in turbidity parameter (α and β) were noticed inversely related, indicating dominance of larger concentration of fine mode particles resulting in climate change. An Environment Observatory was established at Himachal Unit, Mohal-Kullu which comprises of Surface Ozone, SO_2, NO_2 analyzers, etc.

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.

Biotechnological Applications (BTA)

During the reporting year efforts were directed mainly towards the newly initiated in-house projects. Based on the leads obtained from the concluded projects (reported last year) and in keeping with the stake holders' demands, R&D initiatives have been planned. Focus was concentrated on developing suitable propagation methods, field performance and subsequent conservation and sustainable use of economically important species of central, western and eastern Himalaya. Large scale multiplication and field plantation of R. maddeni, an endangered species, have been carried out in Sikkim. Investigations on looking for alternative methods of active ingredients by developing calls and hairy root cultures of Himalayan medicinal plants, under laboratory conditions, have been undertaken; this has commercial implications and would reduce the pressure on natural population. Exploration of microbial diversity with specific reference to plant growth promoting microorganisms and mycorrhizal associations comprises another important aspect and is being carried out in Himalayan soils, including north-east region of India. Rhizosphere populations associated with different age groups of *Ginkgo biloba* were investigated. Besides colonization of free living microorganisms and arbuscular mycorrhizae, occurrence of endophytic organisms, got attention. Among extremophiles, species of *Streptomyces* (cold tolerant) and *Aspergillus* (cold and pH tolerant) have been studied for their antagonistic and enzyme producing properties. Field assessment of microbial inoculants has yielded positive results and is being continuously monitored on a long term basis. Studies on diversity and reproductive habits of fishes in relation to environmental parameters of Senkhi River in Arunachal Pradesh are underway; an addition of eight new species for the district, four for the state and one new species (*Erethistoides senkhiensis*) to science has been made. Initiatives on capacity building for rural folks and training of students for (MSc & PhD) continued in the reporting year. In a recently concluded externally funded project on Technology Demonstration and Improvement of farm productivity in Sikkim, various agricultural production potential in farmers' fields with better management and improvised collateral practices were demonstrated. Under the pond-based integrated farming system, two new sites were developed in the Kumaun region; such initiatives have not only effected improvement of income generation for rural women but also demonstration of technologies.

Knowledge Products and Capacity Building (KCB)

There are hundreds of different cultures in the Indian Himalayan region, each with its unique practices and way of looking at life. Through their reliance on and interaction with nature and natural resources, communities have acquired an immense knowledge of their natural environment. Yet this accumulated knowledge is rapidly disappearing as the traditional communities are steadily becoming more uniform culturally and biologically. With greater realization of the value of this knowledge base, for looking at issues linked to

social process and natural resource management there is increasing realization that in many ecological/social situations, knowledge should be an integral part of a holistic and cost-effective approach to sustainable development. The knowledge accumulated, documented, produced/developed over a period of time in any field for human well being and natural resource management, is required to be transmitted or exchanged through capacity building efforts in empowering all the stakeholders The level of understanding, skills, enthusiasm and values of the user groups are considered key factors in stimulating the learner's interest and appreciation of implementation of knowledge produce. The Knowledge Product and Capacity Building (KCB) theme of the Institute has focused on sound principles of traditional knowledge to develop its training programmes conducted through Rural Technology Centres. Use of information technology, latest instrumentation as central facility, are the other key activities under the theme during this year.

1. INTRODUCTION

The year 2008-09 is twentieth 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 Products 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 2008-2009 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

Base Paper for Planning Commission, Govt. of India

The Planning Commission, Govt. of India has given the responsibility to the Institute of developing a Base Paper for the Task Force to look into problems of hill states and hill areas and to suggest ways to ensure that these states and areas do not suffer in any way because of their pecularities.

Base Paper for Ministry of Environment & Forests, Govt. of India

The Institute has developed a base paper on "Conservation of Himalayan Eco System and

Adaptation/Regulation Measures" for the Ministry of Environment & Forests, Govt. of India. Issues that are relevant to the sustainable development of Himalayan ecosystem, such as waste management, hill town planning and architectural norms, ecologically safer roads, energy options, regulating tourists and pilgrimage to sensitive areas, promoting ecotourism and regulation of commercial tourism, conservation areas and forest zone management for community development, rejuvenation of springs and degraded sites, monitoring networks, awareness building and role of local communities in the development of IHR have been outlined in this base paper.

National Training Programme on Common Property Resources

The Garhwal Unit of the Institute organized a three day workshop (April 7-9, 2008) on Common Property Resources (CPRs) and Livelihood. About fourteen participants from different consortia (SKUST-S, SKUST-J, GBPUA & T, Ranichauri, ChSKHPKV, Palampur, VPKAS, Almora, GBPIHED HQs, CSWCRTI, Dehradun) participated in this workshop. Lectures on CPRs and livelihood were delivered by different experts and they also illustrated certain success stories and experiences in the field of CPRs. During a field visit of the Institute, the participants discussed various issues related to common property resource management and exchanged ideas and views on CPRs.

Farewell to Dr. Uppeandra Dhar, Director of the Institute

A farewell function was organized on April 30, 2008 on the day of superannuation of Dr. Uppeandra Dhar, Director of the Institute. Dr. Dhar served the Instuitute from 1990 in various capacities and made remarkable contributions for the development of the Institute. Presently he is based at Delhi. Dr. L.M.S. Palni, Former Director of the Institute, returned to the Institute after a period of 5 years service on deputation (as Senior Scientific Advisor and Project Director of State Biotechnology Programme, Govt. of Uttarakhand) on Ferbuary 18, 2008. Dr. Palni was handed over the charge of the Director by Dr. Dhar.

Lecture Series by Dr. Bruce Roberts

Dr. Bruce Roberts, U.S. Fullbright visiting Lecturer, Deptt. of Anthropolgy and Earth Sciences, Minnesota State University, USA delivered a series of lectures to the Institute faculty and researchers on (i) Contrasting approaches to development; (ii) The impact of development on peasants; and (iii) Anthropological perspectives on human adaptation: cold and high altitude (May 21-22, 2008).

International Day for Biological Diversity

International Day for Biological Diversity was celebrated at the Institute HQs and all four regional Units under the theme entitled "*Mountain biodiversity and sustainable agriculture – focus on conservation and management of pollinators*" (May 22, 2008). On this occasion, Dr. L.M.S. Palni, Director, GBPIHED focused on the importance of biodiversity in the Himalayan region. The chairman of the function, Dr. Bruce Roberts, Minnesota State University, USA informed that the sustainable management of biodiversity appears to be better in India. On this occasion lectures on the mountain biodiversity were delivered by various Scientists. To celebrate this occasion a concurrent programme was organized at the Institute's Arboretum "Suryakunj" particularly for the school students of Kumaon region, emphasizing on Himalayan agriculture and traditional farming systems. A total of 53 students along with 12 teachers participated.

Several competitions, like drawing, creativity assessment, group discussions quiz and extempore speeches were conducted for the school children. Dr. L.M. S. Palni, Director Incharge deliberated the closing remarks and encouraged the school children for active participation and in their efforts towards conservation of biodiversity in the Himalaya.

World Environment Day

The World Environment Day was celebrated as "A day with students", with a focus on "Water supply and sanitation in mountain context", at Rural Technology Complex of Institute HQs, Kosi-Katarmal, Almora (June 5, 2008). Over 375 students from 12 schools of the region participated in the programme. On this occasion demonstrations on specific subjects such as, testing of water, water conservation, climate change, bio-diversity, bio-technology, microbiology, rural technologies etc. were held by the Institute resource persons. Information about sanitation & water was given by SWAJAL programme officials of Govt. of Uttarakhand. On this occasion poster competition and essay competition on the theme of the programme was organized and a documentary about water conservation and sanitation was displayed.

Hands-on Training on Statistical Techniques

A short term training programme on '*Statistical techniques for design & research*' (June 23-28, 2008) was organised at the Institute HQs, Kosi-Katarmal, Almora. A total of 48 participants (36 from HQs and 12 from Units) participated in the training programme. The aim of the programme was to provide some basic knowledge of statistical concepts and hands-on training to research scholars of the Institute. The training programme included lectures on various topics i.e., sampling procedures, experimental designs, testing of hypothes and various statistical tests by subject experts invited from various Institutions. Besides, hands on training on some statistical softwares like MINITAB, GENSTAT and STATISTICA was also imparted to the participants.

Training on Disaster Safe Hill Area Development

A five day training programme was organized (July 7-11, 2008) at the Sikkim Unit of the Institute in collaboration with Land Revenue and Disaster Management Department, Government of Sikkim. Emphasis was laid on the preparation and creation of Disaster Safe Development models in the state for effectively coping with the disaster related issues. It has also been stressed that the constitution of village level disaster management committee can help a lot in handling the disasters at the local level. A total of 34 participants from state and central Government organizations comprising of architects, engineers, geologists, researchers, foresters, and NGOs etc. took part in the training programme.

Annual Day Celebration

The Institute celebrated its Annual day on the occasion of 121st Birth Anniversary of Bharat Ratna Pt. G. B. Pant (September 10, 2008) at its HQs and four regional units. Inaugurating the function, the Chief Guest, Lt General Dr. M.C. Bhandari (Retd.), paid rich tributes to Panditji and remembered his childhood of days spent with this great son of the soil. He emphasized that it would be a true tribute to him if we could take inspiration from his life. He also expressed happiness on the progress of collaborative programme between GBPIHED and National Cadet Corps on various environmental issues. In his welcome speech, Dr. L.M.S. Palni, Director of the Institute highlighted the work of the Institute. On this occasion special guest Dr. M. C. Joshi, founder director of Defence Agriculture

Research Laboratory, Almora recalled his moments spent with Pt. Pant Ji and urged everyone to follow the ideology of Pt. Pant ji. Over 100 participants were present during the function.

Deliberation of 14th Pt. Govind Ballabh Pant Memorial lecture

The Instute organized its 14th Pt. Govind Ballabh Pant Memorial lecture on September 19, 2008 at its Headquarters Kosi-Katarmal, Almora. Dr. L.M.S. Palni, Director briefly introduced all the guest members & the speaker of G.B. Pant Memorial Lecture. Delivering the 14th G.B. Pant Memorial Lecture entitled, "***How Green could Tommorrow's Aircraft be? Climate Change, Environment and Aviation***", Prof. Roddam Narasimha, FRS, Member, Space Commission & Chairman, Engineering Mechanics Unit, Jawharlal Nehru Centre for Advanced Scientific Research, Bangalore made a detailed power point presentation on various scientific problem of climate change. He described about the ethical issues of climate change and also described aviation and GHG emissions related issues. Besides, the Chief Guest Dr. R.S. Tolia, IAS, Chief Information Commissioner, Govt. of Uttarakahnd delivered a inaugural address and remarks were made by Mr. Hem K. Pande, IAS, Joint Secretary, Ministry of Environment & Forests, Govt. of India and Member, Governing Body of GBPIHED. During the function some Institute Publications/Documents were released namely, "Surya-Kunj: Ex situ conservation and nature Interpretation Site" released by Prof. Roddam Narasimha, FRS; "Institute Folder" released by Dr. R.S. Tolia, IAS and "Pragati (Magazine, Campus School) and Him Prabha" released by Mr. Hem K. Pande, IAS. The staff of all the four units participated in the function organized the HQs throrgh video conferencing facility.

Science Motivation Programme

A five day workshop on "generating scientific temperament among high school students through organization of science motivation programme" was conducted by the Garhwal Unit of the Institute (September 24-28, 2008) at Triyuginarayan (district Rudraprayag). The programme was inaugurated by Chief Development Officer, Rudraprayag, Mr. Kotiyal. The participants and local people were briefed about the R&D activities of the institute. Experts from various organizations [e.g. H.N.B. Garhwal University Srinagar, KVK, Ranichauri of G.B. Pant Agriculture University, Pantnagar, Block Development Officer (BDO), Village council, etc.] delivered lectures and encouraged students to take up science subject as a future career. The topics selected for deliberation covered biological sciences, physical sciences, chemical sciences and earth sciences and its related branches. A field visit was also organized for the students during the programme to give exposure about forest ecosystem services, rural technology, medicinal plants, wild life conservation, etc. Participants were also exposed to a demonstration site of the Institute at Triyuginarayan (Distt. Rudraprayag) where practical know how on the land rehabilitation and biodiversity conservation was given. A total of 40 students (from different schools) actively participated in the workshop.

MoU between ICIMOD and GBPIHED

Realizing the need of implementing appropriate cost-effective and environment-friendly R&D based technologies to address the environment and development issues of the region, a formal memorandum of understanding (MoU) was signed between the Govind Ballabh Pant Institute of Himalayan Environment and Development (GBPIHED) and the International Centre for Integrated Mountain Development (ICIMOD) on

September 25, 2008. The MoU was signed by Dr. L.M.S. Palni, Director, GBPIHED and the Director General, ICIMOD, Dr. Andreas Schild in the presence of Sri Vijai Sharma, Secretary Ministry of Environment & Forests, GOI. Among other officials from the Ministry, Sh. B.S. Parsheera, Special Secretary, Sh. R.H. Khwaja, Additional Secretary, Sh. J. Mauskar, Additional Secretary, Sri M.B. Lal, ADGF, Sh. Hem Pande, Joint Secretary, and Sh. Vivek Saxena, Director, were present during the signing in ceremony.

Under the provisions of this collaboration, GBPIHED being an autonomous Institute of the nodal Ministry (i.e., Ministry of Environment & Forests), will serve as the Key Player in developing programmes to find solutions on priority issues pertaining to environment and development in the Indian Himalayan Region. The Ministry views this relationship with enthusiasm and hopes, especially at the time when the National Action Plan for Climate Change has recognized the fragility of the Himalayan ecosystems, and the Government of India has initiated a National Mission for Sustaining the Himalayan Ecosystem. Realizing the importance of mountain ecosystems in general, the Ministry has constituted National Advisory Committee (Mountain Perspective) to advise on issues concerned with mountains and also about ICIMOD programme in India. This MoU shall be valid for a period of five years and shall be renewed thereafter for a further period on mutually agreed terms and conditions. Besides, another MoU was signed with Kumaun University, Nainital (29.09.2008).

Wild Life Week Celebration

On the occasion of Wildlife Week 2008, the Institute organized a two day (October 3-4, 2008) Biodiversity exposure and interpretation campaign for students and teachers of Almora District. The aim of the campaign was to make the youth (school children and teachers) aware on Biodiversity Conservation. Particular emphasis was given on inculcating interest among the children for diversity of life in their immediate surroundings. Exposure visit to the 'Suryakunj' - Nature Interpretation and Learning Centre (NILC) established within the Institute Campus was the main event, which was followed by various on-spot competitions for the students. The education material was provided through Zoo Outreach Organization: ALERTIS fund for Bear and Nature Conservation; Wildlife Conservation Society; Chester Zoo; World Association of Zoos and Aquariums; Conservation Breeding Specialist Group; Awley, Apenheul, IZE, IUCN/ SSC Primate Specialist Group, South Asian Primate Network. A total of 79 students and 19 teachers from 21 schools participated in the programme.

Awareness Workshop on Weather, Climate Change and Biodiversity

Himachal Unit of the Institute organized one day awareness workshop on "Weather, Climate Change and Biodiversity" on October 25, 2008. The workshop was sponsored by the Department of Science and Technology, New Delhi. Prof. S.K. Dash, Centre for Atmospheric Sciences, Indian Institute of Technology, New Delhi was the Chief Guest. Shri S.S. Negi, Chief Conservator of Forests, Mandi Himachal Pradesh was the guest of honour and Dr. J.K. Pathak, Scientist, represented DST, New Delhi. Resource persons delivered lectures on: change in weather parameters in India, issues and strategies for temperate fruit cultivation in changing climate scenario in mid hill areas; biodiversity in relation to climate change; species response to climate change in mountain ecosystem; and climate change and free air CO_2 enrichment (FACE). At the end, Dr. S.S. Samant, Scientist In-Charge, Himachal Unit presented the progress of the project entitled "Expanding Outreach through Participation of Youth in Real-Time/Field Observations to Benefit the Education in the

Himalayan Region A total of 98 participants including officers from the Forests, Agriculture, Horticulture, Education and other departments of the State Government, Scientists from the Universities, State and Central Government Organizations, NGOs, Hydro Electric Projects, Farmers, Media persons and Teachers partcipated in the Workshop.

Workshop on Traditional Health Care System

A two day workshop (November 5-6, 2008) on "Traditional Health Care System: Problems and Prospects" sponsored by National Medicinal Plants Board (NMPB), Govt. of India was organized by the Garhwal Unit of the Institute at Triyuginarayan (Rudraprayag). The objective of the workshop was to provide a platform for sharing traditional knowledge among the *vaidyas* of different regions, resource persons and the stakeholders. The workshop was inaugurated by Prof. R. D. Gaur, Emeritus Professor, HNB Garhwal University, Srinagar (Garhwal). While presiding over the inaugural session of the workshop Dr. M. S. Rawat, Senior Scientist, NMPB, New Delhi briefed about different activities in medicinalplant sector, resource persons from different disciplines also delivered valuable talks. A total of 70 traditional medical practioners (*Vaidyas*) attended the workshop.

Training for Promoting Conservation Education

A seven day orientation/refresher course (November 5-11, 2008) and training workshop (November 9-11, 2008) was organized at GIC, Kausani (Bageshwar). The main focus of the event was to create awareness about the contemporary issues on biodiversity assessment and its conservation. During the orientation coursea, total of 25 teachers from the 25 schools (representing 4 districts - Almora, Bageshwar, Champawat and Pithoragarh) participated. The major objective of refresher course was to focus on newer issues through adding some adjoining attributes. Attempts were made to inculcate deeper understanding on domestic biodiversity, wild biodiversity and livelihood options. Besides classroom delebrations, practical exposures were emphasized so as initiate multidimensional interactions among the teachers. During training workshop 17 teachers and 47 students (from 24 schools) participated. The workshop included different modules (i.e. introduction, assessment, value and value addition, conservation and linking biodiversity with other environmental issues i.e. climate change, water and land).

Exposure Visit

Scientists of Chinese Academy of Sciences visited the Institute on November 12-13, 2008. During their visits, Prof. Lee presented the various Research and Development Programmes of the Department of Botany, Chinese Academy of Science, China and discussed the various issues of Research and Development. The Director of the Institute presented the Institute's work and highlighted the need of collaborative research in order to maintain quality. The Chinese scientists also visited Surya-Kunj – Nature Interpretation and Learning Center of GBPIHED where they were exposed to various types of medicinal and aromatic palnts of Himalaya. The visit was coordinated by the Scientist of Birbal Sahani Institute of Paleobotany, Lucknow, under a bilateral exchange peogramme between India and China.

Awareness Workshop on High Altitude Wetlands

The Himachal Unit of the Institute organized one day awareness workshop for the stakeholders on High Altitude Wetlands Conservation in Himachal Pradesh on December 2, 2008 in

collaboration with WWF, Field Office, Shimla. Mrs. Vandana Thapliyal, WWF, Shimla gave brief presentation about the workshop and activities of the WWF, Shimla on high altitude wetlands conservation. Resource persons made presentation on various aspects of high altitude wetlands. This workshop was attended by 47 participants including tour operators, trekkers, members of taxi unions, hoteliers, NGOs, etc.

Campus School Annual Day

The Campus School of the Institute celebrated its annual day on December 27, 2008. Inaugrating the functiuon, Chief Guest Dr. L.M.S. Palni, Director of the Institute lighted the lamp and encouraged the school children and teachers for their progress during the year. Shri Gokul Singh Rawat, Basic Siksha Adhikari encouraged the school children and said that to achieve the goal students should work hard. Mrs. Bhagirathi Joshi, Principal of the campus school presented the annual progress report of the school. On this occasion a cultural programme was presented by school children. Over 50 participants including guardians of school children, Institute's faculty and others were present on the occassion.

Governing Body Meeting (s)

The 33rd Governing Body Meeting of G B Pant Institute of Himalayan Environment and Development, was held on January 28, 2009 at the Ministry of Environment & Forests, New Delhi. Shri Vijai Sharma, Secretary, Ministry of Environment & Forests, New Delhi, Chaired the meeting. Among members, Shri B. S. Parsheera, Special Secretary, MoEF, Shri P.R. Mohanty, DG (Forests) & SS, MoEF, Prof. J. S. Singh, Prof. V. K. Gaur, Prof. S. K. Sopory, Shri E.K. Bharat Bhushan, Joint Secretary & FA, MoEF, Shri Hem Pande, Joint Secretary, MoEF, and Dr. L.M.S. Palni, Director (Member Secretary) attended the meeting. Secretary, Department of Biotechnology, New Delhi, Chief Secretary, Govt. of Uttarakhand and Shri Vivek Saxena, Director (CS), MoEF also attended the meeting. The Governing Body approved the draft Annual Report and statements of the Accounts for the year 2007-08.

PEC Meeting

The 15th meeting of the Project Evaluation Committee (PEC) was organised and convened under the Integrated Ecodevelopment Research Programme (IERP) of the Institute at its headquarters (Kosi-Katarmal, Almora, Uttarakhand) on 27-28 March 2009 in which 109 project proposals were examined critically by the members of the PEC and 48 projects were recommended for funding. The meeting was held under the chairmanship of Dr. R.R. Rao, the emeritus scientist of the CSIR. Seven members, including one special invitee, attended the meeting. Dr. L.M.S. Palni, the Director of the Institute, welcomed all the distinguished members of the PEC to its 15th 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 the above,

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

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

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

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

The importance of biological resources for human welfare is tremendous and beyond question since early times. With increasing human population and demand for bioresources, its sustainable and judicious use is essential for the long time survival of the people of the entire world and particularly those in the Indian Himalayan Region, which covers a total geographical area of approximately 591,000 km^2 (18% of India) and is inhabited by about 3.7% of the total population of the country. This region harbours a variety of plant, animal and microbial populations, and is considered a "hot-spot" of biodiversity; it also caters and contributes significantly to supporting livelihood and contributing to the economic well being of the people. However, the changing world scenario stresses the need for increasing food production, pharmaceutical and other products, along with heavy industrialization, which has compelled biologists to contemplate on serious issues, like conservation of biodiversity, climate change, biotechnological interventions for improved productivity, etc. The group focuses on aspects of biodiversity conservation and management, and on applications of biotechnological methods for improving the rural economy of the Indian Himalayan Region.

Theme

WATERSHED PROCESSES & MANAGEMENT (WPM)

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

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

The services provided by the watershed hydrology have largely been neglected in water management. The policy makers have now realized the importance of using knowledge of hydrological processes for recharging the water sources through source centered catchment area treatment plans and other different water conservation techniques to avoid severe water scarcity in hills. 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 focuses on this interface of water demand & availability, major land uses (forest land, agriculture/waste land and urbanization) and optimizing water allocation for different competing uses for water sustainability in the fragile Himalayan watersheds. The study is conducted in the northern part of the Kosi basin (upper Kosi watershed between 29° 30' and 29° 55' N Latitudes and 79° 30' and 79°45' E Longitudes covering 480.15 km^2 area) spreading over the Lesser Himalayan domain and administratively within district Almora,

Uttarakhand state and Taktsom chu watershed (lying from 27°15' to 27°20' N and 88°37'30" to 88°42'30"E embracing an area of 35.42 sq. km), as a tributary of Rani Khola, in Teesta basin.

Objectives

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

Achievements

- Establishment of two permanent gauging stations at Kosi and Ranman and Two automatic weather stations at Ranman and Kosi has been completed. Daily monitoring of stage and flow at five monitoring sites i.e. Bijoria, Menol Gad, Ranman, Nanakosi and Main Kosi is presently being done along with daily monitoring and archiving of Weather data from Kosi and Ranman. Generation of hydro-meteorological data has also been initiated in Taktsum Chu watershed, Sikkim.
- Water balance is calculated for Bijoria sub-watershed and upper Kosi watershed for year 2008. The net rainfall was 1708.66 mm in 2008 after deducting interceptional losses from gross rainfall. Runoff is about 23.89% of rainfall from Kosi watershed (Table-1). The runoff coefficient for the main watershed is similar to the values reported for other mid-elevation watersheds with moderate degradation. In forested Bijoria sub-watershed net rainfall is only 1114.83 mm, whereas the runoff is about 39% of the net rainfall.

Table 1: Water balance in Kosi Watershed

Month	Rainfall(P)	Runoff (R O)		Evapo-transpiration	Soil Storage
		Surface	Base	(Et)	(dS)
January	6.91	0.37	7.66	7.78	-8.90
February	5.61	0.43	6.50	10.41	-11.72
March	11.66	0.28	5.01	20.73	-14.37
April	52.90	0.25	3.16	29.48	20.01
May	124.13	1.61	3.02	35.72	83.77
June	313.02	7.64	4.97	43.03	257.38
July	421.86	62.16	15.45	46.33	297.93
August	429.63	138.62	42.91	45.15	202.94
September	322.86	63.14	15.73	38.71	205.29
October	4.53	4.09	9.21	25.43	-34.19
November	14.90	1.06	7.68	16.58	-10.43
December	0.65	0.02	7.36	9.58	-16.32
Total	1708.66	279.67	128.66	328.93	971.38

Table 2: Change in Land Use Land Cover for Taksom Chu watershed (1962-63 and 1997)

Cover Class	Year (1962-63) Area sq.km	% Change for the year 1962-63	Year (1997) Area sq.km	% Change for the year 1997
Forest Cover	23.00	64.94	22.00	62.11
Arable Land	7.22	20.38	9.2	25.97
Open Scrub	5.20	14.68	4.22	11.92
Total	35.42	100.00	35.42	100.00

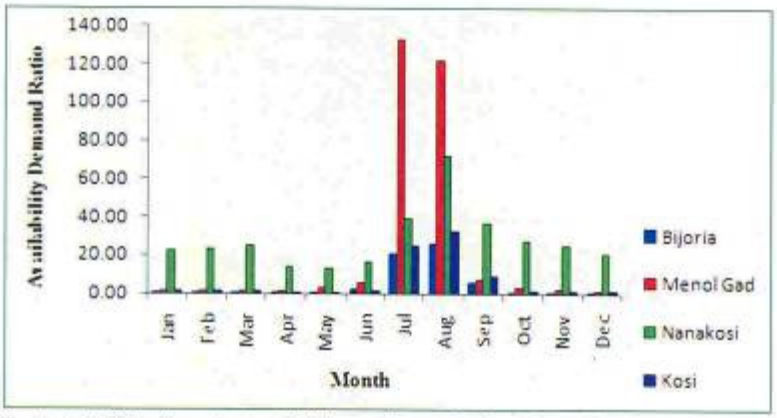


Fig. 1. Availability demand ratio of different sub-watersheds and upper Kosi watershed (2008).

- Availability and demand ratio of different sub-watersheds is given in Fig. 1. In case of Menol Gad and Nanakosi sub-watersheds, available water is generally more than the demand, but in case of Bijoria (located in headwaters) and Main Kosi demand is greater than availability in summer months. This suggests need for optimizing the water allocation in these watersheds.

- For Taktsum Chu watershed in Sikkim, preparation of base maps for various themes viz., altitude zonation map, settlement maps has been completed. Land use and land cover maps of the watershed have been prepared for year 1963 and 1997 on the basis of satellite data. Maximum positive change has been noticed in arable land category (Table-2).

Developing sacred landscape model for eco-restoration and biodiversity conservation in the Central Himalayan Region (2007-2012, In-house)

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

Badrinath shrine), which is recognised as an inspiring model for rehabilitation of degraded lands and conservation of biodiversity based on the 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. The model 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.

Objectives

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

Achievements

- The survival, collar diameter and height of various tree species were recorded at three different model sites in the Kolidhaik village (Lohaghat) of Champawat district. At the multipurpose tree model (MTM) site, the average survival of plants was 80%. *Alnus nepalensis* showed maximum survival (95%) whereas *Grewia oppositifolia* showed the minimum (43%). At the sacred forest model (SFM) site, the average survival of plants was 54%; *Alnus nepalensis* exhibited maximum survival (81%) whereas *Celtis australis* exhibited minimum survival (15%). At the horticultural tree model (HTM) site, the average survival of plants was 77%; *Citrus reticulata* showed maximum survival (95%) and *Carya illinoinensis* showed minimum survival (45%).
- As per needs of the local communities, almost 6,440 saplings of 17 multipurpose tree species were planted at different model sites (1,510 at the MTM site, 4,515 at the SFM site and 415 at the HTM site) in the Kolidhaik village of Champawat district during August-September 2008.
- Analysis of soil samples, which were collected from the project sites during pre and post-monsoon seasons of the year 2008, revealed slight enhancement in the soil fertility status (organic carbon from 0.72 to 1.4 % and available nitrogen from 160 to 199 kg/ha). The soil was also found comparatively better in terms of the availability of phosphorus and iron.
- The rate of transpiration of 20 promising tree species recorded between 6 a.m. and 6 p.m. at 3 hourly intervals during September 2008 at the MTM site indicated highest rate of transpiration by *Ficus roxburghii* leaves whereas it was exhibited lowest by *Aesculus indica* leaves (Fig. 2).
- Based on the data obtained on the thermal gradient between leaf and air, the trees planted at the MTM site were classified in to 2 categories. Six (6) tree species were observed

as '*over-temperature* ones whereas rest of the 14 species were observed as 'under-*temperature*' ones (Fig. 3).

- The results obtained on growth behaviour, eco-physiological health and adaptability potential of 20 promising tree species when planted at the project sites in Kolidhaik village revealed that '*under-temperature*' species exhibit higher rate of transpiration as well as energy absorption, negative temperature difference between leaf and air, and significant gain of energy by the convection of heat. These observations indicate suitability of '*undertemperature*' species for plantation in degraded land areas having exposed slopes.

- For the purpose of soil and water conservation measures, 11 contour lines (6 at the MTM site and 5 at the SFM site) were made. Almost, 25 quintal root stocks/cuttings of *Napier* hybrid grass were planted at these two sites to fulfill the fodder requirement of local villagers. The villagers of 79 families collected 6.1 tonne dry fodder during the months of October and November 2008 from the project sites. The rain water tank constructed at the plantation site was found to store sufficient water for the use of people besides irrigating the plants.

- A two-day on-site training programme on "*Horticultural development in degraded community land for income generation*" was organized at 'Daikhura Kattarkandi Sacred Hill' project site in December 2008 for skill up-gradation of various stakeholders consisting of 53 farmers/women of the Kolidhaik village.

- The project site consisting 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') in the Kolidhaik village of Champawat district was strengthened and maintained properly during the year 2008-09.

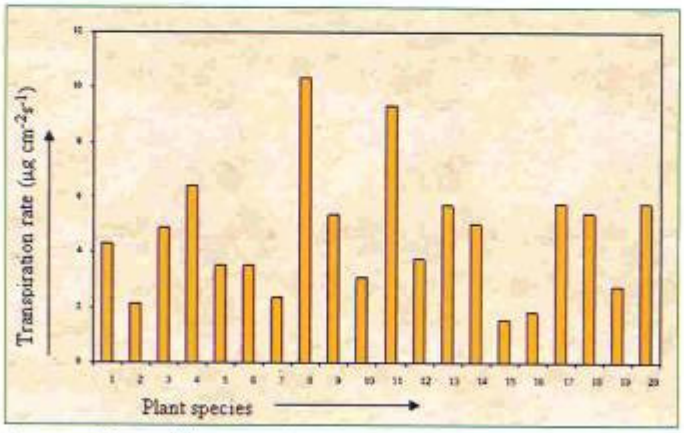


Fig. 2. Transpiration rate of 20 promising tree species planted at the Multipurpose Tree Model (MTM) sitea t Kolidhaik village in Lohaghat (*1. Fraxinus micrantha, 2. Alnus nepalensis, 3. Celtis australis, 4. Quercusleucotrich-ophora, 5. Quercus serrata, 6. Toona ciliata, 7. Sapindus mukorossi, 8. Ficus roxburghii, 9. Rhododendron arboreum, 10. Morus serrata, 11. Grevia optiva, 12. Dalbergia sissoo, 13. Quercus glauca, 14. Pittosporum spp., 15. Aesculus indica, 16. Cinnamomum tamala, 17. Prunus cerasoides, 18. Quercus floribunda, 19. Carpinus viminea, 20. Ficus palmata).*

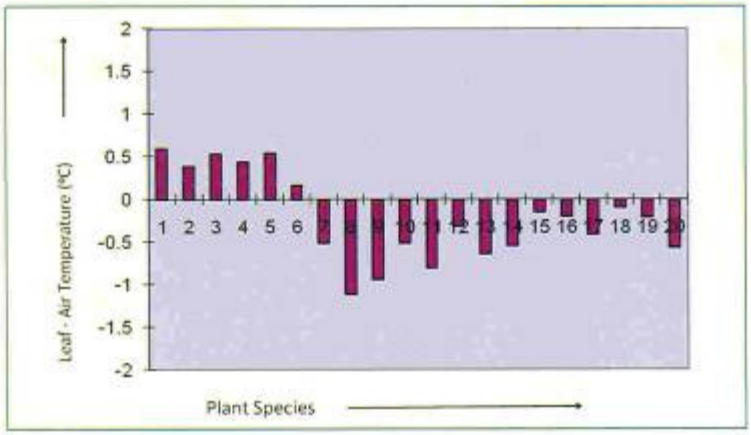


Fig. 3. Leaf to air temperature differences of 20 promising tree species planted at the MTM site at Kolidhaik village in Lohaghat (Name of the spp. numbered from 1-20 are same as given in Fig. 2).

Installation and Operation of the Permanent GPS Stations for the Quantification of Tectonic Deformation and Assessment of Stability of Himalayan Urban Centers (2005-2010, MoES, Govt. of India, New Delhi)

The proposed experiment will quantify the strain suffered by the region from NW to NE along the Himalayan arc using continuously operating GPS receivers installed in permanent mode. The proposed experiment, envisaged, establishment of a network of GPS sites in selected urban centers to quantify the slip rate along reported faults. Repeated measurements at the above mentioned sites provide information on the 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 stations for the future campaigns of the study of Himalayan deformation rate and will fill the gap in National network of permanent stations in unrepresented areas. Daily processing of the data is being done using GAMIT/GLOBK software for baseline changes along E-W and N-S transects.

Objectives

- Quantification of tectonic deformation field by experimentally determining the displacements of fixed sites using GPS Geodesy with high resolution.
- To measure slip rates across reported faults in the area towards improving assessmemt of the stability of different parts of the mountain urban centers.

Achievements

- A preliminary field observation shows that the areas around all the five stations are tectonically active. Series of landslides and neo-tectonic indicators suggest that the terrain is unstable and accumulating continuous strain.
- The velocity of IISC is ~ 50 mm/year, which is approximately of same magnitude as the

Table 3: Velocity of Permanent and IGS stations for year 2009-2006

	2009-2008		2008-2007		2007-2006		2009-2006	
Station Name	Velocity (mm/y)	Error (mm/y)	Velocity (mm/y)	Error (mm/y)	Velocity (mm/y)	Error (mm/y)	Velocity (mm/y)	Error (mm/y)
KUNM	38.13	0.47	37.27	0.58	30.48	5.67	35.11	0.61
LHAS	46.96	0.61	49.62	0.36	48.84	3.24	48.08	0.24
HYDE	52.83	0.61	52.68	0.91	37.39	4.39	53.95	1.93
IISC	52.97	0.92	53.12	0.57	40.73	4.32	52.96	1.24
SELE	30.38	0.87	29.47	0.69	34.30	3.63	28.26	0.30
POL2	27.64	0.92	27.45	0.47	32.32	3.40	27.92	1.36
KIT3	29.90	0.92	27.35	0.48	25.41	3.28	28.30	1.00
GBPK	**47.63**	**0.99**	**48.33**	**0.58**	**32.69**	**4.27**	-	-
GBSK	**50.79**	**0.86**	**46.43**	**0.92**	**52.99**	**4.30**	-	-
GBNL	**46.27**	**0.99**	**44.58**	**1.16**	**38.97**	**8.20**	-	-
GBSN	**47.05**	**1.66**	-	-	-	-	-	-
GBKL	**48.09**	**1.65**	-	-	-	-	-	-

velocity of GBPK (Katarmal) and also GBSK (Pangthang) (Table-3). Velocities for GBKL (Kullu) as ~47mm/year and GBSN (Srinagar) as ~48mm/year have also been calculated in this year.

- Results of baseline changes for year 2006-2009 show that there is no significance baseline change between IISC and GBPK and GBNL. Results also indicate that, the LHAS (Lahse) is moving toward East with a baseline extension of ~ 18 mm (2009-2006) relative to GBPK. The baseline changes between GBPK and GBSK is ~ 23mm (2009-2006), as GBSK is moving towards East in comparison to GBPK. Some new baselines have also been calculated in this year for the Srinagar-Garhwal (GBSN) and Kullu (GBKL) stations.

Stabilization of Landslide through engineering and bio-engineering measures in Sikkim (2007-2012, In-house)

In the recent year a large number of landslides cause of extensive damages to the roads, buildings, forests and agricultural fields in many parts of the terrain and also the ongoing developmental activities in Sikkim Himalaya. These hazards cannot be prevented in all cases but its impacts can be minimized to a certain extent by taking effective timely measures to cope up with them for disaster preparedness. The Himalayan terrain, in the past witnessed several major natural hazards, related to earthquakes and landslides. Apart from its complex geological set up, this terrain is characterized by high tectonic seismicity and also receives heavy annual precipitation. As

a result, the mountain slopes are characterized by an inbuilt fragility. In such a kind of fragile mountain ecosystem mass wasting process is the commonest natural hazard. Improperly planned construction practices, without taking into account the inherent but adverse geological conditions, may add to existing hill slope instabilities. In a rapidly booming economy like ours, one cannot escape the positive outcome of development projects. It is equally important to ensure that these schemes should not suffer any kind of hurdle due to geo-environmental imbalance. Hence, the requirement for investigation and study of landslide phenomena following a systematic approach is necessitated.

Objectives

- Landslide inventory in Sikkim Himalaya.
- GPS monitoring of Bakthang fall subsidence/slide.
- Stabilization of Landslide through engineering and bio-engineering measures.
- Performance/monitoring of engineering and bio-engineering measures in different landslide and comparison.
- Technical know how about stabilization measures to Forest Department (GoS).

Achievements

- Landslide location map of Sikkim developed using Survey of India (SOI)I toposheets (1962), remote sensing data (1997) and field survey (2007-09). Total 97 slides from SOI toposheets, 57 slide from RS data and 102 slide from field study locations were marked on the Sikkim state map (Fig 4).
- Five GPS campaigns completed in the Bakthang fall subsidence/slide. Surface area map of the slide generated.
- Habitat assessment (vegetation) in and around Bojeck fall landslide also carried out. In all 42 plant (tree, shrubs and herb) species identified.
- Detailed geotechnical investigation of Bojeck landslide carried out indicating landslide boundary, soil depth, lithology and land cover.

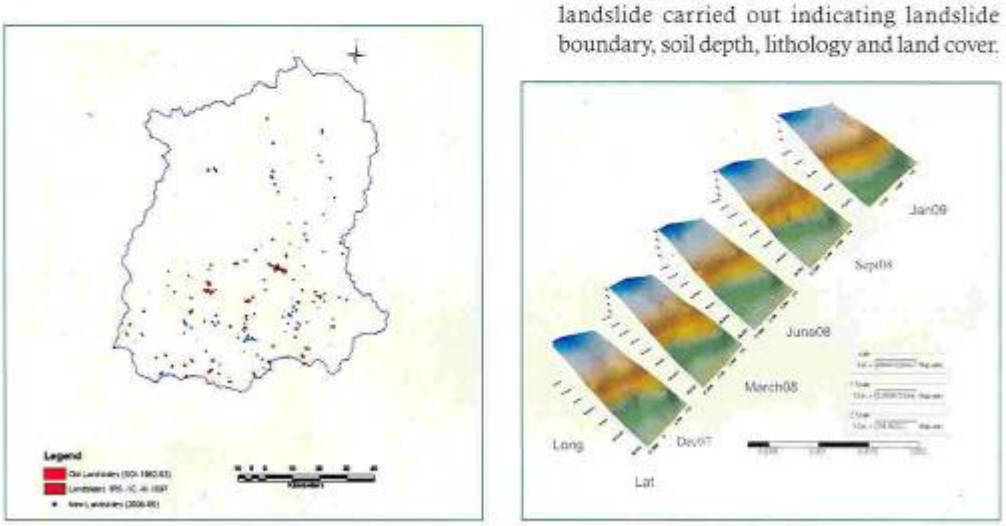


Fig. 4. Landslide location map of Sikkim and Bakthang fall subsidence/slide surface 2007-2009

Glacier Study Centre

a. Geohydrological and sediment load studies of Thelu Glacier (Gangotri Glacier system), Uttarakhand Himalaya (2005-2009, DST, New Delhi)

The Himalaya has direct influence on climate control, regional hydrology and environment of the subcontinent. About 17 per cent of its mountain area is covered by the Himalayan glaciers. The Himalayan glaciers are retreating at present. Gangotri glacier (one of the biggest glaciers of Himalaya) has receded at the rate of ~ 12 m/year between 2004-2007. The recession and overall decrease in the volume of the glacier is adding to the total area of erosion every year. It generates large amount of suspended sediment load, which is carried from the glacierized basin. Meltwater draining from these ice and snowfields is important in regulating the hydrology of the Indian sub-continent. Though it contributes only about 5 percent to the total runoff, it releases water in the dry season. The present project envisages estimation of sediment load and its relation with meltwater discharge in a tributary glacier of Gangotri glacier.

Objectives

- To attempt the quantification of discharge and sediment load of melt water stream of Thelu glacier, a tributary glacier of Gangotri glacier.
- To evaluate role of tributary glaciers in temporal distribution of the suspended sediment load of the Gangotri glacier and its relationship with melt water discharge.
- To monitor the recession rate of tributary glaciers of Gangotri i.e. Raktavarn, Thelu and Chaturangi glaciers.
- To evaluate the sediment source area, production mechanism and transport pathways of the sediment load of the glacier.

Achievements

- Melt water plays a definite role in the sliding process and it acts as an agent of sediment transport. During the entire monitoring period of 2008 the average daily discharge of Gangotri glacier was 15.25m^3/s. The maximum discharge was observed as 60.36 m^3/s in July, and minimum value of 6.74 m^3/s was recorded during the month of September (Fig.5). The total discharge

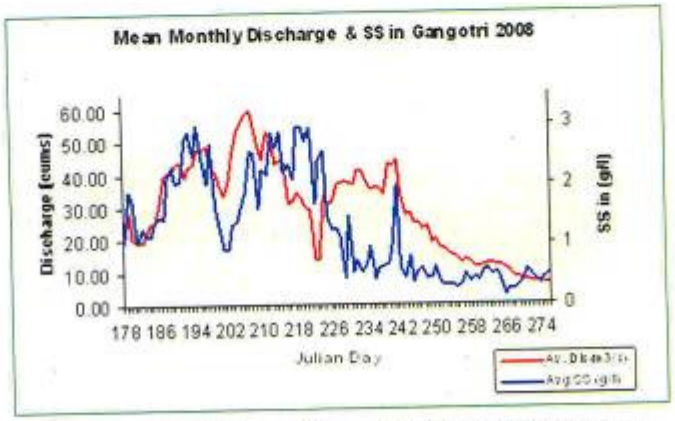


Fig. 5. Mean daily Discharge and Suspended Sediment of Gangotri glacier.

volume observed in the entire monitoring period of Gangotri glacier was 254.62 x10^6 m^3, which is lower than also to last year. It indicated lower melting rate in recent years.

- Glacial melt water streams carry high sediment load due to large supply of sediment by glacial processes. The average suspended sediment (SS) concentration during the monitoring period of 2008 was 1.53 g/l. Maximum and minimum SS concentration were recorded as 3.75 g/l in July and 0.14 g/l in September, respectively.

- Total rainfall in the Gangotri valley was recorded as 126.86 mm, which is lower than previous years. The mean day temperature in June, July, August and September was 9.9, 11.5, 12.4 and 8.2 °C, respectively.

b. Glacier retreat studies in Kumaon Himalaya (2006-2009, Space Applica-tion Centre, Ahmedabad)

Glaciers are important cryospheric indicators for climate change in the Himalayan context. Glaciers are retreating globally and Himalaya is no exception. Glaciers control summer flow in major rivers of the North India. The retreat of these glaciers can have direct impact on the flow of these rivers both in short and long term. In Kumaun Himalaya, the distribution of simple and compound glaciers in Goriganga and Dhauliganga valleys is not uniform. The elevation of the basins varies from 600-6600 meters from the sea level. The study of glacier retreat is undertaken in Sikkim and Kumaun Himalaya in collaboration with Space Application Centre, Ahemadabad. The digital map for important glaciers has been prepared as a base map which will be utilised for Glacier retreat monitoring in future.

Objectives

- To determine the retreat of Dhauliganga ganga and Gori ganga basin glaciers in Kumaon Himalaya.

Achievements

- Identified and mapped 26 glaciers in Goriganga basin and 104 in Dhauliganga basin from LANDSAT, TM data of 1990 and Indian Remote Sensing Satellite data of 2005. For this on-screen digitization of the glacier boundaries was done to map the glaciers of Goriganga and Dhauliganga basin.

- The total area covered by glaciers in Goriganga basin is 272.02 sq.km and 261.48 sq.km in 1990 and 2005, respectively. The total area covered by glaciers in Dhauliganga basin is 362.44 sq.km in 2005.

- A field expedition was organized to Dhauliganga basin in September 2008 for monitoring of snouts, crevasse, snow cover, etc. The Baling glacier (N 30° 11' 48.3" and E80° 32' 26", altitude 3420 m), Neola glacier (N 30° 13' 59.1" and E 80° 30' 10.7", altitude 3440 m) and Nagling glacier (N 30°09'27.02" E and 80°31'13.16", altitude 3410 m) (Fig. 6) were marked for future studies.

Fig. 6. Snout of Nagling glacier

c. Snow and glacier Studies in Sikkim Himalaya (2006-2009, Space Application Centre, Ahmedabad)

Snow and glacier cover is an important natural resource in the Himalayas. Valley glaciers, particularly over the Himalayan region are much sensitive to climate change. The morphology of the glaciers (e.g. ice volume, thickness, length, width) is determined by the balance between accumulation of ice or snow and its rate of melting, calvation and evaporation. The major parameters affecting the balance between glaciers are temperature, precipitation, humidity, wind speed and albedo i.e. why snow and glaciers have an important feedback effect on regional climate. The distribution of simple and compound glaciers in Teesta Valley is not uniform and they lie in various sub-basins of Teesta. Their number varies from one basin to another, but it depends on the amount of precipitation and the deposition that takes place at the time of accumulation. The glacier has two zones i.e. an accumulation and an ablation zone. The line separating the two zones is called the equilibrium line. It is permanent snow that leads to the formation of glaciers. They are sensitive indicators of climate change within a time span, growing and wasting in response to changes in temperature and amount of snowfall.

Objectives

- To monitor snow cover using AWIFS data using NDSI algorithm.
- To determine the retreat of glaciers of Teesta basin using high resolution Satellite data available in the last 10 years.

Achievements

- Identified and mapped 57 glaciers in Teesta basin, from Indian Remote Sensing Satellite data of 1997. Total area of the glaciers was about 403.20 km^2 in 1997.
- Snow cover map of Sikkim has been prepared from Indian Remote Sensing Satellite data (IRS-1C-LISS III) of 2004 and the total snow cover area has been calculated as 1094.85 sq. km. (Fig. 7).
- Glacier index map of Sikkim has been prepared with their numerical ids using the LANDSAT, TM, digital data of 1990 (Fig. 8).

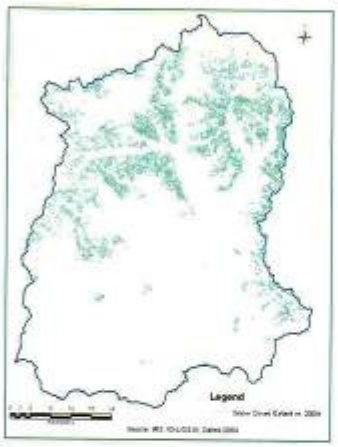


Fig. 7. Snow Cover map of Sikkim

Fig. 8. Glacier Index map of Sikkim

Disaster Management Faculty-Sikkim (2003-2012, National Institute of Disaster Management (NIDM), Ministry of Home Affairs Govt. of India, New Delhi)

Disasters like earthquakes, landslides and floods are regular features causing vast losses of life, property and livelihoods. They are the consequence of various geophysical characteristics and the related social situations that are subjected to a hazard. These events are location dependent in the sense that a hazard is aggravated by the geology, topography and land cover at the location of the hazard. These events aggravate natural environmental processes to cause disasters to human society such as sudden tectonic movements leading to earthquakes. It might be mentioned that environmental disasters are always viewed in terms of human beings. The intensity of environmental disaster is weighed in terms of the quantum of damage done to the human society. Being one of the youngest folded mountain ranges in the world, the subterranean Himalayas are geologically very active. Subsequently, the Himalayan frontal is one of the most seismically active regions in the world. Landslides are among the mainly expensive, harmful natural hazards in mountainous regions, triggered mainly under the influence heavy rainfall and earthquakes or their cumulative effect. Awareness plays an important role to cope up with disasters. In view of the increase in disaster events, it in felt that the awareness among all levels of our society is very much needed. The introduction of D.M. Faculty is an urgent present day need.

Objectives

- Training and Awareness generation
- Research studies
- Documentation
- Development of data base

Achievements

- Developed Training modules and leaflets.
- Training programs for various levels of stake holders in the state (Fig. 9). Total training organized is 14 covering 2449 participants from the state.
- Documentation/data collection various related departments and update the existing informations.
- Survey of the disaster triggered in the state.

Fig. 9. Training programme on earthquake prevention in the school

Energy use pattern in rural domestic sector of Uttarakhand State – Issues, Options & Challenges (2007-2012, In-house)

Use of energy is an essential key in the functioning of human society. Nature and availability of energy determine pace of development and magnitude of many global processes (changes in forest cover and habitat alteration, land production and degradation, climate change, and politics of fossil fuel). More than half of the world's population lives in rural areas, nearly 90% of them in the developing countries, dependent on the traditional fuels often using primitive and inefficient

technologies. Rural domestic energy requirements are mainly for cooking, lightning, and space heating. Thus, in addition to affluence as a variable, geography also plays a crucial role in energy use and associated processes. Increasing demand of the growing rural population has put additional pressure on the local resources. Wide variety of energy resources and their highly site-specific and variable nature, coupled with different types and qualities of energy needs, pose a challenging problem in the designing of an integrated planning and management system. This study will build synergy between the local options and governmental efforts, and is expected to highlight socio-economic and environmental benefits of various energy options. Providing mechanism for integration of rural energy requirement and convergence of incentives with other development factors for better implementation of energy management is expected.

Objectives

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

Achievements

- Half of the rural households (50.3%) in the State of Uttarakhand use electricity among various energy options for lighting purpose, followed by kerosene oil (46.7% of the total rural households). Use of solar energy for domestic lighting in rural areas of Uttarakhand is highest among all the Himalayan states.
- Domestic sector of Uttarakhand state utilizes 30% of the gross electricity generated (2005-06). Rural electrification programme under Rajiv Gandhi Mission has gained momentum and after the year 2000, more than two thousand villages have been electrified which expands the electrification programme to 93% of the total villages in the Uttarakhand State. Major part of rural electrification is done by Uttarakhand Power Corporation Limited (96.6% of the total inhabited revenue villages in the State) while 497 villages have been covered by Uttarakhand Renewable Energy Development Authority (3.4% of the total electrified villages in the State).
- Use of renewable energy for lighting is being done by the different generation technologies of micro hydro or solar photovoltaic technologies. State has recently implemented (2008) a policy for harnessing renewable energy sources with the involvement of private sector/community participation which targets power generation as well as power conservation.

Fig. 10. Transportation of LPG Cylinder is a big constraint in popularization.

- Among the cooking energy options, LPG is in demand but initial investment and recurring costs are high. State has launched a scheme for BPL families by providing assistance in procuring primary infrastructure such as stove and cylinder for promoting use of LPG, however, availability is a constraint in its popularization (Fig. 10). Decentralized mode of distribution through market channels, even at rural markets/service centres will be an efficient mechanism in switching over to LPG from traditional fuels like firewood.

Exploration, diversity, and mapping of vegetation in the urban forests of Kumaun Himalayan towns using Remote Sensing & GIS (2008-2011, Ministry of Environment & Forests, Govt. of India, New Delhi)

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

Objectives

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

Achievements

- Various maps of two towns viz., Almora and Nainital procured from different agencies (e.g., 1:10,000 from Survey of India, urban area boundary maps showing different wards from Municipality Offices), have been georeferenced in GIS.
- Tree diversity (natural & planted trees) in urban vegetation of Almora town included 24

families, 33 genera and 50 tree species, and may be grouped into the following categories- Native of natural vegetation (11 species), Fodder (5 species), Fruit (20 species), Ornamental (6 species) and others (8 species).

- Nearly one-fourth of the total number of tree species were trees of surrounding natural vegetation. Remaining tree species were planted for different purposes. Most of the cultivated tree species were fruit trees (nearly half of the total cultivated species).

- Built up area of Almora was further categorized into different spaces - Residential (governmental and private), Institutional Premises (educational/ professional/ government offices), and Public Open Spaces (park/along roads and drainage channels). Total tree diversity was higher in the premises of individual houses then in Educational institutes. Among the distribution of tree species in the different premises (attributed by use and ownership) most of the species occurring in the town of Almora were represented in the premises of privately owned houses (41 species out of total 50). Almost all the fruit tree species occur in these individual houses (private space owned by individuals) followed by Government offices (Fig. 11).

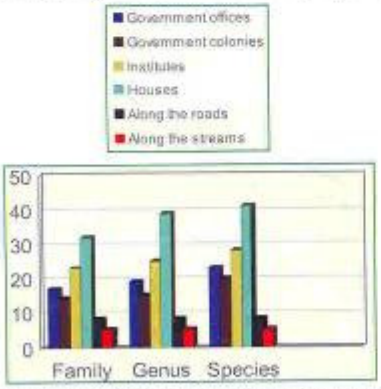


Fig. 11. Tree diversity in different ownerships of Almora town area.

Nematode diversity in the traditional agro ecosystem of central Himalaya, their impact on soil health, crop growth and development of demonstration model for agro-ecotourism (2007-2012, In-house)

The neglect of traditional food crops has weakened the household nutrition security system of the hill people. It has also prevented the Himalayas from becoming the home of health foods of the future. Cultivation of traditional food crops opens an opportunity for building a dynamic eco-food industry. Nematodes are important mineralizers in systems poor in nitrogen, approximately 40% of total mineralization in certain ecosystem is due to grazing of microbial populations by nematodes and other soil fauna. Information on soil nematode diversity and their role in the traditional cropping system is fragmentary. The gap for promotion of traditional cropping system needs to be filled for sustainable development. Developing an understanding of fluctuations in nematode diversity and nitrogen mineralization is desirable for exploiting the supply of nutrients that might become available for crop use.

Objectives

- To examine the nematode diversity in the traditional agro ecosystem across the year under different cropping combination.

- To analyse the relationship of the nematodes with soil health (nitrogen dynamics) under different cropping combination.

- Identification/creation/conversion of the above experimental site into a demonstration site for agro ecotourism by growing different crop combinations under traditional cropping and farming practiced in central Himalaya, nematode diversity, traditional field implements, food, nutrition and medicinal properties etc.

Achievements

- The soil at the experimental site at Pipalkoti, (altitude 1233masl, lat. 30° 25'N and long. 79°25'E) across the treatments at the beginning of *kharif* season was acidic in nature with pH ranging from 6.2 to 6.7, it is sandy loam with bulk density of 0.98 gcm^{-3}. Moderate water holding capacity of 34 to 39%, and low moisture retention capacity 14.9 to 18.5%. The soil is poor in organic carbon content ranging from 0.28 to 0.60%. Total nitrogen is only 0.06%.
- At the beginning of the experiment the major part of mineral N was found in ammonium form (7 to 7.96μg g^{-1} dry soil). Nitrification was low with an average of 0.22 to 1.82μg g^{-1} mol^{-1} dry soil (Table-4).
- Nematode population count per 100g soil ranged from 137 to 219 (Table-4) which declined at the end of Rabi season, probable reasons being low temperature and low soil moisture. At the end of Rabi season nematode population was found in the range of 94 to 110 per 100g soil (Table-5). Soil from mustard plots showed lowest nematode population probably due to allelopathic effect from mustard root exudations.
- Identification of nematodes into five feeding groups has been completed. The major players in the decomposition cycle namely the bacteriovores constituted 34% followed by fungivores 30% which indicated a healthy soil condition.

Table 4: Soil biochemical characteristics at the beginning of *Kharif* season. Treatments are Paddy sole cropping (Paddy SC), Paddy: Foxtail millet cropped in the ratio of 4:2, 3:3, and 2:4 and Foxtail millet sole cropping (SC). Values are mean ± 1SE, n=15.

Parameters	Paddy SC	Paddy Foxtail 4:2	Paddy :Foxtail 3:3	Paddy :Foxtail 2:4	Foxtail SC
Total N (%)	0.06±0.34	0.06±+0.004	0.06±0.003	0.05±0.004	0.06±0.005
Olsen P (%)	0.03±0.008	0.05±0.009	0.03±0.003	0.04±0.008	0.04±0.009
K (%)	0.65±0.37	1.12±0.45	0.95±0.29	0.86±0.11	0.84±0.08
Organic Carbon (%)	0.28±+0.02	0.35±0.56	0.32±0.002	0.31±0.01	0.33±0.04
Organic Matter (%)	0.48±0.04	0.60±0.10	0.55±0.004	0.53±0.02	0.57±0.07
Ammonium N (μg g^{-1} dry soil)	7.76±0.15	7.96±0.35	7.01±0.22	7.00±0.06	7.20±0.24
Nitrate N (μg g^{-1} dry soil)	0.75±0.06	1.06±0.07	0.75±0.15	0.75±0.05	0.06±0.06
Mineral N (μg g^{-1} dry soil)	8.52±0.11	9.02±0.42	7.76±0.20	7.75±0.11	7.80±0.31
Nitrification (μg g^{-1} mo^{-1})	1.82±0.02	1.40±0.16	1.45±0.24	0.22±0.01	1.58±0.08
N-mineralization (μg g^{-1} mo^{-1})	16.41±0.58	13.52±0.01	15.65±0.71	11.60±0.71	13.88±0.12
Nematode abundance per 100g soil	219±3.83	160±2.18	210±3.61	137±1.36	209±3.49

Table 5: Soil biochemical characteristics at the beginning of *Rabi* season. Treatments are Wheat sole cropping (Wheat SC), Wheat: Mustard cropped in the ratio of 4:2, 3:3, and 2:4 and Mustard sole cropping (SC). Values are mean ± 1SE, n=15.

Parameters	Wheat SC	Wheat:Mustard 4:2	Wheat:Mustard 3:3	Wheat :Mustard 2:4	Mustard SC
Total N (%)	0.05±0.009	0.06±0.02	0.06±0.016	0.07±0.007	0.06±0.013
Olsen P (%)	0.04±0.01	0.03±0.01	0.03±0.001	0.04±0.01	0.04±0.003
K (%)	1.08±0.27	1.1±0.20	0.77±0.4	1.13±0.19	1.5±0.34
Organic Carbon (%)	0.43±0.01	0.46±0.009	0.51±0.02	0.49±0.15	0.48±0.04
Organic Matter (%)	0.74±0.02	0.79±0.16	0.88±0.04	0.86±0.03	0.82±0.06
Ammonium N (μg g^{-1} dry soil)	7.7±0.44	3.3±0.25	6.41±0.83	4.4±0.08	11.36±1.22
Nitrate N (μg g^{-1} dry soil)	0.09±0.43	1.61±0.60	0.71±0.11	1.54±0.10	2.27±0.15
Mineral N (μg g^{-1} dry soil)	8.53±1.03	4.91±0.70	7.13±0.78	5.94±0.73	13.64±1.13
Nitrification (μg g^{-1} mo^{-1})	1.02±0.17	1.01±0.36	0.77±0.26	0.58±0.12	0.77±0.26
N-mineralization (μg g^{-1} mo^{-1})	5.18±1.33	2.36±0.35	5.55±0.23	4.09±2.23	3.59±0.07
Nematode abundance per 100g soil	110.3±4.8	106.33±4.4	102±3.78	99±4.04	94±2.6

Soil Nitrogen Dynamics in relation to quality and decomposability of plant litter traditionally used as manure in the central Himalaya (2007-2010, Department of Science & Technology, SERC, Govt. of India, New Delhi)

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

Objectives

- To assess concentration of N, C, lignin and total phenolics and the C/N ratio in senesced leaves as indicators of litter quality of five plant species traditionally used as manure.
- To compare N and organic C concentration, rate of N-mineralization, nitrification and microbial biomass C, N, flush in the soil

amended with the five litter manure under paddy (*Oryza sativa*) and wheat (*Triticum aestivum*) cropping systems.

Achievements

- The soil pH content across the three sites ranged from 6.4 to 7.08. Soil moisture ranged from 14.87to 23.25% and water holding capacity ranged from 30.76 to 36.86%. The soil was moderately fertile with organic carbon ranging from0.84 to 1.21% and Total N 0.09 to 0.12%. Nitrogen mineralization ranged from 7.26±0.52 to 2.72±0.34 μg g^{-1}dry soil $month^{-1}$. After initial assessment of soil characteristics five litter species were collected from nearby forest, allowed to decompose for six months in pits and then applied at the rate of 2kgm^{-2} (Fig.12).
- Quality of fresh litter before placement of litter bags were assessed for their C and N content and their C:N ratio. The C:N ratio for the litter were as follows: *Quercus* 17.6, *Lyonia* 20.6, *Rhododendron* 23.3, *Pyrus* 21.9, *Pinus* 33.5 (Table-6). Usually plant material with C:N ratio of <20 mineralize faster than those exceeding the limit. So based on only C:N ratio the litter nutrient release efficiency may be ranked as *Quercus*>*Lyonia*>*Pyrus*>*Rhododendron*>*Pinus*. Lignin and total phenolics estimation is in progress.

Table 6: Concentration of Organic Carbon (%), Total Nitrogen (%) and C: N ratio in senesced leaves as indicators of litter quality of five plant species traditionally used as manure

S. No.	Name of Litter species	Organic C (%)	Total Nitrogen (%)	C:N ratio
1.	*Quercus leucotrichophora* (Banj)	32.04=1.21	1.82+0.06	17.6
2.	*Lyonia ovalifolia* (Aiyar)	37.55=0.66	1.75+0.01	20.6
3.	*Rhododendron arboreum* (Burans)	38.85+0.59	1.67+0.06	23.3
4.	*Pyrus pashia* (Melu)	38.49+1.91	1.61+0.02	21.9
5.	*Pinus roxburghii* (Chir)	46.57+1.35	0.39+0.06	33.5

Fig. 12. Five litter species were collected from forest floor dcomposed in pits and applied to the plots at the rate of 2 kgm^{-2}

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 strengthen the practices and create potential for enterprises, which, in turn leads to economic upliftment and growth of the society. In India, traditional health care practices, particularly use of medicinal herbs for healing is a practice since times immemorial. Such practices still exist in rural areas as they are inexpensive, culturally familiar and readily available. However, due to excessive removal of herbs from the 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 majority of traditional health care practitioner (THCP), locally called *vaidyas*, are found in remote rural areas and have great utilities to the community in absence of modern health services. The *vaidyas* use largely medicinal herbs for preparation of formulations and treatments.

Objectives

- Documentation of traditional health care practices,
- Documentation of plant species used in traditional health care practices,
- Documentation of IK of practices, processes, knowledge and resources use in traditional health care practice,
- Assessment of status of herbs used by the traditional herbal healers in the wild,
- Evaluate present status of traditional health care practiceners,
- Identification of possible IPR value.

Achivements

- About 53.67±4.05% households of the 10 villages of Upper Alaknanda valley were surveyed for traditional therapies used in the area. About 50.62% people admitted that traditional *vaidya* system was a cheap easily available, system of therapy. It is followed by *ojha/ pujari* system (24.14%), allopathy (9.10%) and both the traditional *vaidya* and *ojha/pujari* systems (8.22%).
- Nearly 27.51% respondents were satisfied with treatment of traditional *vaidya* system, *26.93%* were satisfied with *treatment of ojha/ pujari* system, 25.12% were satisfied with treatment of both the traditional *vaidya* and *ojha/pujari* systems, 15.34% were satisfied with allopathy and only 5.03% respondents were satisfied with treatment of naturopathy. On an average 42.61% respondents had faith in traditional *vaidyas* (Fig. 13).

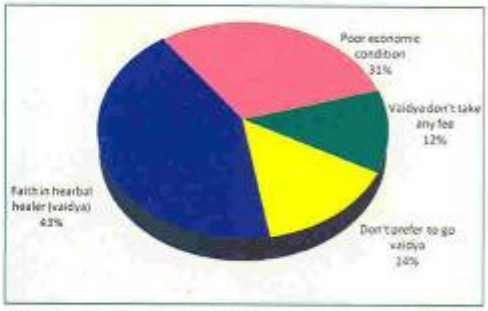


Fig. 13. Acceptance of traditional vaidya system in rural areas of the Upper Alaknanda valley

- Study of various herbal formulations used for treatment of various ailments such as cough and cold, cough, fever, gastroenteritis, leucorrhoea, jaundice, rheumatism, *khusa* disease (hair fall) heart trouble, boils on skin, pneumonia and various ailments of cattle

such as *khurpaka*, galghontw and urinary bleeding suggests that a large number of formulations for treatment of the same ailment were common in the different villages of the study area but a few were totally different, from one antoher in certain villages.

- Total 154 herbs species used by traditional vaidya, traditional *ojha/pujari*, naturopath and village man and woman for day to day treatments have been documented. Some of the herbs such as *atis* (*Aconitum heterophyllum*), *balchor/laljadi/nayanjot* (*Arnenia benthamii*), *choru* (*Angelica glauca*), *kuth* (*Saussurea costus*), *kutki* (*Picrorhiza kurrooa*), *kalimusali* (*Curculigo orchioides*), *pashanbhed/silphoru* (*Bergenia ciliata*), *Salam misri* (*Satyrium nepalense*), thuner (*Taxus baccata subsp. Wallichiana*), timur (*Zanthoxylum armatum*) and *ban kakri* (*Podophyllum hexandrum*) were of commercially high value and ecologically rare medicinal plants.

Theme

BIODIVERSITY CONSERVATION AND MANAGEMENT (BCM)

Understanding the magnitude of biodiversity at gene, species and ecosystem levels is crucial for ensuring its sustainable use and long term management. The scale of investigation is immense and considerable investments are required to bridge existing knowledge gaps and also to transform available information in to knowledge products. As such, recognition and characterization of biodiversity largely depends on genetic, taxonomic, and ecological studies. Among others, the long-term research sites and programmes provide essential information on trends of biodiversity change across spatial and temporal scales. Assessment of intensity of these changes is important while delineating impacts of anthropogenic and natural processes. In particular, human induced activities have been identified amongst most critical factors for biodiversity loss and global climate change. All these have necessitated the need for inventory preparing and monitoring of biodiversity at different levels and climatic regimes. Besides, biodiversity conservation measures such as establishment and maintenance of live repositories in different climatic zones will help in ensuring quality planting material for the promotion of conservation programmes, and enhancement of the capabilities of the stakeholders at local, regional, state and national levels to manage and disseminate information on the subject. The studies conducted in the BCM theme are in tune with the above. Realizing the importance of biodiversity for sustainable development and environmental conservation, the Biodiversity Conservation and Management (BCM) group envisages the objectives: to assess, valuate, prioritize, map and monitor biodiversity of the protected and unprotected areas at gene, species and ecosystem levels across the IHR for understanding the status, availability, potential and patterns; to evaluate response of Himalayan biodiversity under changing climatic conditions across the IHR; to develop packages of practices for maintenance and optimal use of sensitive biodiversity components and improvement of bio-resource based livelihood options for indigenous communities; to establish and maintain live repositories (Arboreta, Herbal Gardens, Nurseries, etc.) in different agro climatic zones across the IHR for ensuring the availability of quality planting material; to sensitize diverse stakeholders and building partnerships to develop and demonstrate best practices of management and optimal use of biodiversity components

Response Assessment and Processing of Knowledge Base to Serve Long-term Management and Use of Biodiversity in the Himalaya - Focus on representative protected sites (2007-2012, In-house)

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

Objectives

- Synthesis and use of information on biodiversity components of selected areas.
- Investigations on recruitment trends and compositional patterns of forest communities along altitudinal gradient.
- Understanding use patterns of resources by the inhabitants.
- Identify and prioritize human wildlife conflicts.
- Study the grazing competition among livestock and wild ungulates.
- Determine the livestock depredation and retaliatory killing of wild carnivores.
- Identify threat categories of the biodiversity.
- Suggest policy interventions with a view of general applicability; and drawing comprehensive biodiversity management plan(s) for alternative scenarios

Achievements

Nanda Devi Biosphere Reserve (NDBR), Uttarakhand

- In order to detect changes in forest biodiversity components over two decades, extensive field survey were conducted in identified Pindari region of NDBR (2050-3000 m amsl). A total of 11 forest communities across 18 stands were identified and assessed following standard phytosociological methods. Preliminary comparative results of tree species richness patterns over time are depicted (Fig. 14).
- Over 294 field specimens of plural elements have been collected and are in the process of authentic identification. Among others, discovery of one new species namely *Arnebia nandadeviensis* Chandra Sek. & Rawal family Boraginaceae (Fig. 15) and a new record for Uttarakand, *Avena fatua* L. subsp. *meridionalis* Maiz. family Poaceae, deserve special mention.
- Three high altitude watersheds, namely Sunderdhunga, Pindari and Kafni, were explored extensively for floristic diversity patterns in alpine zone (3200-4000 m). While species diversity patterns varied in watersheds, there was a significant decrease of species richness with increasing altitude in general.

Nargu Wildlife Sanctuary (NWLS), Himachal Pradesh

- A total of 52 sites covering 12 habitats were sampled. Results revealed that shady moist

habitat represented maximum (37) sites. Among the 31 communities (Forest 20; Shrubs 3 and Herbs 8), the maximum sites (11) were represented by *Quercus leucotrichophora* community. The total Basal Area (0.2-91.6 $m^2 ha^{-1}$) and total tree density (80-560 Ind ha^{-1}) varied among the communities. The total sapling density across communities ranged from 20-830 Ind ha^{-1}, seedlings 50-1080 Ind ha^{-1} and shrubs 400-5330 Ind ha^{-1}.

- While analysing species diversity, tree-diversity ranged from 0.15-1.78 and the maximum species diversity was recorded in *Picea smithiana-Rhododendron arboreum* mixed community. Similarly, saplings diversity ranged from 0-1.76, seedlings 0.33-1.96, shrubs 0.72-3.31 (Fig. 16).
- Across communities, a total of 15 species were found under different categories of threat (Table-7).

Khangchendzonga Biosphere Reserve (KBR), Sikkim

- Resource surveys in buffer zone/fringe villages were KBR targeted. Use patterns of ethnomedicinal plants the western part of KBR were assessed. Phytosociological studies (with geo referencing) along six major sites (1700-2400m) were conducted. The Entire zone (24 sites; 240 plots) was analyzed for 75 woody plant species. Ericaceae (18 sps) emerged as dominant family. Highest plant density (36630 Ind ha^{-1}) and highest seedling density (27320 Ind ha^{-1}) was recorded for site 19, and highest sapling density from site 4 (9600 Ind ha^{-1}). Significant variation in species richness ($r = -0.891$; $p<0.0001$) was observed along different distribution altitudes (Fig. 17). In site 19, *Acer campbelli* (2 11200 Ind ha^{-1}) and *Prunus nepalensis* (48700 Ind ha^{-1}) showed high recruitment density.
- Based on stakeholders' demand, field training workshop, 'Biodiversity Conservation and Livelihood Options in Khangchendzonga Biosphere Reserve' was organized at U. Dzongu (north Sikkim), especially targeting high value medicinal plants. Over 60 stakeholders (villages, farmers, EDCs, NGO, Panchayat members, forest officials) participated.
- As per stakeholders' consultation and based on primary studies/survey, a comprehensive Brochure on 'Tholung-Kisong' eco-trek in Dzongu landscape, in KNP/KBR was developed and published.

Table 7: Species under different threat categories in Nargu WLS, HP

Critically endangered	Endangered	Vulnerable
Aconitum heterophyllum	*Angelica glauca*	*Rhododendron campanulatum*
Malaxis muscifera	*Cinnamomum tamala*	*R. lepidotum*
	Dioscorea deltoidea	*Polygonatum verticillatum*
	Polygonatum cirrhifolium	*Rheum australe*
	Paris polyphylla	*Valeriana jatamansi*
	Taxus baccata subsp. *wallichiana*	*Hedychium spicatum*
	Zanthoxylum armatum	

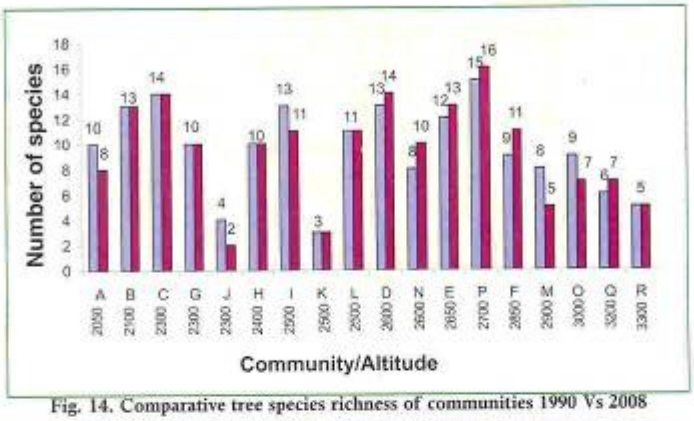


Fig. 14. Comparative tree species richness of communities 1990 Vs 2008

Fig.15. *Arnebia nandadeviensis* along with associated plants

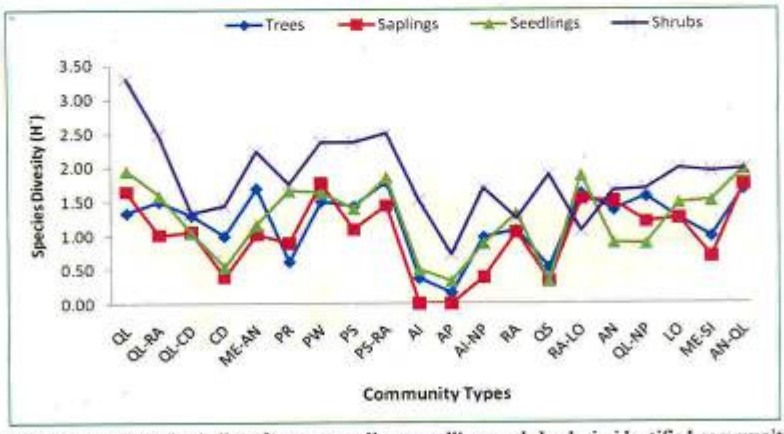


Fig. 16. Species diversity indices for trees, saplings, seedlings and shrubs in identified communities

Abbreviations used: QL=*Quercus leucotrichophora*; QL-RA=*Quercus leucotrichophora-Rhododendron arboreum*; QL-CD=*Quercus leucotrichophora-Cedrus deodara*; CD=*Cedrus deodara*; ME-AN=*Myrica esculenta-Alnus nitida*; PR=*Pinus roxburghii*; PW=*Pinus wallichiana*; PS=*Picea smithiana*; PS-RA=*Picea smithiana-Rhododendron arboreum* mixed; AI=*Aesculus indica*; AP=*Abies pindrow*; AI-LU=*Aesculus indica-Neolitsea pallens*; RA=*Rhododendron arboreum*; QS=*Quercus semecarpifolia*; RA-LO=*Rhododendron arboreum-Lyonia ovalifolia*; AN=*Alnus nitida*; QL-NP=*Quercus leucotrichophora-Neolitsea pallens*; LO=*Lyonia ovalifolia*; ME-SI=*Myrica esculenta-Sapium insigne*; AN-QL=*Alnus nitida-Quercus leucotrichophora*.

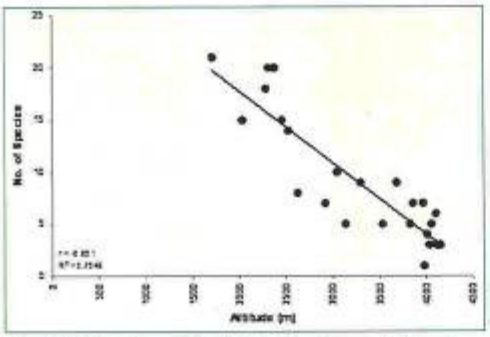


Fig. 17. Woody species distribution along altitudes in South-West KBR (W. Sikkim)

Conservation and sustainable utilization of medicinal plants in Himachal Pradesh, North Western Himalaya (2007-2012, In-house)

The Himalayan Region has been identified as one of the richest habitats for medicinal plants. In the region, most medicinal plants are being extracted for drugs, pharmaceutical industries and oils. Majority of the medicinal plants are also used in Ayurvedic, Unani, Tibetan and other traditional systems of medicine. With the increasing world demand and renewed global interest in traditional ethnopharmacy coupled with the increasing preference for natural substances in health care systems, the natural stock of medicinal plants of Indian Himalayan Region (IHR) is under tremendous pressure. Himachal is being seen as a herbal state and medicinal plants as a major source of income generation for the inhabitants. The Kullu and Lahaul & Spiti districts of the State are rich in medicinal plant diversity with plenty of scope for the promotion of medicinal plant cultivation and conservation. An integrated study on conservation and sustainable utilization of the medicinal plants has not been carried out so far. Therefore, the Upper Banjar Valley (1,500-3,600), Mohal Khad Watershed (1,200-3,000m); Parbati Watershed (1,100- 6,500m) and Upper Beas Valley (2,300- 5,000m) in Kullu district and Chandra Valley (3,300-5,000m) in Lahaul & Spiti districts have been selected to conduct studies on conservation and sustainable utilization of medicinal plants.

Objectives

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

Achievements

- Populations of threatened medicinal plants (09 – Critically Endangered; 16 Endangered and 14 Vulnerable) were assessed in different watersheds. In the Mohal Khad watershed the mean relative density of *Podophyllum hexandrum* was 0.01%, *Polygonatum verticillatum* 0.12%, *Rhododendron arboreum* 5.43%, *Valeriana jatamansi* 2.63%, *Taxus baccata* subsp. *wallichiana* 1.54% and *Zanthoxylum armatum* 17.45%; and in the Upper Banjar Valley, the mean relative density of *Angelica glauca* was 0.03%, *Bergenia stracheyi* 0.89%, *Paris polyphylla* 0.76%, *Polygonatum multiflorum* 0.09%, *Polygonatum verticillatum* 1.02%, *Taxus baccata* subsp. *wallichiana* 4.2%, *Valeriana jatamansi* 1.59%, *Rhododendron arboreum* 0.93% and *Zanthoxylum armatum* 6.12%.

- Germination trials for seeds of three populations of *Hippophae rhamnoides* subsp. *turkastanica* was carried out in different conditions. Pre-sowing treatments of KNO_3 and $NaHClO_3$ showed maximum germination (Fig. 18).

- Seeds of 27 medicinal plants were collected and sown in the nurseries at Mohal and Kasol and the herbal gardens at Mohal and Doharanala, & the seed germination was monitored. Over 5200 seedlings/plantlets of different medicinal plants were developed, planted and distributed among stakeholders at Doharanala, Kasol and Mohal

- A three day training programme on Medicinal plant cultivation and conservation was organized to train participants of Malana village. Another training programme on Medicinal plants conservation and cultivation was organized for participants of Kullu and Lahaul Valley.

Up-scaling applicability of *ex-situ* mechanisms for conservation and utilization of high value plant species –focusing on promotion of conservation education & capacity buildings (2007-2012, In-house)

The Indian Himalayan Region occupies a significant position on the earth due to its rich and socio-economically important biodiversity. 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

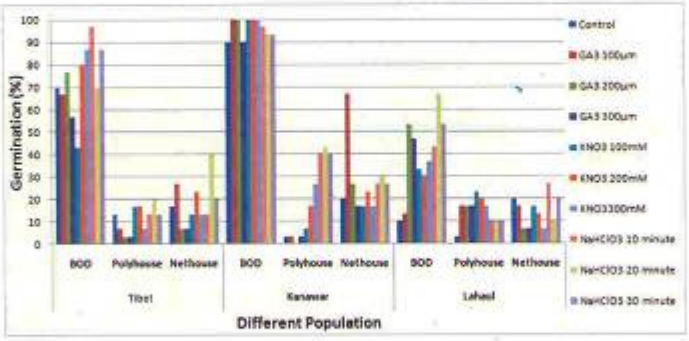


Fig. 18. Seed germination of *Hippophae rhamnoides* subsp. *turkastanica* in different conditions

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. In addition, there is a need to integrate the Conservation Education and promotion of ex-situ mechanisms of conservation and use to up-scale the applicability for effective utilization of high value species.

Objectives

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

Achievements

Uttarakhand –Headquarters

- Experiments on Micropropagation of *Hedychium spicatum,* conducted at Kosi-Katarmal, revealed that single nodal segment can produce 6 shoots/explants in MS medium supplemented with BA and NAA combination.
- Plant material of *Valeriana wallichii, Habenaria edgeworthii, H. intermedia, Hedychium spicatum, Roscoea procera* from different localities of Uttarakhand were collected and planted in the herbal garden to increase the number of accessions.
- Phytochemical investigation on *Berberis asiatica,* collected during different seasons, revealed that samples collected in summers exhibit significantly ($P<0.01$) higher berberine content as compared to the rainy and winter seasons (Fig. 19).
- In order to disseminate the technology to various stakeholders in ToT mode and to promote outreach through Conservation Education, a seven days Orientation Course and three day Training Workshop was conducted at G.I.C., Kausani (November 4-11, 2008). 47 school children and teachers from 25 schools participated (Fig. 20) in these programmes.

Himachal Pradesh-Himachal Unit

- Seeds of 11 species were sown in the nursery and germination of *Alnus nitida* (10.5%); *Aesculus indica,* (40%); *Fraxinus micrantha,* (26.7%); *Grewia oppositifolia* (30.8%); *Grevillea robusta* (67.5%); *Melia azedarach* (69.0%); *Quercus floribunda* (27.2%); *Quercus lecotrichophora* (40.0%); *Sapindus mukorossi* (16.2%); *Toona ciliata* (53.8%) and *Withania somnifera* (92.0%) was monitored.
- Over 2500 seedlings/plantlets of 13 species were developed for plantation in the arboretum sites and distribution amongst

farmers. Over 2400 seedlings and seeds of 8 species were distributed to different stakeholders namely State Forest Department, farmers, and NGOs.

- 870 seedlings of 23 ecologically and economically important species were planted in the Arboretum sites Pathways were developed and *Cactus monacantha* was planted along the boundary for biofencing to the protection from livestock.
- Fresh seeds of 17 species of trees and shrubs were collected and stored in the laboratory for strengthening the nursery.

Sikkim- Sikkim Unit

- Nursery seedling emergence/plant survival was monitored for 10 multipurpose taxa. After one growing season, plant survival ranged from 3% (*Azedirachta indica*) to 100% (*Michelia excelsa*). High seedling emergence was recorded for *Eryobotrya petiolata* (71%) and *Juglans regia* (79%). Greenhouse raised *Swertia chirayita*, planted in natural habitats/ arboretum and in open beds was monitored. Six populations of *Swertia chirayita* were tested for seed germination after 30 months' storage; 3 populations exhibited about 25%, 2 showed and 01 responded by 3% germination.
- In *Michelia excelsa*, a highly preferred timber, seedlings' growth significantly (between $p<0.05$ and $p<0.001$) differed with age (1 to 4 year; Fig. 21). Stem height very significantly correlated with collar diameter, root diameter and root length ($p<0.001$; $r=0.905$, 0.911 and 0.687, respectively). Stem basal diameter also appeared as important trait assessing seedling quality, which significantly correlated with above parameters ($p>0.001$). Seedlings were transplanted in the arboretum to monitor further survival.
- A two day training workshop, 'Conservation of Biodiversity' was organized for students/ teachers (45 the students/teachers; 14 schools). Feed back received gave greater satisfaction. In addition, a few exposure workshops were arboretum organized for school students in the arbovetuim.

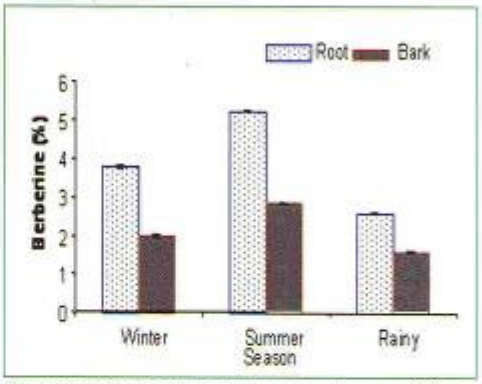


Fig. 19. Variation in Berberine content across different seasons and plant parts of *Berberis asiatica*

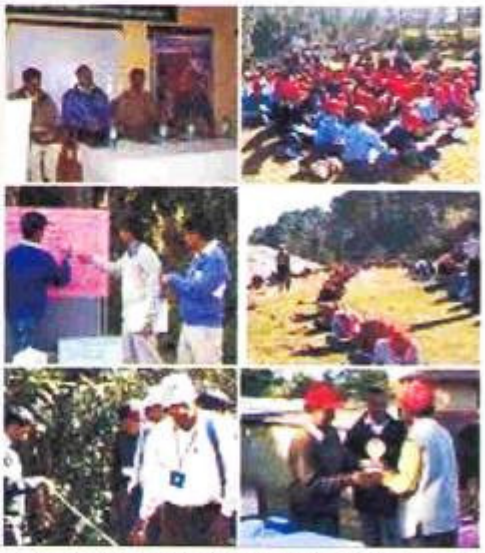


Fig. 20. Various activities during on-site training programme on conservation education

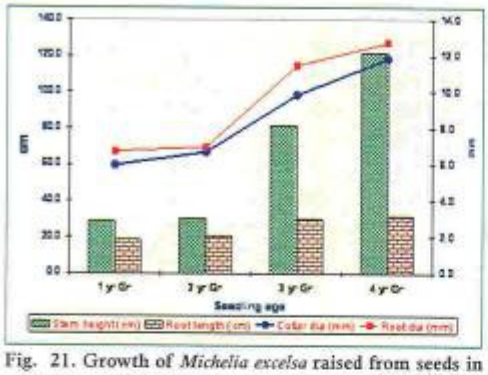


Fig. 21. Growth of *Michelia excelsa* raised from seeds in nursery condition (Sikkim)

Evaluation and propagation of two vitality strengthening Astavarga plants of west Himalaya (2006-2009, NMPB New Delhi)

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 deal with the sustainable utilization of resources. Development of such approaches needs 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 their cultivation are some areas where one can achieve both conservation also sustainable utilization goals.

Objectives

- To analyze the phytochemical properties within and among populations of selected species.
- To develop propagation and storage protocols using conventional as well as biotechnological tools for conservation and sustainable utilization.
- To maintain the accessions of each individual collected from different localities in gene banks.
- To compare the phytochemical properties of wild with cultivated planting material; and maximize the field transfer of plantlets obtained from elite stock.

Achievements

- Phytochemical analysis of samples (tubers) of *Habenaria edgeworthii*, collected from different localities of Uttarakhand, revealed that the total phenolic content varies significantly among populations. Sample collected from Gangolihat showed highest phenolic content (5.31mg/g DW) followed by that of Pithoragarh and Munsyari. The HPLC profile revealed presence of two phenolics of which Gallic acid ranged between 2.95 to 7.61mg/100g DW. However, hydroxybenzoic acid was found maximum in the Munsyari population (8.66 mg/100g DW).
- Towards developing mass scale planting material, callus was induced in *Habenaria*

Fig. 22. Different stages of organogenesis

edgeworthii. Callus pieces (10-20 mg), transferred in MS medium supplemented with different plant growth regulator combinations and concentrations, showed maximum shooting percentage (83.3%) in T6 treatment after 6 weeks, however, number of shoots was found maximum (10.83 shoot callus^{-1}) in T2 treatment (Fig. 22 & Fig. 23).

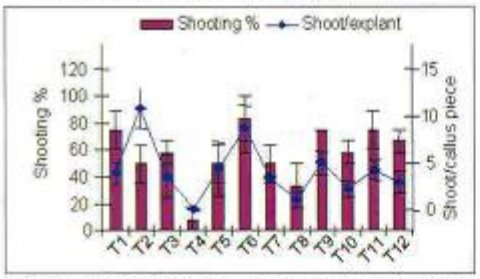


Fig. 23. Effect of different plant growth regulators on shoot multiplication

Population status assessment and screening of active chemical constituents in the selected medicinal plants of Uttaranchal (2007-2010, UCOST)

Medicinal plants are of particular interest because they contain a variety of phytochemicals and biochemicals 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.

Objectives

- To screen selected plants of Uttaranchal for natural source of antioxidants.
- To determine the potential of bioactive ingredients using bioassay methods.
- To address the issues related to conservation and sustainable utilization of these plants in the state.

Achievements

- In order to analyse the antioxidant potential of the *Roscoea procera* rhizome, various bioassay operations were performed. Bioassay using ABTS, DPPH and FRAP assay showed that the species have antioxidant potential and 100 g dry weight is equivalent to 0.649-1.693 mM ascorbic acid (Fig. 24).

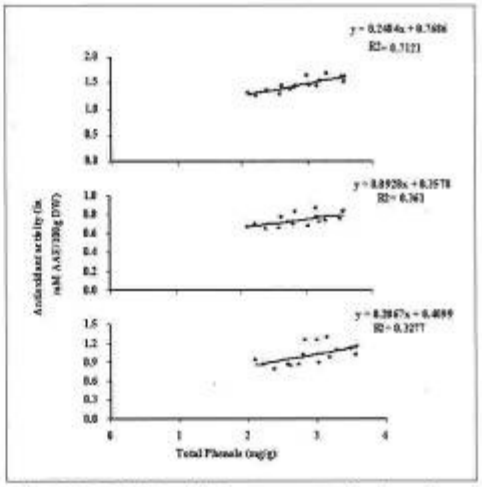


Fig. 24. Relationship between total phenol and antioxidant activity in *Roscoea procera* extract

Meteorological Data Collection, Monitoring, Processing and Analysis to Evaluate Climate Variability in the State of Uttarakhand (2003-2009, DST)

Participation of youth in Real time/field Observations to Benefit the Education in Uttarakhand 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.

Objectives

- To provide an opportunity for participatory learning for school children on mountain meteorology and biodiversity in an integrated manner.
- To inculcate among students excitement of understanding and working on different aspects of natural sciences through their involvement in interactive use of data/ information.
- To establish a network database on Himalayan meteorology and bioresources for effective use by different stakeholders.
- To study local/regional impacts of weather and climate on biological diversity in different parts of IHR.

Achievements

- All the identified U-PROBE schools were interactively involved in regular weather data collection and using these data for interpretations of variations in responses of various bioresources.
- Analysis of weather data collected by the U-PROBE students at Government Intermediate College, Almora revealed variation in minimum and maximum temperature (Fig. 25). A significant ($P<0.01$) decrease and difference on daily maximum and minimum temperature was recorded.

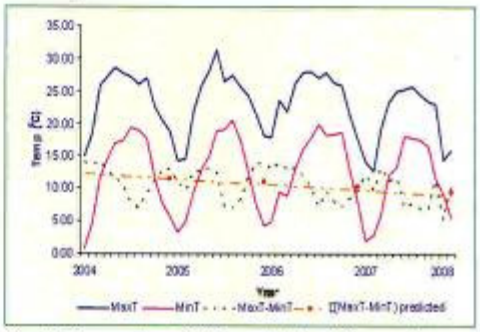


Fig. 25. Temporal variability and daily difference between Maximum and Minimum Temperature

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

Conservation of biological diversity has become a global concern in view of its rapid depletion. The Indian Himalayan Region (IHR) covering approximately 4,19,873 km^2 area, supports representative, natural, unique and socio-economically important floristic diversity. This may be due to unique topography, diverse habitats and large altitudinal range. Due to the dependence of local communities on plant resources for medicine, food (wild edible), fodder, fuel, timber, making agricultural tools, fiber, religious purposes, etc., the population of many economically important plants is depleting fast. Himachal Pradesh which is very well known for its typical topography, large altitudinal range, diverse habitats, representative, natural, unique and socio-economically important biodiversity, is also facing high pressures. Although, the State has been

explored by many workers mainly for its floral, ethnobotanical and faunal diversity, very few studies have been carried out on quantitative assessment of the vegetation. However, studies integrating different components of floristic diversity and prioritization of habitats, species and communities have not been carried out so far. This has necessitated the initiation of biodiversity studies along an altitudinal gradient and the present study has been carried out for the first time on these lines in the State.

Objectives

- To assess plant diversity of the Himachal Pradesh in relation to climate and altitude.
- To assess status and distribution pattern of the native and endemic species in relation to climate and altitude.
- To study the utilization pattern of plant diversity including indigenous knowledge and practices along an altitudinal gradient.
- To identify rarity of the species.
- To prioritize potential sites for conservation and high value potential species for socio-economic development of the local communities.

Achievements

- Distribution of vascular plants among different catchments revealed the presence of maximum 660 species in Hirb and Shoja Catchments (HSCs), 550 in Chail Chowk-Rohanda-Kamrunag Area (CRKA), 255 in Ghanahatti-Shimla forest and 160 in Mandi-Pandoh Area (Fig. 26).
- Regeneration studies in 9 forest communities showed the variation among forest communities. Results revealed that 02 forest communities showed highest regeneration of co-dominant species and 07 mixed forest communities with highest regeneration of one of the dominant species in the HSCs. Similarly, in CRKA, 08 forest communities showed the highest regeneration of dominant species, 06 communities with highest regeneration of co-dominant species and 01 community with poor regeneration of dominant species in Mandi-Pandoh Area.
- In HSCs, 137 species (28 Trees; 33 Shrubs and 76 Herbs including 2 Ferns) belonging to 106 genera and 60 families were identified under different threat categories.

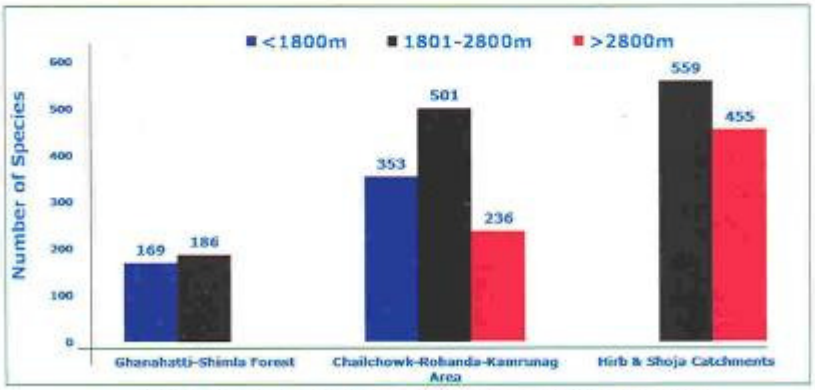


Fig. 26. Altitudinal Distribution of Species in different study areas

Studies on diversity and conservation status of plants in a proposed Cold Desert Biosphere Reserve of Trans and North West Himalaya (2006-2009, MoEF, New Delhi)

In most of the Biosphere Reserves, studies are confined to floristic inventory and ethnobotany, and very few studies on the structural and functional diversity are available. In most cases the available information is fragmentary. It is very difficult to determine the biodiversity status, and develop adequate strategy for the management with fragmentary information. The Cold Desert Biosphere Reserve (CDBR), the potential area for the conservation of Trans and North Western Himalayan ecosystem, is one of the Proposed Biosphere Reserves of the Indian Himalayan Region. Lahaul and Spiti district in Himachal Pradesh form the part of a proposed CDBR. The district lies between 31° 44' 57" to 32° 59' 57" N latitudes and 76°46' 29" to 78°41'34"E longitudes. The inhabitants belong to Indo-Mongoloid and Indo-Aryan groups. They are dependent on the floristic diversity for medicinal, wild edible, fodder, fuel, house building, religious and various other purposes. It supports a representative, unique, natural and ecologically and economically important species. The CDBR has been explored for the flora and ethnobotany by some workers. Studies integrating different components of biodiversity and prioritizing habitats, species and communities have not been carried out so far. This has necessitated to initiate studies on these lines.

Objectives

- To assess the plant diversity of the Cold Desert Biosphere Reserve.
- Community patterns and regeneration status of the tree species; species diversity and similarity in the vegetation of the identified habitats and communities.
- To assess the distribution pattern and status of the native and endemic species.
- To identify the ecologically and economically important species and assess the populations of selected species.
- Identify the rare endangered species.
- Identify the economically important species including medicinal and wild edible plants.
- Assess the populations of the ecologically and economically important species.
- To prioritize habitats, species and communities for conservation of economically important species for the socio-economic development of the Tribal Communities.

Achievements

- A total of 742 species of the vascular plants belonging to 310 genera and 92 families were recorded in Cold Desert Biospheare Reserves. Among these, 29 families were monotypic and Asteraceae (91 spp.) followed by Poaceae (58), Rosaceae (47), Fabaceae (39), Apiaceae (33), Polygonaceae and Ranunculaceae (30 each), Lamiaceae (28), Brassicaceae (24), Scrophulariaceae (24) and Caryophyllaceae (23 spp.) were the dominant families.
- While considered with altitude, the maximum species (30 trees, 69 shrubs and 597 herbs) were recorded at 2801-3800 m asl. Among the 164 sites surveyed, the maximum 18 habitats and 8 aspects were identified between 2400-5200 m asl. Among the 35 plant communities (17 trees; 13 shrubs and 5 herbs), *Juniperus polycarpos, J. communis, Rosa webbiana, Pinus wallichiana* and *Salix fragilis* were found to be distributed with wide altitudinal range.

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

In view of the unprecedented rate of global climate change and its impacts on biodiversity, it is imperative to make young generation aware on these issues. This is possible only if the subject(s) receive due attention right from the schools. To achieve this, there is a great need of making the science, in particular the nature science, related education, interesting and society oriented. However, while considering this we need to incorporate interdisciplinary thinking into it. This can be achieved through an efficient use of the existing infrastructure of formal education. Responding to the need of making science education interesting and useful, Department of Science & Technology (DST) under its Inter-Sect oral Science & Technology Advisory Committee (IS-STAC) took a lead by initiating a scheme on participation of youth in schools for acquisition, generation, use and disseminations of field data. Under the scheme a programme entitled "Participation of youth in Real time/field Observations to Benefit the Education (PROBE)" is being implemented in the state of Uttarakhand. The G. B. Pant Institute of Himalayan Environment & Development (GBPIHED), Kosi-Katarmal, as one of the Technical Resource Centers (TRC), under U-PROBE has been facilitating execution of the programme in the state. The programme was extended to Himachal Pradesh through Himachal Unit in 2008 to educate the students, & teachers and to develop a Technical Resource Centre at Mohal- Kullu.

Objectives

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

Achievements

- Weather laboratories were established and made functional in 22 schools of Kullu, Mandi, Bilaspur, and Hamirpur districts of Himachal Pradesh (Fig. 27).
- The data are being collected/monitored by the identified teachers. Analysis of the data is under progress.

a

b

c

d

Fig. 27 (a-d). Various activities of establishing weather laboratories in different locations of Himachal Pradesh; a. Map showing the locations of weather stations; b-d. Weather stations at Randhara and Bran schools

Summary of Completed Project / Activity

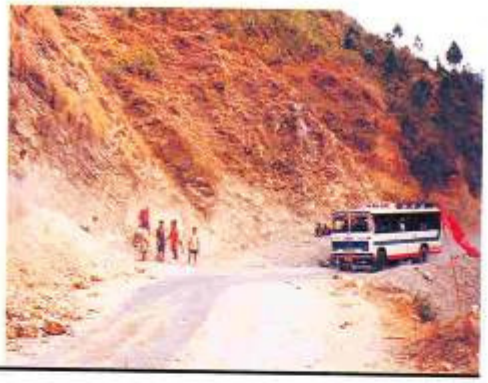
Lead Coordinating Institution for Nanda Devi, Manas, Dibru-Saikhowa, Dehang-Debang & Kangchendzonga Biosphere Reserves (2006-2008, MoEF)

The Ministry of Environment and Forests, Government of India, New Delhi, under its Man & Biosphere Programme, has identified Lead/Coordinating Institutions for designated Biosphere Reserves (BRs) in the country. These Institutions mainly serve as a focal point for: (i) research based information on respective BRs; (ii) assessment of research needs and identification of crucial issues requiring research efforts; (iii) facilitating development of suitable research projects in priority/gap areas; and (iv) bringing out relevant publications for educating the diverse stakeholders. The G.B. Pant Institute of Himalayan Environment and Development (GBPIHED), Kosi-Katarmal, Almora, has been successfully functioning as Lead/Coordinating Institution for five BRs [i.e., Nanda Devi (Uttarakhand), Manas and Dibru-Saikhowa (Assam), Dehang-Debang (Arunachal Pradesh) and Knagchendzonga (Sikkim)] of Himalayan region since 1999. Being a coordinating Institute, GBPIHED has made the following major contributions during the tenure of the project:

- Prepared feasibility documents for Cold Desert Biosphere Reserves (Himachal Pradesh & Jammu & Kashmir) and Tawang –West Kameng (Arunachal Pradesh) Biosphere Reserves.
- Developed UNESCO MAB Net Nomination Documents for Kangchendzonga (Sikkim) and Manas (Assam) BRs and submitted to the Ministry of Environment and Forests, New Delhi. Draft document was developed for the Dehang Debang Biosphere Reserve, & the review of document is in progress.
- An electronic user friendly Bibliographic Database on Himalayan Biosphere Reserves (1990-2008; with 658 references) has been developed.
- Developed database for Avifaunal diversity (851 species; 18 orders, 71 families and 341 genera); Mammalian diversity (218 species, 11 orders, 37 families and 119 genera) and Reptilian diversity (105 species) of the Himalayan BRs.
- Survey document on the Assessment of the Seville Strategy: Madrid Action Plan for Nanda Devi Biosphere Reserve has been prepared and submitted to the Ministry of Environment and Forests, New Delhi.
- Organized, a National Workshop on 'Defining role under global change scenarios of climate and human economies' (6-7 July, 2007). Also, organized BR specific stakeholders Consultation Meetings/Workshops to understand the issues and concerns.
- Facilitated formulation of viable R&D projects on Himalayan BRs so as to fill in the knowledge gaps.

Theme

Environmental Assessment and Management (EAM)



In view of changing scenarios under the pressure of globalization, economic changes occurring in the Himalayan states, impacts of climate changes, and development interventions, changes in the life style of the people and the ecology and environment are occurring at a faster pace. The future implications of such occurrences are not well known and understood. Tracking of such changes for the well being of the society and the search for suitable management solutions for our agriculture, environment, and society through continuous monitoring of environmental phenomenon and through analyses of possible solutions is a must. EAM theme will have focus on assessment and monitoring of environmental attributes related to various kinds of developmental interventions/policies/plans in the IHR. Status assessment, impact assessment, valuation, and database development would be covered under the theme. Global warming, climate change related issues, and macro level studies on impact assessment of developmental interventions for planning and management solutions would be the core areas of R&D under this theme. The objectives of the EAM theme are: comprehensive assessment and monitoring of environment with respect to various kinds of developmental interventions/policies/plans in the IHR; and development/formulation/suggestions on appropriate management plan/s for ensuring ecological and economic security in IHR.

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

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

In the Central Himalayan mountains forests are the integral part of sustenance of the inhabitants and people derive a variety of goods and services from these forests. This study was initiated to quantify and evaluate selected ES of the two major forest ecosystems of Central Himalaya (viz., Oak and Pine) involving comparative forest sites in different localities of this region. Outcome of the study will have comparative advantages of conservation and management of either of these two forest types.

Objectives

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

Achievements

- Quantification of various goods derived from the surrounding forests by the village community was estimated by using a structured questionnaire in 13 selected villages in Bageshwar, Chamoli and Champawat districts. Among the nine villages surveyed around Oak forests (Table-8) the quantity of fuelwood extracted was found ranging from 192-1212 kg/capita/year. Similarly, quantity of tree fodder also varied considerably (range= 161-1746 kg/capita/yr). Ground fodder (green and dry) and bedding leaves were another form of goods derived substantially from these forests.
- In the four villages surveyed in the vicinity of the Pine forests the fuelwood extraction was found ranging from 493-761 kg/capita/yr. Furniture timber wood was an additional good provided by the Pine forests not provided by the Oak forests (Table-9). Among the other tangible goods wild edibles and other NTFPs were also derived from these two forests.
- In terms of monetary value (as per local rates) different goods equivalent to Rs. 9448/capita/yr. from Pine forests and 5664/capita/yr. from Oak forests were derived from these forests.
- People attach distinct value to the intangible services derived from these two forests. Our survey of 664 households reveals that Pine forests were inferior as compared to Oak forests with regard to ES those are not tangible. The Oak forests scored (8 out of 10) as compared to the (5 out of 10) of the Pine forests. The Pine forests were particularly acknowledged for furniture wood, packing material and most importantly resin which do not provide the Oak forests.
- To understand the various ES accrued from the forests a consultative meeting was organized with 70 rural people (particularly women; Fig. 28) in village Swar (Distt. Chamoli) and they altogether listed a total of over 30 different ES of the forests and valued each of them differently. The two new ecosystem services recognized by them were (i) use of ash as an insecticide & (ii) the air of Pine forest is beneficial for Tuberculosis patients.

Table 8: Quantity and monetary values (Rs. in parentheses) of some major goods derived from Oak forests

Ecosystem goods derived from forests (Kg/ capita/ Yr.)	Villages studied around Oak forests (n= number of households sampled per village)									
	Devsthali (n= 43) Chamoli	Izarpatha (n= 24) Chamoli	Chivila (n=35) Chamoli	Lausary (n= 61) Chamoli	Ulagra (n=58) Chamoli	Banlekh (n=100) Champawat	Nakuri (n=30) Bageshwar	Sauli (n=11) Bageshwar	Badrinath (n=59) Bageshwar	Average
Fuel wood	487 (1359)	602 (1295)	546 (1465)	310 (579)	192 (645)	1212 (3361)	248 (866)	333 (989)	235 (894)	463±35 (1272±93)
Tree fodder	1651 (3143)	1724 (1598)	1746 (3500)	984 (1192)	909 (932)	414 (695)	161 (563)	248 (554)	140 (348)	886±76 (1392±128)
Ground fodder- green	2350 (4239)	1714 (2464)	2439 (4296)	558 (757)	409 (710)	304 (526)	204 (813)	152 (356)	277 (506)	934±106 (1630±179)
Ground fodder- dry	315 (1269)	555 (1916)	354 (1519)	390 (548)	258 (559)	327 (981)	261 (1060)	622 (2239)	680 (2447)	418±18 (1393±77)
Bedding leaves	575 (1239)	974 (1795)	677 (1395)	265 (474)	231 (484)	978 (1567)	159 (435)	241 (333)	227 (391)	481±37 (901±65)

Table 9: Quantity and monetary values (Rs. in parenthesis) of some major goods derived from Pine forests

Ecosystem goods derived from forests (Kg/capita/Yr.)	Villages studied around Pine forests				Average
	Hat- Kalyani (n= 97)	Maggeena (n= 15)	Dharonj (n= 100)	Lwani (n= 31)	
Fuel wood	761 (1211)	548 (1568)	591 (968)	493(1086)	598±58 (1208±130)
Tree fodder	-	1951 (3131)	577 (902)	344 (2974)	957±434 (2335±622)
Ground fodder- green	1265(1709)	2106 (3580)	476 (713)	1490 (2816)	1334±337 (2204±628)
Ground fodder- dry	305 (739)	538 (2139)	308 (590)	636 (2242)	447±83 (1427±442)
Bedding leaves	649 (907)	1053 (2059)	918 (848)	858 (1677)	869±85 (1373±297)
Furniture wood	20 (31)	23 (47)	55 (33)	-	33±10 (37±5)

Fig. 28. Stakeholders consultative meeting with people in village Swar (Distt. Chamoli)

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

The Government of India has accorded top priority to harness the hydro power potential, keeping in view the needs for the economic development and for meeting the growing energy demand of our country. As a follow up, a number of hydropower projects are being set up. India currently generates only about 14% electricity from hydroelectric plants mainly located in Himachal Pradesh, Uttarakhand, and the northeast region. As the impacts of such projects are many-fold in the fragile Himalayan mountains specific provisions are laid down through the EIA notification and acts in terms of protected areas; rare/threatened/endangered species; noise/air/water pollution etc. However, the cumulative impacts of these hydropower projects, inter linkages and inter relationships among and across the project cycle are necessary to understand to devise environmental management plans. Strategic Environmental Assessment (SEA) is a decision making tool which captures the cumulative impacts of the projects and can help in sustainable development of hydropower projects. In the absence of SEA framework in terms of legislation within the country, this work is an attempt to provide a representative overview

of SEA as a research work to provide suitable clues for necessary policy framework.

This study was initiated in Alaknanda river valley of Garhwal Himalaya where 10 HEPs are sited (both in operation and planning phase).

Objectives

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

Achievements

- EIA reports and related project documents were reviewed and the issues or limitations of the project level EIA were identified, which will be incorporated in the Strategic Environment Assessment.
- Initially for the primary sampling on the various environmental attributes, 10 hydropower projects located in the Alaknanda valley were selected and influence zone map was prepared (Fig. 29).
- Vegetation survey was carried out in the influence zone of the HEPs in the Alaknanda valley using proportionate stratified random sampling method. During the survey, a total of 336 species of plants (Gymnosperms, Monocots and Dicots) belonging to 107 genera and 64 families have been recorded (Table-10). Of these recorded species, 64 species were trees, 84 shrubs, and 188 herbs. Among these families, the largest number of species was recorded for family Poaceae (35 species).
- The vegetation of the influence zone was further classified into two categories: Impact zone (zone of primary impacts) and Contagious zone (zone of secondary impacts). In case of tree layer, species diversity (Shannon Wiener index) and species richness (Margalef Index) was maximum in contagious zone, whereas shrub and herb layer shows maximum diversity in the Impact Zone (Table-11).
- Resource dependency survey was carried out in 15 villages falling in the influence zone of HEPs. Data were compiled for six villages and fuelwood consumption per household ranged from 11.3–19.1 Kg/day during summer & 18.9–26 Kg/day during winter. Fodder consumption ranged from 25-45 Kg/day.
- The case studies were conducted on four hydropower projects, namely, Kashang (66 MW), Shyang (3 MW), Tangling (5 MW) in Kinnaur district and Chaba (1.7 MW) in Shimla district which unfolded some important information. Shyang and Kashang are under construction, Tangling is proposed and Chaba is under proposal. Kashang (31°35.697' N & 78°17.874' E) had seven

affected villages, namely, Pangi, Dhullu Dogri, Asrang, Janghi, Akpa, Rarang, Lippa and Purbani. The flora such as Chilgoza *(Pinus gerardiana)*, Deodar *(Cedrus deodara)*, Chir *(Pinus roxburghii)*, Kail *(Pinus wallichiana)*, Banj; *(Quercus leucotrichophora)*, Akhrot *(Juglans regia)*, Tosh *(Abies pindrow)*, willow *(Salix* spp.) and wild animals like panther, black bear, mask deer, cats, fox, etc., were observed to be prone to adverse effects due to construction of hydropower projects (Fig 30).

Table 10: Number and percentage of families, Genera and Species of Gymnosperm, Monocots and Dicots present in the influence zone of HEPs in Alaknanda valley

Group	Families		Genera		Species	
	Number	Percent	Number	Percent	Number	Percent
Gymnosperms	4	6.3	8	7.5	10	3.0
Monocots	9	14.1	31	29.0	53	15.8
Dicots	51	79.7	68	63.6	273	81.3
Total	64	100.0	107	100.0	336	100.0

Table 11: Values of diversity based on phytosociological analysis in the influence of zone of HEPs in Alaknanda river valley.

Study area	Vegetation Type	Species Diversity	Index of Dominance	Species Richness	Evenness Index
Impact Zone	Tree	2.45	0.137	5.64	0.683
	Sapling	2.17	0.188	3.96	0.737
	Seedlings	1.86	0.220	2.34	0.810
	Shrubs	3.60	0.038	8.23	0.886
	Herbs	4.22	0.023	16.18	0.864
	Trees	2.72	0.113	6.05	0.753
Contagious Zone					
	Saplings	2.64	0.121	5.41	0.794
	Seedlings	1.61	0.319	2.04	0.699
	Shrubs	3.52	0.040	7.88	0.891
	Herbs	4.02	0.025	12.84	0.876

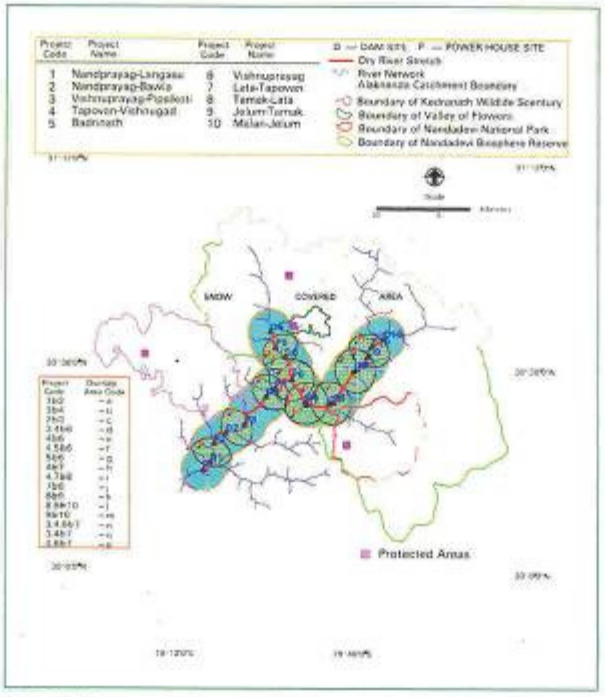
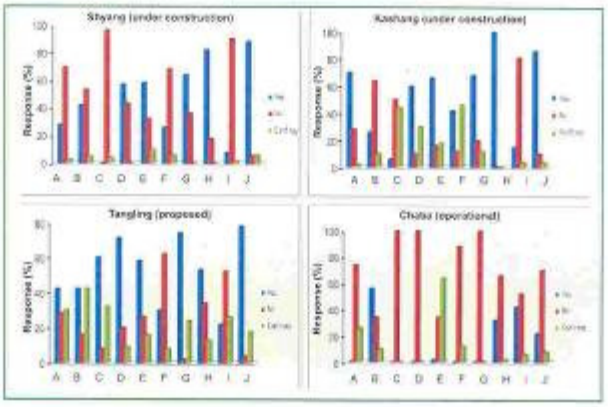


Fig. 29. Influence zone boundaries of the HEPsa in Alaknanda river valley



A. Agriculture loss B. Pasture loss C. Water industry loss D. Deforestation E. Medicinal plants loss
F. Water pollution G. Air pollution H. Solid waste problem I. Employment opportunity for natives
J. Other cultural problems

Fig. 30. Socio-economic survey of the Shyang, Kashang, Tangling & Chaba hydropower projects

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 continuously expanding urbanization, the Himalayan urban towns are becoming pressurized and degraded due to migration of villagers to urban towns as well as ever growing number of native populations and their activities in the towns. The situation is going to worsen when most of the towns sprawl outside the municipal limits and convert into urban localities. In the absence of proper and inadequate infrastructural services, some of the human induced pollutions such as solid waste and air pollution have been continuously increasing in the hilly towns in Himachal Pradesh and others. Open waste dumping becomes unhygienic and develops a home to breed cockroaches, insects, worms and rats. These later become a cause of many health diseases and disorders. Solid waste if dumped openly deteriorates water quality in streams and rivers. Sometimes, loose disposal practices at local levels such as burning waste, emit hazardous gases into our atmosphere; as a result ambient air quality degrades. Keeping in mind such environmental problems, the study during this reporting period was conducted on solid waste composition and characterization and management issues in six selected towns- Bilaspur, Kangra, Mandi, Hamirpur, Chamba and Keylong with different altitudinal gradients from Siwalik to Trans Himalayan range to represent the whole of Himachal Pradesh.

Objectives

- To identify sources, quantity, nature and composition of solid waste.
- To monitor particulate and gaseous pollutants in ambient air to establish background values.
- To suggest solid waste management plans and air pollution models for policy implications.

Achievements

- The solid waste study conducted during summer (April to June, 2008) and monsoon (July to September, 2008) seasons in the selected study towns showed that a total of 685 samples of one feet^{-3} garbage were characterized. These included 371 samples (1917 kg) in summer and 314 (2015 kg) in the monsoon which represented existing households, open dumping sites as well as municipal bins.
- The waste segregation results of the total wastes in the study towns indicated that readily biodegradable waste (RBW) consisted of 57.3% in summer and 45.7% in monsoon season. The RBW waste the composition under the study towns in both the seasons was 55.8% the highest in Bilaspur and 46.3% the lowest in Keylong. On an average, 51.6% of the total segregated waste in the six towns belonged to readily biodegradable waste.
- The biodegradable waste (BW) composition was 26.3% of the total segregated waste in summer and 24.6% in monsoon. The BW composition of the total generated waste in six towns varied from 31.7% in Kangra as highest to 22.4% in Keylong as lowest. Overall, 22.4% of the total segregated waste was biodegradable.
- In summer season, non-biodegradable waste (NBW) was 34% the highest in Keylong and 12.4% the lowest in Mandi. It was monsoon season, when NBW remained as high as 33% in Mandi and as low as 26.9% in Bilaspur.
- The capita^{-1} day^{-1} household waste generation in summer season was noted to be as high as 232 gm in Kangra & as low as 173 gm in Keylong. However, during monsoon season, the per capita waste values remained highest

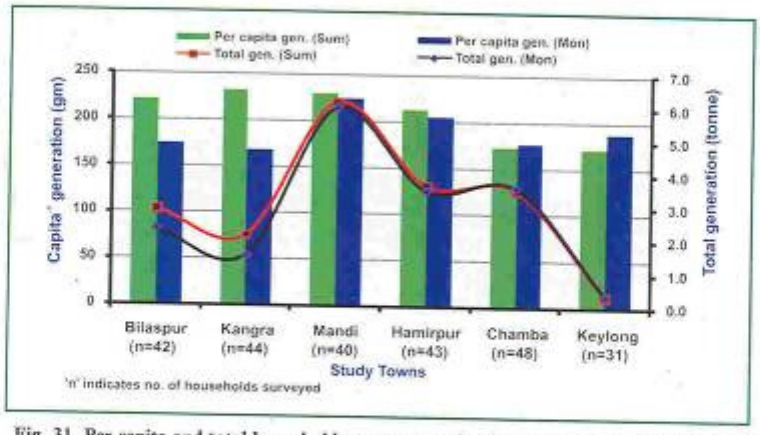


Fig. 31. Per capita and total household waste generation in the study towns of Himachal Pradesh in summer and monsoon seasons, 2008.

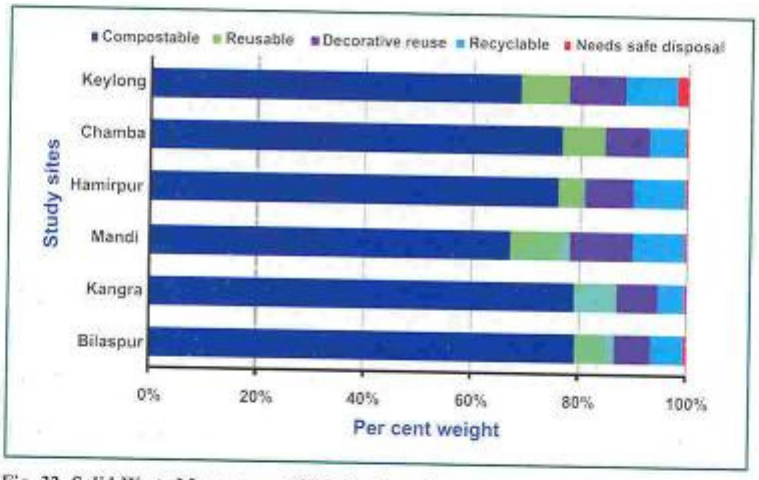


Fig. 32. Solid Waste Management (SWM) options for study towns in Himachal Pradesh in summer and monsoon seasons, 2008

in Mandi (224 gm) and lowest in Kangra (168 gm) (Fig. 31).

- The characterized solid waste was further broadly grouped as compostable, reusable, decorative reuse, recyclable and that which needs safe disposal. Looking at the results from all the towns, about 74.1% of the total segregated waste was found useful for compost process, 8.2% for direct or indirect reuse, 9.2% for decorative reuse, 7.8% for recycling and 0.7% medical waste for safe disposal. If town wise compostable waste was looked into, it was as high as 79.3% in Bilaspur, followed by 79.1% in Kangra and 76.4% in Chamba towns. However, the lowest compostable material was 67.2% the lowest

in Mandi (Fig. 32). If this practice is under taken at town levels, the majority of the waste disposal problem can be resolved.

Aerosol climatology over north-western Indian Himalayan region, Himachal Pradesh (2005-2012, ISRO-GBP Funded Project)

Atmospheric aerosols play a crucial role in the earth's radiation budget. The extinction or total aerosol optical depth is a measure of radiation extinction, due to aerosol scattering and absorption. The aerosols have a cooling as well as green house effect on the earth's surface thereby increasing air temperature that alters normal life of humans, plants and wildlife. Mohal was selected to study aerosols climatology broadly in two different modes; fine-accumulation and coarse. The wavelengths based aerosols measurement have been monitored through a Multi-wavelength Radiometer ranging from 380 nm to 1025 nm in relation to anthropogenic as well as natural factors responsible in an ecosystem.

Objectives

- To obtain aerosol optical- depth (AOD) with respect to spectral variations at ultra violet (<390 nm), visible (390-770 nm) and near infra-red (>770 nm) wavelengths using Multi-wavelength Radiometer (MWR).
- To analyse aerosol size distribution and atmospheric turbidity using Angstrom parameters; α (alpha) and β (beta).

Achievements

- The AODs averaged on monthly basis over the months are plotted in Fig. 33 which clearly indicate their high values at shorter wavelengths compared to longer wavelengths. This phenomena showed dominance of small size aerosol particles over the larget sizesd ones which were-directly related to ever increasing human interferences in the present study region. As the result, the regional climate is also being affected adversely.
- The monthly mean values of AODs from April 2008 to March 2009, remained as

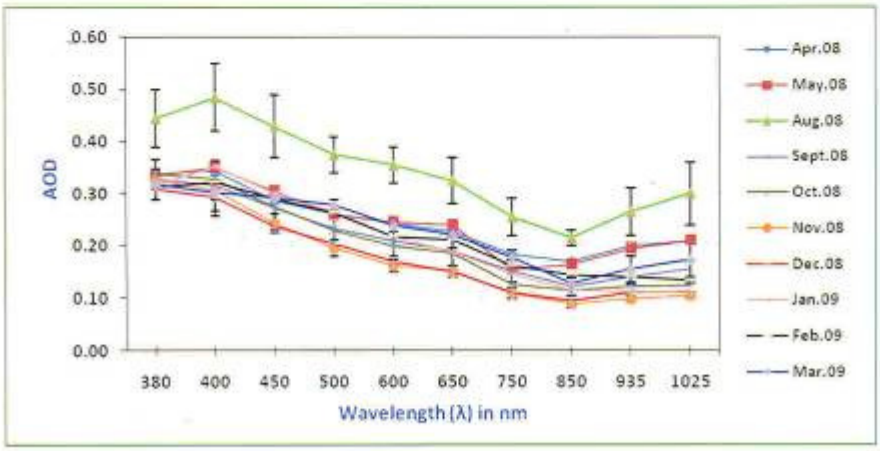


Fig. 33. Mean AOD variations during clear sky conditions from April 2008 to March 2009

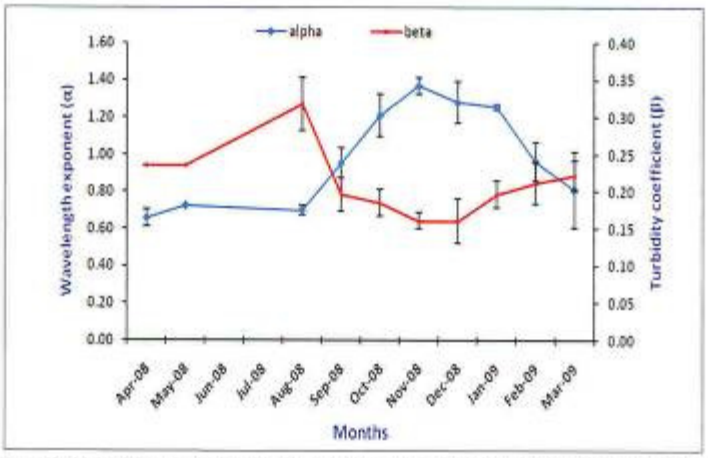


Fig. 34. Monthly mean variations in Angstrom exponent (a) and Turbidity coefficient (b) during clear sky day conditions from April 2008 to March 2009

0.33±0.01 at 380 nm, 0.24±0.01 at 500 nm and 0.15±0.01 at 1025 nm. It was August when AOD was 0.45±0.06 as highest. This is because the experimental site mostly remains under rain shadow effect during rainy season. As a result, this location has shown entirely different results compared to other regional parts of the country. The minimum AODs were noted to be in the month of November 2008 indicating 0.33±0.02 at 380 nm, 0.20±0.02 at 500 nm and 0.10±0.01 at 1025 nm.

- The aerosol size distribution indicated further dominance of smaller size particles. Fig. 34 shows α (alpha) and β (beta) with inverse relationships indicating higher values in fine-accumulation mode compared to coarse mode. Highest value of60 â¨$%â¨á â¨$%â¨ was 1.37±0.04 in November 2008 and minimum was 0.66±0.05 in April 2008, while the highest60 â¨$%â¨â â¨$%â¨ was 0.32±0.04 in August 2008 and lowest was 0.16±0.01 in November 2008. Increase in60 â¨$%â¨á' and decrease in60 â¨$%â¨â' means low values of coarse size particles. This is directly related to the degree of anthropogenic interferences in the region.

Gaseous air pollution in the background site of sprawling urban environment of Himachal Pradesh (2008-2011, ISRO ENV-OBSR Funded Project)

The air pollutants remaining in suspended conditions in the form of gases, liquids and solids are termed as 'aerosols'. Trace gases such as surface ozone (O_3), sulfur dioxide (SO_2) and nitrogen dioxides (NO_x) are of anthropogenic origin. As a result, these are chemically reactive and influence ambient air quality at a regional level. Recent studies indicate that the concentrations of surface ozone in the troposphere is increasing by about 1-2% per year and may triple within the next 30-40 years, especially in industrialised and high biotic pressurised locations. When the level of O_3 in the atmosphere remains more than 70 parts per billion (ppb) for a period of 20-90 minutes, coughing, choking and

severe fatigue in human health are noticed. Ozone is a phototoxic air pollutant that can lead to serious injury to plant tissues and reduction in their growth and productivity. The ultrafine aerosols act as the carriers of chemical and biological species in the atmosphere which have the potential to cause many adverse health impacts, inhibit plant growth and ultimately affect the local weather and climatic conditions. All these lead in due time to a climate change in regional perspectives. The major effects on the surrounding environment of these aerosols have mainly been the respiratory health hazards, deposition on plant surfaces and visibility reduction. But all this depends on the size of particles varying from 10 Å to 200 Å (0.001 μm to 0.02 μm). These aerosols specifically here are termed as 'aitken nuclei', or 'ultrafine aerosols', or 'nano particles' which work as a nuclei for fog formation close to the surface and cloud condensation nuclei (CCN) for cloud formation above the surface affecting local weather phenomena for shorter period and climatic conditions for longer period. At Mohal, the Ozone Analyser (ML9811, Monitor Europe) was used to observe surface ozone concentration. And the Particle Counter (PEM-PC 2, Polltech make) was used to measure ultrafine aerosols in different three cut-offs (200 Å, 30 Å (0.003 μm) & 10 Å).

Objectives

- To measure important concentration of gaseous pollutants (surface ozone) using U.V. Ozone Analyser at Mohal and ultrafine aerosol concentrations (N cm^{-3}) mainly using Particle Counter (PC) at Mohal.
- To document local pollution sources such as biomass burning and vehicular flux.
- To observe local meteorological conditions and to relate with the gaseous pollutants such as surface ozone and ultrafine aerosols.
- To suggest mitigating measures to bring under control all these similar pollutants, implementable at policy level.

Achievements

- Monthly mean variation in surface ozone concentration at Mohal (1154 m) was found as high as 17.7±3.0 ppb. Diurnal highest mean value for 24 h was as 27.7±1.5 ppb on May 8, 2008. The highest hourly value was noted to be 69.9 ppb on May 8, 2008 (Fig 35). It was also observed that the peak hourly values were always between 1500-1600 hrs while the minimum values were found at 300-400 hrs.
- Monthly mean variation in ultrafine aerosols at Mohal (1154 m) was as high as 7946±996 N cm^{-3} at 200Å, 5885±249 N cm^{-3} at 30Å and 2052±673 N cm^{-3} at 10Å in June. Contrarily, this monthly mean variation in August was lowest with 4994±183 N cm^{-3}, 3854±103 N cm^{-3} and 1251±25 N cm^{-3} at 200Å, 30Å, 10Å, respectively.
- The diurnal mean variation in ultrafine aerosols was as high as 10392 N cm^{-3} at 200Å, 7214 N cm^{-3} at 30Å and 2120 N cm^{-3} at 10Å during 1300 hrs, 1200 hrs and 1300 hrs. While looking at the range of variations from the highest to lowest values of ultrafine aerosols, this difference was again quite comparable. In spite of the absence of any major industrial activity, the concentration of pollutants at Mohal are mainly attributed to vehicular emissions in summer and frequent biomass burning in winter.
- The particle concentration showed close correlation with increasing traffic activities. It has been observed that the highest concentration of particles in all three sizes exist during peak traffic hours (0800 to 1200 hrs and 1600 to 1800 hrs). In winter, the ultrafine aerosols are more due to anthropogenic activities such as burning of fire wood, forest fire and coal burning.
- In January, wood consumption was maximum followed by November and December. Highest wood consumption

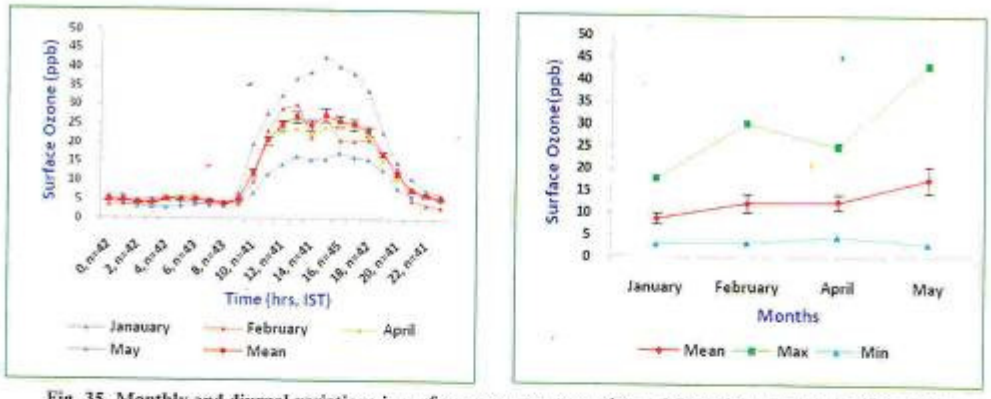


Fig. 35. Monthly and diurnal variations in surface ozone concentration at Mohal from January to May 2008

occurred in the month of January 2.27kg capita^{-1} day^{-1} and 41.51kg per household per day. The fuelwood species being used in accordance with priority of consumption were *Pinus roxburghii*, *Alnus nitida*, *Quercus leucotrichophora*, *Berberis lyceum*, *Olea ferruginea*, *Prunus domestica*, *Robinia psedoacacia*, *Malus pumilus*, *Grewia oppositifolia*, *Prunus armeniaca*, *Pyrush pashia*, *Ficus palmata*, *Pinus wallichiana* and *Zea mays*.

- Maximum daily vehicular influx was observed 2535 vehicles in March 2009, followed by 2492 vehicles in June 2008. As far as ultrafine aerosols concentration is concerned it was again observed highest in June. This means that ultrafine aerosols are closely related to vehicular emissions.

Appraisal of Tourism for Sustainable Management – Case Study of Sikkim Himalaya (Proposed In-house Activity)

In Hill States of Himalaya where developmental avenues are limited Tourism is emerging as a sector of great economic potential, which is being promoted in all Himalayan states. In view of its importance for regional development, its holistic assessment is a must. This study on Sikkim attempts to investigate this in light of the tourism process, its impacts and economics, and appraisal of management options and policy issues for its sustainability. Secondary information on the subject was collected, compiled, and analyzed for scenario simulation, trend prediction, and understanding of impacts. Sikkim is mainly a market of domestic tourism where annual inflow of tourist has grown from approximately 15,000 in 1980 to 4, 80,000 in 2008. Compilation of Quarterly inflow suggests a bimodal pattern of tourist influx with domestic influx peaking during the April – June period, and influx of foreign tourists reaching a maximum during the October – December period. In hill regions of Himalaya where developmental avenues are very limited, tourism, for which all ingredients are inherent in their environment, is emerging as a sector of great promise that has potential to revolutionize the hill economy. Tourism development also results in host of negative impacts for the ecology, resources, and culture of the host environments which often hamper its growth, results in its premature extinction hence loss of its benefit streams. Today tourism is being promoted in all the states of the Himalayan Region; considering its potential for the economic development its sustainability/sustainable management becomes an intriguing concern.

Tourism in Sikkim is mainly nature based; of-late, with the spurt in tourist influx popular tourism has also evolved. The state government is promoting it as a priority sector through institutionalization, capacity building trainings, advertisement campaigns, system of fees / permits, and through active community and NGO participation. The tourist influx to Sikkim has increased from 15,000 in 1980 to 4, 80,000 in year 2008. Besides, the economic gains, now the negative impacts of tourism are becoming manifest in terms of cluttered settlement, expansion of urban areas, traffic congestion, problem of solid-waste, abandoning of agriculture and changes in agricultural practices and traditions, etc. Therefore, considering its significance for the state's economy its holistic assessment is a must. This study attempts to achieve this through broader analysis of state's tourism and specific case studies.

Objectives

- Study of tourism's nature and process.
- Analysis of its impacts and economics.
- Appraisal of sustainability of tourism through the analysis of management options and policy issues.

Achievements

- Literature was reviewed and secondary information was collected and compiled; models for analysis of inflow patterns and trends were identified for understanding the future course of tourism process, scenario development, and impact speculations. Preliminary analysis of available tourist inflow data was carried out. Trends in Fig 36, suggest almost continuous growth in annual turn-out of total tourists (Indian

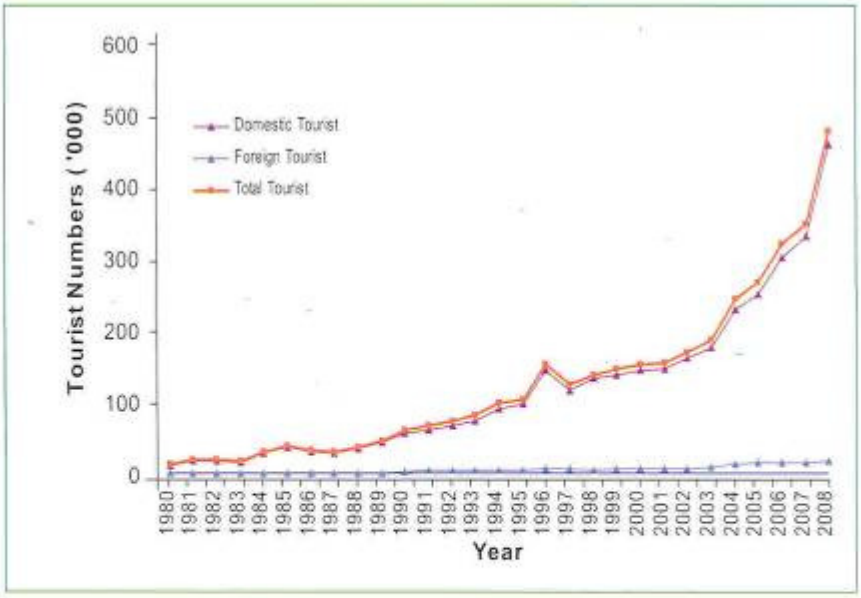


Fig. 36. Trends of Tourist Influx in Sikkim

Tourists + Foreign Tourists) from 1980 to 2008, & also hint in the degree/scale of impacts in future.

- Quarter wise assessment of data for the period 1987- 2008 vide Table-12, shows a bimodal pattern of tourist inflow for both the Indian and Foreign Tourists. The maximum rush for Foreign Tourists is during the October – December period i.e. Q4 (Mean inflow – 3326.50, SD – 1960.08, Percent of annual tourist rush – 38.76 %) while that of Domestic Tourists is during the April –June period i.e. Q2 (Mean inflow – 62652.41, SD – 45888.89, Percent of annual domestic rush – 41.20 %).

Table 12: Quarterly Pattern of Tourist Influx to Sikkim

Period	Quarter	Foreign Tourists		Domestic Tourists	
		Mean influx (sd)	Percent of annual Influx	Mean influx (sd)	Percent of annual Influx
1987-2008	Jan-Mar Q1	2107.64 (1306.18)	23.09	25651.05 (21858.78)	20.12
	April- June Q2	2374.96 (1319.19)	24.33	62652.41 (45888.89)	41.20
	July-Sept Q3	1191.00 (700.73)	13.82	20828.05 (15038.34)	13.88
	Oct- Dec Q4	3326.50 (1960.08)	38.76	40993.14 (2642.33)	24.92

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 with over 60-80% holdings are being <1 hectare and are mostly rainfed and distributed into tiny terraces over rugged terrain. Settled agriculture is the predominant economic activity between elevations of 1000 and 2500 m asl and this zone is also referred to as the most 'populated' or 'problematic' zone. Inhabitants of this region depends heavily upon the surrounding natural resources to sustain themselves. Despite market linkages and other developmental activities, viz. agriculture, forests, livestock and people are highly integrated in the region which results in resource degradation and depletion. A major challenge is to identify policies, institutions, and technologies to achieve the three goals of growth, poverty alleviation, and sustainable natural resource management in the region. Therefore working on/ with smallholders forms an important priority area for the IHR. Improvement of the status of

such farmers desires simultaneous handling of issues of arable land degradation, rural income diversification and rehabilitation of common property resources with respect to farmer's 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 the village itself. Considering this, the Institute has taken up a project on "Small holder farming systems: strategies for economic and environmental viability in the western Himalaya". The project would identify basic issues related to farming system development with a main focus on documenting 'best stories' of successful community initiatives for on- and off-farm livelihoods and natural resource management, and implementation of such initiatives as per community perspective in a representative village of the Kumaun hills.

Objectives

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

Achievements

- To initiate project interventions Patharkot village was selected. This is a representative village of mid-hills of the Western Himalaya which is inhabited by smallholder farmers. Average size of village, traditional agriculture pattern, higher dependency upon natural resources, low income opportunities etc. were some of the criteria for the selection of the village.
- In depth assessment of farming systems in the village was carried out and it reveated that 51 out of the 53 families in the village, are marginal farmers. The average land holding in the village is 51-0.45 ha. The average agronomic yield per household is given in Fig.37. The annual fruit yield (peach, pear,

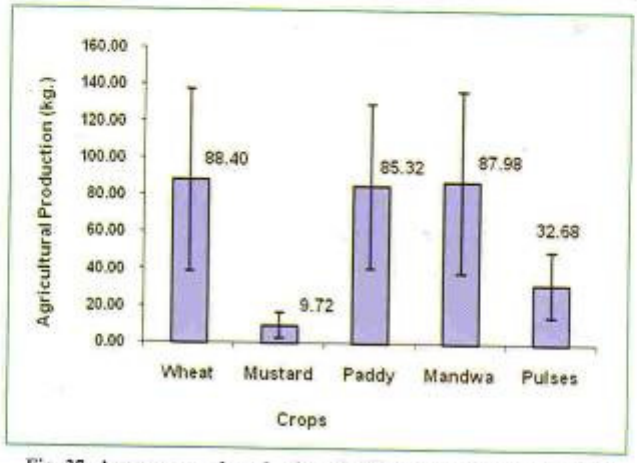


Fig. 37. Average annual production of different crops (kg/household)

plum, lemon, walnut, guava etc.) in the village is 682 kg.

- Estimation of fuelwood/fodder requirement and consumption in the village indicated that there is a huge gap between demand and supply. The fuel and fodder demand was computed at 418.86 MT and 402.72MT, respectively, against an annual availability of fuelwood (211.03 MT) and fodder (281.76MT) (Table-13).
- To promote the horticultural production in the village culturable wasteland (5.9 ha) 2250 fruit trees of different species planted in 2008 recorded a mean survival of 66% in March 2009. In January 2009 again 1390 saplings of different fruit species were planted in this land. In addition, 2100 saplings of different fuelwood and fodder species were planted in the degraded community forest land and 35% survival was recorded after two years. Five water harvesting tanks were dug in this land at suitable places to store spring and rain water for irrigation of the fruit plants (Fig. 38).

Table 13: Total fodder demand and contribution of fodder from different sources in the village

Fodder	Sources	Area (ha)	Quantity (dry matter) MT
Green Grasses	Agricultural Fields and Forest	15	197.58
Dry Grasses	Grasslands (Mange)	9.04	62.70
Tree Fodder	Agricultural Fields	NA	3.91
Agricultural residues	Agricultural Crops	15	6.99
Oak leaves	Forests	33.04	10.78

Fig. 38. Construction of waterharvesting tank

Shifting Agriculture: Issues and options with focus on adaptive interventions to make it ecologically, economically and socially viable (2007-2012, In-house)

In the North-East Himalaya, shifting agriculture commonly known as jhum, which was once considered to be an efficient system of cultivation being sustainable both ecologically and economically, is gradually becoming untenable under pressure due to a number of factors and besieged with conflicting views in regard to the degradation/conservation of ecosystem and the way of life for the upland people. Irrespective of the conflicting opinions, shifting agriculture continues to be the predominant land use system and primary livelihood option of the majority of the upland communities. Further, documentation of traditional ecological knowledge (TEK) particularly those associated with management of shifting agriculture has assumed high priority. Over the centuries, the tribal and other forest dwelling communities of North East India who are basically shifting cultivators have accumulated a rich and time tested traditional knowledge on the management of natural resources for their livelihood sustenance.

Thus the present study aims to review both traditional practices and state introduced policies on shifting agriculture for possible synchronization, introduce potential low cost technologies for improving shifting agriculture, validate indigenous soil and water conservation practices and analyze the impact of shifting agriculture on faunal diversity in Arunachal Pradesh with recommendations to make the system more conservation oriented, if possible.

Objectives

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

Achievements

- 22 of the 28 states in the country are reported practising some forms of shifting cultivation. Of the 22 states, the practice is sparsely distributed in 13 states where as the practice of shifting cultivation is predominant in 9 states, mostly in the North Eastern states, where the practice of shifting cultivation is prevalent in 36 districts (accounted to about 46% districts of the region). In order to achieve the objectives of the project, so far, 15 villages across 4 districts of Arunachal Pradesh have been selected.
- Analysis of the elements of the intervention programmes in Watershed Development Project in Shifting Cultivation Areas (WDPSCA) and National Watershed Development Project in Rainfed Areas (NWDPRA) implemented by the

Table 14: Development component activities and status of NWDPRA of Arunachal Pradesh implemented during Xth plan.

Activities	Area/Unit treated
Contour trenches with bunds	1861 ha
Soil moisture conservation measures	6320 nos.
Agronomic conservation measures	2367 ha
Compost pit	21 nos.
Water harvesting structures	159 ha
Land development by terracing	628 ha
Repairing of existing structures	1310 ha
Half moon terracing for horticultural plantations	6000 nos.
Vegetable hedges for agronomic conservation	1003 ha
Pineaaple plantation on contour bunds	364 ha

Source: Director of Agriculture, Naharlagun, Arunachal Pradesh

Government departments in the study area revealed the emphasis towards changing land use/farming system (Table-14) rather than improving the shifting cultivation practices.

- The *Patat* is a unique landuse division among the Adis for shifting agriculture. Specific numbers of such patats are found in each village. Generally, a single *patat* is cleared for jhuming in a year for all the villagers and shifted in a sequential manner. Jhum cycle therefore corresponds to the number of *patats* (Table-15).
- Three major categories of soil conservation practices viz. Agronomic measure, Soil management and Mechanical methods have been documented. Ecological quantification of weed species revealed 55 species under 53 genera and 28 families in shifting agricultural system of the study area. Among the weed flora, family Asteraceae represents the highest species (21.43%), followed by Poaceae (17.86%) and Commelinaceae and Melastomaceae (14.29% each).
- Vegetation composition of different successional fallow ages was investigated (Table-16). 37 large mammal as well as 13 small mammal (mainly of rodents) species were recorded from the landscape of the study area.
- Germplasm conservation is also attempted in the project. A total of 27 landraces were deposited with NBPGR, Shillong (Rice – 21, Maize – 3, Millet -1, Sesame – 1, Jobstear – 1) with Indigenous Collection (IC) No. ICM 564932-564958 and Mission Code – E20070016Z204.

Table 15: Patat system in Mopung village.

Sl.No.	Name of the *Patat*/Plot	Year of cultivation	Distance from the village settlement (km)
1	*Dumrung-Arying*	2008-09	2
2	*Delar Korhing*	2007-08	1
3	*Puhing*	2006-07	< 0.5
4	*Koka*	2005-06	1.5
5	*Momiyang*	2004-05	1-1.5
6	*Ammuk*	2003-04	< 0.5
7	*Moyo*	2002-03	2
8	*Tadog notti*	2001-02	4-5
9	*Garak*	2000-01	3-4
10	*Reging*	1999-00	7-8
11	*Arying*	1998-99	5
12	*Rotkon*	1997-98	1.5
13	*Nenyak*	1996-97	1
14	*Pego Karak*	1995-96	0.5
15	*Dumrung Arying*	1994-95	2

(Total No. of *Patats* - 15; Jhum Cycle: 16 Years)

Table 16: Successional stages and associated vegetation attributes

Age of fallow	Absolute density of trees (trees/ha)	Mean girth at breast height (mean [± SE]) (cm)	Number of species	Mean distance between trees (cm)
1-year old	0	0	0	NA
7-year old	2961.622	15.84 (8.34)	20	3.37
15-year old	2366.301	20.88 (11.1)	21	4.226
50-year old	2207.59	29.99 (25.25)	28	4.53

Scaling up innovative resource management practices for improved livelihoods in the mid hills of the central Himalaya (2007-2012, In-house)

Depletion of natural resources in the Himalayan region is mainly due to over exploitation and improper management of the resources. The mountains of the Himalaya which make vital contribution to the ecological sustainability of the region are threatened by increasing population, open grazing, deforestation and loss of biomass cover, and overall biodiversity. The follow up of the efforts made under different activities aiming to address these problems, was probably not well planned and as a result such efforts were

not able to halt the process of degradation of the resources. Building on the lessons learned from different studies and innovations tested for the improved livelihoods of the people, technical back stopping and material support is required to be provided to the villagers, particularly to the marginal farmers in the adoption/ adaptation process. The present study aims to follow the adoption/ adaptation process and scenario of the tested options/ innovations and facilitate improved management of the natural resources through up-scaling farm based interventions, strengthening market linkages, soil and water conservation, rehabilitation of community degraded lands, strengthening of weakened farming system concept, etc. in Garurganga watershed of Bageshwar district.

Objectives

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

Achievements

- Stakeholder consultation followed by base line survey for adoption/ adaptation of different options of improved livelihoods and management & conservation of natural resources during last 15 years has been completed in 32 villages (212 house holds). Based on the preliminary results, the farming system, as a whole, is under stress due to scarcity of water, sectoral approach of the developmental activities, weak of backstopping, and unstructured monitoring system. In fact, overall improvement on livelihoods of the people during the period has been realized, but this has also adversely impacted the availability of natural resources and overall farming system of this region.
- The traditional agriculture is either in a process of transformation to cash crop (if water is available) or 'no agriculture' due to a number of reasons. Adoption scenario clearly indicates that the farmer is a selective taker and adopts very few, out of a long list of options.
- Weakening of Van Panchayat Institution, due to the ownership issues and limited monitory resources, waste land/ community land rehabilitation is not in the list of people's priority. Like wise, introduction of hybrid live stock merely helped on improving livelihoods due to non availability of desired climatic conditions and quality feed.
- Up scaling of a few options, knowledge dissemination, conservation and storage of water linked with fish culture, protected cultivation, etc. was done. Conservation and storage of water linked with fish culture, protected cultivation, composting etc. have already been initiated for small land holders.
- A market place was jointly identified at Garur. Preliminary observations reveal that all concerned parties are satisfied and news of these innovations are encouraging for other farmers, who are not in a position to carry out self experimentation, afford the risk of losses.

Table 17. On-farm livelihood options: Adoption/Adaptation

Major Livelihood options	Demonstrations	Adoption/Adaptation	
		Villages	Farmers
Off season veg.	2	24	67
Composting	2	18	42
Vermi-Compost	4	16	56
HYV seeds	2	38	153
Rehab. comm. land	1	2	
Improved grasses	4	34	148
Inte. fish farming	3	32	96
Cash crops	Facilitation	26	135

Table 18. Preliminary results: a few examples

Options	Adoption	Probable causes
Soil conservation (Engineering structures)	Limited to the irri. land	Low productivity of the upland farming; options are not economically viable
Water harvesting & storage	Not significant	Proper utilization of stored water is not possible due to fragmented land holdings
Fish culture (value addition to the water harvesting)	Adoption rate is high	Ensured short term benefits without additional work load. Water could be limiting factor.
Green fodder/ winter fodder	Adoption rate is high	Availability of green fodder is a limiting factor to the dairy sector
Rehabilitation of community degraded land	Not significant	Ownership issues, high input with low short term benefits and weakening of institutions
Improved/ hybrid livestock	Failure	Climatic conditions and inferior quality of
fodder/ feed		
Apiculture	Failure (after 1992)	Increasing use of insecticides etc. Viral diseases
Cash crop cultivation	Significant	Low volume- high value option and short term benefits ensured
Protected cultivation	Significant	Ensured short term benefits. Market is available. Availability of quality seeds could be limiting factor.

Based on questionnaire survey of 32 villages; 3 meetings with stakeholders and long term field observation.

Institutionalizing technology backstopping and capacity enhancement for sustainable agricultural development and encouraging entrepreneurship development based on simple rural technologies within the tribal areas of North East India (2006-2009, Department of Science and Technology, Govt. of India, New Delhi)

Agricultural development in the uplands of the NE India to be sustainable 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. Given the growing demand for both technologies and capacity building and the urgent need of a decentralized technology backstopping system, capacity building, demonstration and dissemination have been institutionalized in the context of technology backstopping and agricultural development in five NE states. The mechanism has also been utilized for feedback to facilitate technology up-gradations and for prioritizing location-specific technology needs at the grassroots so that appropriate technologies addressing the needs are developed and grassroot issues are incorporated in research agenda. The project focuses on the tribal population of North East India. The tribes include Boros, Hmar and Biete of Assam; Mao Nagas and Tangkhul Naga tribes of Manipur; Mizos of Mizoram; Garos, Reangs, Debbarmas and Darlongs (Kukis) of Tripura and Jiantias of Meghalaya, respectively. Agriculture practice in these areas is predominantly shifting agriculture or Jhum barring the Boro dominated areas in Assam where they practice settled cultivation. Terrace cultivation is also a common practice in Manipur. The tribes are mostly agriculturists in occupation. The Boro and Darlong tribes are more or less settled agriculturists, while the rest are shifting cultivators. The North East Unit of the Institute is the Co-ordinating Agency for technology development, up-gradation, modification, demonstration and capacity building (including technologies developed by other agencies). Upscaling of technology dissemination is being carried out through seven PNGOs, who have established technology demonstration parks in their respective areas, preferably on their own land, so that such parks will become a permanent technology demonstration and dissemination centre for the relevant state/district. The PNGOs have been demonstrating, disseminating and establishing On-farm demonstration sites of relevant technologies, appropriate to the needs of the farmers of their respective areas. Identification of technologies is need based and is demonstrated in selected villages, purposely sampled through survey and PRA exercises.

Objectives

- To institutionalize a process mechanism for technology backstopping & capacity building of rural upland farmers in simple, low-cost, appropriate technologies.
- To set up a network of credible NGOs to showcase simple, low-cost, appropriate technologies.
- 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.
- To build up the capacity of Partner NGOs (PNGOs) in this regard.
- To facilitate a Process mechanism for identifying technology input needs in remote marginalized areas and build a community-driven process mechanism for addressing technology gaps.

- To establish a process mechanism for Capacity Building in On-Farm Technologies and enhance technology dissemination through On-Farm demonstration and trainings
- To technically validate technology modifications/adaptations for further technology upgradations.
- To develop technology dissemination material (ICT- printed, audio-visual and other material) and ensure wider dissemination in local languages through Partner NGOs.
- To encourage entrepreneurship development among rural youth, especially women, based on simple low cost, appropriate technologies.

Achievements

- Up scaling of technology dissemination and backstopping is carried out across the North Eastern region with the help of seven Partner NGOs (PNGOs) through the establishment of seventeen Demonstration Centres and about twenty seven On-farm demonstration sites in twelve Development Blocks spread over eight districts in five states helping in the capacity building of more than 1800 lead farmers/farmers during the year 2007-08 (Table-19).
- Concentrating first on the lead farmers and then on the marginal farmers, who in turn

Table 19: Number of lead farmers and farmers trained during the period 2008-09

Sl. No.	Name of PNGOs	No. of Lead farmers trained			No. of Farmers trained		
		Male	Female	Total	Male	Female	Total
1.	IIRM, Assam	84	13	97	195	31	226
2.	CEP, Mizoram	124	8	132	634	152	784
3.	SSRD, Manipur	6	6	12	20	15	35
4.	NIDA, Manipur	7	3	10	83	157	240
5.	St. VWS, Tripura	13	25	38	12	29	41
6.	NAM-RHEN, Meghalaya	10	8	18	124	124	248

Fig. 39. Training on Modified Jhum

have adopted a number of technologies, the Partner NGOs have disseminated the appropriate technologies suitable to their respective areas.

- The farmers in the project sites have accepted a number of appropriate technologies and also have modified a few without compromising with the basic principle of a particular technology. Some of the technologies like bio-composting, biobriquetting, hedgerow, etc., have a tremendous acceptance and, therefore, popularity in the project areas and farmers are trying to convert these into a small scale entrepreneurships.
- The field manual distributed during the training programme has been translated to local languages by the PNGOs for an effective adoption of technologies by the target group.
- For a wider impact, networking has been done with other institutions and the project activities are being linked to programmes likes IFAD-MRDS, Meghalaya, and Watershed development project of Govt. of Arunachal Pradesh in collaboration with State Institute of Rural Development, Arunachal Pradesh.

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

Major strategies for livelihood in the Himalayan region involve diversification of agriculture and conservation/management of the associated resource base. Intensification of resource use is often viewed as a necessity for achieving increase in food output, yet it is also potentially detrimental to vulnerable resources such as soil and water. Extension of cropping land causes deforestation, and land degradation which leads to major loss of habitat and biodiversity that affects productivity. Similarly, many income diversification activities also put natural resources at risk. Therefore, another important component of the project is to develop 'Indicators of Sustainable Development' to provide basis for decision-making at all levels and to contribute to a self-regulating sustainability of integrated environment conservation and development. It is hypothesized that designing the three dimensional research programme including the natural resource aggradations, diversified integrated farming system and allied livelihood development may help to realize the goal of environment, food and livelihood security. Enormous possibilities of diversification based on niche potential of varied growing conditions and very low consumption of agro-chemicals offer enormous potential for raising the productivity for enhancing livelihood on sustainable basis. The goal of the project "Niche based sustainable development and livelihood security in agriculture and allied sectors" is proposed to be addressed, by enhancing agricultural productivity through management of natural resources, diversified farming, processing for value addition, allied livelihood activities, capacity building, social organization and marketing.

Objectives

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

Achievements

- This project is being executed in Champawat and Tehri districts with the help of village Van Panchayat and people's representatives at all the selected 6 village clusters. The results illustrated that the *Amomum subulatum* exhibited the minimum survival percentage in all three clusters (5.6 % in Hadiya to 27.60 % in Manjgaon) on the other hand the maximum of 86 % survival was recorded for *Syzygium cumini* in Jamnikhal cluster. In general *Morus alba has* a good survival percentage (72.60 to 77.20%) in all the three clusters. *Bauhinia purpurea* (50) and *Sapindus* sp. also exhibited more than 57 % survival in all clusters. However, poor survival was recorded for *Quercus* species in all clusters excluding Jamnikhal where it survives at the rate of 59 to 68 %. *Melia azedarach* shows 34% (Hadiya) to 64 % (Jamnikhal) survival. Other multipurpose species, like (*Cinnamomum tamala*, *Emblica officinalis*, *Pennisetum purpureum* etc. exhibited higher mortality rate in all clusters.
- Organized three day National training (7-9 April, 2008) on Common Property Resource (CPRs) and Livelihood. Fourteen participants from different partner organizations participated in this training programme followed by an exposure visit to Bhiri Banswara (a demonstration model for Agro-forestry).

Table 20: Villagers perception on land management

Treatments/Inputs	Clusters (%)			
	Dharaunj (n=96)	Bunlakh (n=104)	Gumod (n=45)	Chaurnie (n=51)
Plantation				
Fodder yielding	100	20	100	100
Fuel yielding	100	15	100	100
Wild edible plants	20	09	45	95
Agroforestry				
MPTs + Horticulture	85	85	87	68
MPTs + Agriculture	55	57	39	56
Horticulture+ Agriculture	75	95	98	75
MPTs+ MAPs	88	65	76	100
Pasture land development				
Local grass	57	34	67	34
Napier grass	100	100	100	100
Lemon grass	100	100	100	100
MAP & Floriculture				
Herbs/Shrubs	100	100	25	45
Trees	65	67	86	55
Floriculture	100	100	35	46
Soil and Water Conservation				
Water harvesting tanks	100	100	100	100
Roof water harvesting	100	89	100	100
Biological measures (Soil conservation)	100	100	98	98
Mechanical measures (Soil conservation)	89	79	89	100

Biodiversity Conservation through Community based Natural Resource Management in Arunachal Pradesh (GOI-UNDP-CCF-II Project (2008-2010, UNDP through MoEF, GOI)

The state of Arunachal Pradesh with an area of 83,743 km^2 is renowned for its biological richness. This is located in the Eastern Himalayan Biodiversity Hotspot and is also listed among the 200 Globally Important Ecoregions. The state's unique location at the biogeographic realms further enriches the region's biodiversity. The state is estimated to have nearly 50 % of the total flowering plant species in India. It has been designated as a globally important Endemic Bird Area, and out of the 1200 bird species in India, nearly 600 have been recorded from Arunachal. It is also home to 26 major and 100 odd minor indigenous communities, who continue to be dependent on natural resources for food, medicine, traditional rituals and customs as well as a source of cash income. As elsewhere in the globe, centrally administered preservationist biodiversity conservation programmes that rely on the use of force to achieve conservation goals, have limited applicability or merit for these traditional communities of Arunachal Pradesh. Hence any conservation effort would require ingenious and innovative solutions with great support from the local people, considering the cultural and historic values and being sensitive towards their needs. Keeping this in view, these projects intend to develop a viable, replicable and effective community based natural resource management initiative in the Tawang-West Kameng Biosphere Reserve (Proposed) and Apatani Plateau (Lower Subansiri District) of Arunachal Pradesh. This project intends to provide sustained incentives and support to the local communities to effectively protect and enhance the biodiversity conservation. Specific attention would be paid to a few critical issues such as hunting, shifting cultivation, community welfare and alternative livelihood

Objectives

- To promote participation of local communities in biodiversity conservation measures and resource management.
- To promote alternative livelihood schemes like ecotourism, agro forestry, and micro enterprise in the project areas to provide incentives and reduce natural resource dependence.
- To improve upon shifting cultivation and promote livelihoods through technological interventions.
- To enhance community well being (Primary health care and education).
- To carry out studies and inventories about the lack of information for improving policies, knowledge base and monitoring.

Achievements

- Identification of project intervention sites-Proposed Tawang-West Kameng Biosphere Reserve or the Tsangyang Gyatso Biosphere Reserve and Apatani plateau has been done.
- Identification of partner institutions to work on specific issues - NERIST, Nirjuli and NCADMS, Ziro for Apatani plateau and SFRI, Itanagar and WWF, Dirang for proposed Tawang-West Kameng has been completed.
- A database on topography, history of study area, people, culture, way of life and degree of dependency on natural resources, etc., has been created.
- Consultations with state government line departments and agencies for field implementation of the project are

continuously being carried out. A State level Steering Committee with the PCCF of Arunachal Pradesh is being constituted to continuously monitor the progress of the project. In consultation with the Dept. of Horticulture, and Environment and Forests of Arunachal Pradesh, a technology Demonstration Centre is being established at Hapoli in the premises of Department of Horticulture and nursery in Siro village owned by Department of Environment and Forest in Apatani plateau project site.

- Identification of technologies for enhanced agricultural yield, which are to be established in two project sites (Table-21), is completed.
- Village Biodiversity Conservation Councils (VBCC) has been constituted in 15 targeted villages in Apatani plateau project site and same is initiated in Tawang-West Kameng BR project site.
- Propagation of 4 medicinal and aromatic plant species has been initiated at Apatani plateau project site (Table-22).

Table 21: Low cost farming technologies for sustainable development of agro-ecosystem and to reduce fuelwood demands

	Technologies				
Production	**Nursery Enhancement**	**Soil Erosion Techniques**	**Water Control**	**Post Harvest Management**	**Energy/Fuel Saving**
Weed/Bio-composting	Bamboo propagation	Contour hedgerow	Boon system	Zero energy cool chamber	Bio-briquetting
Liquid manuring	Cutting and grafting	Modified Jhum	Haandi (pitcher) irrigation		
Vermi composting	Polyhouse and agro-shade	-	-	-	-
Polyfilm -	-	-	-	-	
Legume intercropping	-	-	-	-	-
Multi-tier cropping	-	-	-	-	-
Trellises -	-	-	-	-	
Trap cropping	-	-	-	-	-

Table 22: List of selected species for intervention with numbers of saplings developed at the nursery and the targeted area (ha) at farmer's level.

Scientific name	Common name	Saplings (nos.)	Targeted area (ha)
Swertia chirayata	Chirayita	10,000.00	3.00
Taxus wallichiana	Yew	2,500.00	5.00
Amomum subulatum	Large cardamom	10,000.00	10.00
Actinidia deliciosa	Kiwi	2,500.00	5.00
Total		**25,000.00**	**23.00**

Fig. 40. Agro-shade for plant propagation at nursery site of NCADMS

Cultural landscape: the basis for linking biodiversity conservation with sustainable development of Arunachal Pradesh, India (2008-2011, UNESCO-McArthur Foundation, New Delhi)

Cultural landscape can be considered as one of the most striking outward manifestation of intangible values inherent in cultural heritage. Thus it is important to understand the interaction of people and nature over time in such cultural landscape and aesthetic, ecological and cultural values related with the high biological diversity or resources. In contemporary global milieu, it has been well acknowledged that biodiversity conservation approaches do not work in isolation to traditional communities inhabiting the forest margin. The traditional communities are poor and vulnerable people who are most dependent on bioresources as their livelihood sustenance. The traditional communities living near bioresources must be central to designing and implementing any biodiversity conservation strategy, but such relationships between biodiversity and livelihoods are complex, and need extensive investigation. Keeping this in view, the study aims to address biodiversity conservation with concern for sustainable development of traditional communities living in the mega cultural landscape along an altitudinal transect of the West Kameng district comprising of Dirang and Bomdila circle. The forest centered land use practices are predominant livelihood sustenance in Bomdila circle while sedentary agriculture coupled with transhumance following rotational grazing based animal husbandry practices is predominant livelihood in Dirang circle. The communities living in the region have always been closely linked with the landscape around them, being dependent upon both natural and human-managed ecosystem. The cultural landscape that the ethnic communities created around themselves has a distinct imprint of its own, which is the product of the given socio-ecological system, and the traditional ecological knowledge, which in terms reflects the cultural values and beliefs associated with those that the ethnic group possesses.

Objectives

- Landscape system analysis, figuring out the linkages between natural and human-managed ecosystems in the landscape and the manner in which they are linked to the village ecosystem function.
- Trying to evaluate the manner in which traditional societies perceive management of biomass, soil fertility and water resources within the landscape and the kind of eco-

cultural drivers that ensure effective management of natural resources, and its sharing on an equitable basis.

- A detailed analysis of the culture-based non-codified institutional arrangements, such as the organization of cultural calendar linked to the biophysical dimensions of the ecosystems that they are concerned with.
- Issues related to competition vs coexistence of different ethnic groups within and outside the identified boundaries of a given cultural landscape and their implications for sustainable use of natural resources within and between societies.
- The role of institutional arrangements for effective management of natural resources with emphasis upon the traditional institutional arrangements.

Achievements

- Study site has been selected and location map of study site developed. The study site is situated in the West Kameng district of Arunachal Pradesh. Eight villages have been selected for detailed investigation, of which 6 villages are situated in Dirang circle while two in Bomdila circle.
- Documentation of land resources (Fig. 41) and land ownership, traditional institutions and resources management along with agricultural systems, livestock, food and beverage system, religious and rituals of both Sherdukpen and Monpa tribes was done.
- Occupational structure reveals that agriculture is the main livelihood sustenance in Dirang circle where more than 75 % depend on it while other economic sectors dominate in Bomdila circle.
- Field investigation of different types of agricultural systems (Table-23) have been done for the first year cycle. Crops and cropping pattern are being studied for Monpa and Sherdukpen tribes in Dirang and Bomdila circles of the district.

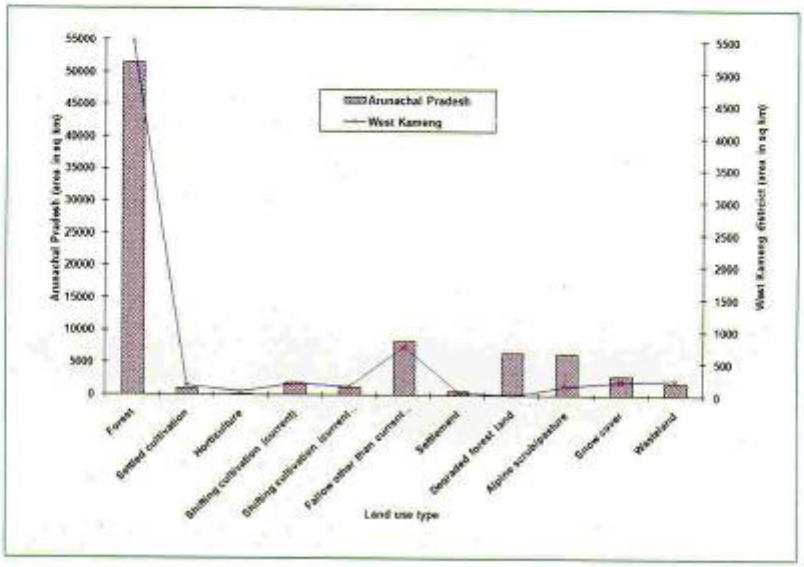


Fig. 41. Comparative land use-cover of West Kameng district and Arunachal Pradesh

Table 23: Agriculture type and crops grown by Monpa and Sherdukpen tribes

Characteristics	Monpa	Sherdukpen
Agriculture	Good cultivators; use manure; they practice permanent type of cultivation with a few exceptions of shifting cultivation in Kalaktang area.	Practice both shifting and permanent types of cultivation but are rather poor agriculturists. Subsidiary means are trade, fishing, hunting, handicrafts.
Use of manure	Make use of Oak leaves for manure and tying cows in fields.	Make use of Oak leaves for manure and tying cows in fields.
Implements used	Make use of plough, which is made of wood.	Primitive type of plough drawn by bullocks.
Crops grown	Barley, maize, chilly, wheat, oat, beans, pea, millet, onion, garlic, radish, pumpkin, and rice (in irrigated field).	Maize, millet, wheat, bean, pumpkin, cabbage and abundant chilly.
Animal husbandry	Yaks, fowls, sheep, cows.	Have special preference for various products of milk and rear cows and goats.

Table 24: Traditional Forest land use classification of Monpas

Local name	Description	Importance
i) Borang	Community forest	Extraction of timber, bamboo, cane, fuelwood & other NTFPs for household requirement. Collection of materials for ritual ceremony, hunting.
ii) Ja-dung Borang	Village forest	-do-
iii) Ja-sesing	Individual forest dominant by oak tree	Extraction of fuelwood and leave litter for mulching in agriculture fields.
iv) Habrang Seshadoksha	Sacred groves (community land)	Restriction of extraction except for ritual purpose. Good seed bank for varieties of spp.
v) Brog	Community/village grazing land	Grazing land for cattle, yak and mountain sheep.

- Traditionally the Monpas uses five types of forest lands viz. *Borang* (Community forest for extraction of timber and other NTFPs), *Ja-dung Borang* (Village forest), *Ja-sesing* (Individual forest for extraction of fuelwood and leaf litter), *Habrang Seshadoksha* (Community Sacred Groves) and *Brog* (Community village grazing lands for livestock) (Table-24).
- The rich biological diversity also plays an important role in the cultural and ritual practices of both the tribes. Monpas and Sherdukpens have traditionally developed strategies of conserving and managing nature and biological resources. Monpas have been conserving 21 plant species (Table-25) while Sherdukpens have been conserving 14 plant and 2 animal species, which are either of cultural or ritual value.

Fig. 42. Sherdukpen couple in traditional dress

Fig. 43. Traditional Sherdukpen house in lowland

Table 25: Plant species used in rituals and festivals by Monpa tribe

Local Name	Scientific Name	Uses
Bathua	*Chenopodium album*	Leaves and grains are used for making variety of ethnic foods during *Losar* and other Buddhist festivals.
Leepii		Used for making *Churpi*, which is extensively used in the ritual and festivals e.g. *Losar.*
Phupur (Better test variety)	*Fagopyrum esculentum*	Powder grain is made into paste and sun dried, which is offered in Buddhist temples. It is also distributed to the persons present during the rituals and festivals of Buddhists.
Phupur	*Fagopyrum tataricum*	Powdered grain is made into paste and then dried, in the sun. This is offered in Buddhist temples. It is also distributed to the persons present during rituals and festivals of Buddhists.
Bundagmo	*Amaranthus* spp.	A precious and culturally important crop used for making the ethnic food *Khapse* useed in *Losar.*
Loosun	*Allium sativum*	It has cultural relations with Buddhist temples. It is used in rituals for curing different ailments.
Mann (large variety)	*Allium* sp.	It has cultural relations with Buddhist temples. It is used in rituals for curing different ailments. It is also offered in *Losar* festival.
Mann (Small variety)	*Allium* sp.	It has cultural relations with Buddhist temples. It is used in ritual for curing different ailments. It is also offered in *Losar* festival.
Odong-Sing	*Rhododendron arboreum*	Flowers are used for offering and leaves and buds are used as incense.
Sulu-Sing	*Rhododendron lepidotum*	Young leaves and stems are used as incense.
Tama-Sing	*Rhododendron grande*	Young leaves and stem are used as asincense.
La-Sing	*Rhododendron* sp.	Used for packing *Churpi* and *Ghee*. The Ghee is used in Buddhist temple.
Lensong-Sing	*Pinus wallichiana*	Young leaves and stems are used as incense.
Ro-Sing	*Pinus roxburghii*	Young leaves and stem are used as incense.
Wang-sing	*Cupressus torulosa*	Young leaves and stem are used as incense.
Wangmu-Sing	*Thuja occidentalis*	Young leaves and stem are used as incense.
	Juniperus recurva	Young leaves and stem are used as incense.
Mong	*Triticum aestivum*	Flour is use for preparation of *Tormu*, grains are thrown in every direction after the rituals.
Sulu	*Capsicum annum*	Dry fruit is burnt to drive away evil spirits
Ning	*Aconitum heterophyllum*	Tuber is worn to ward away evil spirits.
Chandu	*Aconitum ferox*	Tuber is worn to ward away the evil spirits

Theme

BIOTECHNOLOGICAL APPLICATIONS (BTA)

The plants are the primary producers; therefore, a thorough understanding of the factors that govern their productivity and functioning is of paramount importance especially in the light of severe climatic conditions prevailing in the Himalaya, and current concern about the global climatic change. A thorough understanding of the mechanism of plant adaptation to stress, be it of physiological, biochemical or molecular, is extremely relevant for increasing the productivity of the plants. Besides the above, 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). A study on diversity and reproductive success on fish (Ichthyology) has also been taken up. 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. The objectives are: Identification and documentation of bioresources of applied value of IHR; Generation of technological knowhow of the process development; and Human resource development.

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

Systematic work was initiated in this laboratory on the isolation, identification and characterization of microbial communities of the region about 15 years ago. While the temperate and alpine locations have been explored for enumerating the diversity of free-living bacterial, actinomycetes and fungal communities, the symbiotic associations between selected trees and the AM (arbuscular mycorrhizal) fungi have also been investigated. Some work has also been carried out on microbial diversity of two hot spring sites, located in the Garhwal Himalaya, for the exploration of thermophiles. Microbial inoculants suitable for colder regions of mountains have been developed. The present proposal is formulated on the basis of the leads obtained from the work done so far in the area of microbial diversity of IHR with a focus on: (1) rhizosphere microbial communities, and (2) extremophiles. In addition, it is also planned to

take up one microbiology based activity for NE region.

Objectives

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

Achievements

- The rhizosphere populations associated with *Ginkgo biloba* growing under the temperate climatic conditions have been investigated. Besides colonization of free living microorganisms and arbuscular mycorrhizae, this study also reported the occurrence of endophytic organisms in the cortical cells of mycorrhizal infected lateral roots of *G. biloba*. An endophytic bacterium, isolated from cortical cells of *G. biloba* roots has been evaluated for its plant growth promoting abilities.
- Species of *Aspergillus* isolated from the soil samples collected from different locations have been studied for their growth requirements and phosphate solubilization at different temperatures. Actinomycetes isolates (78 nos.) were obtained from the soil samples collected from alpine zones of Pindari glacier region. Following plate based rapid screening, five efficient antagonistic isolates were investigated for further characterization with special reference to their antagonistic properties. Thirteen thermophilic strains originally isolated from hot spring sites have been investigated for their phenotypic and genotypic characters.
- Selected cultures of bacteria, actinomycetes and fungi have been accessioned by MTCC, IMTECH, Chandigarh; ITCC, IARI, New Delhi and Agarkar Institute, Pune. The gene sequences of the important isolates have been accessioned by NCBI.
- Study sites for investigation of microflora after completion of fire operations in agro-forestry sites were selected in NE region. Chemical and microbial analysis of soil samples was carried out.

Development of propagation protocols, multiplication and field evaluation of selected economically important plants in Indian Himalayan region (2007-2012, In-house)

The forest cover of the Indian Himalayan region is gradually getting reduced due to over exploitation, and thus has also resulted in decreasing the availability of many economically important plant species including non-timber forest products. With ever increasing human population along with growing demand for plants and plant based products, there has been 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 not only to provide the much needed planting material for cultivation to derive economic

benefits but also for restoration of degraded land and conservation. Keeping these goals in mind, results of different studies taken up during this year is being reported.

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

Objectives

- Germplasm collection and maintenance in nursery.
- Development of propagation protocols by conventional (by cuttings and seeds) and *in vitro* methods.
- Large scale multiplication and field performance.
- Training of students, farmers and villagers.

Achievements

- Field surveys were carried out in other prospective places to collect plant samples (seeds, cuttings, etc) for all the target species for germplasm collection and obtaining plant material for experimentation.
- Seeds of *O. ferruginea* collected from different populations (Thalaut, Saioond, Kais, Kolibehar) differed considerably in morphological characteristics. Thalaut population showed higher length, width and weight compared to other populations; imbibition curves of seeds of different populations exhibited significant variation in water uptake rates. Mechanical scarification markedly influenced germination and was used for nursery raising and multiplication.
- To develop tissue cultures of *O. ferruginea*, apical shoots and nodal explants with axillary buds when cultured on MS medium containing half the concentration of salts, BAP or kinetin (0.2-2.0 mg/L) and NAA or IAA (0.1-0.2 mg/L) was found to be suitable in inducing bud break and shoot proliferation (Fig. 44).

Fig. 44. In vitro shoot proliferation using nodal explants of *O. ferruginea*

Fig. 45. In vitro propagation of *R. dalhousiae*. (A) Shoot multiplication on MS medium with 2-isopentenyl adenine, & (B) Hardened plants ready for field transfer.

- The effect of seed size (large, medium & small) on germination of *Quercus* spp. seeds was examined following sowing under shade (using net) and in open. The larger and heavier ones required short emergence time, exhibited better germination (70%) and seedling performance (survival 98%) compared to medium and smaller ones. Highest germination was observed in soil ratio mixture of degraded and forest soil (1:1) and it showed maximum germination of 80% when treated with solutions containing a systemic fungicide, Bavistin.
- Air wet technique, a promising alternative method of vegetative propagation, has proved successful in *Rhododendron arboreum*, *R. dalhousiae* and *R. griffithianum*. This method along with using stem cuttings (leafy) was also attempted for *Q. lamellosa* and *Q. pachyphylla*. Stem cuttings were treated with various chemical solutions (IBA, NAA, GA_3, ABA, IAA, Phloroglucinol, Bavistin) and planted in soil at different microclimates. Initial sprouting started in some cases results are awaited.
- The first successful micropropagation protocol for another important Sikkim Himalayan *Rhododendron*, *R. dalhousiae*, was developed (Fig. 45). Large number of plants have been successfully produced and transferred to the field. This has the potential for commercial propagation and conservation of this species.
- Mass scale propagation and conservation of endangered *R. maddeni* using existing protocols are continuing. Planting of quality plants is being continued in the Arboretum and in the Rare and Threatened Conservation Park (RTCP).
- A seasonal effect on root formation in stem cuttings (15-20 cm) of *Z. armatum* was carried out following treatment with various chemicals. Callus formation occurred at the base of some treated cuttings but root formation was not observed. Air layering method was found to be suitable for propagation of this species and a seasonal influence was observed; this technique is being used for multiplication.

Fig. 46. Shoot multiplication of *Z. armatum* in MS medium supplemented with BAP & NAA.

- Aseptic cultures were developed using nodal explants taken from branches of *Z. armatum* trees following culture on basal Murashige & Skoog's (MS) medium. The sprouted shoots were multiplied on MS medium supplemented with BAP (0.5-5.0 µM) and NAA (0.5-5.0 µM). Maximum shoot proliferation was obtained on MS medium supplemented with 4 µM BAP and 1 µM NAA. The shoots are being further multiplied (Fig. 46) for stimulating root formation.
- To establish tissue culture rhizome segments of *A. subulatum*, these were cultured on the MS medium containing cytokinins BAP (0.5-5.0 µM) and kinetin (0.5-5.0 µM). Effective and maximum shoot proliferation was obtained on MS medium supplemented with 0.5 µM BAP and 1.0 µM kinetin; the shoots are being multiplied for obtaining plantlets.

Identifying the environmental correlates leading to reproductive success of fishes for enterprise development of lotic stream fishery (2008-2012, In-house)

Arunachal Pradesh is known for its rich biodiversity. A large part of the state still remains unexplored and the diversity of both floral as well as faunal elements remains largely undocumented. Even where reports exist, many groups remain unstudied. The state has many major rivers and numerous rivulets and streams dissecting the topography, offering diverse habitat to aquatic life. While some rivers of the state have been surveyed for their ichthyofauna, many remain unexplored even today. Senkhi is one of the important streams of the capital town, Itanagar, which caters to 70% of the water needs of the urban population. It also contributes 38% of the Icthyofauna of the state and has also reported an addition of eight new species for the district, four for the state and one new species to science. Senkhi consists of varied microhabitats ranging from deep waters to fast-flowing riffles. Being a perennial stream it is important as it caters to the day-to-day needs of the urban populace. There has been noticeable reduction of vegetation cover in the catchment areas, which has resulted in low discharge of the once fast stream. The fish are part of the tribal folklore and an important source of food. Most of the fishes captured in the state serve to the subsistence needs of the people, and increasing demand for fish is met through imports from outside the state. There is dearth of awareness regarding the commercial breeding activities, and

the government schemes and benefits lack the outreach to the people.

Objectives

- To identify the ambient environmental parameters of water for different species of fishes.
- To carry out regular population estimates of fishes over sampling period.
- To study the behavioral and morphometric parameters of fishes and correlate the same with their population parameters.
- To identify the fecundity of fish over the sampling period.
- To prioritize the fishes based on their reproductive success and population parameters for enterprise development.

Achievements

- Three study sites based on the elevation gradients in the Senkhi stream were selected, i.e., upstream, midstream and downstream, and eight ambient water quality parameters were recorded. Monthly water quality analysis reveals that air and water temperature were lower in upstream but pH showed a reverse trend; similarly organic matter, ammonical nitrogen, nitrate nitrogen, phosphate and BOD showed increased levels from up to down which is indicative of pollutants dumped downstream (Fig. 47).

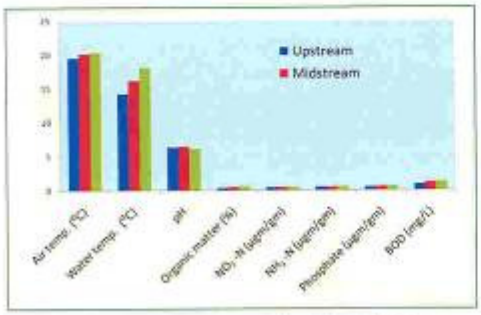


Fig. 47. Ambient water quality of three different sites at Senkhi stream.

- Fish capture frequency classes prepared out of weekly samplings reveals that 6% of species were common, 4% abundant, 8% frequent, 20% occasional, 10% sporadic, 18% rare and 32% were extremely rare (Fig 48).

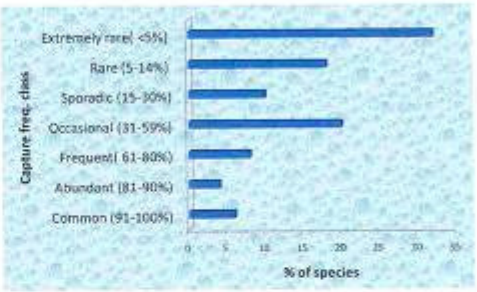


Fig. 48. Capture frequency class of different fishes caught during sampling period.

- During the study, 4 new reports for the state i.e. *Pseudolaguvia shawi*, *Glyptothorax telchitta*, *Balitora brucei* and *Oreochromis mossambica* were added, 12 new reports for the district (Papum pare) and 1 new species to the world, i.e. *Erethistoides senkhiensis* (Fig. 49)

Fig. 49. ***Erethistoides Senkhiensis***

- Feeding zones for 50 different species were identified and gut content analysis was undertaken.
- Length versus weight regression analysis was carried out for the 10 predominant fish species found in Senkhi stream.

Summary of Completed Project/Activity

Development of callus and hairy root cultures as strategy for production of active compounds from two Himalayan alpine medicinal plants (2007-2009, UCOST)

A large number of herbs of the Indian Himalayan region are sources of active compounds which are used for the preparation of high value drugs. Due to increasing demand of these plants by the pharmaceutical companies, they are being subjected to reckless, often illegal harvesting, well beyond their natural regeneration capacity. Although conventional and biotechnological methods have proved promising for multiplication and subsequent cultivation of many of these species, use of callus cultures and genetically transformed hairy roots for production of active ingredients of medicinal value would be an attractive alternative. Use of genetically transformed hairy roots, produced by gram negative soil bacterium *Agrobacterium tumefaciens*, has been reported to be promising for secondary metabolite production in many plant species. Therefore, two economically important species, namely, *Picrorhiza kurrooa* and *Aconitum heterophyllum* have been selected for this investigation.

Objectives of the project are : (i) Establishment of callus and hairy root cultures; (ii) Analysis of active ingredients; and (iii) Scaling up cultures for the production of active ingredients.

Achievements of the project are : (i) Callus cultures of *P. kurrooa* developed from leaf and nodal segments have been scaled for analysis of growth and active ingredients; (ii) Hairy roots developed (following infection with *Agrobacterium tumefaciens*) and confirmed by PCR analysis have been scaled up. Among different types of medium used to determine maximum growth of hairy root lines (8 lines) during 1-8 weeks culture, best growth was achieved in ½ strength Murashige & Skoog's liquid medium; (iii) In all the lines, slow growth occurred in the first 2 weeks followed by a gradual increase in the next 6 weeks; subsequently the cultures showed a stationary/declining trend. In most of the lines better growth with higher biomass was achieved during 3-6 weeks of culture and maximum (15.0 g FW) was recorded in one of the lines, whereas minimum (about 13 g FW) was recorded in another line; and (iv) Active ingredient content (based on picrotin and picrotoxin standards) in these hairy root lines as well as in other samples, was determined following extraction, purification and analysis by HPLC. A wide variation (1.5-45.0 mg/g DW) was detected in all the samples (runners, callus & hairy root lines). In some hairy root lines the levels were higher indicating that secondary metabolite production via hairy root culture could be a potential source for the pharmaceutical companies.

Summary of Completed Project/Activity

Technology Vision 2020, Mission Projects on Agriculture: Sikkim Project (2003-08, Technology Information, Forecasting and Assessment Council (TIFAC), Department of Science & Technology, Govt. of India)

The objectives of the project targeted overall improvement of the socio-economic condition of hill farming communities. The sustainable agricultural development, needs better crop management practices through efficient recycling of available resources. Therefore, this project demonstrated the agricultural production potential in farmers' fields with better management and improvised collateral practices. This involved direct interventions in the farmers' fields to increase the productivity potential of the existing upland on-farm practices and hands-on trainings to the farmers/ village youth for motivation towards increased agricultural potential for envisaged positive impacts on their socio-economics.

The major outcomes of the completed project are: (i) Fifteen low cost poly-houses were constructed in the fields of selected farmers in three villages, (ii) Specialized training of the farmers on improved cultivation technology of vegetables and their seed production carried out in East & South Sikkim, (iii) Low cost poly tanks were provided to the villages for water harvesting. These tanks were a boon to the farmers of Cham Gaon and Tarku. During winters when the precipitation is as low as zero, these tanks are used twice daily, (iv) Specialized training to farmers on disease free ginger cultivation, its storage and seed production, 7 of the 10 farmers of Central Pandam, reported good results (2007–08), (v) Training on solar sterilization of fields and ginger seeds to achieve disease and nematode free crops. (vi) Total 12 beneficiaries from Lingdok and Tumin villages (1700-2000 m) were identified for improved large cardamom cultivation, (vii) New Seller seedlings and grafted saplings of Mandarin (*Citrus reticulata*) were distributed to the farmers of Central Pandam. The planting material was provided by I.A.R.I., Regional Station, Kalimpong, (viii) A total of 9,100 propagules of disease free large Cardamom (Cultivar: *Bharlangay*) were distributed to the farmers (Lingdok and Tumin) and grafted citrus seedling (Central Pandam village) in East Sikkim, (ix) Incidents of diseases and pests: "Chirkey" and "Phurkey" in large cardamom, "Stem borer" and related diseases in mandarin orange and soil borne disease in ginger reported from all the sites have caused sharp decline in productivity, (x) Therefore, training and demonstration on identification of insect, pests and disease of Mandarin, along with their prevention, was organised at Central Pandam, East Sikkim. Mandarin orchards in these areas were surveyed for identification of plants with Citrus Triesta Virus (CTV) infestation, and (xi) Training on 'Protected Cultivation of Horticulture Crops' was imparted to six farmers and two GBPIHED staff members at I.A.R.I., New Delhi.

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 steadily become more culturally and biologically uniform. With greater realization of the value of this knowledge base, it was 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 would certainly generate ecologically sound, economically viable, socially acceptable and institutionally enforceable outputs. The main objectives of the theme are: undertake in-depth studies on documentation and validation of knowledge (traditional/ indigenous/rural); utilize natural resources for livelihood enhancement and income generation using local knowledge and capacities through S&T interventions; translate existing knowledge into products; enhance human capacities and skill in harnessing the potential of knowledge systems for development; and 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.

Enhancement of the livelihood security through sustainable farming systems and related farm enterprises in North-West Himalaya (2007-2012, NAIP/ICAR)

The natural resources are in poor state in central Himalaya because of high dependence on them for diverse subsistence, which leads them to over exploitation. As a result, most of the forests are in dwindling state. Thus the task of sustainable development of natural resources is crucial as local economy is highly dependent on them. Despite increasing levels of economic investment and multiplication of developmental projects in this region, the worsening economic and environmental conditions emphasized the need for a critical re-examination of prevailing developmental planning approaches in this mountainous region of the country. The region is rich in bio-resources, yet appropriate science and

technological interventions are required to harness these resources in order to overcome conservation and development dilemma posed by the fragile Himalayan environment. Therefore, up gradation of natural resource base coupled with sustainable agriculture and requisite training of target groups/ users are important aspects required in the hill region to enhance the livelihood of the local communities.

Objectives

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

Achievements

- Different plant species of fodder, fuel, horticulture and medicinal values were prioritized and selected on the basis of meetings and group discussions held with local communities of three village clusters (Jaminikhal, Hadiya and Manjgaon) in Tehri District.
- Planted 6000 seedlings of MPTs and Medicinal plants under different prototypes covering 14 ha barren/ degraded land belonging to village community of all three village clusters.
- In the years (2007-09) about 2000 horticultural plants (i.e. Apricot, Chestnet, Babugosa, Peach and Apple) were planted in the (village clsuter Jaminikhal- Bainspani, Hadiya-Myani, Manjgaon- Hatwal Gaon) covering 05 ha barren/degraded land belonging to village community.
- The results illustrated that the *Amomum subulatum* exhibited the minimum survival percentage in all three clusters (5.6 % in Hadiya to 27.60 % in Manjgaon) while, on the other hand the maximum (86 %)survival was recorded for *Syzygium cumini* in Jamnikhal cluster. In general *Morus alba* showed a good survival percentage (72.60 to 77.20%) in all the three clusters (Fig. 50).

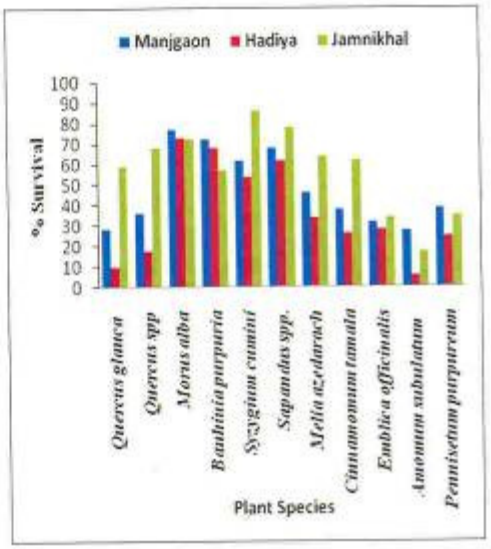


Fig. 50. Survival % of MPTs in Different village clusters

- The horticulture plant species (*Prunus* sp., *Juglans regia*, *Malus* sp., *Pyrus communis* and *Prunus persica*) were observed to possess a good

percentage of survival in all the three village clusters (Fig. 51).

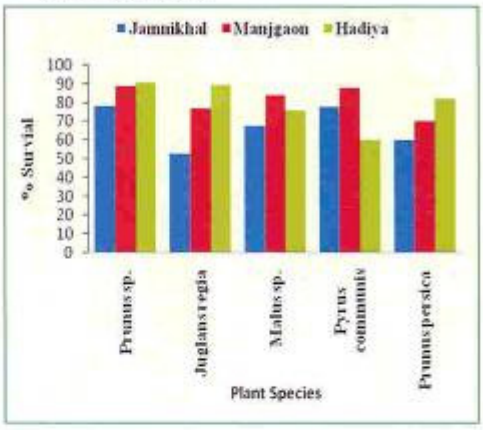


Fig. 51. Survival % of Horticulture plants in different village clusters

Capacity building for entrepreneurship development and self employment in the Himalayan region (2007-2012, In-house)

Poor access to appropriate technologies due to difficult topographies and tough mountain conditions is one of the major causes of poverty, drudgery and natural resource degradation in the Indian central Himalaya. Of late, development planners have realized the importance of suitable or appropriate technologies and practices, and therefore, have stressed upon the need for a large scale demonstration, on-site training, capacity building and skill development of user groups in rural and marginal areas of the region. Technology change is an important instrument in the continuous process of socio-economic development. However, despite of increasing levels of economic investment and multiplication of developmental projects, the worsening economic and environmental conditions emphasized the need for a critical re-examination of prevailing developmental planning approaches in this mountainous region of the country. As already mentioned above that the region is rich in bio-resources, yet appropriate science and technological interventions are required to harness these resources in order to overcome conservation and development dilemma posed by the fragile Himalayan environment. Therefore, introduction/development of new 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. .

Objectives

- To enhance the skill and capacity building of the people as well as self employment through introduction and promotion of hill specific cost-effective potential technologies.
- To select/introduce/develop on farm and off-farm technology packages and their interventions for livelihood options.
- To improve the income of the rural people through implementation and replication of these simple and cost-effective technologies.

Achievements

- Rural Technology Centers established at various locations i.e. Maletha, Triyuginarayan and Tapovan got wide popularity and played a catalytic role in the capacity building of the user groups on various rural technologies introduced and developed.
- The farmers were encouraged/motivated and were provided with the required technical skills on protected cultivation, off-seasonal vegetable cultivation through hands-on training and field demonstrations. The capacity building programme has made a significant contribution, which is reflected from the adoption of some of these technologies into their farm, for example more than 47 progressive farmers in Tosi, Sirsi and Triyuginarayan villages have adopted low cost

polyhouse technologies for nursery raising & vegetable cultivation.

- Organized two training programmes (two days) on "Demonstration/dissemination of rural technologies and conservation/ management of natural resources". About 225 women/farmers of the Kedar valley actively participated in this training.
- The large numbers of stakeholders (350) i.e. students, representatives and govt. officers from livelihood programme, NGOs, officials of NABARD (GM/DGM/DM) of Uttarakhand, Trainees (Assistance Conservator of Forest) of Indira Gandhi National Forest Academy (IGNFA), and local people particularly women from self help group (SHG), visited the RTC at Maletha and they were imparted training on rural technologies and other viable options of livelihood improvement.

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

Uttarakhand is a mountainous state having a strategic location. It is also one of the unique landscapes, with high ecological, cultural, religious, spiritual values. It is rich in biodiversity and has a long history of attracting nature lovers or eco-tourists. The region has great tourism potential however, the tourism/pilgrimage prevailing in the region at present has impacted negatively on the environment and the socio-economic and cultural set up of the local people. The pressure of tourism has been increasing and the state is in the process of exploring new sites or destinations for eco-friendly tourism or eco-tourism. The current realities of tourism sometimes marketed as eco-tourism (in some particular areas of the state) raises several fundamental questions mostly related to local employment, local economy and over all socio-economic development of the area. National tourism policies have so far had marginal impact on the mountain tourism and have generally ignored mountain perspective, mountain specific products, and development of tourism infrastructure. Hence, the present study has been initiated in Kedarnath valley of Garhwal Himalaya for assessing the eco-tourism potential in terms of diversified economies, provide alternative livelihood opportunities for locals, promote biodiversity conservation and above all address the issues related to sustainable tourism/ eco-tourism in new areas/sites making environment an integral part of it.

Objectives

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

Achievements

- Secondary data base and information on total number of tourists, earrings/income

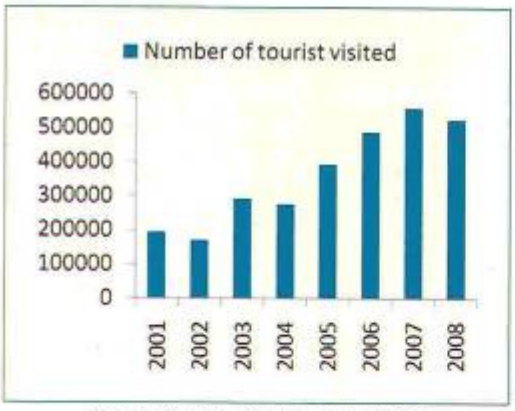


Fig. 52. Number of tourists who visited Kedar valley in different years.

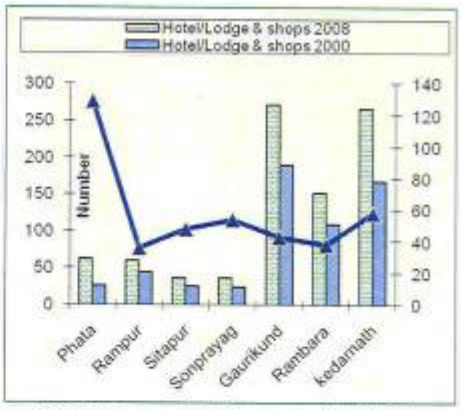


Fig. 53. Increase in infrastructural facilities in Valley & % change(2000-2008).

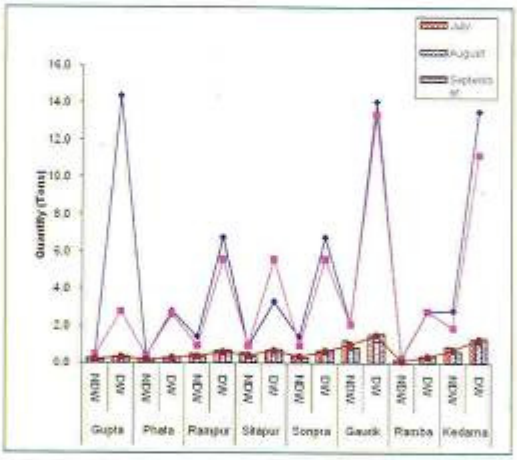


Fig. 54. Quantification of degradable and non- degradable waste

infrastructural facilities available at different locations between the period of 2000 to 2008 have been quantified and evaluated (Fig. 52 & 53). The tourists out numbered the available accomodaton facilities for them.

- An association named KEDAR (Kedarghati Eco-tourism Development Action and Research) was formed and registered by the local stakeholders and this whole process was facilitated by the Garhwal unit of the GBPIHED. Rampur declaration on Peoples' Participation on Sustainable Eco-Tourism in Kedar Valley (An initiative) was also brought out.
- The solid waste production during the tourist/ pilgrimage period was quantified in seven major places between Guptakashi to Kedarnath & was segregated into degradable & non-degradable waste. The total quantity of waste generated was found higher in Kedarnath 16.4 tons and minimum at Phata 3.2 tons (Fig. 54).

- Assessment of environmental, economic and socio-cultural impacts in upper Kedar valley was carried out & it revealed that tourists' impact on natural resources has increased many fold. Besides, it has been observed that tourists have both positive and negative socio-cultural impacts on local peoples.

Conservation and Sustainable Management of Belowground Biodiversity (BGBD) in Nanda Devi Biosphere Reserve (2005-2009, TSBF/ GEF/UNEP)

Owing to diverse topography and climatic conditions, the Central Himalayan region represents different agro-ecological zones and each of these zones in term comprised of myriad microhabitats. It is within this diversity of habitats that an amazing variety of legumes and other crops have been developed over the millennia by the hill farmers and thus this region is considered as an abode of rich agricultural crop diversity specifically the grain legumes. Legumes grown in agriculture provide a major nitrogen input to the associated crops through their ability to fix atmospheric nitrogen due to presence of nitrogen fixing bacteria on their root nodules. Through this process the legume-Rhizobium association represents the most effective, ecologically viable and renewable system of providing reduced nitrogen to a particular ecosystem. Owing to their ability to fix atmosphere nitrogen, legumes have the potential to fulfill their nitrogen requirement and can influence the availability of N to accompanying or subsequent crops.

Keeping the importance of grain legumes in the Central Himalayan agriculture, the attempt was made to analyze the effect of mixed cropping of non-legume viz. Finger-millet (*Eleusine coracana*) on the production and other parameters along with nitrogen fixing potential of three grain legume crops viz. Horsegram (*Macrotyloma uniflorum*), Adzuki bean (*Vigna angularis*) and Black Soyabean (*Glycine soja*) and vice versa.

Objectives

- Inventory and identification of belowground biodiversity in relation to physico-chemical properties of soil and aboveground biodiversity in cultural and protected landscape comprising a range of land use/ land cover types.
- Applicability of available methods of sampling of belowground biodiversity (BGBD) in the Himalayan landscapes.
- Effect of land use, soil fertility level and estimation and assessment of nodulation, *Rhizobia* diversity/legume growth and their impact on soil fertility.
- Indigenous land use (traditional agriculture) related to BGBD and its linkages to aboveground biodiversity and ecosystem functions.
- To enhance awareness, knowledge and understanding of BGBD importance to the sustainable agriculture production in tropical landscapes by the demonstration of the methods for conservation and sustainable management.

Achievements

- Among the three mixed cropping systems (horsegram + Finger millet, Adzuki bean + Finger millet and Black soyabean + Finger millet), maximum N yield (kg/ha) was recorded in Adzuki bean + Finger millet followed by Black Soyabean + Finger millet. However, maximum P and K yield (kg/ha) was recorded in Black Soyabean + Finger millet followed by Adzuki bean + Finger millet mixed cropping. In Horsegram + Finger millet mixed cropping, N, P, K yield (kg/ha) was recorded least.

- Finger millet benefited by the associated legume in all the mixed cropping systems in terms of N supply/transfer. In Horsegram + Finger millet mixed cropping, about 0.40 to 105.08 mg N plant^{-1} was transferred to Finger millet at various growth stages. Similarly, in Adzuki bean + Finger millet and Black Soyabean + Finger millet mixed cropping from 0.49 to 109.29 mg N plant^{-1} and from 0.75 to 136.48 mg N plant^{-1}, respectively, was transferred to Finger millet. Maximum N was transferred to Finger millet by Black Soyabean.
- The results revealed that legume cultivation caused significant increase in N% in soil. Before sowing the N% in soil was 0.34 and 0.30% at 0-15 and 15-30 cm depth, respectively whereas, at final harvest the % N ranged between 0.41 to 0.78% at 0-15 cm depth and from 0.34 to 0.41% at 15-30 cm depth under different treatments (except Finger millet mono crop). Maximum increase in N% in soil was found under Black soyabean cultivation.

A study on prioritization and categorization of ailments specific medicinal plants and their contribution in traditional health care system of tribal and non–tribal communities of high altitude region of Alaknanda Catchment of Uttarakhand (2007-2010, National Medicinal Plants Board)

Traditional herbal remedies have always played a key role in the health care systems in the rural and tribal areas of the country. In the Himalaya, the native people still exploit a variety of herbal plants for curing various ailments. The preparation and administration of plant based drugs vary from place to place and from one community to another. The knowledge of herbal medicines is gradually perishing, although some of the traditional herbal practitioners (men and women) are still practising the knowledge of herbal healing systematically and effectively. Various plant species are frequently used by the local herbal healers of the Himalayan region for curing various diseases. Living close to nature, traditional societies have acquired unique knowledge about the use of wild flora and fauna, most of which are unknown to the people who live away from such natural ecosystem as forests.

Recently ethno-medicinal studies have offered immense scope and opportunities for the development of new drugs. Some modern drugs have been deduced from folklore and traditional medicines. The revitalization of Vaidya system of treatment can provide self-reliance in primary health care and can even contribute to the frontiers of medical knowledge. Therefore, protection of their indigenous knowledge, public awareness, empowerment of local medical practices and education are also important for successful implementation of such activities and in raising the consciousness of local communities regarding the importance of indigenous knowledge system related to the use of medicinal plants.

Objectives

- To identify and list the prominent diseases prevalent in the high altitude region and also prepare the list of plants used by local healers for curing them through traditional health care system.
- To document indigenous knowledge related to the composition of medicinal plants in various drugs and the methods of prescribing these drugs by local healers/Vaidyas.
- To study the dependence of tribal and non-tribal communities on herbal and allopathic treatment for curing some important ailments.

- To study the contribution of medicinal plants in herbal treatment.
- To create awareness among the local communities through workshops/seminars about the role of medicinal plants and local healers.

Achievements

- The study has shown that the tribal and non-tribal communities of eight valleys (Niti, Urgam, Berahi, Nandakini, Pinder, Mandakini, Bhilangana, Binsar) of Alaknanda catchment possess immense traditional knowledge that uses as many as 400 medicinal plants for curing 135 ailments. Among the medicinal plants used in THCS, the root of the majority of the plants (27.9%) followed by leaves (25.2%), are used in curing a variety of diseases. In addition to this, out of the total MAPs used, majority of them belonged to herbaceous community (56.9%) followed by trees (21.9%), shrubs (13.2%), Climber (6.8%), Creeper (0.6%) and Fungus (0.6%).
- Out of the total human population in all valleys, about 66.1% were found depending on herbal treatment practiced by local healers/ Vaidyas and they also preferred it while the rest preferred allopathic treatment for some particular ailments. It was also found that households with low income groups and villages located far away from the road network depend more on traditional system of health care (Fig. 55 & 56).
- A workshop on "Traditional Health Care System and about 10 village level meetings were organized between April 2008 to March 2009 in which a total of 130 participants of which 75 were Vaidyas actively participated and shared their views and perceptions for improvement of traditional health care system (THCS).
- Facilitated local Vaidyas of the region to form an association called "*Paramparik Gramin Chikitsak Sabha (PGCS)*" whose mission is to revitalize the traditional health care system (THCS).

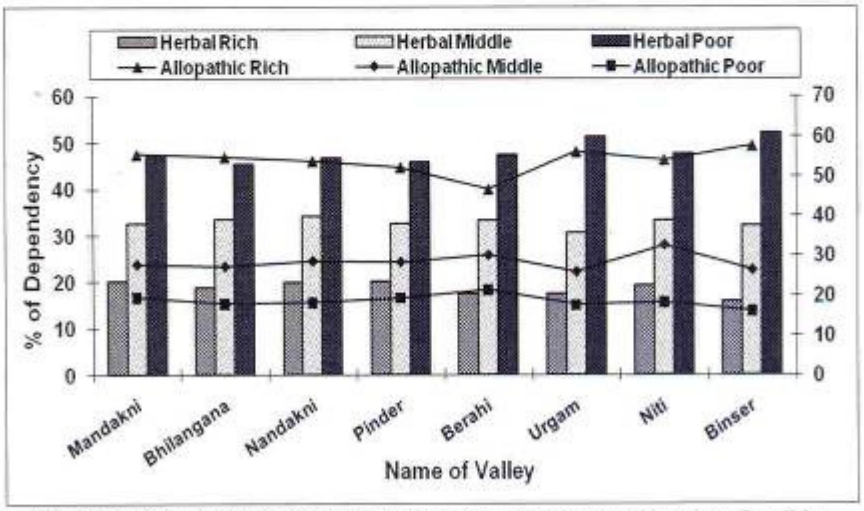


Fig. 55. Dependency of rich, middle and poor family on herbal & allopathic system of medicine

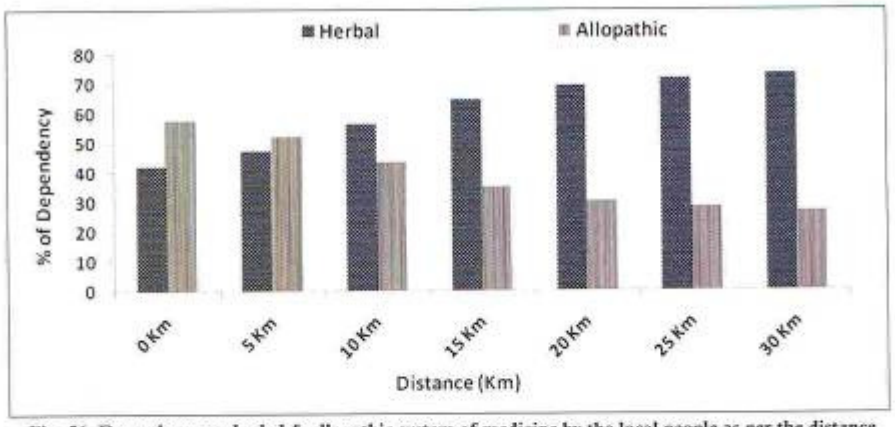


Fig. 56. Dependency on herbal & allopathic system of medicine by the local people as per the distance

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

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 alpine pastures used by pastoralists are often in the land that cannot be used for conventional agriculture. As technical advances are spreading agriculture into new regions, pastoralists are being forced into increasingly inhospitable terrain. Pastoralists make substantial contributions to the economy of traditional communities, 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 the 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. The ecological problems associated with incursions into alpine areas can be placed under the broad category of environmental degradation. Increasingly, researchers investigating the causes of environmental degradation such as soil erosion and deforestation have stressed the necessity for integrating social theory into the analysis. Therefore it can be hypothesized that the amount of resources in alpine meadows utilized by the pastoral and other rural communities varies according to the availability of resources.

Objectives

- To improve scientific understanding of participatory & transdisciplinary approaches.
- To identify the issues related to carrying capacity of pastoralism.
- To integrate results within a broader theoretical understanding of the interrelations between society and nature, and to bridge social and natural science components.
- To provide reliable socio-economic and environmental information on the pastoral systems in the region that has so far remained under-researched, but highly relevant for the sustainability of the higher mountain ranges.

Achievements

- The pastoralism practiced in Garhwal Himalaya is migratory. The annual migration routes from alpine to foothills and vice-versa of the livestock herds were mapped and documented with the help of Global Positioning System (GPS) and available toposheet.
- Area of the available alpine grazing land for the pastoral livestock in Niti valley was measured using GPS and the total area of 12 major alpine grazing lands used by the livestock in this valley is estimated to be about 64.1 km^2.
- The total number of pastoral livestock on these alpine pastures was recorded to be about 12000 nos. during 2008 and the population reached upto 15500 during 2009. The increase in the number of livestock in 2009 is due to the shifting of some herders from Sumna valley to Niti valley due to scarcity of forage resources in the Sumna valley.
- Stocking rate was quantified in 2008 and was observed maximum at 4.05 livestock/ha for Damjan pasture and minimum 0.67 livestock/ha for Kalajawar alpine pasture.

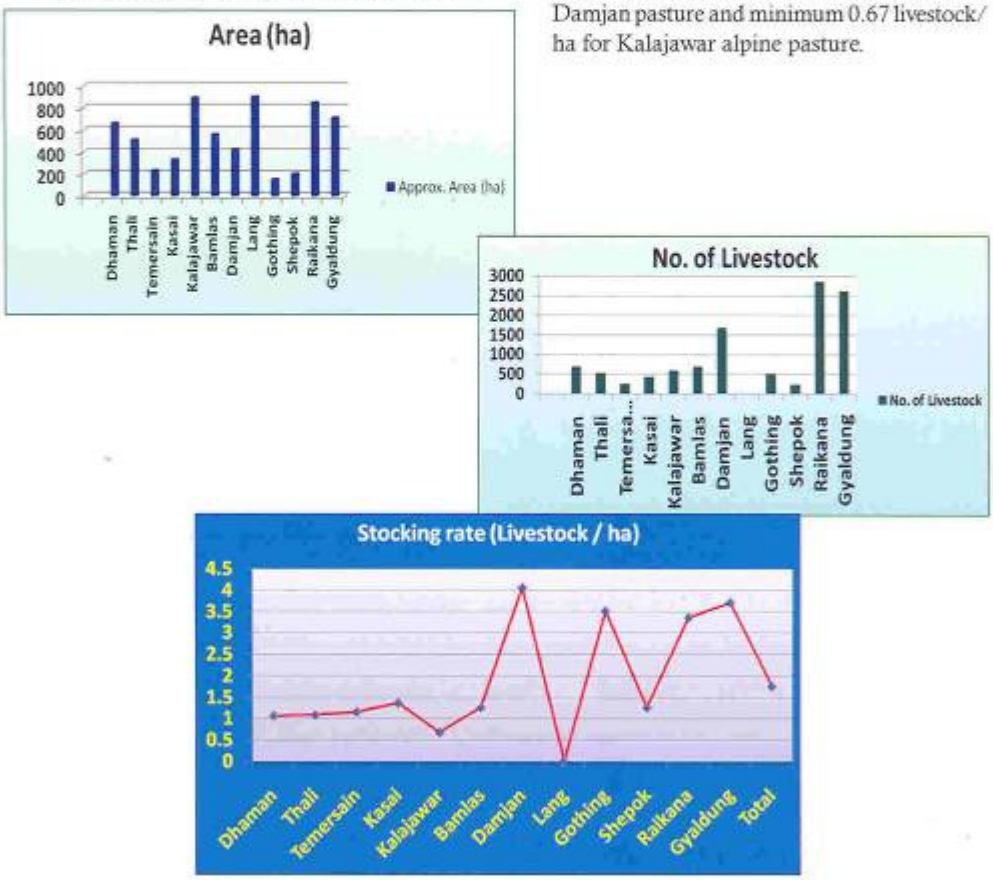


Fig. 57. Stocking Rate (Livestock/ha)

Theme

R&D HIGHLIGHT OF THE REGIONAL UNITS

HIMACHAL UNIT

- Floristic diversity of the Nargu Wildlife Sanctuary (354 vascular plants, 16 threatened species & 31 plant communities), Hirb & Shoja Catchments (660 vascular plants & 137 threatened species), Chail Chowk-Rohanda-Kamrunag Area (550 vascular plants), Ghanahatti-Shimla forests (255 vascular plants) and Mandi-Pandoh Area (160 vascular plants and 21 plant communities) and Lahaul valley, a part of proposed Cold Desert Biosphere Reserve (742 vascular plants & 35 plant communities) was assessed. The species were analyzed for nativity, endemism and threat categories. Different patterns of regeneration were identified in the forest communities. Soil samples from each plant community were collected and analyzed for pH, moisture content, organic matter, carbon, nitrogen and C/N ratio. Fuel extraction trend in Nargu Wildlife Sanctuary was analyzed and species prioritized based on the average collection per household per year and Resource Use Index. In Hirb and Shoja Catchments, habitats and communities were prioritized for conservation based on Conservation Priority Index (CPI).
- Medicinal plant diversity of Chandra, Upper Beas and Banjar Valleys, and Mohal Khad and Parbati Watersheds was assessed and updated. Overall 44 threatened species (Critically Endangered: 09, Endangered: 16 and Vulnerable: 14) were recorded. Forty five medicinal plants were extracted at commercial scale. Populations of >15 species of threatened medicinal plants in Mohal Khad Watershed and Upper Banjar Valley assessed.
- Seed germination protocol for *Hippophae rhamnoides* subsp. *turkastanica* was developed. All the treatments of KNO_3 and $NaHClO_3$ showed maximum germination. Seed germination and vegetative propagation protocols for the *Olea ferruginea* were developed. Aseptic cultures of this species were developed using nodal ex-plants and shoot-tips; these proliferated on Murashige & Skoog's medium fortified with half strength of salts, cytokinins and auxins.
- Review of the various reports like EIAs, DPRs, PFRs and EMPs of the hydropower projects was carried out and gaps identified. Socio-economic survey of the projects under construction (Shyang 3MW and Kashang 243 MW), proposed (Tangling 5 MW) and operational (Chaba 1.7 MW) from the Sutlej basin was completed.
- Solid waste characterization surveys in six sprawling urban towns namely Bilaspur,

Kangra, Mandi, Hamirpur, Chamba and Keylong were conducted and solid waste sources, quantity, nature and composition were assessed. The study reveals that all the towns are facing the problem of biodegradable waste (>70%) as compared to non-biodegradable waste.

- The columnar aerosols were monitored between 380-1025 nm wavelengths with the help of Multi Wavelength Radiometer. The averaged spectral AOD indicated high value of AODs at shorter wavelengths rather than at longer wavelengths. A significant variation at 380 nm, 500 nm and 1025 nm noticed very high AODs during the summer months and very low AODs during the winter months. The variations in turbidity parameter (á and â) noticed were inversely related.
- 870 seedlings of 23 ecologically and economically important species in the Arboretum and 5200 seedlings/plantlets of 28 medicinal plants at Doharanala, Kasol and Mohal were planted. About 5000 seedlings of ecologically and economically important species and medicinal plants along with the seeds of 12 species were distributed to the Forest Department, farmers, NGOs, etc.
- Manual Weather Stations (19 nos.) representing 19 Schools of Kullu, Mandi, Bilaspur and Hamirpur districts in Himachal at different altitudes, aspects and microclimatic conditions were established for monitoring weather data (i.e., temperature, wind speed, wind direction and rain fall) with the participation of teachers and students.
- Environment Observatory comprising of Surface Ozone, SO_2 and NO_2 analyzers, Geographic Information System (GIS) and Tissue Culture Facilities were established.
- A three day training programme on Medicinal plant cultivation and conservation (23 farmers of Malana village): One day training programme on Medicinal plants conservation and cultivation (62 participants of Kullu and Lahaul Valleys) and one day Awareness Workshop on People's Participation in Weather Monitoring, Climate Change and Biodiversity Conservation (77 Principals, Teachers and Students) were organized. Over 1200 stakeholders (Line Departments, Forest Guards, Students, Teachers, Panchayat Members, Farmers, NGOs, Mahila Mandals, etc.) were educated through exposure visits organized on various occasions.

GARHWAL UNIT

- During the year the activities of the Garhwal Unit focused on research, demonstration and dissemination related to study of documentation, prioritization and categorization of ailment specific medicinal plants and their indigenous knowledge and contribution in traditional health care system practiced by local Vaidyas in 7 valleys of high altitude region. Conservation status of some high value medicinal plants has been compared following the red data book/ IUCN criteria and CITES list and field experience and perception of local healers. It also facilitated local Vaidyas of the region to form an association called Paramparik Chikitsak Sabha (PGCS) whose mission is to revitalize the traditional health care system (THCS). The indigenous knowledge of pastoralism and transhumance and indigenous post harvesting, seed storage techniques, focusing on traditional crops, were studied. The assessment of nutraceutical potential of traditional crops, pulses, medicinal plants (used as spices and condiments) and wild edibles (fruits and vegetables) has been initiated. Bio-prospecting and value addition of some potential bio-resources of the region was done for eco-tourism product development

and livelihood improvement of the marginal societies of the region.

- Studies on environmental, economic and socio-cultural impacts of ecotourism/ pilgrimage were continued and studies on checklist of resource inventory and carrying capacity assessment in upper Kedar valley have been initiated during this year. Classification and quantification into waste categories for solid waste management options, field experiments and management practices has been carried out for effective recycling and management. Established demonstration models of different prototypes i.e. silvipasture, silvi-medicinal and silvi-horticultural in a three village cluster (Hadiya, Manjgaon and Jaminikhal) in the village common land while covering 17.5 ha land under NAIP project through participatory approaches.
- In view of the importance of below ground biodiversity (BGBD), data base on inventory, species richness and abundance of macro-micro fauna were prepared and analyzed under different land uses of Nanda Devi Biosphere Reserve. Studies on soil nitrogen dynamics in relation to quality and decomposability of plant litter used traditionally as organic manure was undertaken.
- Unit has established participatory training and action research centre at Triyuginarayan at high altitude region which provides training and builds improved skill and builds capacity of the users and local farmers in hill specific, eco-friendly technologies. During this year a total of 307 farmers and other stakeholders were trained. The participatory action research framework and approaches for scaling up of stakeholders in the field of bio-resource utilization, livelihood options and natural resource conservation and management was the main thrust of the programme. With regard to adoption and follow up of technologies by stakeholders, on site monitoring and evaluation has been initiated to know the impact of the intervention. Medicinal plant cultivation, value addition of local bio-resources, land rehabilitation, water harvesting, eco-tourism product development etc., are out-reach activities of the Garhwal Unit on which local farmers/extension agencies/ line departments were provided information of kits and hands on field training during the year. Science motivation, integrated natural resource management and environmental education programmes are being regularly organized particularly for high school level students and is highly recognized and appreciated by DST (NCSTC).
- A policy brief on hill agriculture and role of the state of forest in the context of Uttarakhand besides, some other important publications was brought out.

SIKKIM UNIT

- Using standard phyto-sociological approach, Yuksom-Dzongri landscape in Khang-chendzonga Biosphere Reserve (south-west) in Sikkim, covering a total of 24 sites along 1700 to 4200m altitude, was developed for recruitment trends and forest community patterns.
- In Khangchendzonga Biosphere Reserve (north Sikkim), along Tholung-Kisong trek, 7 major sites were studied along 1800m to 3000m for 55 woody taxa; based on stakeholders' consultation and primary studies, a comprehensive Brochure on 'Tholung-Kisong' eco-trek in Dzongu landscape, in KNP/KBR was developed, published and distributed.
- Based on stakeholders' demand, field training workshop cum demonstration on

'Biodiversity Conservation and Livelihood Options in Khangchendzonga Biosphere Reserve' was organized at Upper Dzongu (north Sikkim).

- Different populations of *Swertia chirayita* were tested for seed germination following 30 months' storage; 3 populations exhibited about >25% germination; offered fair chances of storing seeds for longer periods.
- Different training workshops were organized for Students and Teachers, viz. 'Conservation of Biodiversity', GBPIHED, Pangthang, Sikkim.
- Interactive Meeting on 'Biodiversity and Agriculture' on 'International Day for Biodiversity' was organized.
- Scientific technical knowhow on Spring Development Plan was imparted by the unit to Department of Rural Management and Development, Govt of Sikkim.
- Large number of conventional and tissue culture raised plants of *Rhododendron maddeni and R. dalhousiae* were planted in the *Rhododendron* section of the Institute's Arboretum and unique Rare & Threatened Plant Conservation Park (RTCP)' of Zoological Park, Gangtok, most attractive site for rhododendron loving community, where they are growing well.
- Organized a Training Program on Community Based Disaster Management Preparedness Plan-Ranka Block Administrative Centre, Ranka for Panchyat Members along with Aganwari Workers, Teachers, Field Facilitators, RDAs and NGOs of Ranka Block jointly with Land Revenue and Disaster Management Department, Govt of Sikkim.
- Organized a Training Program on Disaster Safe Hill Area Development for Senior to middle level officers of line departments of Govt. of Sikkim jointly with National Institute of Disaster Management, New Delhi & Land Revenue and Disaster Management Department, Govt. of Sikkim.
- Organized Training on Concept of Natural Disaster and Disaster Management to Student and Teacher of Panthang Junior High School, Pangthang, East Sikkim.

NORTH EAST UNIT

- Policies and programmes on shifting agriculture were analyzed; review of policies revealed apparent change in perception towards shifting agriculture, i.e., change from regulatory/authoritarian to accommodative attitude acknowledging it as way of life. Land tenure, customary rights and role of socio-cultural institutions of two major tribal communities (Adi and Nishyi) of Arunachal Pradesh on shifting agriculture are being studied.
- Two indigenous soil and water conservation practices (*Phai* of Nishyi community and *Panpeng* of Adi community) are scientifically validated. Vegetation composition of different successional fallow ages was investigated. 37 large mammal as well as 13 small mammal (mainly of rodents) species were recorded from the landscape of Upper Siang District. In an effort for germplasm conservation, 27 landraces were deposited with NBPGR, Shillong (Rice – 21, Maize – 3, Millet -1, Sesame – 1, Jobstear – 1) with Indigenous Collection (IC) No. ICM 564932-564958 and Mission Code – E20070016Z204.
- Identification and prioritization of human-animal conflicts in the proposed Tawang-West Kameng BR (also known as Tsangyang Gyatso BR and Peace Park) to foster better co-existence between people and park is being carried out. The major conflicts identified are livestock depredation induced retaliatory

killing, crop raiding induced killing, and grazing competition among livestock and wild ungulates. So far, 40 mammalian species belonging to 34 genera and 107 bird species have been documented in the proposed BR.

- Critical issues such as hunting, shifting agriculture, community welfare and alternative livelihood in the proposed Tawang-West Kameng BR and Apatani Plateau in Arunachal Pradesh are addressed through GOI-UNDP-CCF-II project on Biodiversity conservation through CBNRM in Arunachal Pradesh. This project is being implemented by the Institute in collaboration with four identified partners - NERIST, Nirjuli, SFRI, Itanagar, WWF, West Kameng and NCADMS, Ziro (a NGO in Lower Subansiri district). So, far 14 Village Biodiversity Conservation Councils (VBCC) have been constituted in Apatani Plateau. Propagation of 4 medicinal and aromatic plant species *(Swertia chirayata, Taxus baccata* subsp. *wallichiana, Amomum subulatum, Actinidia deliciosa)* has been initiated at Apatani plateau project site.

- A new species of cat fish *Erethistoides senkhiensis* has been discovered (new to science) from Senkhi stream in Papumpare district in Arunachal Pradesh. Also three new reports for the state (*Balitora brucei*, *Glyptothorax telchitta* and *Pseudolaguvia shawi),* 10 new reports from the district (*Balitora brucei*, *Glyptothorax telchitta*, *Pseudolaguvia shawi*, *Glyptothorax cavia*, *Glyptothorax pectinopterus*, *Glyptothorax horai*, *Glyptothorax brevipinnis*, *Tilapia mossambica*, *Oreicthys cosuatis* and *Labeo gonius)* were published.

- Study on linkages of culture in biodiversity conservation and sustainable development is being carried out in West Kameng and Tawang districts of Arunachal Pradesh covering two major tribal communities, i.e., Monpas and Sherdukpens through UNESCO-McArthur supported project on cultural landscape. Monpas and Sherdukpens have developed strategies of conserving and managing nature and biological resources. Monpas have been conserving 21 plant species while Sherdukpens have been conserving 14 plant and 2 animal species, which have either cultural or ritual value.

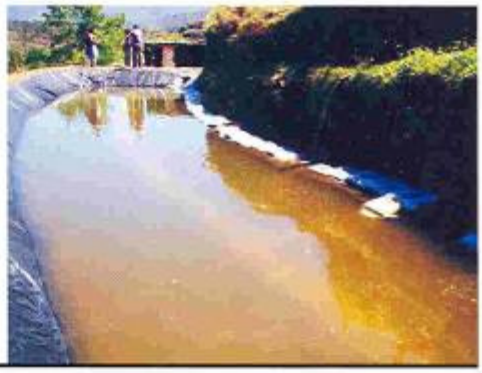
- Up scaling of technology dissemination and backstopping is carried out across the North Eastern region with the help of seven Partner NGOs (PNGOs) through establishment of 17 Demonstration Centres and about 27 On-farm demonstration sites in 12 Development Blocks spread over 8 districts in 5 states helping in the capacity building of more than 1800 lead farmers/farmers during the year 2008-09. Under a Sensitization programme on integrated farming practices under watershed development, the NE Unit in collaboration with State Institute of Rural Development, Arunachal Pradesh has given training to about 60 farmers/Zila Parishad members on low cost simple technologies. Also training on low cost simple technologies have been given to members of Agency for Integrated Development Agency (AIDA), Nagaland and NGOS and farmers from Assam, Meghalaya, Manipur, Tripura and Mizoram. The Unit, in brief, has helped in the capacity building of about 2000 farmers in low cost simple technologies during the year 2008-09.

- The Unit faculty and research staff has published 8 papers in indexed journals and 14 popular articles and presented the findings of various projects in about 31 workshops/meetings. One filed manual on "Appropriate low cost technologies for sustainable livelihood and entrepreneurship development" has been developed. This field manual has been distributed during the

training programmes; for an effective adoption of technologies by the target group, the manual has been translated to local languages by the PNGOs. Networking has been done with other institutions and technology dissemination activities are being linked to programmes like IFAD-MRDS, Meghalaya, and Watershed Development Project of Govt. of Arunachal Pradesh in collaboration with State Institute of Rural Development, Arunachal Pradesh.

Theme

APPLICATION OF R & D OUTPUTS IN DEMONSTRATION AND DISSEMINATION



Field evaluation of microbial inoculants developed for use in mountains (2007-2010, UCOST)

With a view of developing microbial inoculants for use in the colder regions of mountains, a long term study was conducted. At the very outset, field inoculation trials were carried out at higher elevations using available microbial inoculants. The study confirmed effectiveness of microbial inoculants only at the lower elevations, and indicated that there was a need of isolation, screening and selection of native microorganisms originally from higher elevations, that could be developed in the form of microbial inoculants specifically for colder regions of mountains. Systematic screening experiments based on Petri-dish assays, bioassays, greenhouse and field based assays efficient microbes were selected and developed in suitable formulations. The present project was developed for testing selected microbial inoculants at field level in collaboration with local people.

Objectives

- Field testing of the carrier based microbial inoculants using important agricultural and forest species of mountains.
- Bringing awareness to the local farmers about this eco-friendly microbe-based technology through on farm demonstrations.

Achievements

- Microbial inoculation trials have been conducted for two consecutive years on selected agricultural and forest species in nursery and farmers' plots and in net house, respectively.
- The selected plant species belong to: (1) agricultural crops (cereals, millets and legumes), and (2) forest species (*Cedrus deodara*, *Taxus baccata* and *Ginkgo biloba*). While an increase in biomass and yield of the agricultural and forest species was observed, increase in chlorophyll in leaves, leghaemoglobin in nodules and protein content in various plant parts was also recorded.
- Microbial analysis revealed the stimulation of native beneficial microflora and suppression of pathogenic fungi.
- The villagers showed a positive attitude to adopt this inexpensive and ecofriendly microbe based technology in integration with the traditional use of organic inputs and water management.

Capacity Development and Economic Upliftment of Rural Women through Pond based Integrated Farming System Approach (2007-2010, Science and Society Division, DST Govt. of India, New Delhi)

Agriculture is considered a quick route to rural poverty reduction. Diversification of cereal crops to high value crops such as fruits, vegetables, mushroom, poultry, fish and milk products has been identified as the best option to increase productivity of the farming system as also quickest way to reduce poverty among small hold farmers. There are a number of technology packages, which can be useful for the hilly areas. Among these, pond-based Integrated Farming System (IFS) concentrating on location and area specific integration(s) has great potential for socio-economic development of rural women of Uttarakhand hills. Besides, providing nutritional support to the families, the enterprise has the potential to generate income and improve the social position of hill farmers also.

Encouraged by the results of the concluded project integrated fish farming in hills, a study was proposed 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) for high economic return in resource poor farmer's fields. The proposed study has been sanctioned as a Young Scientist project by Science and Society Division of Department of Science and Technology. The proposed model(s) facilitate optimum utilization of resources and effective recycling of nutrients within the system, and will increase farm productivity and income of the farmers with minimum investment. Further, motivation and capacity building of rural women will be the key component of the project.

Objectives

- 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.
- To provide employment, income generation opportunities and nutritional security to rural folk.
- Motivation and capacity building.
- To determine seasonal changes in physico-chemical and microbiological parameters of water, fish diseases, vegetable diseases and their management.
- Documentation of success stories.

Achievements

- Two villages in Almora district, namely, Sunaulla, and Patherkote, Hawalbagh block were selected in mid-elevation zone (1000-1500m) for the development and investigations of pond-based IFS (Fig. 58).
- Two models, each consisting of a fish pond (polylined), a low cost poultry house at dyke of the pond, a vermin-composting unit (8.0'x2.5'x1.0') and a small unit for

Fig. 58. A view of IFS model at Sunola village

Fig. 59. A View of IFS model under construction at Patherkot

mushroom production, have been constructed at Sunaulla (1200 m; Fig. 58) and at Patherkot (Fig. 59). Agricultural fields approximately 500 m^2 for vegetable cultivation have also been integrated with composite carp culture. Underused land more than 200 m^2 has been utilized for fodder grass production.

- Steps were taken to maintain the existing IFS models (namely, Manan and Basoli) developed under Woman Scientist scheme during 2004-2007.
- Fingerlings of Chinese carp species viz., silver carp (*Hypophthalmicthys molitrix* Valenciennes), grass carp (*Ctenopharyngodon idella* Valenciennes) and common carp (*Cyprinus carpio* Linnalus) at a density of 3/ $m,^2$ were stocked in both the ponds at Sunaulla, Patherkot, Manan and Basoli village during month of March-April. Fingerlings exhibited a high survival rate (88-94%).
- Hybrid chick bird (Kurioler), weighing approximately 125 gm, were integrated with fingerlings exhibited a high survival rate (88.0-94.0%) at Sunola during 2008. High survival (93.4%) and substantially high growth rate was recorded (0.950-1.25 kg) within 4 months.
- Microbiological estimation of pond water revealed the presence of 24 species of extra-aquatic fungi and 16 species of watermolds, which included virulent fish pathogens.
- Capacity building of 20 women of Sunola on IFS was carried out through demonstrations and on site skill oriented vocational training. In all, 663 persons including 265 women were exposed to the IFS through lectures, audio-visual presentations and field visits.
- Besides earning Rs 4250 from vegetable cultivation (yearly) the farmer's family got fresh vegetables for their own use.

Integrated Eco-development Research Programme (IERP) in the Indian Himalayan region (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. During the previous financial year, 6 R&D themes and 16 policy problems/R&D needs were identified by the Scientific Advisory Committee (SAC) of the Institute for execution of its R&D activities in the Indian Himalayan region. The project objectives are: 1) 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); 2) To develop scientific capabilities in the IHR and strengthen infrastructure for environmental research; 3) 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.

Fifteenth meeting of the Project Evaluation Committee (PEC) was organised and convened at the headquarters of the Institute (Kosi-Katarmal, Almora, Uttarakhand) on 27-28 March 2009 in which 109 project proposals were examined critically by the PEC and 48 projects were recommended for funding. Seven members, including one special invitee, attended the meeting of the PEC. Based on the recommendations of the PEC, 15 projects (7 to the Universities, 3 to the NGOs, 2 to the Govt. Institutions and 3 to Indian Army), under 5 identified R&D themes of the Institute, were sanctioned during the financial year 2008-2009. During the year, funds for forty eight (48) 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 nineteen (19) on-going projects were processed and referred to the subject experts for evaluation. Subsequently, the comments of the subject experts on the APRs were communicated to the concerned PIs for follow-up action. Final Technical Reports (FTRs) of eighteen (18) completed IERP projects, received from different organizations, were sent to the various Govt. Agencies, etc., for follow-up action on the recommendations of the completed projects and also to the subject experts for their comments/ suggestions. Coordinated programme entitled "*Sacred values, eco-restoration and conservation initiatives in the Indian Himalayan region*" was continued and strengthened in 3 States (namely, Uttarakhand, Himachal Pradesh and Meghalaya) of the IHR under the IERP of the Institute. Follow-up action on 350 project files (old/fresh/on-going/ miscellaneous, etc.), excluding routine correspondences of about 695, was also initiated/ completed during the year 2008-09.

Library Facility of the Institute

The Central Library of the Institute at its headquarters, at the end of financial year 2008-2009, had 14,360 books. The library is subscribing a total of 107 periodicals (68 Foreign and 39 Indian). For management of Library and Information Centre, a network version of the software PALMS developed by the Scientist of this Institute is being used. As a result, the Library is providing a number of services such as Article Alert, Current Awareness, Selective Dissemination of Information, Reprography, Reference, Indexing, Bibliography, Web Services (Online Journals) etc., for the development of the human resources. The Library of the Institute is accessible through the Institute's web site (http://gbpihed.gov.in). During the reporting year, 396 new book titles were added to the Library. R & D achievements of the Institute were disseminated through its regular in-house publications, namely Hima-Paryavaran – a biannual newsletter, 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 ENVIS 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 of Himalayan Ecology from various District Information Centres, Universities/University Campuses, Research Centers, NGOs, Experts, and Institutions working in the Indian Himalayan region (IHR) were collected and compiled during the year. Abstracts/articles/technical reports and news clippings on Himalayan environment related issues were also collected and compiled for publication in the 'Selected Abstracts' and 'News and Views' section of the ENVIS Bulletins. ENVIS Bulletin Volume 16 (No. 1 & 2) and ENVIS Newsletter Volume 5 on Himalayan Ecology were prepared and published during the year 2008-09 and distributed widely through print and electronic media.

Home page as well as the other web pages of the ENVIS website <*http://gbpihed.gov.in/envis/envis.html*> were modified by the amendment of pop-up menu for accessing classified information and re-modelling of some web-links to the home page of the website. The web page district profile of the Indian Himalayan region (IHR) was re-designed by providing web links to the districts of the IHR States; hit counter on the home page of the ENVIS website was also provided during the year. Latest information on the Himalaya, current topics and seminars/conferences/workshops, etc., held in the Institute (GBPIHED), were also uploaded in the ENVIS website of the Institute. About 210 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. This database, at present, contains above 1,915 abstracts/ research papers/technical reports. About 225 queries, related to the various aspects of Himalayan environment and development, were received by the Centre during the year and responded through e-mails and print media. Website of the ENVIS Centre on Himalayan Ecology <*http://gbpihed.gov.in/envis/envis.html*> was upgraded, re-designed and maintained during the year at the headquarters of the Institute. ENVIS Bulletins [Vol. 1 (1-2) to Vol. 16 (1-2)], Monographs (No. 1 to 3) and ENVIS Newsletters (Vol. 1 to 5) were made online during the year 2008-09 for effective dissemination of information on various aspects of Himalayan Ecology. ENVIS seminar on 'Changing Himalayan environment and its impact on development' and 'ENVIS Centre's evaluation workshop' were organised at the headquarters of the Institute (Kosi-Katarmal, Almora, Uttarakhand) on 23-24 March, 2009. Various officials of the MoEF and resource persons from different parts of the country attended the seminar. The members of the technical committee also evaluated progress of 18 ENVIS Centres during the occasion of the workshop.

Strengthening & Management of IT Infrastructure in the Institute

Institute has two backbone networks, one is from NIC, New Delhi (NICNET network) which provides 128 kbps shared (HQs and Units) bandwidth for internet access and other is from BSNL-HUB, Bangalore which provides 512 kbps shared (HQs, Units and MoEF) bandwidth through VSATs for video conferencing & internet access. The bandwidth is distributed within the Institute HQs & Units through Local Area Network (LAN). The Institute website has been developed and hosted at the Internet Data Centre (IDC) of NIC, New Delhi. The URL of the Institute website is *http://gbpihed.gov.in*. A VPN

(Virtual Private Network) has been created on NICNET for remote web site updation at 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 completed. The Institute is now having video conferencing with units & arranging live telecast of Annual day function and various other programmes through video conferencing service to Units. A database of Scientific/Technical and Research Scholars has been developed and uploaded on the Institute website. The official e-mail accounts on NIC mail server (mail.nic.in) have been created and provided to all new Scientists and Technicians.

Central Laboratory Facility

The Institute has strengthened the facilities of physico-chemical, biological, heavy metal analysis of drinking, raw, waste water and quantification of volatile compounds of soil and plant samples. The heavy metals in the water and soil samples are detected through Atomic Absorption Spectrophotometer (Make- Varian AA280Z, equipped with graphite tube atomizer). For the quantification of aromatic and volatile compounds the Institute has a Gas Chromatograph (make- Chemito, Ceres 800+). Institute is also having the facility of detection of C, H, N & S through CHNS-O analyzer (make- Elementar, Vario EL-III) and UV-Vis spectrophotometer (make- UV 5704, Electronics Corporation of India Ltd.) for soil, water & plant analysis. The Institute has extended these services for other organizations (NGOs and other Government Organization) on payment basis. In the financial year 2008-09, Institute has collected 10.62 lakh rupees as a central laboratory service charge from 65 organizations (18 - Govt. organizations & 47 - NGOs). Fig. 60 shows month wise collection of testing charges and services offered to other different organizations.

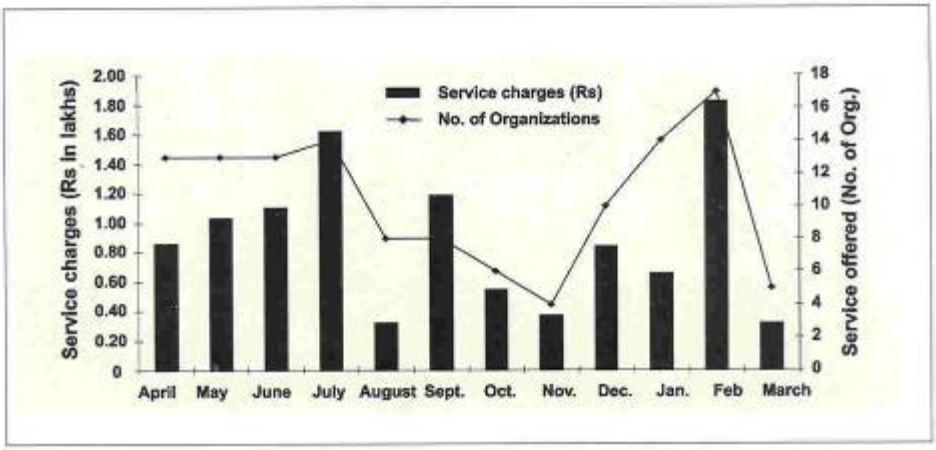


Fig. 60. Graphic representation showing total fee charged from Central Laboratory Services in 2008-09.

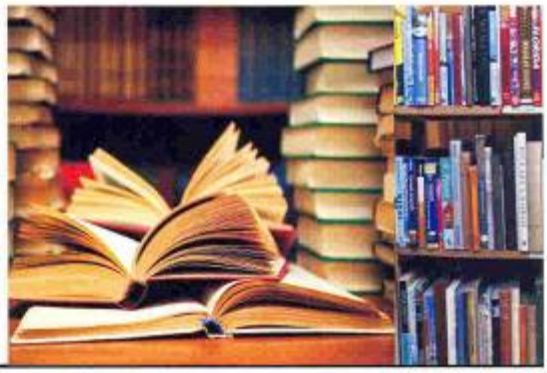
DISSEMINATION THROUGH INTERACTIVE FORUMS

FORUM/EVENTS	VENUE/DATE	TARGET GROUPS
Organized three days Training Programme on *'Diversity, nursery development and agro-techniques of medicinal plants* in collaboration with Paryavaran Evam Kalyan Sansthan, Manali	Himachal Unit, Mohal-Kullu, April 5-7, 2008	Villagers of Malana
Organized Exposure visit of the Himachal Unit of the Institute	Himachal Unit, Mohal-Kullu, April 27, 2008	Trainees (Farmers and Forest Officers) of the Mid Himalayan Watershed Project
Organized Exposure Visit of Medicinal Plants and Multipurpose Trees Nurseries, Herbal Garden, Arboretum, Germplasm collection and Conservation in Green and Shade Houses.	Himachal Unit, Mohal-Kullu, May 17, 2008	Students and Teachers (47) of Emmanuel B.T.C. Centre, Gandhinagar, Kullu
Organized two days Training Programme regarding *Geographic Information System (GIS) and Remote Sensing (RS)*	Himachal Unit, Mohal-Kullu, May 26-27, 2008	Project staff of the Institute
Celebration of World Environment Day	Himachal Unit, Mohal-Kullu, June 5, 2008	Teachers and Students of Government and Public Schools
Organized Meeting of the "Indian Man and Biosphere Programme" sponsored by the Ministry of Environment and Forests, New Delhi	Manali, June 13-14, 2008	Members of the IMABC, Biosphere Reserves Managers, Scientists from Lead Institutions of the Biosphere Reserves, Officers from State Forest Departments and Scientists
Organized One Day Awareness Workshop on "Weather, Climate Change and Biodiversity sponsored by Department of Science and Technology, New Delhi	Himachal Unit, Mohal-Kullu, October 25, 2008	Teachers, Students, NGOs and Farmers
Organized One Day Workshop on "High Altitude Wetlands Conservation in Himachal Pradesh" in collaboration with WWF India, Shimla	Himachal Unit, Mohal-Kullu, December 02, 2008	Tour operators, NGOs and Tour guides
Organized Exposure Visit of the Institute for the students and teachers	Himachal Unit, Mohal-Kullu, October 04, 2008	Students and Teachers (37) of Government Post Graduate College Ludhiana, Punjab
People's participation in Weather Monitoring, Climate Change and Biodiversity Conservation	Himachal Unit, Mohal-Kullu, February 28, 2009	Principals, Teachers and Students (77)
One Day Training Workshop on "Conservation and Cultivation of Medicinal Plants in Himachal Pradesh"	Himachal Unit, Mohal-Kullu, March 13, 2009	Farmers, NGOs and Fruit Growers Association

Celebration of International Biodiversity Day	HQs and Units, May 22, 2009	Students and Teachers of Government and Public Schools/Institutes
Celebration of World Environment Day	HQs and Units, June 5, 2009	Students and Teachers of Government and Public Schools/Institutes
Celebration of G.B. Pant Anniversary	HQs and Units, September 10, 2008	Students and Teachers of Government and Public Schools/Institutes/ Universities, Senior Citizens, Farmers etc.
Organized a two day Workshop on Traditional Health Care System: Problems and Prospects, Sponsored by NMPB, New Delhi.	Triyuginarayan, Rudraprayag, Uttarakhand, November 5-6, 2008	Vaidyas, Stakeholders, Representatives of communities etc.
Organized a two day Workshop on Role of *Vaidyas* In Traditional Health Care System, Sponsored by NMPB, New Delhi.	Garhwal Unit, Srinagar, Uttarakhand, March 25-26, 2008	Vaidyas, Stakeholders, Representatives of communities etc.
Organized three day Workshop on Common Property Resource (CPRs) and Livelihood, Sponsored by NAIP, New Delhi	Garhwal Unit, Srinagar, Uttarakhand, April 7-9, 2008	Scientists from different institutions, Professor, Students, Scholar, Associates etc.
Organized five days Awareness Programme on generating scientific temperament among high school students, Sponsored by NCSTC, New Delhi.	Triyuginarayan, District Rudraprayag, Uttarakhand, September 24-28, 2008	Students and Teachers from Schools, Scientists, Professors, Experts, Officials from Line departments, etc.
Organized one day Workshop on Tourism/ ecotourism, Problems/ Issues and Potentials in Kedar Valley	Triyuginarayan, District Rudraprayag, Uttarakhand, March 18, 2009	District Magistrate, SDM, DFO, Farmers, Stakeholders, Scientists, etc.
Organized, Training workshop for Students and Teachers, 'Conservation of Biodiversity'	GBPIHED, Sikkim Unit Pangthang, Sikkim. 19-20 March 2009.	Students and teachers of 15 schools of Sikkim
Organized, *Stakeholders Training Workshop on* 'Biodiversity Conservation and Livelihood Options in Khangchendzonga Biosphere Reserve'.	Upper Dzongu, North Sikkim, 12 Feb., 2009,	Stakeholders of KBR (farmers, EDs, NGO, forest department personnel
Training on Disaster Management: Role of Police	Sikkim Armed Police, Pangthang. 26th June 2008.	Middle level officers of Sikkim Armed Police
Organized, Interactive Meeting on, 'Biodiversity and Agriculture' on 'International Day for Biodiversity'.	GBPIHED, Sikkim Unit, Pangthang, Sikkim, 22 May 2008	Stakeholders of KBR (farmers, EDs, NGO, forest department personnel, etc)
Organized, Field training exposure to students and teachers, Class XI (Science), 'Conservation of Biodiversity'.	GBPIHED, Sikkim Unit, Pangthang, Sikkim, 22 May 2008	Students and teachers
Workshop-Cum-Training on Appropriate Low Cost Technologies	Midpu, Doimukh, Arunachal Pradesh 21-23 May 2008	Participants from an NGO (Agency for Integrated Development Agency - AIDA, Nagaland)

Project Review Workshop on Cultural Landscape: The basis for Linking Biodiversity Conservation with Sustainable Development in Arunachal Pradesh in collaboration with NERIST, Nirjuli	Nirjuli (Itanagar) May 28-29, 2008	Reviewers from UNESCO & JNU, Principal Investigators of UNESCO projects (DU, GBPIHED-NE Unit, NERIST, CCRD)
Second Empowered Project Steering Committee (EPSC) Meeting, GOI-UNDP CCF-II Project on Biodiversity conservation through community based natural resource management in Arunachal Pradesh	Itanagar May 30, 2008	National Project Director, Members of the EPSC, Govt. officials, Principal Investigators of GOI-UNDP CCF-II Project
Sensitization Program on Integrated Farming Practices under Watershed Development in collaboration with SIRD, Arunachal Pradesh	Itanagar September 23-24, 2008	Farmers, Zilla Parishad Members
Sensitization Program on Integrated Farming Practices under Watershed Development, in collaboration with SIRD, Arunachal Pradesh	Itanagar September 29-30, 2008	Farmers, Zilla Parishad Members
Assessment-Cum-Monitoring Workshop for Partner NGOs from NE States	Itanagar January 18, 2009	NGOs from 5 NE States
Training workshop on low-cost simple technologies	Itanagar January 17, 2009	Progressive farmers, Farmers (males & females)
Stakeholders' Interactive Workshop on Shifting Agriculture	Itanagar March 26, 2009	Officials/planners from line departments, officials from Central and State government institutes, academicians, researchers, NGOs, public

MISCELLANEOUS ITEMS



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(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	26	49	31	07	42	**155**
• Training Courses	30	06	12	04	14	**66**
• Meetings	17	02	34	03	19	**75**
• Participation as a Resource Person	22	08	63	10	36	**139**
• Any Other	07	00	26	00	33	**66**
International	00	02	03	00	05	**10**

ANSUL AGRAWAL & CO.
Chartered Accountants
Sela Khola, Chaughan Pata, Near P.W.D. Office, Almora – 263 601 (Uttarakhand)
Tel.: 05962-230158, 232158, Fax: 05962-231030, Mobile: 94101-83805, 098101-53504
e-mail: ansulagrawal@rediffmail.com

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

We have audited the attached Balance Sheet of **G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT (A Institute of Govind Ballabh Pant Himalaya Paryavaran Evam Vikas Sansthan)** which are in agreement with the books of accounts, maintained by the Institute as on 31st MARCH, 2009. 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, 2009 and

ii) In the case of Income & Expenditure accounts of the INCOME of its accounting year ending 31st MARCH, 2009.

FOR ANSUL AGRAWAL & Company
CHARTERED ACCOUNTANTS

Sd/-

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

DATED: 22-9-2009
PLACE: ALMORA

Branch Office: 3/37, First Floor, Main Shivalik Road, Malviya Nagar, New Delhi – 110 017
Tel: 011-26683630, 26683640, Fax: 011-26683640, Mobile: 98101-53504

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

BALANCE SHEET AS ON 31ST MARCH 2009

PARTICULARS	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
CORPUS/CAPITAL FUND	1	47528301.92	32304568.85
RESERVE AND SURPLUS	2	391723534.08	378479980.63
EARMARKED/ENDOWMENT FUNDS	3	0	8768985.48
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	66510802.39	43173510.58
TOTAL		**505762638.39**	**462727045.54**
ASSETS			
FIXED ASSETS	8	391723534.08	379329006.82
INVEST. FROM EARMARKED/ENDOWMENT FUND	9	26920216.48	8768985.48
INVEST. OTHERS	10	0	0.00
CURRENT ASSETS, LOANS, ADVANCES ETC.	11	87118887.83	74629053.24
MISCELLANEOUS EXPENDITURE			
TOTAL		**505762638.39**	**462727045.54**

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: 22-09-2009
PLACE: ALMORA

SEAL

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

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

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

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

INCOME & EXPENDITURE A/C FOR THE YEAR ENDED 31ST MARCH 2009

PARTICULARS	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
INCOME			
Income from Sales/Services	12	207851.00	273571.00
Grants/Subsidies(net off exp)	13	112847390.50	83011898.12
Fees/Subscriptions	14	0.00	0.00
Income tfr from Fixed Assets fund	-	17110095.83	15935537.88
(to the extent of depreciation & WDV of asset sold)			0.00
Income from Royalty,Income from Inv. Publication etc.	16	295.00	320.00
Interest Earned	17	1994486.59	2184411.19
Other Income	18	2068148.00	2002388.00
Increase (decrease) in stock of Finished goods and work in progress)	19	0.00	0.00
TOTAL (A)		**134228266.92**	**103408126.19**
EXPENDITURE			
Establishment Expenses: a) Institute	20	50548909.00	24530234.00
b) Projects		7251892.00	6243554.00
c) F.C (Projects)		685111.00	352235.00
Administrative Expenses : a) Institute	21	33503336.50	31130191.12
b) Projects (As per Annexure)		11676147.00	8786758.00
c) F.C (Projects)(As per Annexure)		962320.00	846978.00
Expenditure on Grants, Subsidies etc.	22	8219675.00	11121948.00
Interest			0.00
Depreciation (Net Total at the year-end-as per Sch. 8)		17110095.83	15935537.88
TOTAL (B)		**129957486.33**	**98947436.00**
Balance being excess of Income over Expenditure (A - B)		4270780.59	4460690.19
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		**4270780.59**	**4460690.19**
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES AND NOTES ON A/c	25		

AUDITOR'S REPORT
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D.D.O

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

SEAL

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

RECEIPTS & PAYMENTS A/C FOR THE YEAR ENDED 31ST MARCH 2009

RECEIPTS	CURRENT YEAR	PREVIOUS YEAR	PAYMENTS	CURRENT YEAR	PREVIOUS YEAR
I. Opening Balances			**I. EXPENSES**		
a) Cash in hand	60228.90	12238.90	**a) Establishment Expenses**	55343127.77	19103666.76
			I) Institute	0.00	
b) Bank Balances			**b) Administrative expenses**		
			a) Institute	18951661.50	16987636.00
i) In current accounts	5106946.12	3263638.93	b) R&D(Rev) expenses	14353501.00	13866573.12
ii) In deposit accounts	14301869.00	15894994.00	c) Payments for current liabilities (gratuity/leave)	2004670.00	
iii) Savings accounts	24929601.18	36408166.87	**C. Capital expenditure**		
c) Advances & Others	29950992.60	16263220.11	a) Purchase of Fixed Assets	15392302.25	18133153.00
(As per annexure Attached)			b) Expenditure on Capital Work in Progress	10000000.00	10000000.00
			c) Aquirement of land (Lease money)	172000.00	3849026.00
F.C. ACCOUNT			**II.Payments made against funds for various proj.**		0.00
A) Cash in hand	6439.33	13364.33	**Expenditure State govt. projects**		
b) Cash at bank	465491.67	701801.36	a) Capital	3910135.00	1584983.00
c) FC Advances	0.00	0.00	b) Revenue:		
II. Grants Received			Establishment exp	6455104.00	5901932.00
a) From Government of India			Administration exp	11664349.00	8779624.00
i) Institute	79559465.00	74313343.00	**Expenditure FC projects**		
ii) IERP Projects	8500000.00	11284010.00	**a) Capital**	0.00	79088.00
b) From Other agencies	27669119.00	22083346.00	**b) Revenue:**		
c) From other sources [from FC]	1962244.00	1422255.00	Establishment exp	685111.00	352235.00
III. Income on Investments from			Administration exp	962320.00	846978.00
a) Earmarked/ Endow.Funds	0.00	512205.00	**IERP grant released**	8219675.00	11121948.00
b) Loans, Advances etc.	0.00	0.00	**III Investmeses and deposits made**		
c) Corpus Fund	2183967.00	0.00	a) Out of Earmarked/ Endowment funds	0.00	512205.00
IV. Interest Received			b) Out of own funds (Investments Others)	0.00	0.00
a) On Bank deposits savings a/c	1498206.59	654184.73	c) Corpus Fund	2183967.00	0.00
b) On term deposits a/c	220546.00	831906.46	**IV Refund of Surplus money/Loans**		
c) Loans, Advances etc.	283734.00	698820.00	a) To the Government of India	563119.00	442451.00
			b) To Others/ security/ caution money)	226100.00	728922.00
V. Other Income			c) Grant refund FC	0.00	58781.69
(As per annexure Attached)	2276294.00	2276279.00	**V Other payments**		
VI. Amount Borrowed		0.00	Current liabilities	30869213.62	23024650.80
VII. Any other receipts.			**VI Closing balances**		
a) Advance FC a/c		0.00	**a) Cash in hand**	179483.09	60228.90
b) receipts current liabilities	30613823.29	23562128.48	**b) Bank Balance**		
c) IERP grants refunded by grantee Org.	340877.00	0.00	I) In Current account	12207958.84	5106946.12
d) Construction Fund	10000000.00	10000000.00	ii) In deposit accounts	26920236.48	14301869.00
e) Corpus Fund FDR'S	24199219.00	0.00	III) In savings accounts	17868236.48	24929601.18
			C) Advances and others	50080885.63	29950992.60
			FC Project		
			a) Cash in hand	6439.33	6439.33
			b) Bank Balance	907187.67	465491.67
TOTAL	**270123063.68**	**210195422.17**	**TOTAL**	**270123063.68**	**210195422.17**

AUDITOR'S REPORT
As per our separate report of even date annexed.
FOR: ANSUL AGRAWAL & CO.
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D.D.O
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 2009
STATEMENT OF OPENING & CLOSING BALANCES

PARTICULARS	OPENING AMOUNT	CLOSING AMOUNT
Cash & Bank Balances		
Cash In Hand :		
Srinagar	4.85	1.85
Sikkim	17014.00	3083.00
Kullu	1191.36	390.36
Itanagar	26790.97	19577.16
Grant in aid in transit Biotech-xiii	184000.00	184000.00
Cash & Bank Balances		
SBI Almora A/c No.01170003256 (Endo)	52641.48	54499.48
SBI Tadong A/c No 01000050044	1209790.59	1295128.00
SBI Kullu A/c NO.01100076038	5835712.82	2178799.82
SBI Itanagar A/c No 01100050337	643699.82	572274.63
SBI Srinagar A/c No 01100030433	1531690.53	862179.53
Advances		
House Building Advance	2962463.00	3182691.00
Motor cycle/Car Advance	419002.00	374186.00
Festival Advance	17250.00	15000.00
C.P.F	36.00	36.00
Income tax deducted at source	191498.00	191498.00
Units of Institute:		
Sikkim Unit	-56125.82	0.00
HP Unit	-219085.00	-52662.18
Garhwal Unit	-55686.00	-401924.00
NE Unit	-24179.00	-83873.00
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	0.00
Fixed Deposits		
With SBI Endowment Fund	7884942.00	0.00
Interest Accrued on FDR(Endowment Fund)	831402.00	0.00
Interest Accrued on FDR(General Fund)	1665929.00	0.00
Corpus Fund FDR'S	0.00	24199219.00
Interest Accrued on Corpus fund FDR	0.00	2666498.00
Asset under installation	0.00	0.00
FDR (Margin Money/LC A/C)		
Institute	2511364.00	2805057.00
BIOTECH -XI	577.00	577.00
DST -KK-IV	0.00	1600000.00
TOTAL:	**25933523.60**	**39927836.65**

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Brought forward	**25933523.60**	**39927836.65**
Due Staff/Other IC A/c		
Post Master G.P.O Tadong (Sikkim)	2154.00	2154.00
Post Master G.P.O Almora	20625.00	21634.00
Employment News	48287.00	48287.00
Sigma Aldrich Chemicals	10590.00	10590.00
Siltap Chemicals Ltd (Biotech -III)	408.00	408.00
NRSA Hyderabad	35300.00	35300.00
R.K. Nanda & Sons	28517.00	28517.00
NICSI New Delhi	35106.00	35106.00
B S N L Banglore	2912596.00	2912596.00
Security Deposit CET Sikkim Unit	11000.00	11000.00
M/s OTT Messachute	8500.00	0.00
Uttranchal Renewal Energy Development Agency (UREDA)	165000.00	165000.00
Dr. S.C. Joshi (TA)	0.00	10000.00
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	7220.00	0.00
F.C. Inter A/C	2500.00	2500.00
M/s CCU New Delhi	70898.00	70898.00
M/sAnton Par GMBH Australia	293000.00	285909.00
Security Deposit NE Unit	1750.00	1750.00
Sh. Khailendra Singh Kanwal (UJVNL)	6618.00	0.00
M/s Delta T-Devices, England	0.00	101150.00
M/s Bajrang Motors, Haldwani	0.00	1000000.00
EE, CCU (Servicing of Sub station)	0.00	854000.00
NCADMS, Itanagar (MOE&F CC-II)	0.00	611411.00
N.E. Regional Institute, Itanagar (MOE&F CC-II)	0.00	611411.00
M/s Solar Lite Co. USA (ISRO-GBP EO PRL-JCK)	0.00	1069133.00
EE R.E.S. Almora (MOE&F (BG) RSR	0.00	1600000.00
MOE&F (S. Sharma) NRSA Hyderabad	0.00	147000.00
M/S Kipprozones B.V. Netherland	0.00	159895.00
TOTAL	**2,99,50,992.60**	**5,00,80,885.65**

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

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2009

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

SL. NO.	DESCRIPTION	GROSS BLOCK				DEPRECIATION				NET BLOCK	
		Cost as at beginning of the year	Additions during the year	adj/deduction during the year	Cost at the end of the year	depreciation for prior periods	depreciation for current year	adj/deduction for previous years	Total up to the end of the year	As at the current Year end	As at the previous year-end
A. FIXED ASSETS:											
1	LAND:										
	a) Freehold	75639.23	0.00	0.00	75639.23	0.00	0.00	0.00	0.00	75639.23	75639.23
	b) Leasehold	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	19183344.61	3500457.40	0.00	22683802.01	192068185.99	195568643.39
3	PLANT MACHINERY & EQUIPMENT										
	a) Scientific Equipments	137632649.11	7523335.00	0.00	145155984.11	51335135.03	6894909.25	0.00	58230044.28	86925939.83	86297514.20
4	VEHICLES	5479633.25	976542.00	0.00	6456175.25	4249120.05	639211.26	0.00	4888331.31	1567843.94	1200327.23
5	FURNITURE FIXTURES	18727145.40	1502012.00	0.00	20229157.40	10069074.28	1280505.66	0.00	11349579.94	8879577.46	8658071.13
6	OFFICE EQUIPMENT	8562977.35	3576826.00	0.00	12139803.35	4644214.20	1153281.32	0.00	5797495.52	6342307.83	3918763.15
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	34748.35	2895.70	0.00	37644.05	23317.96	26213.66
9	LIBRARY BOOKS	66971786.50	5723722.25	0.00	72695508.75	23663350.13	3453036.67	0.00	27116386.80	45579121.95	43308436.37
10	TUBE WELLS & W. SUPPLY										
11	OTHER FIXED ASSETS										
	GLASS / NET HOUSE	3911549.00	0.00	0.00	3911549.00	2165602.53	185798.58	0.00	2351401.11	1560147.89	1745946.47
	TOTAL OF CURRENT YEAR	**456174329.84**	**19302437.25**	**0.00**	**475476767.09**	**115344589.18**	**17110095.83**	**0.00**	**132454685.01**	**343022082.08**	**340799554.83**
	PREVIOUS YEAR	**438990968.84**	**14217029.00**	**0.00**	**438990968.84**	**88511843.85**	**14531151.45**	**0.00**	**103042995.30**	**335947973.54**	**335947973.54**
	B. CAPITAL W I P										
	Aquirement of land (Lease money)	3849026	172000.00		4021026.00	0.00	0.00	0.00	0.00	4021026.00	3849026.00
	CCU Delhi	34680426.00	10000000.00		44680426.00	0.00	0.00	0.00	0.00	44680426.00	34680426.00
	ASSET UNDER INSTAL/TRANSIT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	TOTAL	490854755.84	29474437.25	0.00	524178219.09	115364589.18	17110095.83	0.00	132454685.01	391723534.08	379329006.83

SEAL

Himalyan Glaciers

INSTITUTE SUPPORTING STAFF

HEAD QUARTERS

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

GARHWAL UNIT

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

HIMACHAL UNIT

S.P. Maikhuri	Office Superintendent
Daulat Ram	Peon

SIKKIM UNIT

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

INSTITUTE FACULTY

HEAD QUARTERS

L.M.S Palni	Director	Plant Physiology; Biochemistry; Biotechnology
P.P. Dhyani	Scientist-G	Plant Physiology; Restoration Ecology
Kireet Kumar	Scientist-F	Environmental Engineering; Hydrology
S.K. Nandi	Scientist-F	Plant Physiology; Biochemistry
R.C. Sundriyal	Scientist-F	Plant Ecology; Rural Ecosystems
D.K. Agrawal	Scientist-E	Soil & Water Conservation Engg; Impact Assessment
Anita Pandey	Scientist-E	Microbiology
S.C.R. Vishvakarma	Scientist-E	Plant Ecology; Rural Ecosystems
B.P. Kothyari	Scientist-E	Plant Pathology; Restoration Ecology
D.S. Rawat	Scientist-E	Settlement Geography; Rural Ecosystems
R.S. Rawal	Scientist-E	High Altitude Ecology; Conservation Biology
G.C.S. Negi	Scientist-D	Forest Ecology; Watershed Management; EIA
R.C. Prasad	Scientist-D	Library & Documentation
Subrat Sharma	Scientist-C	Agroecology; Remote Sensing / GIS
I.D. Bhatt	Scientist-C	Plant Physiology; Phytochemistry
R.K. Singh	Scientist-C	Information Technology
A.K. Sahani	Scientist-C	Social Science; Anthropology
Rajesh Joshi	Scientist-C	Mathematical Modeling
K.C. Sekar	Scientist-C	Plant Taxonomy; Animal Taxonomy
Shilpi Paul	Scientist-C	Molecular Biology; Plant Biotechnology
Vasudha Agnihotri	Scientist-B	Soil Science; Plant Analysis; Instrumentation
R.G. Singh	Technician-B	Applied Arts; Photography, Social Science
B.S. Majila	Technician-B	Forest Ecology; Restoration Ecology
Subodh Airi	Technician-B	Forest Ecology; Biotechnology

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
R.K. Sharma	Scientist-C	Policy Analysis; Environmental Management

SIKKIM UNIT

H.K. Badola	Scientist-E	Morphoanatomy; Conservation Biology
K.K. Singh	Scientist-D & In-charge	Plant Physiology; Stress Physiology
Varun Joshi	Scientist-C	Environmental Geology
Ranjan Joshi	Scientist-C	Ecology Economics; Resource Valuation
L.K. Rai	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
S. Tarafdar	Scientist-C	Weather & Climate Change; Glaciology; Hydrology

NORTH-EAST UNIT

P.K. Samal	Scientist-E & In-charge	Social Science; Anthropology
M.S. Lodhi	Scientist-C	Environmental Assessment
S.C. Arya	Scientist-B	High Altitude Ecology
S. Chaudhary	Technician-B	Conservation; Biological Diversity

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