ANNUAL REPORT
2006-2007

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

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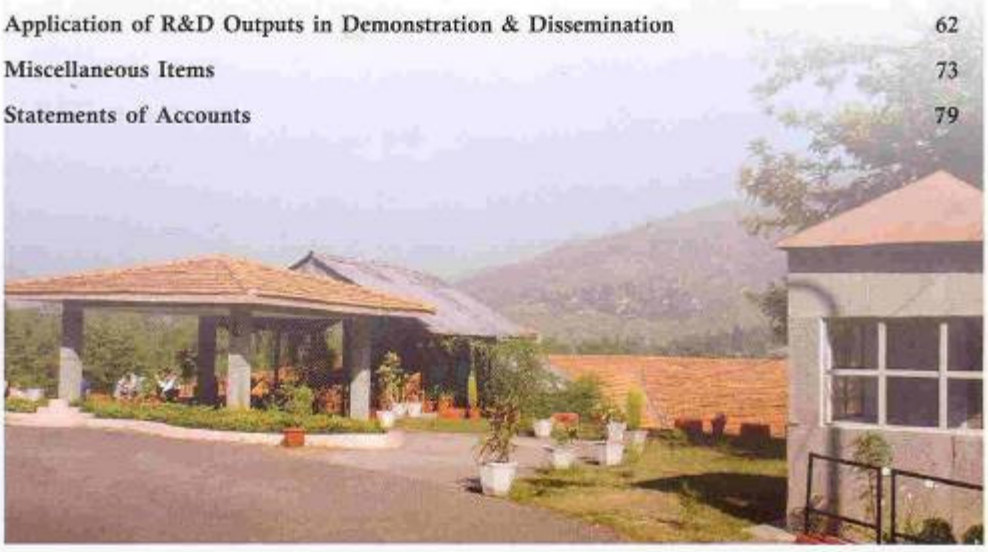


Foreword

The Institute has, over the years, established an impressive foundation to plan and build a successful future. And as the reporting period (2006-07) provided opportunity to introspect on the progress and achievements of X plan period, it also helped us to keep up the momentum and prepare to take up those topical and need based research areas whose results show increasing societal permeability.

In the above context, following a thorough consultative process and involving a wide range of stakeholders, the Institute came up with the VISION-2015 document. The vision envisages bringing in qualitative difference of approach through various mechanisms. These include, among others, i) strengthening institutional collaboration and ii) increased stakeholder's involvement. Both the above key approaches will scale up Institutes' outreach. While this exercise has provided adequate opportunity for a range of stakeholders to express their views on priority research areas, it also was a learning process for the Institute faculty and researchers.

The priority research areas and policy problems were deliberated upon during Scientific Advisory Committee Meetings and keeping in view the expertise of the Institute faculty, a perspective plan of research and development activities for XI plan period was developed. Watershed Processes and Management, Biodiversity Conservation, Environmental Assessment and Management, Socio-economic Development and Biotechnological Applications are the identified thematic thrusts for the Institute. Knowledge product and capacity building will be the inbuilt component for all the above themes.

Development of an approach, first of its kind in India, for monitoring active landslide and glacier retreat using kinematic GPS surveys, institutionalization and upscaling of technology backstopping and capacity enhancement for sustainable agricultural development within the tribal areas of north-east region; strengthening of ex-situ conservation efforts through improvement of seed germination and in vitro protocols of selected high value taxa, formulation of UNESCO-MAB Net documents for Kanchendzonga and Manas Biosphere Reserves, and development of strategy and action plan for ecotourism promotion in the Nanda Devi Biosphere Reserve were notable research achievements.

Dissemination of R & D packages and capacity building of a range of stakeholders in ToT mode through i) organization of training programmes/orientation courses on environment-friendly rural technologies, ii) biodiversity conservation, and iii) disaster management, were some of the major achievements for promoting outreach.

The Institute duly recognizes the importance of developing synergy with relevant organization and State Government Agencies in the Indian Himalayan Region. A major initiative in this direction included reorientation of its approach to facilitate extra mural funding under Integrated Eco-development Research Programme (IERP). The reorientation further strengthens synergy of IERP projects with identified thematic thrusts and regional priorities of the Institute and envisages integrating GBPIHED generated data sets with those emanated from IERP projects.

The Institute thanks all those persons who provided suggestions and directions for effective implementation of Institute programmes.

(Uppeandra Dhar)
Director

Major Achivements (2006-07)

1. Developed VISION – 2015 document based on a series of brainstorming meetings and stakeholders' consultation across the HQs and Units of the Institute. Prioritization of stakeholder driven R&D activities and development of Rolling Plan of activities for XI Plan Period for the Institute.
2. Development of approach, first of its kind in India, for monitoring of active landslides and glacier retreat using kinematic GPS survey.
3. Documentation of indigenous knowledge and practices relating to: (i) fermented food and beverages, medicinal plants use in health care, pastoralism, and post harvest practices among tribal communities of Uttarakhand; (ii) natural resource management and seed storage practices in selected ethnic communities of Arunachal Pradesh; (iii) best management practices in shifting cultivation; and (iv) fallow management practices among the Tangkhuls of Manipur.
4. Institutionalization and up-scaling of technology backstopping and capacity enhancement for sustainable agricultural development based on simple rural technologies within the tribal areas of north-east region; and review and analysis of study report on shifting cultivation by Task Force Commission (constituted by GOI).
5. Strengthening of *ex-situ* conservation efforts through: (i) improvement of seed germination of *Angelica glauca* and *Saussurea costus*; (ii) development of *in vitro* propagation protocols for *Rhododendron maddeni* and *Dendrocalamus hamiltonii*; (iii) field transfer of tissue culture and conventionally propagated plants of important *Rhododendron* spp. of Sikkim in Rare and Threatened Plant Conservation Park' of Zoological Park, Gangtok; and (iv) characterization and improvement of tea through biotechnological tools.
6. Further strengthening of wasteland restoration activities in identified locations across IHR through: (i) SWEET demonstrations; (ii) Silvi-pasture development; (iii) sacred landscape; (iv) school conservation models; and (v) catchment area treatment.
7. Formulation of UNESCO-MAB Net nomination documents for Kanchendzonga (Sikkim) and Manas (Assam) Biosphere Reserves. And, preparation of feasibility document for proposed Tawang-West Kameng Biosphere Reserve (Arunachal Pradesh).
8. Developed strategy and action plan for (i) ecotourism promotion in Nanda Devi Biosphere Reserve; (ii) sustainable development of bioresources in a selected developmental block of Almora; (iii) cultivation package on sea buckthorn (*Hippophae rhamnoides*); and (iv) EIA/ EMP plans for hydropower projects in western Himalaya.
9. Dissemination of R&D packages and capacity building of a range of stakeholders in ToT mode through - organization of over 50 training programmes/orientation workshops on environment-friendly rural technologies, biodiversity conservation education, NRM, and disaster management. Also, initiated a rural technology centre in Kedarnath valley, Uttarakhand.

EXECUTIVE SUMMARY

The institute with a strong commitment for sustainable development of 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, the Institute follows multidisciplinarity and integration as 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. To achieve this, efforts are made to keep a balance of Research, Demonstration and Dissemination activities. A brief summary of R&D activities of the Institute during the reporting year 2006-07 is as follows:

Land and Water Resource Management (LWRM)

The research activities of the LWRM core programme revolved around the central theme of land and water resource management practices. Among the research activities, focus was to: (i) understand traditional systems of soil and water conservation (SWC) in prevailing agricultural practices (i.e., bench terrace systems in central Himalaya and jhum cultivation in NE); (ii) water sustainability studies (water availability and use pattern in Kumaun Himalaya); and (iii) trends of glacier retreat (Gangotri, Thelu, Dokriyani and Milam glaciers), in the western Himalaya. Through use of Global Positioning System (GPS) geodesy with permanent and campaign mode surveys for quantification of tectonic deformation and landslide monitoring, datasets were further strengthened for surface mapping and landslide monitoring. The demonstrations included: (i) modification and scaling up of Sloping Watershed Environmental Engineering Technology (SWEET) package for rehabilitation of community wastelands in Kumaun region; and (ii) implementation of Village Environment Action Plan (VEAP) in a model village under a joint programme with NCC namely *'Operation PARADE'*. Dissemination of R&D outcome was ensured through field trainings on SWC, water recharge using catchment treatment approaches, nursery development and plantation.

Sustainable Development of Rural Ecosystems (SDRE)

The SDRE core programme considered documentation of resource dependency and use patterns in the different parts of the Himalayan region as a major focus. In eastern Himalaya, the information was generated among selected tribal communities and in the central Himalaya on settled rural ecosystems, with particular reference to agricultural production and strategy for sustainable development. Use of pastures by migratory livestock was also investigated. Setting-up of demonstrations for restoration/ rehabilitation of degraded ecosystems in

participatory manner were stressed during the year. A collaborative programme on Bhimtal lake catchment restoration was carried out with Lake Development Authority, Govt. of Uttarakhand. Further, realizing the need of technology transfer to a range of stakeholders across the IHR capacity building programme through Rural Technology Centers (RTCs) at Institute HQs, Kosi-Almora and regional units (i.e., Technology Park at Maletha village, Garhwal Himalaya; Demonstrations at Midphu, Itanagar) were conducted in a ToT mode.

Conservation of Biological Diversity (CBD)

During the reporting period, CBD core programme of the Institute attempted to: (i) update the database on Himalayan bioresources, (ii) undertake intensive assessment of biodiversity in biodiversity rich areas; (iii) strengthen field gene-banks as demonstration and training sites; and (iv) promote conservation education in participatory manner. Consolidation of information for Himalayan temperate plant families improved the understanding on endemic diversity. Database was also strengthened for the identified Himalayan Biosphere Reserves (BRs) so as to address their research and management issues. Development of UNESCO nomination documents for Manas (Assam) and Kanchendzonga (Sikkim) BRs was amongst the major achievements. The activities for establishment of gene banks at institute HQs and regional units (Sikkim & HP) were further strengthened through R&D interventions. These sites were used extensively for teaching, training and demonstration to different target groups. *Ex-situ* conservation efforts were also strengthened through laboratory based studies on seed, tissue culture and biochemical investigations on important plants. Promotion of conservation education in school/college students and teachers was achieved through orientation courses and training workshops. Organization of biodiversity assessment campaign and execution of programme to ensure participation of youth in weather and biodiversity monitoring was major outreach activity.

Ecological Economics & Environmental Impact Analysis (EE & EIA)

The Himalayan mountains are fragile and sensitive with regards to local, regional and global changes. The developmental activities that are taking place in the region have both negative and positive impacts on surrounding environment. Therefore, understanding these impacts and measuring their magnitude to suggest mitigation plan is a challenging task. Activities of this core programme were therefore focused on assessing impact of tourism on ecosystem with particular reference to municipal waste generation and air quality in selected destinations in Uttarakhand and HP, social and ecological considerations in EIA of hydropower projects in western Himalaya, impact assessment of alternative land uses (tea cultivation), and impact of land use and land cover on water quality of springs in Uttarakhand hills. Successful completion of activities relating to rapid EIA and formulation of environmental management plans for hydropower projects and silvi-pasture development took place during the reporting period.

Environmental Physiology and Biotechnology (EPB)

Environmental control on plants' responses and adaptation mechanism of plants to the changing environment is a very fascinating branch of science. Such an understanding enables us to develop strategies not only to maximize plant productivity but also to devise suitable actions to achieve the conservation goals. During the reporting period, the core activities were focused

on understanding the factors that govern the overall productivity and functioning of plants. Physiological and biochemical investigations for development of propagation protocols for selected economically important plants were also adequately attempted. The use of chemicals on improvement of root formation in cuttings was applied for plant propagation. Considering the need of improving plant survival and increasing production, the role of microorganisms remained a major focus of investigations. Several bacteria, isolated from different types of soil were developed as inoculants to achieve improved survival and growth of *in vitro* raised plants. The microorganisms isolated from various sources are being maintained under laboratory conditions for further investigations.

Institutional Networking and Human Investment (INHI)

Rehabilitation of degraded lands with a blend of science and religion, and also through capacity building of local communities remained the major thrust of INHI core programme in 2006-07. Through the Integrated Eco-development Research programme (IERP) R&D work was fostered across the Universities/ Institutions/ NGOs in the IHR. An IERP coordinated programme entitled "*Sacred values, eco-restoration and conservation initiatives in the Indian Himalayan region*" was also strengthened in 5 states (namely, Uttarakhand, Himachal Pradesh, Assam, Meghalaya and Arunachal Pradesh) of the IHR. In all, 114 projects are currently on-going in ten States of IHR. Conducting IERP workshops to identify prospective PIs in the IHR and on-site training programmes are the regular activities of the Core. Strengthening of Library and Information Centre through subscription of Research Journals and Books, publication of ENVIS Bulletin and ENVIS Newsletter, and upgrading of the Institute website are some other activities that were performed to fulfill the goals of the Core.

Indigenous Knowledge Systems (IKS)

Considering that the IHR is as a repository of indigenous knowledge, and the bio-physical diversity of the region has given rise to innumerable indigenous practices of resource management upon which the mountain communities subsists, the R&D activities of this core focused on consolidation upon the previous IKS documentations on use of medicinal plants in traditional health care by *Vaidyas*, post-harvesting and seed storage practices, preparation of beverages, NRM practices in the tribes of NE region etc. Attempts were also made to validate such knowledge. The core will further strengthen: (i) documentation of traditional ecological knowledge with reference to biodiversity and NRM of selected ethnic community of Arunachal Pradesh, and (ii) development of Digital Library on Himalayan IK.

The year 2006-07 witnessed development of Institute's VISION-2015 document following a thorough consultative process. The document defines GBPIHED as a development research Institute with a focus on applied and action-oriented research. The envisaged focus is to: (i) generate interdisciplinary critical knowledge on Himalayan environment; (ii) evolve, demonstrate and disseminate innovative packages/technologies to contribute in sustainable development; and (iii) strengthen policy advocacy, strategy development and technological backstopping. The VISION envisages bringing in the qualitative difference of approach through various mechanisms. Strengthening institutional collaborations and stakeholders involvement are the two key elements to scale up Institutes' visibility in the field. Towards achieving this, the Institute has identified thematic thrusts and priority policy problems to be addressed during XI plan (2007-2012) period.

BOX - I

Completed R&D Projects of the Institute (Year 2006 - 07)

- *Environmental impact of recession of Himalayan glaciers: a case study of Dokriani Bamak (DST Funded: Period 2004-2007)*
- *Changing behaviour of ambient air quality and surface ozone in hill spots: A case study of Kullu-Manali tourist complex, northwestern Himalaya (DST Funded: Period 2003-2006)*
- *Comprehensive EIA and formulation of EMP for Lakhwar and Vyasi HE project (NHPC Funded: Period 2005-06)*
- *People and resource dynamics in mountain watersheds of the Hindu-Kush Himalaya (SDC, IDRC, ICIMOD Funded: Period 1997-2006)*
- *In vitro approaches towards commercial cultivation of Podophyllum spp. (DST Funded: Period 2004 -2007)*
- *Capacity building and economic upliftment of hill women through integrated livestock-fish-crop farming (DST Funded: Period 2004- 2007)*
- *Characterization and improvement of tea through biotechnologicalt tools (DBT Funded: Period 2005- 2007)*
- *Conservation and sustainable management of belowground biodiversity in two altitudinal windows of Garhwal Himalaya (TSBF/GEF Funded :Period 2005-2006)*
- *Global climate change studies in the high altitude Himalayan ecosystems (Deptt. of Space Funded: Period 2003-06)*
- *Identification of elite genotypes of Hippophae rhamnoides for multiplication and large-scale domestication in the higher Himalayan region of Uttarakhand (DST Funded: Period 2003- 2006)*
- *Demonstration of a silvi-pasture model for wasteland restoration in western Himalaya (Ministry of Rural Development Funded: Period 2002-2006)*
- *Biotechnological interventions for propagation and improvement of apple rootstock (DBT Funded: Period 2003-2007)*

1. INTRODUCTION

The year 2006-07 is eighteenth 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 the information to various stakeholders. 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 the programmes supported through the core funds provided by the Ministry of Environment and Forests (MoEF), Govt. of India, projects financed by external funding agencies (National and International) and also through consultancy services. The Institute is also supporting 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 and help to develop new R&D programmes.

At present, the R&D activities of the Institute are centered on seven designated Core Programmes. Summaries of various activities/ projects concluded during the reporting year (Box – I) 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 2006-2007 on various ongoing and newly initiated projects, and a brief account of the academic and other activities, along with the statement of accounts, have been presented in this report. Institute would be grateful for critical comments, suggestions for improvement and for indication of shortcomings in our efforts to achieve the target set for us by the MoEF, Govt. of India.

2. MILESTONE EVENTS

Consultative Brainstorming on Vision Document

While formulating VISION-2015 document for XI Plan period and beyond, a series of consultative Brainstorming Sessions were organized under the Chairmanship of Dr. Prodipto Ghosh, Chairman Governing Body of the Institute. The broad emphasis was to stimulate action oriented research programmes, so as to make the Institute a 'Developmental Research Institute'. It also aimed at streamlining Institute's expertise and potentials to achieve the mandate of the Institute. Contents of the document also included: competence of the Institute, ongoing R&D thrusts and identified gap areas, and basic infrastructure available with the Institute for taking up R&D activities. The document emphasizes on the need for demand-driven research as emanated through stakeholder's consultations at different places in the IHR. Also, based on the interactions/ feedback received from partners, and suggestions offered by the distinguished members of Institute's apex bodies (Society, Governing Body and Scientific Advisory Committee). Contents

of the draft document were discussed during the three brainstorming meetings held at Himachal Unit, Kullu (11 September 2006) and Ministry of Environment & Forests, New Delhi (31 October 2006 & 5 January 2007). The summary of the VISION-2015 is presented (Box –II).

BOX-II

GBPIHED VISION 2015 - SUMMARY

1. The Indian Himalayan Region (IHR) and the problems associated with it are diverse, complex and multifaceted. Environment being all encompassing, G. B. Pant Institute of Himalayan Environment and Development (GBPIHED) is the only Institute of its kind to address physical, biological, social and economic issues of the region and its people so as to ensure sustainable development while maintaining ecosystem health of IHR. Institute's major strengths include: (i) IHR as exclusive focus of work; (ii) multidisciplinary skills and approaches with decentralized setup; and (iii) focus on integration of Research and Development. Further, strengthening R&D on priority environmental problems; developing and demonstrating suitable best practices, technology packages and delivery systems for enhanced livelihood of the people are the core issues covered under most programmes and activities in the Institute.
2. Over the years, the Institute has taken significant strides in identifying problems, developing region specific approaches, demonstrating their efficacy in the field and disseminating the information to various stakeholders. Diverse problems thus addressed related to ecology, resource conservation, traditional practices, livelihood opportunities, land restoration, propagation protocol development, biotechnological interventions, etc. As a result large quantum of data was generated, analyzed and synthesized. This helped the Institute to be recognized at national and international level as an Institute of eminence through its quality peer reviewed publications. While this was happening, concurrently, Institutes' demonstrations on best practices of watershed management, agro forestry, biodiversity conservation, spring sanctuary, ex-situ mechanisms, land restoration models at representative sites all across Indian Himalayan Region provided the required impetus for replications and further up scaling.
3. The Institute realized that the mechanism for resolving the problems needed a re look keeping in view the immense wealth of information generated in diverse fields. A few questions came up. How research product can be optimally utilized by stakeholders? How Institute can contribute in improving the quality of the life of people? How interdisciplinary data sets can be made more useful? And how the Institute can develop state of art knowledge products, which are innovative and offers better understanding of the dynamic processes. At this point of time, the Institute thought of a paradigm shift in the approach. Some sort of convergence was required, which could help us to build on the achievements thus far and the lessons learned.
4. And thus a process of developing a Vision – 2015 was felt necessary. Consultative processes started all across – at the HQ and in Institutes' Units. Representatives of all stakeholder groups were invited for their inputs. This was followed by a series of brainstorming sessions involving experts of diverse disciplines and other stakeholders.
5. Under changing scenario, GBPIHED – a development research Institute with a focus on applied action oriented research – is mandated to i) generate interdisciplinary critical knowledge on Himalayan environment; ii) evolve, demonstrate and disseminate innovative packages/technologies to contribute in sustainable development, and iii) to strengthen policy advocacy, strategy development and technological backstopping.
6. The Vision has four major components. One that focuses on development of state-of-art methodologies/ approaches as knowledge product. This will help in i) integration of interdisciplinary data sets for planning process, ii) better understanding of dynamic processes and iii) application of research results in the field.

Box 1 Contd.....

7. Another component of the Vision envisages to focus on i) creating models of research design that will ensure institutionalization of partnerships and collaboration and ii) develop inbuilt mechanisms of stakeholder consultations right through inception, planning, implementation and monitoring phases. This will help to scale up Institutes' demonstrations from micro to macro level. In this context, Institute's involvement in Training of Trainers (TOTs) and broader community networks (i.e. implementing agencies/departments) is proposed to be further promoted.
8. The third component calls for developing system approach based on collateral imperatives towards solution of problems. This will ensure development of holistic strategies and policies as opposed to those which acts in isolation to the whole.
9. The last component of the Vision recognizes the importance of existing policy frameworks including National Environmental Policy as guiding principles for developing mountain specific policy briefs and strategic implementation mechanisms.
10. The effective drivers of the Vision are as important. These are as follows: i) the Institute need to have evocative information system in place, which will not only cater to retrieval mechanisms but also, more importantly, serve as a foundation for model development. ii) Establishment of a Rural Enterprise Cell to link the farmers and unemployed youth with bioresource based income generation activities and for training of upcoming entrepreneurs. iii) Augmenting core group of scientists in appropriate streams, and iv) Allocation of appropriate budgetary provisions.
11. The Vision envisages bringing in the qualitative difference of approach through various mechanisms. Strengthening institutional collaborations and stakeholders involvement are the two key elements to scale up Institutes' visibility in the field. This is critical. In order to ensure this, a project cycle with several alternate scenarios has been finalized, which provides a road map for the Institute, its faculty and partners. While considering the structure of projects and programmes in the Institute, a major shift has been envisaged in the form of bigger projects so as to develop generic models on certain broad areas through multi-institutional partnership. The vision is to gear up the Institute to play greater role in addressing issues under broad society oriented themes such as: poverty and livelihood; infrastructure and land use planning; green development, etc.
12. While the Institute is committed to follow the envisaged path, the road ahead is expected to be full of challenges and opportunities. In view of the remoteness of most of our establishments, including the HQ, isolation may, at times, prove an impediment. In order to avoid such a pattern, the Institute needs to organize consultations, workshops, seminars periodically and Annual Partners Meet. Besides, a chair for full time adjunct Professor of eminence could also play a catalytic role in fulfilling our mandated goals.
13. Another issue of paramount importance relates to the nature and extent of feedback of policy makers and implementing agencies at the state as well as central level. While the Institute is committed to persuade policy advocacy, the support and guidance of Ministry of Environment and Forests, Govt. of India will be sought.
14. The document provides a structural mechanism and broad envisaged targets and goals in conformity with the elements of Vision. It also features the manpower and infrastructure requirements to achieve the targets in stipulated time frame.
15. The Vision has broadened the scope and further increased our responsibilities. The Institute has established an impressive foundation to plan and build a successful future.
16. This exercise has provided the opportunity for all of us and the stakeholders to air their views in a very frank and informal manner. We are all enriched and like to place on record our thanks and appreciation to all those who contributed in realizing the Vision.

Identification of R&D Themes for XI Plan Period

Under the provisions of VISION -2015 and following a thorough stakeholder's consultations across the region, including the Scientific Advisory Committee of the Institute, a perspective plan for XI Plan period (2007-12) has been developed for the Institute. The identified thematic categories include the following: (1) Watershed Processes and Management; (2) Biodiversity Conservation; (3) Environmental Assessment & Management; (4) Socio-economic Development; (5) Biotechnological Applications; and (6) Knowledge Products and Capacity Building. The R&D Themes and Policy Problems under each of these categories are as follows:

	S. No.	Thematic categories/ R&D Themes and Policy Problem
Watershed Processes & Management	1.1.	Watershed services, management and land use policy
	1.2.	Domestic energy needs – options and challenges
	1.3.	Improved economic and ecological viability of Himalayan farming systems
Biodiversity Conservation	2.1.	Conservation and sustainable use of biodiversity
	2.2.	Protected areas – Management issues and solutions
Environmental Assessment & Management	3.1.	Climate change impacts – land and water resources
	3.2.	SEA and EIA specific to the Himalaya
	3.3.	Disaster mitigation and management – data bases and knowledge products
	3.4.	Environmental Management of Urban areas
Socio-economic Development	4.1.	Sustainable tourism
	4.2.	Entrepreneurship and self employment in the Himalaya
	4.3.	Indigenous knowledge: traditional lifestyle, architecture and health care practices
	4.4.	Migration: socio-economic and cultural implications
Biotechnological Applications	5.1	Biotechnological interventions in environmental rehabilitation
Knowledge Products & Capacity Building	6.1.	Resource materials: mountain ecology and environment
	6.2.	Capacity building and technology transfer/absorption

Annual Day Celebration

The Institute celebrated its Annual Day function on the occasion of 119th birth anniversary (September 10th, 2006) of Pt. Govind Ballabh Pant (*Bharat Ratna*) at its Himachal Unit (Mohal-Kullu), and also at other regional Units and Institute HQs. Chief guest of the function, Dr. Prodipto Ghosh, Chairman Governing Body GBPIHED, inaugurated the function. Prof. S. S. Handa, Former Director, RRL-CSIR, Jammu delivered the 12th G.B. Pant Memorial Lecture entitled, 'Medicinal Plants for Health Care', and emphasized upon the need for redefining values and potentials of Himalayan bioresources in tune with the emerging global scenarios. Shri B.S. Parsheera, Additional Secretary, MoEF, GOI, introduced the speaker Prof. Handa. On this occasion two manuals compiled by the Institute, namely: (i) Bio engineering measures for hill slope stabilization-concepts, practices, application and performance evaluation; and (ii) Action plan for disaster mitigation, prevention and preparedness-building a safer and prosperous Sikkim, were released by Dr. Ghosh and Dr. Handa, respectively. Dr. R. S. Tolia, Chief Information Commissioner (Uttarakhand), members of Governing body GBPIHED (Prof. V. K. Gaur, Prof. J. S. Singh), former Director GBPIHED (Prof. A. N. Purohit), and various representatives of State Government Departments were present on the occasion.

State-Level Workshop on R&D Collaborations

A State-Level Workshop (August 11, 2006) on "R&D Collaborations and Dissemination of Information Packages to Different Stakeholders of Himachal Pradesh" was organized at GBPIHED, Himachal Unit, Kullu. The objectives included – establishment of effective network between the R&D organizations and State Government Departments; dissemination of information and technology packages to the stakeholders, development of memorandum of understanding with the State Government Departments on various R&D activities. The Chief Guest, Dr. R.K. Sood, Joint Member Secretary, Himachal Pradesh State Council for Science, Technology and Environment, emphasized on the need for collaborations with the Institute for R&D, information dissemination to stakeholders in the State. In the Technical Session held on 'Possibilities of R&D Collaborations and Dissemination of Information Packages' participants from State and Central Government Departments and NABARD also emphasized on such needs. The Institute scientists briefly presented the R&D work of the Institute on different aspects of environment and development.

Brainstorming on Increasing Outreach

A brainstorming meeting was organized at the Institute HQs (10th September 2006) to address the basic issues and approaches for strengthening outreach and delivery systems among the rural communities of IHR. The participants included scientists, representatives of Govt. line departments, R&D Institutions, academicians, NGOs, decision makers and the key farmers. The deliberations in Ist Session (Increasing outreach: Framework, issues, strategies and bottlenecks) strongly stressed for coordination amongst agencies and stakeholder groups for better impacts. The IInd Session (Improving bottlenecks for outreach) dealt with possible solutions to achieve rural development goals. The issues and concerns raised during discussion were subsequently grouped into: (i) Approach needed to increase outreach in the rural areas, (ii) Methods to increase coordination among the developmental agencies, institutions, user agencies and villages/target areas, and (iii) Conservation of community based natural resources. Motivating local people, capacity building, planning with villagers, involvement of students, women and youth, linkages with village traditions, establishing forward-backward linkages, and market connections were listed as prerequisites for successful implementation of

a programme. Pooling of resources, knowledge, technologies, and funds of different agencies with a lead agency/Institute was also suggested for effectively implementation of programs in rural areas.

Interactive Workshop on Shifting Agriculture: Issues and Options

At the NE Unit of the Institute (Itanagar) an interactive workshop on 'Shifting Agriculture: Issues and Options' was organized (10 September 2006), which was attended by identified participants representing the State and Central Government Institutions, University faculty and others. The Chief Guest of the Workshop, Shri G.N. Sinha, Director, State Forest Research Institute and Managing Director, Arunachal Pradesh Forest Corporation Ltd. presented a paper on 'Shifting Agriculture: State Polices, Laws and Acts'. Two more key papers on, "Shifting Agriculture: Customary Laws and Practices" and "Shifting Agriculture: Culture and Community Perception", were presented by representatives of Arunachal Institute of Tribal Studies and Rajiv Gandhi University, Itanagar, respectively. The recommendations emerged were: (i) Documentation of shifting agriculture practices and fallow management, (ii) Development of appropriate improved cultivation technologies and food crops for shifting agriculture, (iii) Alternative sources of livelihood and production systems, e.g., animal husbandry, cash crops cultivation, dry-land farming, integrated fish culture and sedentary agriculture, and (vi) Harmonizing development efforts in shifting agriculture with tradition, documentation of IKS, land ownership issues and gender issues.

Governing Body Meeting of GBPIHED

29th Meeting of Governing Body (GB) of the Institute was held at Himachal Unit (Kullu) on September 11, 2006 under chairmanship of Dr. Prodipto Ghosh, Secretary, Ministry of Environment & Forest, GOI, New Delhi. The meeting was attended by GB Members Prof. J. S. Singh, Prof. V. K. Gaur, Prof. Sudhir Sopory, Shri B. S. Parsheera, Mrs. Veena Upadhyaya and Dr. Uppeandra Dhar, Director of the Institute. Dr. Dhar briefed the GB on the progress of the Institute and explained the action taken on decisions of previous GB. The Governing Body members expressed satisfaction on progress of the Institute and provided valuable suggestions for further improvement of Institutes' Research & Development programmes.

Training on Disaster Management

A State-level "Training-cum-Workshop on Disaster Management" was organized (December 14, 2006) by the Disaster Management Faculty, GBPIHED Sikkim Unit, in collaboration with Land Revenue and Disaster Management Department, Government of Sikkim. The programme was supported by Ministry of Home Affairs, Govt. of India. The Chief Guest, Shri K.N. Sharma, Secretary, Land Revenue and Disaster Management Department, Govt. of Sikkim inaugurated the programme. The programme was attended by the State nodal officers for disaster management and other officials related to the subject. The presentations focused on disasters in Sikkim State and role of State Govt. in disaster management, general guidelines for safe construction practice and earthquake resistant designs of buildings, role of civil defense and fire services in disaster management.

G.B. Pant Society Meeting

The XIII meeting of the G.B. Pant Society of Himalayan Environment and Development was held under the Chairmanship of Thiru A. Raja, Hon'ble Union Minister of Environment and Forests, Government of India on 22nd March 2007 at MoEF, Paryavaran Bhavan, New Delhi. The other dignitaries present in the meeting were-Vice-President of the Society Shri Namo Narayana Meena, Hon'ble Minister of State, Environment and Forests, GOI, Shri Sher Bahadur Subedi, Hon'ble Minister for Forest,

Wildlife and Environment, Govt. of Sikkim, Dr. Prodipto Ghosh, Secretary, MoEF; Shri G.K. Prasad, Director General and Special Secretary, MoEF; Shri B.S. Parsheera, Additional Secretary (CS), MoEF; Dr. Pradeep Kumar, Special Secretary, Department of Mines; Shri G. Balachandhran, Joint Secretary, MoEF and Shri B. Anand, Director (P), Ministry of Human Resource Development, GOI, New Delhi.

In his opening remarks, the Minister MoEF took note of the major R&D achievements of the Institute and the Vision Document – 2015 developed by the Institute. He emphasized that the Institute should devote more efforts in some of the key areas such as, provisioning of drinking water, environment-friendly techniques for cultivation of cash crops, wasteland restoration, and efficient resource conservation strategies for poverty alleviation of vulnerable communities. He also stressed upon the need to build up stronger linkages and synergy with other Institutions and State Govts. in order to achieve the overall goal of sustainable development of the IHR. The Director, GBPIHED, highlighted salient achievements of the Institute in research, demonstration and dissemination activities across the IHR. He also briefly mentioned that the development of Vision Document- 2015 by the Institute was finalized through various stakeholder's consultative mechanisms and would be strictly adhered to during the 11th Plan Period.

A brief presentation was also made by the Hon'ble Minister of Forests, Wildlife & Environment, Govt. of Sikkim Shri S.B. Subedi on priority and prospective areas where collaborations with the Sikkim Unit of the Institute can be developed. He also briefed on the collaborative activities already going with the State Forest Deptt., on watershed management, and training programmes for Govt. officials of Sikkim on landslide control, and acknowledged the technical inputs provided by the Institute in preparation of draft document for UNESCO nomination of Kanchandezonga Biosphere Reserve. He stressed upon strengthening of the basic facilities and infrastructure at the Sikkim Unit of GBPIHED. At this occasion the President of the Society released a booklet 'Microbial Inoculants for Improving Plant Performance in Mountains' based on the work of Institute scientists, and Vice-President of the Society released a Newsletter 'MoRe EXPRESSIONS', brought out by the researchers of the Institute.

3. RESEARCH AND DEVELOPMENT PROGRAMMES

The R&D activities of the Institute are essentially multi-disciplinary in nature. All the activities are based on conscious efforts to inter-link natural and social sciences to promote sustainable development in the region. Institute's activities are centered on seven core programmes, viz., Land & Water Resource Management; Sustainable Development of Rural Ecosystems; Conservation of Biological Diversity; Ecological Economics and Environmental Impact Analysis; Environmental Physiology and Biotechnology; Institutional Networking and Human Investment; and Indigenous Knowledge Systems. Institute's R&D projects are implemented all across the IHR and the sites have been selected keeping in view the biophysical heterogeneity and location-specific needs and aspirations of the inhabitants. All activities are need-based, target-oriented and time-bound. Efforts are made to provide practicable solutions rather than theoretical prescriptions. The Institute HQs and the regional Units are well equipped with facilities and services, especially the laboratories and computation facilities. Research, demonstration and dissemination are underlying elements of all project activities that lead to development of technology packages. While a number of projects were completed during the year, a few new projects have been initiated. Highlights of the progress made during the year 2006-2007 are summarized for individual projects falling under each of the seven Core Programmes.

Core Programme

LAND AND WATER RESOURCE MANAGEMENT (LWRM)

Himalayan region harbours precious land and water resources. However, to meet the pressure of growing population and ever increasing demand for resources, management of land and water resources has become critical. In this endeavour indigenous practices of land and water resource management also need due consideration. Activities under this programme seek to address these issues through amalgamation of research and pilot demonstrations on appropriate technologies.

Traditional Soil and Water Management Practices

(A) North-East Region

In the North East region land is the vital component of all socio-economic activities and the soil and water losses from croplands is a major environmental issue. Tribal communities of the region follow different indigenous practices of soil and water conservation (SWC) in shifting cultivation areas. These practices need to be assessed for better management of land resources. The results on SWC experiments conducted with Nyishi tribe in Chimmi village of Papum Pare district, Arunachal Pradesh are as follows:

- Ten distinct indigenous land use types were studied (Table 1). Nine experimental plots (10m X 5m size), 3 each in Jhum fallow (*Nyibi*), with traditional SWC (*Phai*), and Jhum without soil and water conservation (WSWC) were established for runoff and soil loss measurements.
- Total soil loss (11.04 $tha^{-1}y^{-1}$) recorded in the traditional SWC practice *(P<0.05)* and Jhum fallow *(P<0.001)* was significantly low than that of WSWC. Surface runoff (1467.4 $m^3ha^{-1}y^{-1}$) in shifting cultivation without SWC practice was found significantly more *(P<0.001)* compared to *Nyibi* and *Phai* land use practices (Fig. 1).

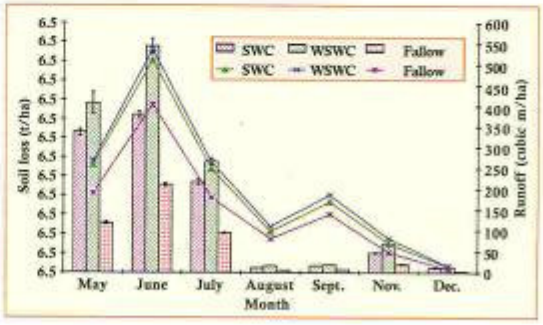


Fig. 1. Soil loss ($t\ ha^{-1}y^{-1}$) and runoff ($m^3\ ha^{-1}y^{-1}$) in three land use practices ***(SWC=soil & water conservation measure, WSWC= without SWC and fallow=jhum fallow; and line bar indicate runoff and solid bar soil loss)***

Table 1. Traditional land use classification and holding of Chimmi village of Nyishi community

Land use type	No. of plot(s)	Average no./ household	Description of land use type
More (Community forest)	1	-	Community forest where resources can be extracted by whole community. However, forest department classified community land legally under Unclassed State Forest and charge revenue on forest products which created a conflict and lead to unsustainable extraction.
Oming-Olang (Village/Clan forest)	2	-	Village/Clan forest is totally owned by the particular village or clan only. Resource extractions are regulated by the village clan headmen with full consensus of all the male members.
Atu-Olang (Individual land)	N.A.	N.A	Individual land is of recent trend in shifting cultivation region where the land tenure systems are slowly transformed into permanent ownership. Data is not included as the ownership of individual lands is in conflict within the villagers.
Eeh-Nyumra (Bamboo groves)	61	2.65	Bamboo groves are either owned by individual or village community.
Nyibi (Fallow land)	287	11.22	Fallow lands are either fall under temporary tenure or permanent ownership. It is particularly use for shifting cultivation.
Nengken-Rongo (1st year jhum field)	41	1.78	1st year jhum field is either re-cultivation of fallow land or cultivation after clearing forest.
Nyengnyi-Rongo (2nd year jhum field)	6	0.26	2nd year jhum cultivation trend is observed rarely as most of the field are left fallow after one year of cultivation.
Sapiya	26	1.13	Wet rice field is of recent transformation whereby valley lands are use for cultivation of rice.
Bolu	23	1	Home garden
Nam-Olang	23	1	Household

(B) Central Himalaya

Bench terraces in the mountains are generally considered helpful for SWC and watershed management. In this study (January 2005 – March 2006) soil loss using natural boundary erosion plot (NBEP) concept from the bench terraces in Kuwagad micro-watershed, Kumaun Himalaya was quantified.

- This study involving 12 experimental plots indicated that plots with lower bed slope (< 3°) cause low runoff, whereas, outward sloping longer plots yielded high runoff coefficient (up to 22%). The soil loss recorded was 0.18 - 2.49 t ha^{-1} and increased with increase in terrace slope.
- The terrace risers contribute a large part of runoff (runoff coefficient up to 20%) and soil loss (0.06 - 0.46 t ha^{-1}). High rainfall intensity generated more runoff and soil loss from terrace risers with height > 1 m. The soil loss and runoff values of terraces and risers are comparable with watershed level soil loss on spatial scale, suggesting that specific attention are needed for protection of terrace risers under SWC programs.

Water Sustainability in Watershed

Keeping in view the enormous spatial and temporal variations of precipitation in Himalayan region, knowledge of the regional rainfall is essential for planning land conservation strategies and water resources management. To address the management issues, perceptions of local inhabitants about water availability and use provide important clues. This concept and approach has been applied in upper Kosi watershed, Kumaun Himalaya.

- GIS database on village boundaries and other attributes in the watershed were developed. About three-fourth of the total human population resides in 342 villages. Of the total village area, 38% is under cultivation, however only 10% of it is irrigated.
- A majority of villages (211) are dependent on natural water sources for drinking, the rest are supplied with tap water. The annual water demand for urban population (5500 KL) was computed about 29% of the total domestic need of the watershed. Rural water demand was expected to increase by 8.5% compared to the last decade. Monthly and seasonal variations of rainfall volume were analyzed (Table 2) following approach of average aerial rainfall.

Table 2. Monthly averages of rainfall depth and volumes

Month	Rainfall depth (mm)	Rainfall Volume ($x10^6$ cum)
January	52.0	16.88
February	55.7	18.31
March	43.3	14.25
April	29.7	9.76
May	58.0	19.08
June	214.7	70.60
July	410.7	135.07
August	392.0	128.93
September	205.7	67.64
October	43.3	14.25
November	8.0	2.63
December	22.0	7.24

Rehabilitation of Degraded Land through *Jatropha* Plantation

Jatropha curcus (common name- Ratanjot) is a multipurpose shrub thrives well on the degraded land in the warm valleys of Uttarakhand. It is also known to reduce soil erosion, bushes used as biofence, seeds are source of biodiesel and medicine, and oil cake is a nutrient-rich manure. The potential of this species for rehabilitation of a community wasteland in Pauri Distt. (Uttarakhand) was studied.

- 12,500 *Jatropha* seedlings/cuttings from 85 accessions collected across Uttarakhand planted during June – September 2006 recorded 61% survival. A bark eating caterpillar alone caused mortality of 253 saplings.
- Physical characteristics of soil of this site were as follows: poor water holding capacity (range= 12.74±1.73 - 18.36±0.89%), gravimetric soil moisture (6.11±1.14 - 13.70±3.11%), bulk density (mean= 1.13g cm^3) and pH (range= 5.03±1.22 - 6.33 ±0.34).

Studies on Glaciers

(A) Sediment Load of Thelu Glacier (Gangotri Glacier System), Uttarakhand (DST funded; 2005-2008)

The Himalaya constitutes one of the most important glacier systems in the world with 38221 sq. km of glaciated area. Snow and glacier covered mountains in the Himalaya are the perennial sources of most of the north Indian rivers and streams. In every ablation season (May to September) melt water flows down from the glaciers along with suspended sediment (SS). The investigation focused on quantification of seasonal variation in runoff and sediment from snowmelt of the tributary glaciers of Gangotri (i.e., Raktavarna, Thelu and Chaturangi glaciers).

- Daily data of discharge and SS was collected during May to September 2006 (Figs. 2 and 3). Average discharge of Gangotri, Raktvarna and Thelu glacier was computed 59.59, 6.55 and 0.65 cum sec^{-1}, respectively with corresponding SS loads of 1.41, 0.90 and 0.27 g l^{-1} in 2006. Maximum runoff volume and SS was recorded in July in Gangotri and Thelu and in August in Raktvarna glacier (Table 3). A major GLOF event (7th May 2006) increased the discharge of Gangotri glacier three times (35.76 cum sec^{-1}) within half an hour and contributed 19.77 g l^{-1} SS load.

Table 3. Monthly Volume and Sediment of Gangotri, Raktvarna and Thelu in 2006

Month	Gangotri		Raktvarna		Thelu	
	Discharge (in m^3x10^6)	Sediment (in $Tx10^6$)	Discharge (in m^3x10^6)	Sediment (in $Tx10^6$)	Discharge (in m^3x10^6)	Sediment (in $Tx10^6$)
June	113.72	11.56	14.80	1.21	0.75	0.010
July	269.37	88.73	18.68	3.82	2.58	0.129
August	177.81	17.51	19.44	0.66	2.30	0.070
September	67.19	3.89	16.29	0.55	1.13	0.028

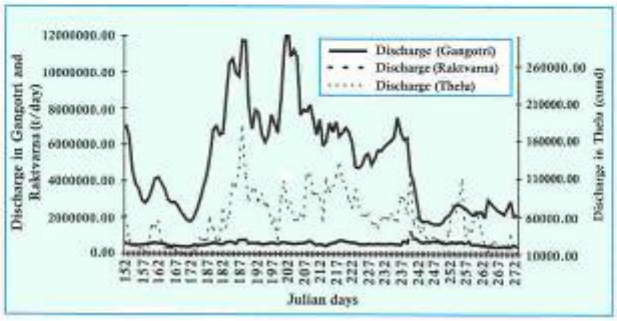


Fig. 2. Comparison of Gangotri,Raktvarna and Thelu discharge in 2006

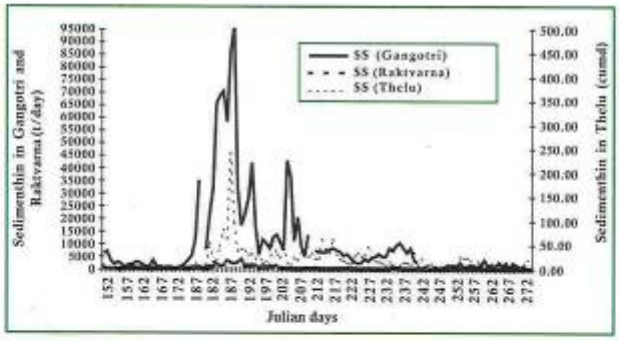


Fig. 3.Comrarison of Gangotri,Raktvarna and Thelu sediment in 2006

- Electric conductivity of sub glacial melt waters ranged from 81.0 - 15.0 mS cm^{-1}, 92.0 -24.0 mS cm^{-1} and 118.0 - 34.0 mS cm^{-1} for Thelu, Raktverna and Gangotri glaciers, respectively.

(B) Dokriani Bamak glacier

- Comparison of Gangotri and Dokraini glaciers for seasonal and diurnal variations in terms of atmospheric CO_2 concentration revealed that CO_2 concentration was high near snout of Gangotri (Gaumukh) as compared to Dokraini. Drop in CO_2 level during day time was lower in Gangotri, while it was higher in Dokriani. Overall concentration of atmospheric CO_2 was high during summer months in both the glaciers.

Landslide Hazard Modeling Using GPS, Kumaun Himalaya *(DST funded; 2002-07)*

Approximately one-half of the India's 36-40 mm yr^{-1} northward motion is absorbed by convergence of the Himalaya. In order to monitor and study the crustal motion along the two major transects in Kumaun Himalaya, Kali valley (Lipulekh to Tanakpur) and Gori valley (Dung to Almora), GPS monitoring networks of 34 sites in each geologic tectonic block was set up in 2002. And two permanent GPS stations at GBPIHED Campus, Kosi-Katarmal, Almora and Kumaun University Campus, Nainital, were setup as local reference stations. Absolute free and fixed solutions have been used for estimation of baseline changes of all the stations in the network in ITRF00 reference frame. The study involves monitoring of active landslide using GPS survey in static and kinematic mode.

- Annual GPS field campaigns (2002-2006) were carried out across the 34 sites in higher, central and lesser Himalayan parts of Gori and Kali valleys. Velocity and precise position for these sites was determined (Fig. 4). Considering the non-linear nature of the events, implementation of the soft-computing techniques for data analysis and modeling was used. Multi-layer neural network model was developed to establish surface model using GPS data that will be helpful to develop an appropriate algorithm for surface interpolation through neuro-fuzzy computing.
- Seasonal data of Balia-Nala landslide (Nainital) across 70 grid points generated in rapid static mode were processed using SKIPRO, and the rate of movement of control points computed. The slope deformation equation was computed using

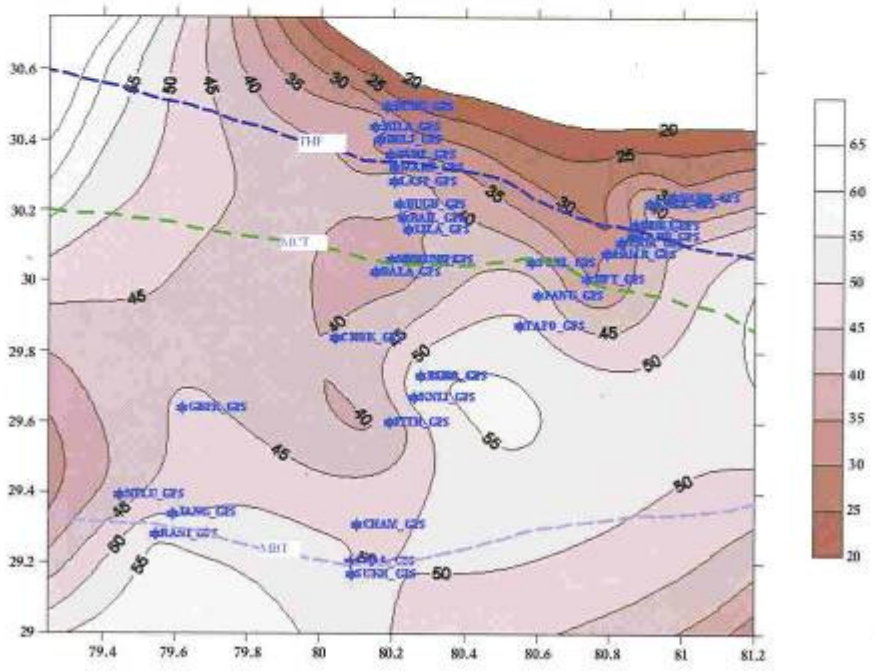


Fig. 4. Contour map depicting the velocity and position of campaign sites

three epoch data from different seasons at same campaign points in rapid static mode. The equation was verified with the previous data and data from campaign carried out in early 2007.

Tectonic Deformation and Assessment of Stability of Himalayan Towns *(DST funded; 2005-2010)*

In this study six GPS stations, Almora, Nainital (Kumaun Himalaya), Srinagar (Garhwal Himalaya), Gangtok (Sikkim Himalaya), Zero (NE Himalaya) and Kullu (West Himalaya) along the E-W transect of Himalaya were established to serve as the reference frame for quantification of Himalayan deformation field. These GPS stations cover E-W stretch of the two most vulnerable thrust systems of Himalaya, i.e., MBT and MCT. The objectives of this study were to assess the stability of urban centers in different parts of Himalaya as a vital input for disaster management.

- Preliminary observations reveal that the velocity of IISC is ~40mm y^{-1}, which is approximately same as the velocity of GBPK and also GBSK stations (Table 4). Velocity of LHAS (Tibetan plateau) is more than the velocity of Indian plate.
- Results of baseline changes for 2005-2006 reveal no significant baseline change between IISC and GBPK stations (Table 5). Convergence of ~20 mm y^{-1} between GBPK - KIT3 and GBPK – POL2 was recorded. Results also indicate that, there is baseline extenstion of 14 mm/year between LHASA and GBPK. Similarly the baseline between GBPK and GBSK shows an extension of 10 mm/year. This change indicates a locking between Indian plate and Tibetan plate and as result an eastward motion of GBSK and LAHSA w.r.t. GBPK.

Active Tectonics of the Darjeeling-Sikkim Himalayas Using GPS *(DST funded; 2004-2007)*

This study aims at understanding the kinematics of active deformation in the Darjeeling-Sikkim area. GPS measurements across a network of campaign-mode stations were carried out for isolating the zones of high displacement and

Table 4. Velocity (mm y^{-1}) of permanent and IGS stations for year 2004-2006

Station name	Velocity (2005-2006)	Error	Velocity (2004-2005)	Error	Velocity in reference to TRF 2000
LHAS_GPS	48.84	3.24	46.47	5.01	46.82 ± 0.70
KIT3_GPS	25.41	3.28	28.2	3.12	28.21 ± 0.70
POL2_GPS	32.32	3.4	29.82	2.64	27.84 ± 0.90
SELE_GPS	34.3	3.63	25.77	3.9	29.67 ± 1.9
GBPK_GPS	32.69	4.27	40.19	4.61	-
GBSK_GPS	52.99	4.3	43.6	4.9	-
IISC_GPS	40.73	4.32	44.9	3.1	41.10±0.90
HYDE_GPS	37.39	4.39	47.43	4.91	-
KUNM_GPS	30.48	5.67	34.99	4.9	20.44 ± 3.7
NTLU_GPS	38.97	8.2	59.62	6.12	

LHAS= Lhasa; KIT3= Kitab (Uzbekistan); POL2= Poligan Ivtan 2 (Bishkek); SELE= Selezaschita (Almaty-Kazakstan); GBPK= GPPIHED, Almora; GBSK= GBPIHED, Sikkim; IISC= Indian Instt. of Science, Bangalore; Hyde= Hyderabad; KUNM= Kunming (China); NTLU= Nainital.

Table 5. Baseline changes (m) for the year 2005 to 2006

Station	Baseline 2006	Baseline 2005	Baseline change (2006-2005)	Error
GBPK -IISC	1845790.001	1845790.001	0.0001	±0.0023
GBPK –KIT3	1568521.524	1568521.544	-0.0203	± 0.0025
GBPK –POL2	1509569.015	1509569.043	-0.0274	± 0.0038
GBPK - LHAS	1110479.711	1110479.697	0.0143	± 0.0019
GBPK -GBSK	910747.7246	910747.7141	0.0105	± 0.0012
GBSK -IISC	1950581.791	1950581.789	0.0020	± 0.0016
NTLU -IISC	1817190.008	1817190.018	-0.0093	± 0.0009
NTLU -LHAS	1128988.006	1128987.992	0.0141	± 0.0013
GBSK -LHAS	355188.2944	355188.2976	-0.0032	± 0.0006

(abbreviations as in Table 5).

strain in the region and comparison with the active deformation in other parts of the Himalaya. The study builds on the data from the fixed GPS station at Pangthang, Sikkim as reference station. Modeling of the surface deformation observed in the Himalayan region from the above results using Coulomb 2.5 (a dislocation based program) by simulating slip on one or more major Himalayan thrust and strike slip faults has been envisaged.

Total 21 sites were selected for detail GPS field campaigns in Sikkim and Darjeeling Himalaya (Fig 5). Analysis of GPS field campaign data of selected stations in Darjeeling-Sikkim Himalaya with respect to GBSK, LHAS, IISC, POL2 and KIT3 GPS baseline are given (Table 6).

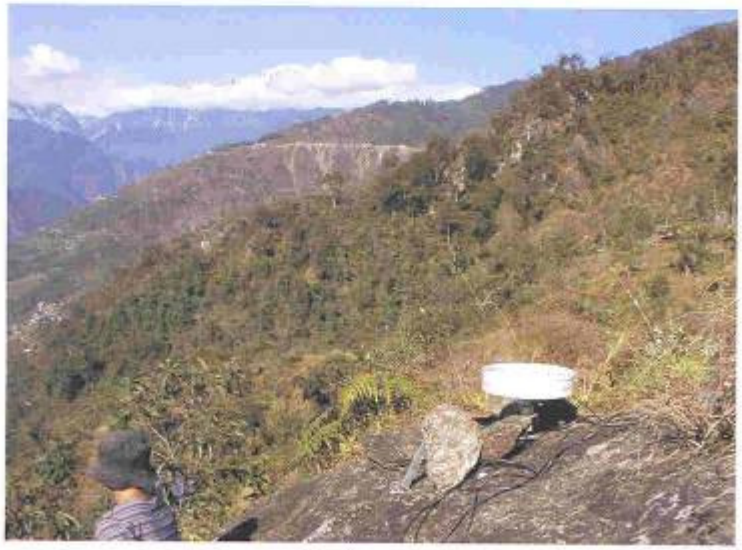


Fig. 5. GPS campaign at Mangan (North Sikkim)

Table 6. Baseline with respect to GBSK, LHAS, IISC, POL2 and KIT3 GPS

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

(abbreviations as in Table 5).

Core Programme

SUSTAINABLE DEVELOPMENT OF RURAL ECOSYSTEMS (SDRE)

The activities under this Core programme aim at to attain socio-economic wellbeing and environmentally sustainable development of the rural areas in the Himalayan region through development of suitable natural resource management strategies, production system research, study of property rights and institutions, and policy and technological interventions. Capacity building for livelihood security, development of scientific acumen amongst rural masses, reduction of drudgery, and empowerment of rural women are the major objectives of the Core.

Resource Management Strategies for Rural Development

(A) Fallow Management Practices among the Tangkhuls of Manipur

Tangkhul tribe of Ukrul district of Manipur practice shifting cultivation with a longer cultivation phase e" 3 years, compared to the normal phase of 1-2 years common elsewhere in Northeast. This longer phase is perhaps sustained by the better fallow management. This study looks into this fact through a complete assessment of soil nutrient dynamics, crop yields, and by recording the choice of species retained during the course of land clearing.

- During the year the soil nutrient status of jhum plots of different age was determined. Slight increase in total Carbon, Nitrogen, and Phosphorous levels showed a decrease in 4th year after a declining trend for initial two years.
- Yield performance for different crops was recorded. Maize and sesame registered an increase in yield after 2nd year, however, the other crops recorded continuous decline in yield from 1st to 4th years (Fig. 6).

(B) Agroforestry and Restoration Models in Garhwal Himalaya

These models implemented in Garhwal Himalaya use soil enriching SWC species and multipurpose tree species, with soil conserving and water harvesting measures and

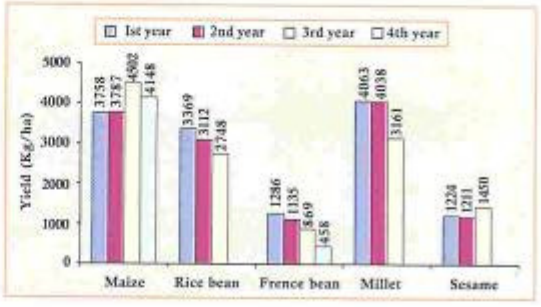


Fig. 6. Yield pattern of major crops in jhum plots of different age

vegetable cultivation, horticulture, floriculture practices as per the site requirements and the community needs. During the year performance appraisal of such demonstrations set up by the Institute in past at Rudraprayag, Tehri and Chamoli districts were carried out.

- For monitoring of ecological success criterion of system sustainability, vulnerability to invasions, productivity, nutrient retention, impact of biotic interventions was used. The practice and framework developed for degraded land rehabilitation was widely accepted by the locals, and adoption of models for rehabilitation work was encouraging.

(C) Documentation of Policies, Laws and Land Tenure Systems for Shifting Cultivation

The viability of shifting cultivation regimes of upland areas of NE India can be achieved through a proper package of policies and technologies. In this study review of ownership rights, land tenure system, and state and central government agriculture and forestry policies and rules were targeted for review, analyses, and mutual synchrony. Application of low cost technologies in shifting agriculture areas was also contemplated for review.

- Six districts of Arunachal Pradesh (viz. East Siang, West Siang, Upper Siang, Lower Debang Valley) and two districts of Manipur state (viz. Ukhrul and Senapati) were selected for the study, and National Forest Policy 1988 and North East Forest Policy 2001, reviewed.
- A reconnaissance of shifting cultivation areas was carried out and land classification pattern of Tangkhul village was documented. It was observed that the shifting cultivators are being supported under Watershed Development Project in Shifting Cultivation Area (WDPSCA) in Arunachal Pradesh and Manipur states; through this nearly 12.3% cultivators in Arunachal and 39.96% in Manipur were resorted to settled agriculture.

Assessment of Agricultural Production and Strategy for Sustainable Development

In view of inherent topographical constraints and increasing population pressure, the assessment of bioresources is essential for prescription of suitable policy and technological interventions. This study makes a geo-environmental assessment of important bioresources, such as agriculture produce, fuel, and fodder for formulation of appropriate strategies for sustainable development of rural areas of the Hawalbagh block in Almora district (Uttarakhand).

- Base maps (Fig. 7) for target area were prepared, demographic data collected, and different fuel sources and their consumption pattern were analyzed.
- Fuel wood collection schedules, efforts and time put in by women in collection, and resource status were studied.

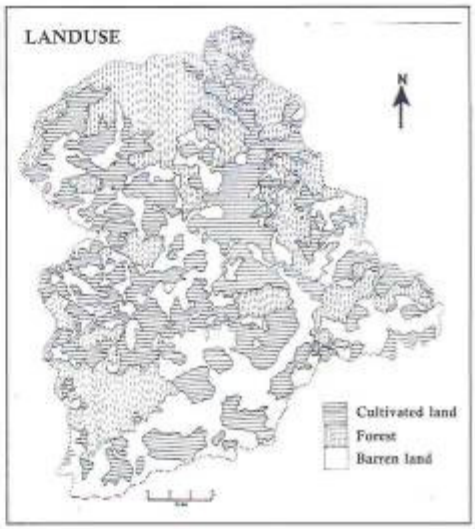


Fig. 7. Land use map of Hawalbagh development block

Belowground Biodiversity in Two Altitudinal Windows of Garhwal Himalaya (*TSBF/GEF funded; 2005-2006*)

Soil microorganisms play a prominent role in soil fertility maintenance and sustenance of the soil nutrient dynamics. Therefore, the abundance and diversity of soil fauna could be an indicator of the status of a terrestrial ecosystem, and can be correlated with general soil attributes and physical parameters. Also, the role of soil faunal diversity is not yet understood. This study, therefore, attempts to address these aspects. During the year the faunal diversity in major agroecosystems of Nanda Devi Biosphere Reserve (NDBR) and Kedarnath valley of Garhwal Himalaya was investigated.

- Soil macrofauna samples from different land uses were collected for population study and seasonal profiling. Higher population density of Myripoda was found at high altitude as well as low altitude forests; under agricultural soils low population densities were recorded.
- Coleoptera and Hymenoptera populations were found in all the land uses at high, middle and low altitudes. These groups were present in all the soil depths. Isoptera population was not found from higher altitudes of NDBR, their presence was recorded in Pine forests of the lower altitudes.

Summary of the Completed Project

Seasonal Migration of Livestock in the Central Himalaya (*In house; 2002-2006*)

Seasonal migration of village population with livestock in search of pasture and livelihoods is an age-old phenomenon in the Central Himalaya. The temporary dwellings made during the course of this movement to high altitude regimes are known as *Thors*. The livestock activities and various products of these seasonal dwelling are integral part of the village life and provide opportunities for additional income generation. This study describes the process and the *Thor* life in the forests of the Dudhatoli region in Uttarakhand.

- The forests of Dudhatoli harbor around 100 *Thors*. One *Thor* accommodates 2 to 20 persons from a maximum of 4 villages. People from one caste or religion were found to stay in one *Thor*, and no caste heterogeneity was observed. The number of people staying in a *Thor* increases with elevation (Fig. 8).
- Nearly 90 % of the cattle of the villages migrate to these *Thors*. The common cattle composition observed in *Thors* is Caprine - 62%, Bovine – 29%, and Ovine 8%. In *Thors* above 2600m altitude average livestock population is 3 times compared to that at elevations below 2600m, indicating more pressure on pasture at higher elevations.
- Number of grazing pockets available per *Thor* decreased with elevation. For each *Thor* number of grazing pockets varied between 8-18 locations in forests, cattle from a *Thor* covered 1-4 pockets/day.

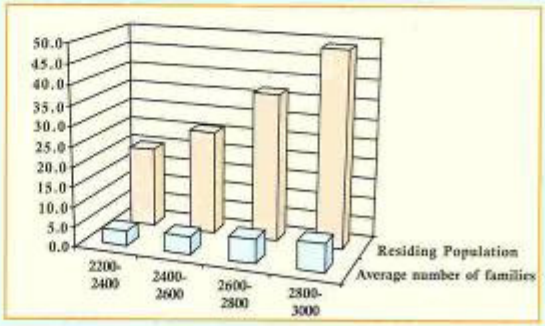


Fig. 8. Patterns of temporary settlements along elevation gradient

Summary of the Completed Project

Global Climate Change Studies in the High Altitude Himalayan Ecosystems

(Department of Space; 2003-2006)

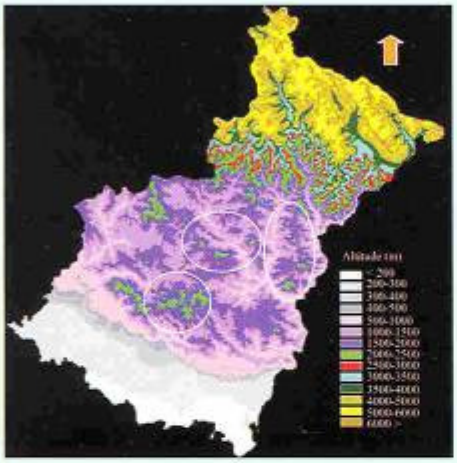


Fig. 9. Outer, Middle, and Inner mountain regions in Kumaun Himalaya

As a consequence of the green house effect and global climate change, vegetation cover is expected to respond to changes in temperature and precipitation. This study was conducted to advance our understanding of the structure and functioning of the high altitude forest ecosystems of the Himalaya with reference to analysis of structure, dynamics, and regeneration of high altitude oaks along altitudinal gradients (Fig. 9).

- Five species of oak- *Q. leucotrichophora*, *Q. floribunda*, *Q. semecarpifolia* *Q. glauca*, and *Q. lanuginosa*, occur in Kumaun Himalaya. Amongst them the first three are most common and form dominant forests types. Along elevation they replace each other, and within well marked elevation zone these are typically gregarious forming pure forests.

- An analyses of Outer, Middle, and Inner Himalaya suggests successive dominance (as reflected from density) of oak species along the elevation gradients, however, their patterns in the three regions differ considerably. While in the low altitude *Q. leucotrichophora* dominates, over mid altitude (1700-1900 m) *Q. floribunda* is dominant. The situation reverses above 1900m, but *Q. floribunda* did not attain same gregarious appearance (as apparent from density). Between 2100 and 2400m four oak species are present with *Q. lanuginosa* in high density. Density of *Q. semecarpifolia* increases with increase in elevation, and towards higher elevations of outer mountains only this oak species is present (Fig. 10).

- Detailed classified map of land use for elevations reveal oaks as the most dominant species amongst different land cover types. Among the different community types - 15.4% coverage of oak mixed conifers, 14.6% of oak mixed deciduous, 13.1% of oak mixed evergreen was observed. Exclusive dominance of Banj-oak (2.5%), Tilonj-oak (2.2%), and Kharsu-oak (3.2%) was observed.

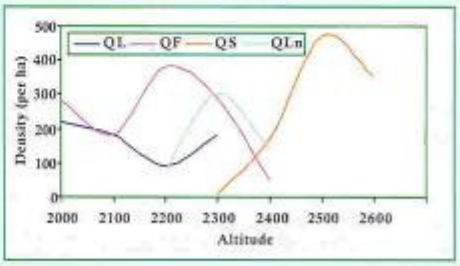


Fig. 10. Dominance and successional appearance of different forest forming oak species along elevational gradient.

Summary of the Completed Project

Elite Genotypes of *Hippophae rhamnoides* for Multiplication in the Higher Himalaya, Uttaranchal

(DST funded; 2003– 2006)

Hippophae rhamnoides is a multipurpose species that has many therapeutic, consumptive, and commercial values. Its domestication, therefore, could be an economically profitable option for the people in the higher Himalayan region. Considering its potential, the study was conducted for identification of its elite genotypes (quality-wise and in terms of productivity) from its natural habitats. *In vivo / in vitro* mass multiplication experimentations, documentation of indigenous knowledge of its uses, and promotion of the species for domestication were made. The salient achievements are summarized as under.

- Twenty five *H. rhamnoides* (Sea buckthorn) locales were identified; and morphological details compiled. The biochemical analyses of populations from Garhwal Himalaya revealed that the source of Gangotri population was best in terms nutritive value and mineral contents.
- For mass multiplication through stem cuttings, Indole Butyric Acid (IBA) - 50 ppm yielded the best rooting followed by Naphthalene Acetic Acid (NAA) and Indole Acetic Acid (IAA). Seed germination in *H. rhamnoides* was achieved through several hormonal and chemical treatments; amongst the samples - the seeds of Bhyundar (Garhwal) showed best germination.
- Awareness efforts resulted in good adoption response amongst the five valleys of the Garhwal Himalaya. Besides, its use as fuel, fodder, and therapeutic purposes for common cold this is also a source of supplemental income for the people.

Traditional Pest Management Practices Among the Tribes in Northeast India

(DST funded)

In upland shifting cultivation areas of NE nearly 45% of the potential yield is lost to pest and diseases. To avoid such losses the indigenous tribes of the region practice a host of rituals, cultural, mechanical and biological pest control measures. This study was carried out to document and validate such practices amongst the three indigenous tribes of North East India, viz. Hmar of N.C. Hills (Assam), Tangkhul of Ukhrul (Manipur) and Jaintia of Jaintia Hills (Meghalaya) those practice Jhum.

- In all 24 traditional pest management practices- 2 cultural, 7 mechanical, 11 biological, 2 ritual and 2 miscellaneous practices, employed by these tribes were documented. Manual picking of caterpillars, use of kitchen smoke for post-harvest storage, use of traditional traps to catch larger pests like rats and monkeys, bamboo fine nets for nursery beds of vegetables, and traditional granary are some of the mechanical methods of pest control (Fig. 11 A-D).
- Use of tobacco leaf extract as a pest repellent in granaries is a common practice, the efficacy, however, depends on the type of solvent. The repellency validation for 5% concentration of extracts for five hour duration was recorded. Also use of crabs for trapping rice bugs yielded 80-85 bugs catch per five days (Fig.11 A-D).

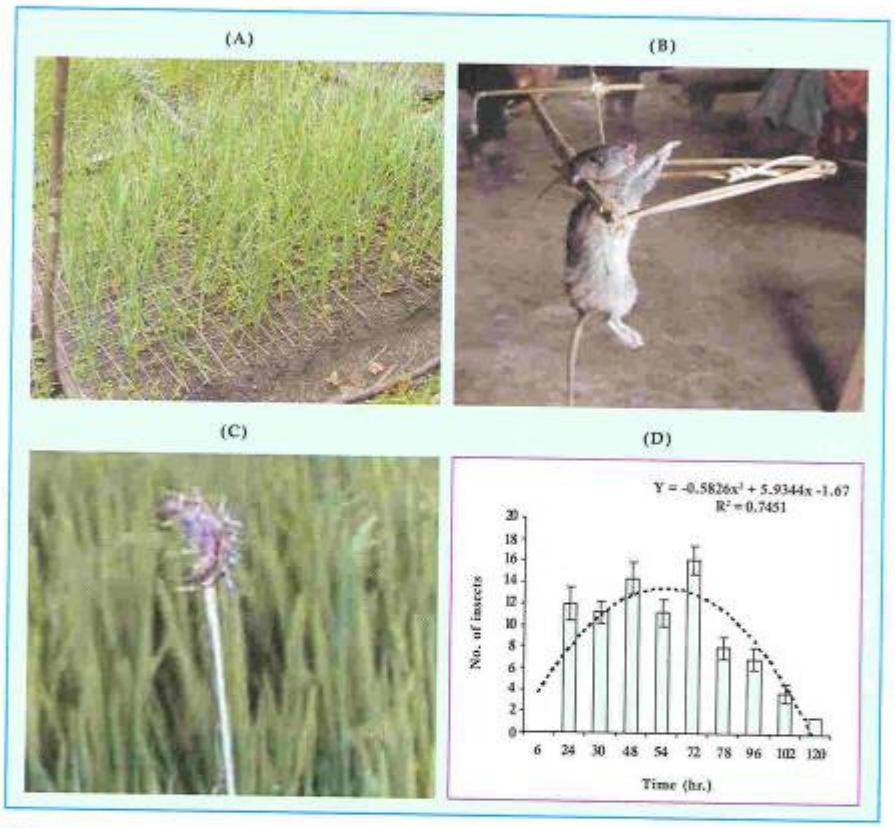


Fig. 11. Protection of onion using bamboo nets (A), traditional rat trap-*Yiang Khne* (B), Gundhi bugs attracted on decomposed crab (C), and rate of attraction of Gundhi bugs on decomposed crabs (D)

Bamboo Resources in Uttarakhand for Economic Security *(DST Women Scientist Project;2005-2007)*

Bamboo is multipurpose species which is used locally for food, fiber, and handicrafts items. The species has good economic potential which can be harnessed in a more effective way by understanding the general scenario of bamboo resource including its status and utilization patterns, the IKS related to its use, and through capacity building trainings on livelihood options. This study attempts to address these issues.

- Scenario on bamboo was recorded through reconnaissance and available statistics (Fig. 12). Two categories of bamboo artisans, namely; *Baruries* (using bamboo) and *Rudias* (using ringal bamboo) exist in Uttarakhand. Survey of traditional bamboo artisans/ craftsman over 20 villages in Almora, Bageshwar, Uttarkashi and Nainital districts, revealed that 62 items of bamboo and ringal are made which comprise a variety of baskets, mats, toys, instruments, etc.
- Due to non availability and high price of bamboo raw material the artisans of town

and outskirts are switching to other occupations. However, village artisans who have free access to bamboo stocks still intensively practice and trade in the craft. Some private growers of bamboo were also noticed in mid hill regions. They offer their bamboo clumps to the artisans on lease; generally a price of Rs.500-2500 is charged for a clump of 30-100 culms.

- During the year two capacity building trainings by subject experts were organized, one was exclusively for women. The 20 women so trained were helped to organize into a group which entered into an agreement with a local NGO for marketing of their bamboo products and earning Rs.800-1200/month.

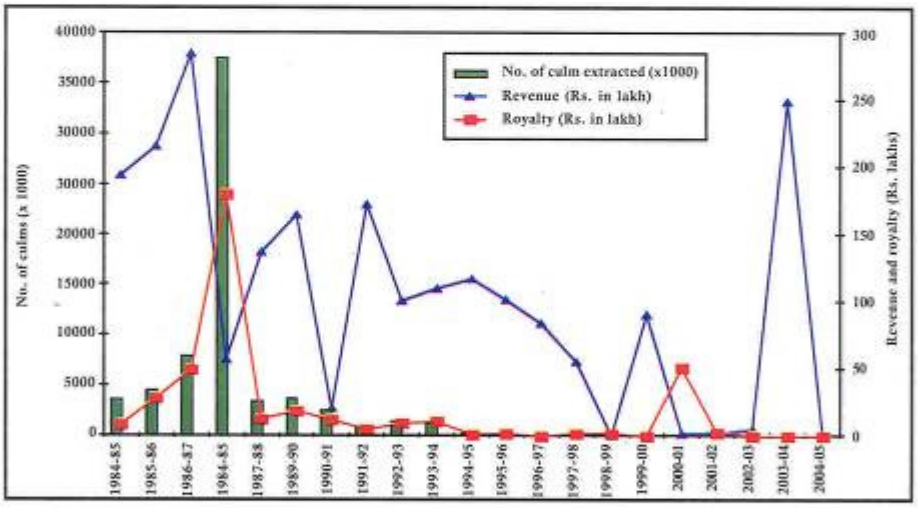


Fig. 12. Total quantity of bamboo harvest and revenue generated in the state of Uttarakhand.

Core Programme

CONSERVATION OF BIOLOGICAL DIVERSITY (CBD)

Himalayan biodiversity is recognized for its ecological and economic values as manifested by ecosystem integrity, adaptability and services. The high plant functional diversity of Himalayan ecosystems adds to resilience. Similarly, the productive value of biodiversity to meet the livelihood needs of both upland and lowland dwellers is well known. All these attributes contribute towards establishing the Himalaya a mega biodiversity 'Hotspot'. Realizing this, the Conservation of Biological Diversity core group of the Institute has designed programmes and activities, responsive to contemporary global thinking especially on mountain biodiversity, and which aim at optimizing benefits while minimizing pressures on biological resources in the region.

Bioresource Inventory of the Himalaya

Adequate baseline information at different levels (i.e. species, population, community, habitat, ecosystem, etc.) helps in identification of priorities for conservation and ensuring sustainable use. Therefore, datasets available in published and unpublished form were synthesized for development of an authentic database on Himalayan bio-resources. Focus is to: (i) develop systematic database of native/ endemic species; (ii) draw information on various attributes of specific habitats/species; and (iii) prioritize species and sites for conservation.

(A) Temperate Plant Endemics

- Studies on fifty temperate plant families of IHR revealed: (i) richness of endemics (1934 spp: 57.7%), and increasing prevalence of endemics from sub-tropical (30.8%) to high alpine (75.2%) zones; (ii) significantly higher endemism than expected in families like Apiaceae (index of endemicity, Ie–2.3), Berberidaceae (Ie-3.4), Caryophyllaceae (Ie-1.6), Gentianaceae (Ie-2.1), Ranunculaceae (Ie-1.8), Rosaceae (Ie-1.9); (iii) interestingly the endemic richness was more in barren habitats (Fig. 13), followed by forests and moraines; (iv) across the IHR, considering various attributes (taxonomic richness,

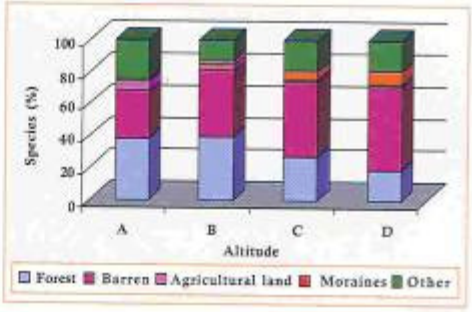


Fig. 13. Proportion of endemic in different habitats along altitudinal gradient (A- <1500, B-1501-3000, C-3001-4500, D->4500)

endemic richness, restricted taxa, weighted endemism index, corrected weighted endemism index), 15 grids (localities) have been prioritized which reflects Trans/ Northwest Himalaya and Central Himalaya as important centers for temperate endemics.

(B) Floral and Faunal Databases

- Detailed inventory prepared and information analyzed for angiosperms of Trans/North-west Himalaya (total 4300 species, 32.4% Himalayan natives). Asteraceae (570 spp.), Poaceae (465), Fabaceae (301), Orchidaceae (244), Rosaceae (222), Lamiaceae (175), Ranunculaceae (166), Cyperaceae (163), Scrophulariaceae (151) and Brassicaceae (145) are species rich families; and *Carex* (66), *Polygonum* (60), *Cotoneaster* and *Potentilla* (47 each), *Astragalus* (46), *Saxifraga* (43), *Artemisia* (38), *Ranunculus* (37), *Poa* (35), *Corydalis, Berberis and Saussurea* (34 each), *Impatiens* and *Euphorbia* (33 each), and *Silene* and *Nepeta* (31 each) are dominant genera.
- Avifaunal database of West & Northwest Himalaya was prepared, which includes 482 species belonging to 20 orders, 52 families and 212 genera (Fig. 14). The database (electronic form) on birds of Himalayan biosphere reserves has been updated.

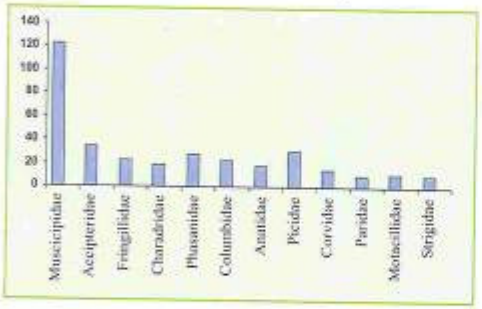


Fig. 14. Species richness of dominant avian families in Western Himalaya (families having >10 spp. only)

(C) Bibliographical Database for Himalayan Biosphere Reserves

- A user friendly electronic database for Himalayan Biosphere Reserves (HBRs) has been developed using Microsoft Access datasheet format. Database includes retrieval options by – biosphere reserves, category, journal, author, year, etc. Also, the update options for data addition, edit data etc. available. Each reference, besides general information, includes an abstract. The database has helped in analysis and gap identification in various types of R&D activities in Himalayan BRs (Fig. 15 a&b).
- Based on the analysis of database on Himalayan BRs, the UNESCO-MAB Nomination documents for Kanchendzonga (Sikkim) and Manas (Assam) Biosphere Reserves have been prepared.

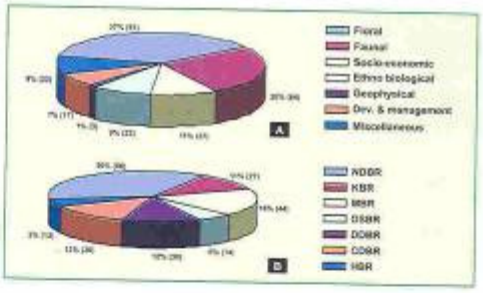


Fig. 15. (A) Analysis of subject wise research work in Himalayan BRs (n=246); (B) Biosphere Reserve wise trend of publications between 2000-2005 (n=246)

Studies on Biodiversity

Lack of authentic datasets on patterns and processes at different levels of biodiversity has emerged as a major impediment in formulation and implementation of appropriate strategy/plan for optimal use and long-term maintenance of biodiversity in IHR. Especially, such datasets for biodiversity rich areas (e.g. Protected Areas-PAs) and sensitive taxa are needed more urgently. The study attempts to address this issue by generating

primary datasets for selected: (i) protected areas, and (ii) sensitive and high value species in the region.

(A) Biodiversity Rich Areas – Protected Areas (PAs)

- Studies completed on herbaceous vegetation of 23 identified forest communities (between 2262-3320m) of Kais Wildlife Sanctuary revealed richness of herbs (23-170 species, density 47.45-164.19 Ind m^{-2} and diversity 2.88-4.26). The *Abies pindrow* (170 spp.) community was most species rich, followed by *Picea smithiana* (160 spp.), *Picea smithiana-Pinus wallichiana* mixed (111 spp.) and *Quercus semecarpifolia* (88 spp.) communities.
- In Manali Wildlife Sanctuary data generated from 19 sites (between 2318-3350m) revealed presence of 12 forest communities and 636 species of vascular plants i.e., Angiosperms (97 families, 323 genera and 572 species), Gymnosperms (3 families, 6 genera and 8 species) and Pteridophytes (16 families, 25 genera and 56 species). Regeneration pattern of *Acer caesium* community was investigated (Fig. 16). The resource use patterns revealed 79 species were used as fodder. Considering the Resource Use Index, *Quercus floribunda* (RUI - 507.0), followed by *Chrysopogon gryllus* (240.0), *Strobilanthes atropurpureus* (230.0), *Chrysopogon serrulatus* (210.0), *Carex filicina* (264.0) and *Indigofera heterantha* (174.0) were most heavily used species in the sanctuary.
- Under MoEF sponsored project for proposed Cold Desert Biosphere Reserves (CDBR), 58 sites were sampled between 2504-5018m for the assessment of plant diversity. A total of 480 species belonging to 74 families, 262 genera were recorded. A total of six forest communities (i.e., *Picea smithiana - Pinus wallichiana* mixed, *Salix daphnoides, Fraxinus xanthoxyloides, Cedrus deodara-Acer cappadocium* mixed, *Juglans regia-Ulmus wallichiana- Acer acuminatum* mixed, and *Abies pindrow- Pinus wallichiana* mixed were identified. Based on detailed demographic profile population structures of *Juniperus polycarpos-Cedrus deodara* mixed and *Abies pindrow-Pinus wallichiana* mixed communities were developed (Fig. 17 & 18). The RUI revealed *Juniperus polycarpos* (RUI=994.71); *Salix fragilis* (977.45); *Pinus wallichiana* (709.37); *Cedrus deodara* (543.05);

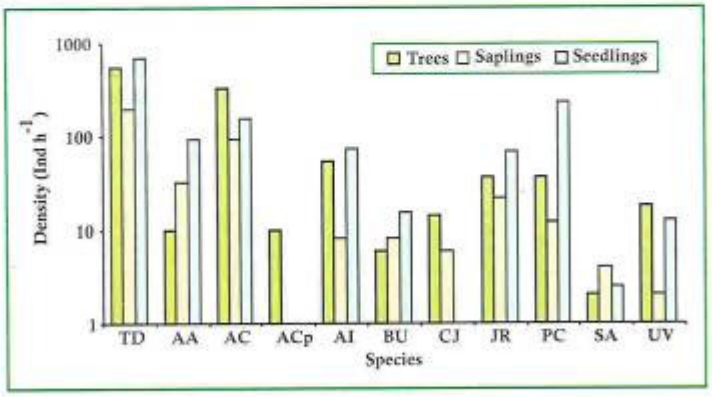


Fig. 16. Population structure of *Acer caesium* community *[Abbreviations used: TD=Total density; AP=Abies pindrow; AA=Acer acuminatum; AC=Acer caesium; ACp=Acer cappadocicum; AI=Aesculus indica; BU=Betula utilis; CJ=Corylus jacquemontii; JR=Juglans regia; PC=Prunus cornuta; SA=Salix alba and UV=Ulmus villosa]*

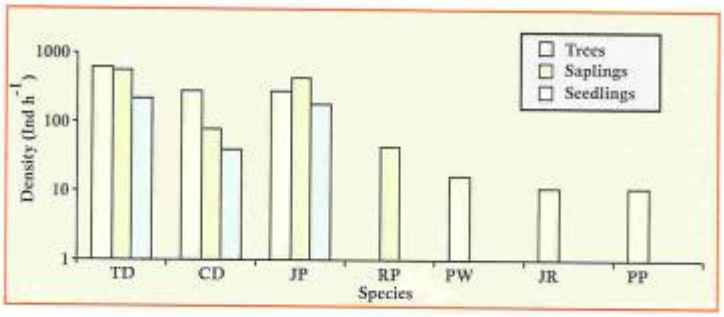


Fig. 17. Population structure of *Juniperus polycarpos-Cedrus deodara* mixed community in Lahaul Valley of the CDBR *[Abbreviations used: TD=Total density; CD=Cedrus deodara; JP=Juniperus polycarpos; RP=Robinia pseudoacacia; PW=Pinus wallichiana; JR=Juglans regia; and PP=Pyrus pashia]*

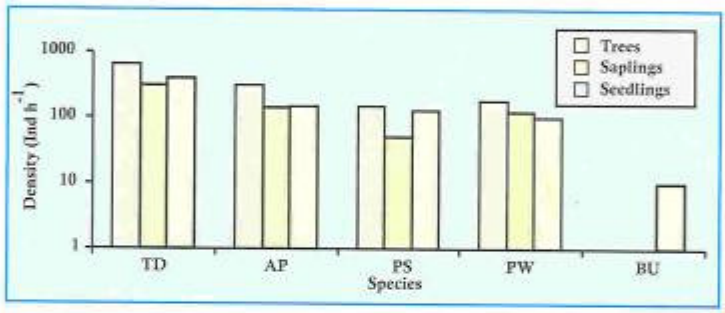


Fig. 18. Population structure of *Abies pindrow- Pinus wallichiana* mixed community in Lahaul Valley of the CDBR *[Abbreviations used: TD=Total density; AP=Abies pindrow; PS=Picea smithiana; PW=Pinus wallichiana; and BU=Betula utilis]*

Picea smithiana (317.88), *Hipphophae rhamnoides* (193.95); *Salix daphnoides* (165.60); *Abies pindrow* (162.07), *Betula utilis* (126.89), and *Corylus jacquemontii* (123.75) as most preferred species. A total of 46 rare endangered species identified and their populations were assessed.

(B) Sensitive and High Value Species

- Population and habitat studies of *Aconitum ferox*, *Rheum acuminatum*, *Dactylorhiza hatagirea* and *Panax pseudoginseng* in different parts of Sikkim showed that the plant density m^{-2} ranged between 1-13 (*A. ferox*), 1-25 (*R. acuminatum*), 1-17 (*P. pseudoginseng*), 1-11 (*D. hatagirea*), etc. Relative density for *Aconitum ferox* varied from 7 % to 58 % amongst populations, and the values significantly correlated with altitude ($P<0.01$). The density of *A. ferox* which varied from 1-12.7 amongst populations was not significantly correlated with altitude (Fig. 19).
- In order to assess the genetic diversity among natural populations of *Hedychium spicatum*, an important medicinal plant of the region, various isozymes (10) were tested. A total of 13 loci representing 32 alleles among the 12 natural populations of *Hedychium spicatum* were found. Remarkable levels of variation were observed in all the loci except MDH

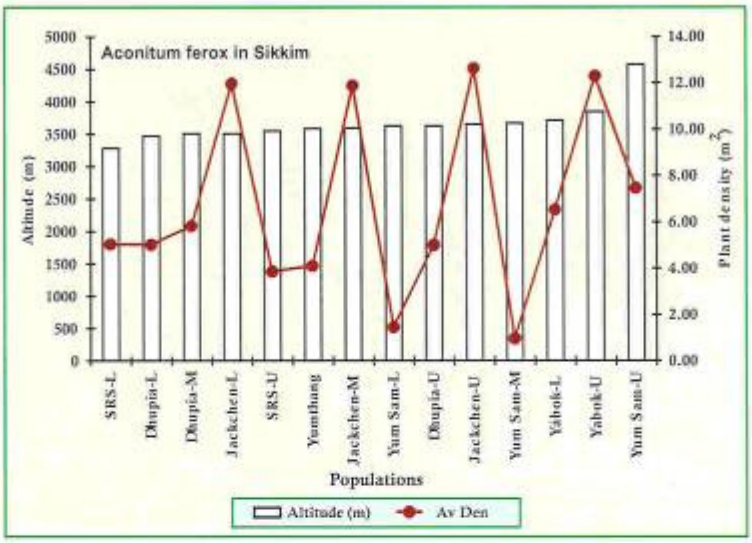


Fig. 19. Plant density of different populations of *Aconitum ferox* along altitudinal gradients in Sikkim

(Malate dehydrogenase). The observed mean heterozygosity for all allozyme loci ranged from 0.410 in population H1 (Thakur) to 0.641 in H8 (China peak). The mean expected hereozygosity (genetic diversity) for all allozymes ranged from 0.328 in H10 (Sitlakhet) to 0.451 in H7 (Mukteshwar). The mean number of alleles for population 1.77 in H3 (Gagar), H9 (Kilbury), H11 (Pandukholi), H12 (Kedarnath) to 1.92 in H4 (Ramgarh). Population H10 (Sitlakhet) showed the lowest percentage of polymorphic loci (61.54%), whereas the population H1 (Thakur) showed the highest percentage of polymorphic loci. The lowest number of polymorphic loci (8) was found in H10 (Sitlakhet), and maximum (11) in H1 (Thakur), H5 (Chaubatia), H6 (Kalika) and H7 (Mukteshwar). Similarly, the H10 (Sitlakhet) showed the minimum effective number of alleles (1.53) while maximum 1.74 were found in H7 (Mukteshwar) (Fig. 20).

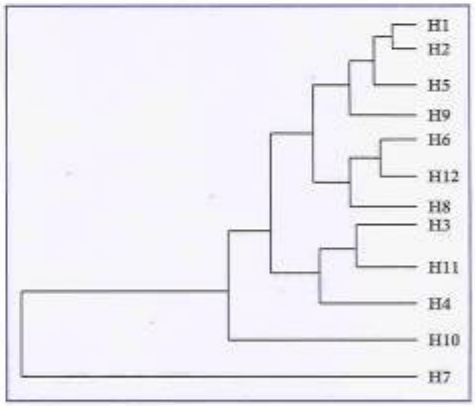


Fig. 20. UPGMA dendrogram of *Hedychium spicatum* based on Nei's unbiased genetic distances

Establishment of Gene-Banks

The activity focuses on: (i) establishment of *ex situ* gene bank of Himalayan species including economically important ones; (ii) development

of propagation protocols for high value and locally acceptable plants; and (iii) large scale multiplication of important species and making the saplings available at local level.

(A) Enriching Gene Banks - Arboreta & Herbal Garden (HQs; Sikkim & HP Unit)

The envisaged objectives include: (i) establishing area specific demonstrations of *ex-situ* conservation of representative plant species; (ii) undertake systematic studies on growth and performance of selected species; (iii) conduct researches for mass scale propagation of commercially viable species for plantation/ cultivation; and (iv) impart training and education on *ex-situ* mechanisms of conservation to different stakeholders.

- The *ex situ* gene-bank site of HQs (Suryakunj -arboretum, herbal garden and nursery) has been developed as nature interpretation site. The site serves as a center for on-site training and extension programmes for various stakeholder groups (Fig. 21).
- At HP unit (Mohal-Kullu) development of an arboretum is in initial stage. Layout of the arboretum has been prepared and sites developed for plantation. Propagules of 16 multipurpose trees and 12 medicinal plants (i.e. *Arnebia benthamii, Artemisia annua, Lilium polyphyllum, Angelica glauca, Podophyllum hexandrum, Hedychium spicatum, Paris polyphylla, Polygonatum cirrhifolium, Rheum australe, Rubia cordifolia, Skimmia laureola,* and *Withania somnifera*) were collected and sown in the nursery. Saplings of multipurpose species and medicinal plants were introduced in the arboretum sites and herbal garden.

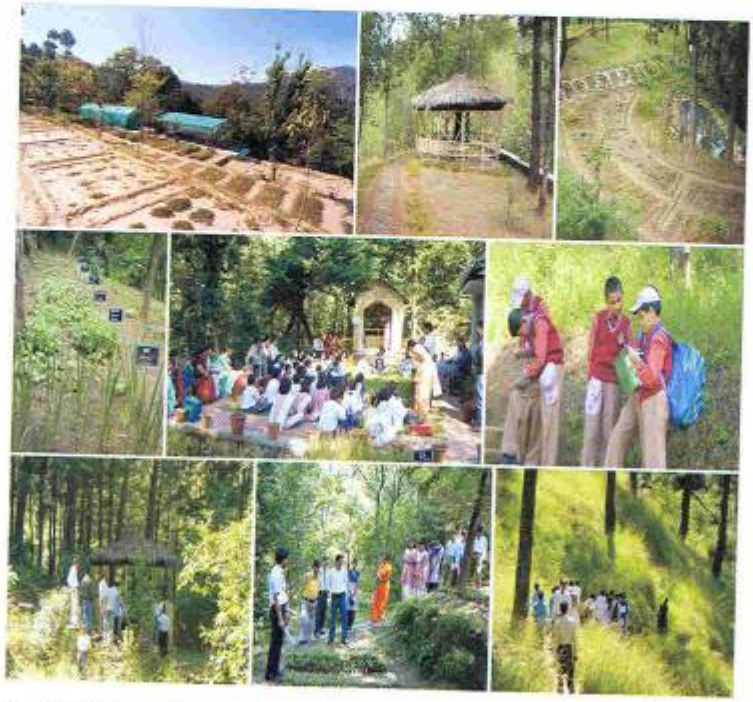


Fig. 21. Glimpses of gene bank and activities in 'Surya Kunj' at GBPIHED-HQs

- In Sikkim over 21000 seeds of 12 multipurpose woody taxa were sown for mass multiplication in nurseries, with maximum of 14000 seeds for *Ficus* species. Plantation of 12 MPTs was also carried out through peoples' participation.
- In collaboration with State Forest Department, development of 2 ha 'Rare and Threatened Plant Conservation Park' in Sikkim has been initiated. Plantation made for *Swertia chirayita* and *Saussurea costus* (> 90 % survival) and *Rhododendron* species (Fig. 22).

Fig. 22. Rare and threatened plants Conservation Park in Himalayan Zoological Park, Gangtok-Sikkim

(B) Propagation Protocols and Cultivation Packages

Medicinal Plants

- At HP unit effect of seed age group (6, 18, 30, 42, 54, 78, 90 months old) on germination potential and seedling emergence of *Saussurea costus* showed continuous decrease in germination with age (Fig. 23).
- Experiments conducted on *Angelica glauca* to improve the percentage germination revealed that treatment of $NaHClO_3$ (30 minutes) under light condition significantly ($P<0.05$) improved percentage germination (100%) followed by KNO_3 (150mM; 94.4%), as compared to control (61.1%) (Fig. 24 a & b).

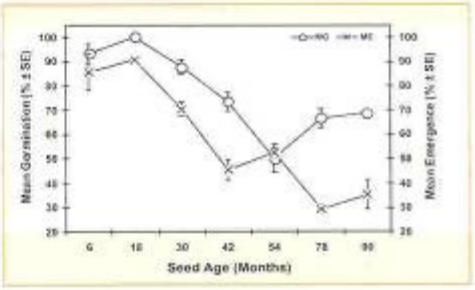


Fig. 23. Seed germination and seedling emergence in *Saussurea costus*

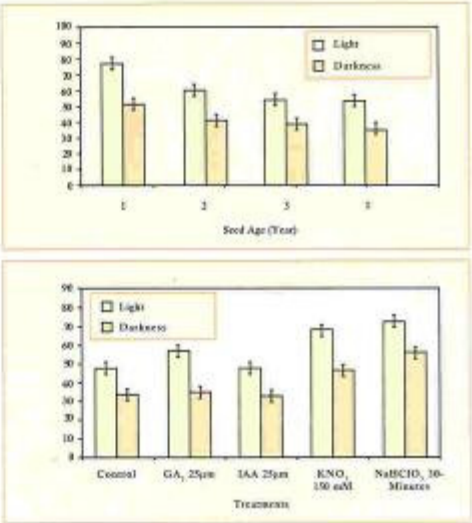


Fig. 24 a & b. Effect of chemical treatments on seed germination and MGT in *Angelica glauca*

High Value Trees

- While attempting propagation and improvement of apple root stock (under DBT Funded project), *in vitro* propagation of clonal apple rootstock MM 106 has been developed (Fig. 25). Axillary buds were established in the MS medium supplemented with 5 µM BA and 1 µM NAA which later on multiplied at the rate of 9.8 ± 0.37 shoots/ explant (Fig. 26A) with average shoot length of 2.4 ± 0.14 cm (Fig. 26B).

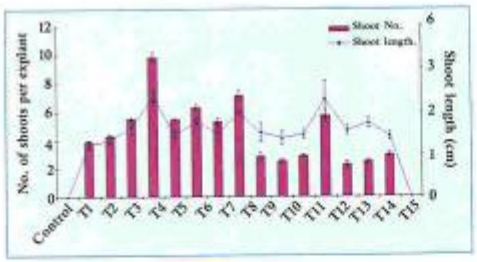


Fig. 25. Effect of PGR concentrations on shoot multiplication using micro shoots (raised through axillary bud explant) in apple rootstock MM 106 (T1-T16: different concentrations of BA and NAA)

Shoots (100%) were rooted by giving 5 days dark treatment followed by light in a half strength MS medium supplemented with 0.1 µM IBA (Fig. 26C). Rooted shoots grown well in this medium with 4.25 ± 0.7 roots/ shoot and 1.70 ± 0.30 cm mean root length. Plantlets were acclimatized in a mixture of vermiculite:perlite:sand:soil (2:2:1:1). After 14 weeks in *ex vitro* conditions maximum survival (75.0±7.22%) was recorded (Fig. 26D). Plants were subsequently transferred in nursery (polythene bags).

Fig. 26. Various stages of *in vitro* propagation of apple rootstock MM106. A – Shoot multiplication, B – elongation, C – Rooting and D - Acclimatized plantlets transferred in soil (after 14 weeks in *ex vitro* conditions)

Summary of the Completed Project

Biotechnological Interventions for Propagation and Improvement of Apple Rootstock *(DBT funded;* 2003- 2007*)*

Optimization of *in vitro* cultural conditions for production of apple rootstock and cultivars was undertaken under the project. Major findings and their implications are as follows.

- True to type and disease free plantlets of apple cultivar Green Sweet and Chaubattia Princess were produced through nucellus raised callus. Self rooted apple plants hold tremendous potentials for establishment of uniform sized apple orchards and allow to avoid drawbacks of grafting, such as graft incompatibility and disease transfer.
- Apple cultivar Golden Delicious was also tested for inducing somatic embryogenesis in nucellas raised callus. Though the embryos could not formed, globular stages were obtained on nucellar callus.
- Efficient regeneration protocol was developed for clonal apple rootstock MM 106 using axillary bud explant. Shoot production reached up to 9.8 shoots/explant and 100% rooting was induced in *in vitro* raised shoots. Successful (75% survival) *ex vitro* transplantation of *in vitro* raised plantlets was achieved.

Core Programme

ECOLOGICAL ECONOMICS AND ENVIRONMENTAL IMPACT ASSESSMENT (EE & EIA)

As elsewhere in the Mountains, Indian Himalayan Region is experiencing various changes due to developmental activities, such as construction of roads, expansion of urban centers, hydropower projects, transmission lines, increased influx of tourists, changes in land use, etc. These activities have a range of impacts on local and regional environment. Assessment of such impacts and analysis of their ecological and economic implications and prepare environmental management plans is the main focus of this programme. The present focus includes Environmental Impact Analysis of Development Initiatives.

Tourism and Urbanization: Impacts on Ecosystems

The aesthetic appeal of the landscape and the socio-cultural heritage of the IHR present immense potentialities for tourism development. While the positive impact of tourism is seen in terms of revenue generation, employment and infrastructure, the negative impacts are many-fold ranging from solid waste generation to air and water pollution. Two hill towns of western Himalaya were investigated: one for solid waste generation (Almora town in Uttarakhand) and other for air quality monitoring (Kullu-Manali tourist destinations in H.P).

(A) Impact of Urbanization on Solid Waste Generation in Almora Town

- Solid waste generated in Almora town (based on survey of 171 households distributed over different socio-economic groups across eight localities) was quantified (Table 7) and categorized (Fig. 27). The average RBW generated (237.8 Kg/family/yr), that comprised of kitchen waste (vegetables, food, fruits, etc). The quantity of waste increased with income and family size. More than 50% respondents felt that status of traffic, burning of garbage in streets, stray animals around city are worsening the problem. About 50% of the surveyed families were not willing to pay any money for the collection of waste from their houses.

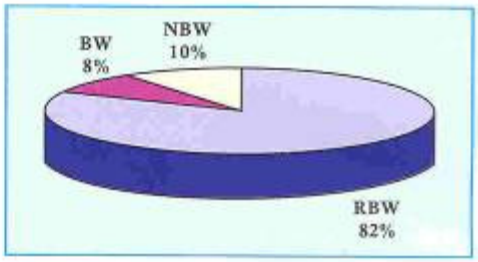


Fig. 27. Different categories of solid waste in Almora town *(BW-Biodegradable Waste; NBW- Non Biodegradable Waste; RBW – Readily Biodegradable Waste)*

Table 7. Average quantity of solid waste generated in Almora town (n= 171)

(values in parentheses is the range across the sampled localities)

Waste categories	Waste items	Quantity of (kg/family/yr)
Biodegradable	Paper	20.37 (12.8 – 39.9)
	Clothes	3.55 (2.1 – 9.2)
	Total	23.92 (15.3 – 43.6)
Non biodegradable waste	Recyclable	
	Glass	0.99 (0.04 – 2.6)
	Metal	1.03 (0 – 0.4)
	Polythene bags	16.73 (1.3 – 59.7)
	Plastic pet bottles	1.67 (0.4 – 3.5)
	Toys	0.68 (0.2 – 2.2)
	Bone china items	1.40 (0.1 – 6.7)
	Flower pots	0.72 (0.1 – 2.5)
	Total	23.21 (2.5 – 79.7)
	Non recyclable	
	Tube light/bulb	0.69 (0.2 – 1.9)
	Thermometer/Syringe	0.06 (0- 0.03)
	Old medicines	1.09 (0 – 2.94)
	Batteries/cells	1.15 (0.4 – 3.7)
	Construction waste	3.43 (0- 10.6)
	Total	6.41 (1.7 – 18.2)

(B) Ambient Air Quality and Surface Ozone in Hills of Northwestern Himalaya

The ever increasing tourism activities in Kullu-Manali (H.P.) have affected its surrounding environmental components in recent decades. Ambient air quality is one of these affected components. The tourist inflow, plying vehicles, snow scooters at some snow points during summer, wood burning for cooking and heating and forest fires are degrading the air quality. The major air pollution parameters, such as total suspended particulate (TSP) matter, particulate matter below 10 micron in size (PM_{10}) among particulate pollution, and surface ozone (O_3) within gaseous pollutants were therefore monitored on 24-hr basis at two stations, Mohal (1154 m) and Kothi (2530 m) in the Kullu valley. Aerosol optical depths (AODs) at Mohal were also recorded.

- Number of visitors/day passing through these spots ranged from 16,116 - 23,825 at Mohal and 1,440 - 10,204 at Kothi. Similarly, the number of plying vehicles ranged from 1,878 - 2,920 at Mohal and 205 - 1,516 at Kothi. Of the total vehicles plying through these locations about half were diesel operated.
- The mean monthly variation in TSP concentration (85 - 110 $\mu g\ m^{-3}$) and PM_{10} value (26 - 104 $\mu g\ m^{-3}$) at Mohal and Kothi is depicted (Fig. 28). The highest forenoon AOD value was 0.9 at 500 nm on April 29,

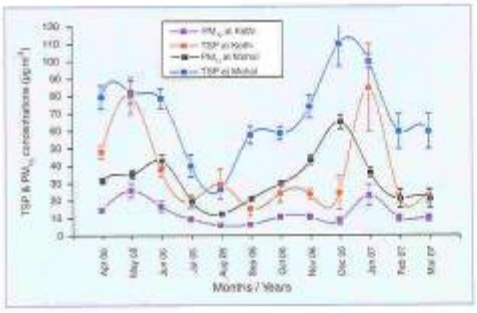


Fig. 28. TSP and PM_{10} concentrations at Mohal and Kothi, April 2006 to March 2007

2006 and highest afternoon value was 0.95 at 380 nm on the same day.

- The annual mean value of surface O_3 at Mohal was recorded 22 ppb. The highest monthly mean value was 34 ppb in June 2006. While the highest daily value was 60 ppb on 13, June 2006. But the highest ever-diurnal value during this period within this year was 84 ppb at 1600 hrs IST on 22, June 2006 (Fig. 29).

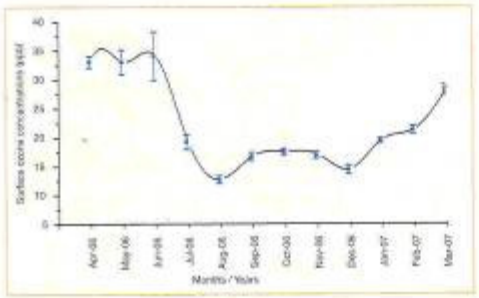


Fig. 29. Surface ozone concentrations at Mohal (April 2006-March 2007)

Environmental Impact Analysis of Hydropower Projects

Hydropower is a renewable, economic, non-polluting and environmentally friendly source of energy and it has been one of the sources of energy harnessed for centuries in different parts of the world. Considering that the Himalayan Rivers have great potential for development of Hydropower; and a number of hydroelectric projects (HEP) are being developed in this region. During the reporting year EIA and environmental management plans (EMP) of selected HEPs in western Himalaya (Himachal Pradesh and Uttarakhand) were conducted.

(A) Environmental Assessment of HEP in Beas Valley of H.P.

- Eleven villages within the influence area of two hydropower projects under construction (9 villages from Parbati Stage II and 2 villages from Parbati Stage III) were surveyed involving around 85% families residing in these villages. Residents of the project area perceived positive and negative impacts of these projects.
- Air quality was monitored through High Volume Sampler (APM-430) close to the dam site. TSP range (11 µg m^{-3} on 20th December 2006 to 240 µg m^{-3} on 6th January 2007) crossed its permissible limit during the dry seasons of summer and winter (Fig. 30).
- Rainwater samples collected from the HEP area (June, 2006 to September, 2006) recorded average TDS 18.8 mg L^{-1} and EC values 34.8 µmohs cm^{-1}. Soil organic carbon ranged from 5.4-15% in horticultural land and forest land of Parbati Stage II, respectively.

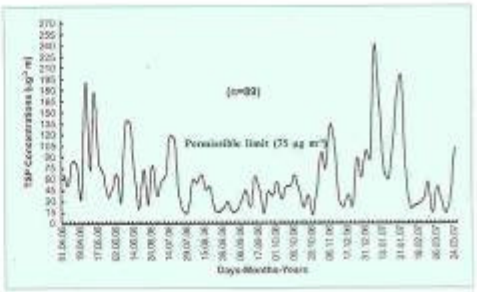


Fig. 30. Ambient air quality status near powerhouse site of Parbati Stage II, and dam construction site at Suind of Parbati Stage III (Beas valley, HP)

(B) EIA and Formulation of EMP for Nandprayag -Langasu & Tamak-Lata HEP in Uttarakhand

- Baseline data on air, water, noise, flora and fauna was collected for both the study sites. The baseline data recorded for noise (Table 8) and water and air quality index (Fig. 31) represents a clear picture about the environmental quality of the area. The ambient air quality levels of all the sites were well within the CPCB standards, however, the air quality varied from one sampling site to the other.

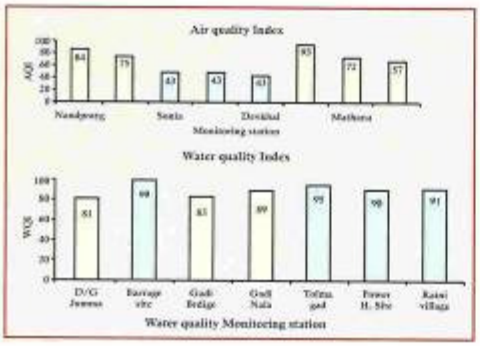


Fig. 31. Environmental quality index for project study area

- Detailed inventory on different faunal component with their conservation status was prepared. Vegetation analysis was also carried out for the influence zone of both of the project sites and rare, endangered, economically important and medicinal plant species were listed. In the influence zone the highest number of species (314 spp.) were recorded for angiosperms, followed by pteridophytes (18), bryophytes (17), algae (12), lichens (7) and gymnosperms (5). Socio-economic surveys and people's perception studies on positive and negative impacts were conducted.

(C) Comprehensive EIA and Formulation of EMP for Lakhwar and Vyasi HE Project in Uttarakhand

- Lakhwar (300MW) and Vyasi (120MW) HE projects are proposed to be constructed on river Yamuna in Uttarakhand hills. The Lakhwar HE project requires 1195.9 ha of land out of this, 177.2 ha is private land, which is spread over 32 villages of Dehradun and Tehri Districts. Similarly, requirement of land for the Vyasi HE project is 135.4 ha. The number of people likely to be affected by these projects is Lakhwar - 6716 and Vyasi

Table 8. Noise quality results of selected monitoring sites in the influence zone of project area

Monitoring sites Time	Sonla	Langasu	Nandprayag (Residential)	Chamoli (Near Alaknanda river)
		Sound level (db)		
7-8 am	38	47	38	44
8-9 am	50	46	34	52
10-11 am	48	46	47	51
11-12 am	32	58	51	49
12-13 pm	52	58	48	60
13-14 pm	50	63	35	58
14-15 pm	60	68	49	53
15-16 pm	57	47	50	50
16-17 pm	58	58	49	53
17-18 pm	62	61	51	52

749 persons. The baseline data for land, water, air, noise, biological and socio-economic environment was collected. The data on land environment was generated through RS/GIS (Fig. 32) and air and water quality monitored.

- Field study was carried out for floral and faunal diversity assessment separately for (i) submergence zone, (ii) influence zone, and (iii) free draining catchments of Lakhwar and Vyasi. Distribution of floral elements in influence zone of Vyasi is given (Table 9).

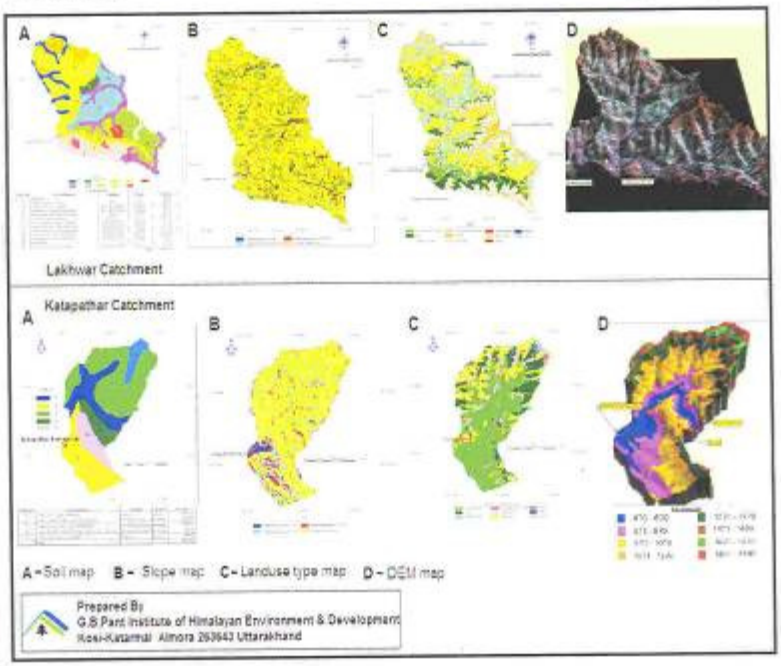


Fig. 32. Soil type, slope, landuse /cover map & DEM map for Lakhwar HEP

Table 9. Percentage distribution of plants groups by family, genera & species in influence zone of Vyasi HEP.

S.No.	Group	Families		Genera		Species	
		Number	Percentage	Number	Percentage	Number	Percentage
1.	Angiosperms	60	70.59	124	80	148	77.49
2.	Gymnosperms	1	1.18	2	1.29	3	1.57
3.	Preidophytes	7	8.25	10	6.45	16	8.38
4.	Bryopytes	5	5.88	5	3.23	7	3.66
5.	Lichen	4	4.71	5	3.23	6	3.14
6.	Algae	8	9.41	9	5.81	11	5.76
	Total	85	100	155	100	191	100

- Based on the evaluation of the likely impacts on various environmental parameters, detailed environmental management plans (EMPs) for both the projects were prepared. The total cost of the implementation of all EMPs for Lakhwar HEP was worked out to be 7106.07 lakh (Fig. 33).

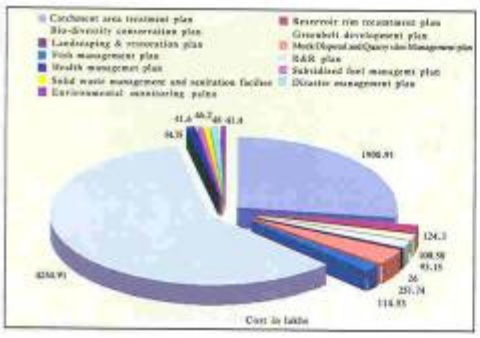


Fig. 33. EMP cost plan for Lakhwar HEP

(D) EIA-EMP Studies for Hydroelectric Project on River Rupin, Uttarkashi

The Rupin HE project, a run-to-the river project, is proposed to be constructed on Rupin River, a major tributary of River Tons in Distt. Uttarkashi in Uttarakhand and expected to involve about 8 km stretch of river Rupin upstream from Naitwar with 42 MW generation capacity through three Stages (III, IV and V).

- Field survey was conducted during winter 2006 for floral and faunal diversity assessment. Five plant species (viz., *Acer caesium, Berberis aristata, Berberis lycium, Bergenia ligulata* and *Thalictrum foliolosum*) were identified under threat category. Among the faunal component a total of 30 genera of Invertebrates and 87 genera of Vertebrates were recorded. A total of 61 species of birds were recorded.
- Some socio-economic characteristics based on household survey in 6 villages around the proposed project site in winter 2006 are given (Table 10). The average livestock size per household (14) consisted of cow and goat/sheep (82%), ox (10%) and others 8% (buffalo, horse, mule, poultry etc.).
- Soil physico-chemical characteristics from different land use/land cover categories were: pH (5.36 - 6.75); EC (19.1 - 78 µs/cm); temperature (9.2 - 10.2 °C); water holding capacity (16.1 – 87.0 %) and bulk density (1.6 – 2.1 gm/cm^3). The physico-chemical characteristics of Rupin river water collected from 8 different points showed pH (6.31–7.0); temperature (9.2–9.4 °C); electric conductivity (32 – 68 µs/cm); dissolved oxygen (4.09–6.85 mg/l) and total nitrogen (2.8–6.4 mg/L) in November 2006.

Table 10. Demographic profile of villages falling in the project area

Village Name	Total house-holds	Total Popu-lation	Male	Female	Literacy		Age classification		
					Male (%)	Female (%)	Child	Young	Old
Naitwar	59	349	180	171	99 (55%)	68 (40%)	107	214	28
Nuranoo	67	363	191	172	16 (8%)	11 (6%)	97	157	109
Ludgiyat	15	90	45	45	14 (31%)	5 (11%)	27	58	5
Pujali	52	332	166	166	90 (54%)	30 (18%)	121	185	25
Devel	16	100	50	50	8 (16%)	15 (30%)	44	50	6
Doni	62	388	189	199	77 (40%)	34 (17%)	123	215	50
Total	**271**	**1622**	**821**	**803**	**304 (37%)**	**163 (20.3%)**	**519**	**879**	**223**

Impact Assessment of Alternative Land Uses- Tea Gardens in Uttarakhand Hills

In the recent decade Uttarakhand Govt. has promoted tea cultivation as an important land management activity. The community grazinglands, abandoned rainfed croplands, old tea gardens have been put under tea plantations measuring about 500 ha area. Tea being a monoculture crop requires frequent soil working to eradicate the weeds. Further, the regular inputs of fertilizers provide a fertile ground for proliferation of weeds. If not weeded regularly these weeds may spread to adjoining areas and change the composition of native flora. Therefore seasonal surveys were conducted across 11 tea gardens (TG; of varying ages) and adjacent non-tea garden (NTG) areas in this region for floral composition, habitat loss of some of the important plants and preponderance of weeds to suggest some corrective measures.

- Plant species recorded from the 11 study sites and their categorization under various habit forms across the three seasons is presented (Table 11). Weed species, such as *Azeratum conyzoides, Chrysocephalum crepeoidi, Chrysanthemum americanum, Galinsoga parviflora, Lepidium sativum* were found growing abundantly in all the tea gardens.
- *Gloriosa superba* a rare species of herb and *Satyrium nepalens* (a rare orchid) was also found growing in the adjacent NTG, indicating that the habitats of rare species and medicinal plants are also being used for raising tea gardens.

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

In the warm valleys of central Himalaya *Lantana camara* has heavily invaded the degraded forest land and abandoned cropfields. This weed proliferates fast and difficult to eradicate and also does not allow other species to grow in the vicinity of its thick bushes. An experiment was therefore conducted to find out the alternative use of this bio-resource as organic mulch material to restore soil fertility and achieve SWC in the agro-ecosystems of this region.

- Crop yield of both wheat (range= 52 – 133 g/m^2) and paddy (37 – 108 g/m^2) in the experimental plots established in Kosi-Almora was recorded maximum for 100% *Lantana* mulched plots as compared to Pine, Oak and FYM mulched plots.

Table 11. Number of species falling under different habit forms in summer, rainy and winter season across the 11 tea gardens.

Growth form/ Number of species	Summer			Rainy			Winter		
	Spp. in TG	Spp. ANTG	Com. Spp.	Spp. in TG	Spp. in ANTG	Com. Spp.	Spp. in TG	Spp. in ANTG	Com. Spp.
Bryophyte	1	3	1	1	4	1	1	2	1
Climber	0	3	0	0	3	0	0	3	0
Fern	2	3	2	4	8	4	3	7	3
Herb	22	78	21	81	150	72	76	117	71
Herb climber	1	1	0	0	3	0	1	3	1
Shrub	13	41	13	12	44	11	17	38	17
Tree	11	39	11	6	39	6	8	32	8
Under shrub	1	12	1	1	2	1	6	6	5
Total	51	180	49	105	253	95	112	208	106

* TG= Tea garden; * ANTG= Adjacent non tea garden area

- The mean annual microbial biomass carbon (range = 308.15 - 495.80 μg g^{-1} dry soils) and mean annual microbial biomass nitrogen (range = 41.88 – 64.32 μg g^{-1} dry soils) was recorded maximum for 100% *Lantana* mulched plots (Fig. 34 a). The MBC and MBN values in soil peaks during rainy season, and drops during winter, for all the mulch treatments. The mean annual value of N-mineralization (range = 2.44 - 6.21 μg g^{-1} $month^{-1}$) and C-mineralization (range= 309.3 - 430.10 mg m^{-2} hr^{-1}) (Fig. 34 b) was also found maximum for 100% *Lantana* mulched plots. The N-mineralization peaks during rainy season and falls during summer, whereas the C mineralization peaks during winter and falls during summer.

Impact of Land Use Changes on Human Food Habits in Cold Desert of HP *(ICSSR funded)*

The cold deserts of Lahul valley in Himachal Pradesh are experiencing land use and land cover changes due to the introduction of cash crops, such as potato, for the last two decades. As a result, the traditional crops earlier occupying the cropland area is declining. This has led to changes in dietary composition of the residents. The inhabitants now import a large quantity of food commodities from outside the region selling the cash crops and have also given away some of the traditional food.

- In four representative villages of Lahaul valley, the land use components comprised

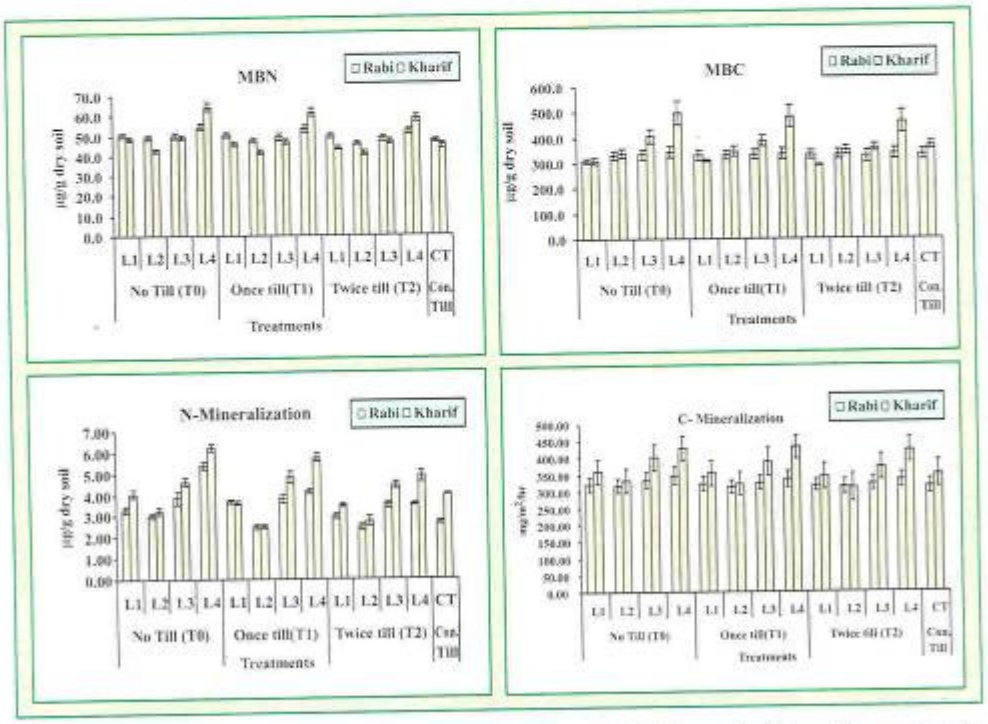


Fig. 34 (a & b). Microbial biomass carbon and nitrogen during Rabi and Kharif season in different tillage and mulch combination

of net sown area (61.5%), *Salix* plantation (8.5%), kitchen garden (1.0%), culturable waste (0.7%), and area under non-agricultural uses (1.4%). The net sown area is occupied with introduced cash crops (10.0%), traditional crops (85.7%) and medicinal plants (4.3%).

- Traditional dishes (*thupka;* made up of small pieces of meat, *chellara;* chapatti made up of buckwheat flour, *surpai;* made up of milk, *etc.*) are losing their ingredients as the traditional crops have been replaced by introduced cash crops. The food intake was found short of calories (up to 9%) as against the standard requirement.

Impact of Geology and Land Use/Land Cover on Spring Water Quality *(MoWR funded: 2003-2006)*

In the western Himalayan region springs and seepages are the main sources of water for household consumption. These water sources emanate from a variety of recharge zones having different geology, rock types, topography, land use/land cover and anthropogenic influence. Therefore impacts of these recharge zone characteristics were determined on water quality of 13 springs located in a variety of geological settings and with different land sue/land cover for remedial measures.

- Land use studies of the spring catchment areas indicated that the total recharge area varied from 0.36 – 19.3 ha across the selected springs. Among the different land uses, waste land, agricultural land, grassland, broad leaf (Oak; *Quercus* spp.) and conifer (Pine; *Pinus roxburghii*) forests were present in the recharge zones of all these springs.
- The various physico-chemical properties recorded across the springs in rainy season 2006 were: pH (6-7 – 7.2), EC (62 - 568 µS/cm), Alkalinity (30 - 170 mg/L), total hardness (76 - 276 mg/L), calcium (11 - 67 mg/L), magnesium (9.2 - 24.0 mg/L) and sulphate (0 - 116 mg/L). Nitrate and chloride was found absent in most of the springs. Bacteria and coliform were detected in most of the spring water, however *Escherichia coli* was absent in all the water samples.

Core Programme

ENVIRONMENTAL PHYSIOLOGY AND BIOTECHNOLOGY (EPB)

The application of conventional techniques along with the sophistication of biotechnology is all set to increase the efficiency and productivity of plants as well as environmental health. Research activities of this core group focused on understanding of different environmental factors that governs plant productivity, physiological and biochemical basis of adaptation of plants in relation to water stress, microbial diversity in Himalayan soils, plant growth promoting rhizobacteria, and mycorrhizal associations in Himalayan trees. In view of the increasing demand for quality planting material attempts were made to develop propagation protocols, using both conventional as well as *in vitro* techniques, for important species.

Water Relation Studies on Multipurpose Tree Species of Himachal Pradesh

In the western Himalayan mountains there is an urgent need for identification, evaluation and selection of tree species that could endure drought and successfully used for plantation in the wastelands. As soil-water stress is the most detrimental factor for the survival of plants, studies on diurnal and seasonal changes in water relation parameters (e.g., water potential, relative water content, succulence, water saturation deficit and water content at saturation) and physiological (e.g., chlorophyll content in terms of SPAD) investigations on selected important multipurpose tree species were conducted.

- Of the eight species studied (Table 12), *Olea ferruginea* and *Robinia pseudoacacia* showed considerably low water potential throughout their active growth period. In general, gymnospermic plants maintained relative higher water potential across the seasons compared to angiospermic plants.
- *O. ferruginea* plants showed higher density of foliar tissue and leaf mass per unit area among other species studied. On the other hand, compared with other species, these species had lower RWC, higher water saturation deficit and water content at saturation. Based on these data it is evident that *O. ferruginea* appears to be more tolerant to drought as compared to other species.

Eco-Physiological Responses of High Altitude Medicinal Plants to Temperature and Water Stress

The responses of plants to abiotic stresses that are expected to occur as result of human induced climate change such as increased temperature and water deficit stress are yet to be understood in the region. In this experiment water potential, RWC and chlorophyll content in terms of SPAD readings in the leaves during vegetative and reproductive stages of *Picrorhiza kurrooa*,

Table 12. Leaf water potential ($ø_w$, MPa), leaf mass per unit area (LMA, g cm^{-2}), density of leaf tissue (g g^{-1}), relative water content (RWC, %), water content at saturation (WCS, g g^{-1}), succulence (mg cm^{-1}) and chlorophyll content (SPAD readings) of some MPTs.

Plant species	$ø_w$	LMA	Foliar density	RWC	WCS	Succulence	SPAD readings
U. wallichiana	-2.26±0.20	0.69±0.06	0.39±0.03	84.98±3.86	0.26±0.03	10.89±1.06	39.94±3.32
O. ferruginea	-4.45±0.49	1.90±0.10	0.50±0.03	74.60±6.56	0.29±0.04	18.76±1.24	75.10±7.86
G.optiva	-3.00±0.32	0.76±0.06	0.37±0.03	79.29±4.84	0.42±0.03	13.59±1.32	38.09±2.68
R. pseudoacacia	-4.02±0.48	0.67±0.06	0.43±0.02	86.40±2.50	0.18±0.02	8.99±1.05	40.32±3.92
U.villosa	-2.14±0.28	0.76±0.07	0.36±0.04	80.73±4.71	0.48±0.04	13.31±1.12	41.84±4.11
P.wallichiana	-2.59±0.14	-	0.38±0.02	84.44±2.53	0.15±0.02	-	-
P. roxburghii	-2.19±0.12	-	0.37±0.02	91.86±3.67	0.15±0.01	-	-
C. deodara	-2.53±0.24	-	0.37±0.03	91.00±2.83	0.20±0.02	-	-

Podophyllum hexandrum and *Rheum moorcroftianum* plants were recorded.

- Among studied species, *R. moocroftianum* maintained relatively high water potential than the others. All the three species showed high RWC. While there was no significant decrease in chlorophyll content in *P. hexandrum* at reproductive stage, chlorophyll content of *P. kurrooa* and *R. moorcroftianum* decreased significantly at reproductive stage compared to vegetative stage (Table 13).

Large Scale Propagation of Elite Plants

Substantial quantities of quality planting material are required to initiate plantation for afforestation, commercial cultivation and rehabilitation programmes. Further, many important species are facing the danger of overexploitation from their natural habitats and require immediate conservation efforts. To achieve this, conventional methods of propagation involving seeds and vegetative (clonal) techniques and plant tissue culture technique was utilized for developing propagation protocols and large scale multiplication of *Rhododendron maddeni, Podophyllum hexandrum* and *Dendrocalamus hamiltonii*.

- *In vitro* raised plants of *D. hamiltonii*, following 18 months of field transfer indicated over 65% survival. Assessment of genetic fidelity of *in vitro* raised plants was carried out. The pattern of RAPD fragments produced by the random primers showed that all amplification products in the mother clone were found to be monomorphic across the *in vitro* propagated plants. The primers OPA3, OPA4, OPA5, OPA9 and OPA15 did not reveal any variation in the mother and *in vitro* raised plants, indicating genetic fidelity among the regenerants of the mother clone.
- More than 100 tissue culture raised plants of *R. maddeni* and over 200 conventionally propagated plants of rhododendron species

Table 13. Water potential, RWC and chlorophyll content (SPAD readings) of alpine plant species during vegetative and reproductive stages.

Plant species	Vegetative stage			Reproductive stage		
	Water potential	SPAD readings	RWC	Water potential	SPAD readings	RWC
P. kurrooa	-1.17±0.05	44.55±2 76	97.37±3.89	1.12±0.06	35.30±2.87	97.40±4.11
P. hexandrum	-1.19±0.08	35.55±1.42	83.22±4.99	1.34±0.06	39.13± 4.30	86.27±6.07
R. moorcroftianum	-0.70±0.04	47.44±2.32	90.34±3.67	0.84±0.04	36.32±4.35	92.71±4.67

(*R. griffithianum R. baileyii, R. maddenii, R. dalhousiae, R. grande,* and *R. cilatum*) have been planted in the 'Rare & Threatened Plant Conservation Park' of Zoological Park, Gangtok. *In vitro* shoot multiplication was achieved in *R. dalhousiae* (Fig. 35).

- Antioxidant potential of 21 species/ subspecies of rhododendrons was studied for their total phenolic contents (TPC), flavonoids, antioxidant activity (AOA) and free radical scavenging activity (FRSA). Out of them *R. baileyii, R. camelliiflorum, R. campanulatum, R. ciliatum* and *R. cinnabarinum* were found to have high TPC, high AOA and FRSA (Table 14).

Fig. 35. Shoot multiplication of *R. dalhousiae* from nodal segment

Table 14. TPC (mg/g gallic acid equivalent), AOA (%) measured by auto oxidation of â-carotene and linoleic acid coupled reaction (on dry wt. basis) and FRSA of *Rhododendron* species measured by using 1, 1-diphenyl-2-picryl- hydrazyl (DPPH) in term of IC_{50} = inhibitory concentration (mg/ml of extract); EC_{50} = efficiency concentration (mg/mg DPPH); ARP = anti radical power and reducing power (ASE/ml).

Species	TPC	AOA	IC_{50}	EC_{50}	ARP	ASE/ml
R. arboreum arb.	57.3	54.2	0.47	20.59	4.85	1.23
R. arboreum cin.	78.5	81.6	0.34	14.78	6.76	1.25
R. baileyii	97.9	92.0	0.14	6.11	16.35	1.09
R. barbatum	44.1	66.5	0.64	28.16	3.54	1.21
R. camelliiflorum	132.2	93.6	0.12	5.32	18.77	1.26
R. campanulatum	123.9	94.4	0.13	5.65	17.69	0.71
R. ciliatum	91.4	71.5	0.19	8.26	12.10	1.43
R. cinnabarinum	93.9	83.2	0.16	6.21	16.10	1.57
R. dalhousiae	55.4	57.2	0.51	22.58	4.42	1.11
R. decipiens	39.6	55.0	0.72	31.40	3.12	1.71
R. falconerii	39.2	30.4	0.82	36.21	2.78	1.63
R. grande	37.3	56.4	0.86	37.39	2.67	1.61
R. griffithianum	165.4	93.4	0.10	4.35	22.93	0.64
R. lepidotum obo.	148.5	79.2	0.12	5.28	18.92	1.00
R. maddenii	87.3	62.8	0.30	13.04	7.66	1.31
R. niveum	106.6	85.2	0.13	5.70	17.52	0.72
R. pendulum	89.3	76.8	0.22	9.88	10.12	1.72
R. lepidotum sal.	97.5	88.4	0.14	6.18	16.15	1.58
R. thomsonii	90.6	90.0	0.22	9.56	10.46	2.03
R. vaccinioides	67.8	72.0	0.45	19.56	5.19	1.16
R. virgatum	208.9	97.4	0.07	3.28	30.48	0.46
Quercetin, Standard	–	–	0.20	8.6	11.6	0.5
LSD at P<0.01	2.61	1.44	0.049	2.18	6.24	0.158

AOA % = 100 X (DRc – DRs)/DRc, DRc = Rate of degradation of control, DRs = Rate of degradation of sample. EC_{50} = IC_{50}/concentration of DPPH in mg/ml; ARP = 100/EC_{50}; ASE = ferric reducing - antioxidant power expressed as ascorbic acid equivalent (1mM = 1 ASE), which is inversely proportional to reducing power.

Rhizosphere Microbiology of Himalayan Plants

Plant-microbe and microbe-microbe interactions are important for biotechnological applications for improving plant performance in the Himalayan mountains. Based on the leads, activities were focused on: (i) assessment of diversity of cold-tolerant and thermophilic microorganisms, and (ii) mycorrhizal associations of Himalayan trees.

- Twenty one species of *Penicillium* isolated from the soil samples collected from IHR were studied for their phosphate solubilizing activity. Eight species exhibited formation of halos (zone of solubilization) around the fungal colonies in qualitative plate assays. During quantitative estimations, conducted up to 30 days, seven species of *Penicillium* brought maximum solubilization after day 15, while *P. oxalicum* showed maximum solubilization after day 21 of incubation. The increase in solubilization coincided with decrease in pH of the broth. Acid phosphatase activity was 1.5-2.0 times higher in comparison to alkaline phosphatase. Many of these species showed wide range of tolerance to temperature, pH and salt concentration (Table 15).
- A variety of fermented foods including beverages are prepared and consumed in various hilly regions of Indian Himalaya. A wheat based starter culture (*balam*), used by *Bhotiya* community was investigated. In all, 32 microbial cultures were isolated from nine samples of *balam*. Two species of gram positive spore forming bacteria and three of yeasts dominated the microflora of *balam*. While the spore forming bacterial species belonged to genus *Bacillus*, the yeast isolates were identified as *Saccharmycopsis fibuligera*, *Kluyveromyces maxianus*, and *Sacharomyces* spp. (Fig. 36).

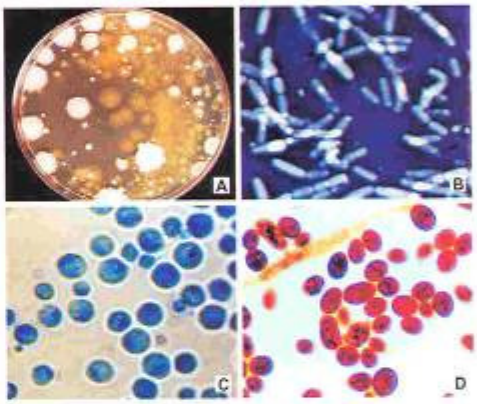


Fig. 36. A dilution plate showing yeast and bacterial colonies, B-D. Microscopic observations on *Bacillus* sp., *Kluyveromyces maxianus* and *Saccharomycopsis fibuligera*, respectively (magnification = x 1000)

Table 15. Growth characters and phosphate solubilization on Pikovskaya medium after one week of incubation

Penicilliumspecies	Temperaturerange (°C)	pHrange	Salttolerance (%)	Zone of solubilization (mm)
P. aurantio-griseum	4-35, opt. 21	3.0-12.0, opt. 4.0-5.0	20	6.3
P. citrinum	9-50, opt. 28	3.0-12.0, opt. 6.0-9.0	20	8.6
P. janthinellum	9-50, opt. 28	3.0-12.0, opt. 5.0	15	5.1
P. oxalicum	4-35, opt. 21	3.0-12.0, opt. 4.0-6.0	15	7.1
P. pinetorum	9-42, opt. 28	3.0-12.0, opt. 5.0-6.0	15	7.3
P. pinophilum	4-35, opt. 28	3.0-12.0, opt. 6.0	15	8.2
P. purpurogenum	9-50, opt. 28	2.0-12.0, opt. 3.0-6.0	05	7.6
P. raistrickii	4-35, opt. 21	1.5-11.0, opt. 4.0	15	5.8

Summary of the Completed Project

Characterization and Improvement of Tea Through Biotechnological Tools

(DBT funded: 2005-2007)

Under a multi-institutional project detailed studies were conducted on development of bacterial and VAM formulation across various tea gardens of IHR. Occurrence of a negative rhizosphere effect exerted by the established tea bushes, in contrast to the normal stimulatory effect exhibited by the young tea bushes, was the most important feature. Preponderance of large populations of antagonists, consisting of species of *Bacillus*, *Streptomyces*, *Trichoderma* and *Penicillium*, and lowering of the soil pH were other important characteristics associated with tea rhizosphere. In case of arbuscular mycorhhizal fungi (AMF), the rhizosphere soil from cultivated tea bushes was found to be dominated by species of *Glomus* and *Acaulospora*. In contrast, occurrence of five genera, viz., *Acaulospora*, *Gigaspora*, *Glomus*, *Sclerocystis*, and *Scutellospora* was recorded from the rhizosphere of natural (abandoned) tea bushes. It was found that various cultural practices, e.g., regular pruning and fertilizer application etc., negatively affect AMF diversity.

Two bacterial species, namely *Bacillus subtilis* and *Pseudomonas corrugata* and selected species of AMF belonging to the genus *Glomus* were found to have growth promoting potential. These were selected as promising inoculants for application in the tea gardens. The promising bacterial inoculants in carrier based formulations have proven useful in respect of seed, cutting and tissue culture raised plants of tea. The AMF associated with the tea rhizosphere were mass propagated through 'trap culture' technique and the soil from these trap cultures was used as AMF consortium. The AMF consortia retained sufficient viability after storage at room temperature and 4 °C, and were found to be effective in promoting the growth of tea plants. The results clearly indicate the potential of AMF consortia developed from the tea rhizosphere for use in tea plantation. The study is particularly important in respect of states like Uttarakhand which are branded as being organic states.

Development of Callus and Hairy Root Cultures for Production of Active Compounds from two Himalayan alpine plants *(UCOST funded: 2006-2009)*

As a consequence of increasing demand for medicinal plants in the pharmaceutical industry, there has been a large scale and uncontrolled collection from the wilds, and in the absence of organized cultivation, many of these plants are now listed under various threat category. There has been very limited progress on restoration and cultivation of alpine medicinal plants. Although *in vitro* techniques have proven to be promising method for multiplication and subsequent cultivation of plant species, use of callus cultures and genetically transformed hairy roots for production of active ingredients of medicinal value in *Picrorhiza kurrooa* and *Aconitum heterophyllum* would be an attractive alternative. Genetically transformed hairy roots produced by infection of plants with *Agrobacterium rhizogenes*, a gram negative soil bacterium, appear to be promising tool for secondary metabolite production.

- The study envisages establishment of callus and hairy root cultures, analysis of chemical constituents, scaling up of cultures, and training of farmers and interested groups.
- Callus cultures have been initiated from seedlings grown aseptically in culture media. Several trials have been undertaken to establish hairy roots in these species using different strains of bacteria.

Summary of the Completed Project

In vitro Approaches Towards Commercial Cultivation of *Podophyllum* spp.

(DST funded: 2004 -2007)

Podophyllum spp., important due to the presence of podophyllotoxin, is being used in the preparation of different drugs for treatment of various types of cancers. *P. hexandrum* has become threatened due to indiscriminate collection from the natural habitat. To augment this and conserve the plant, conventional and biotechnological approaches have been applied to propagate the plant and production of podopyllotoxin. The activity focused on: (i) Modification and standardization of existing *in vitro* protocol for *P. hexandrum* (selected elite plants) and *P. peltatum* for large-scale multiplication, (ii) Biological hardening of *in vitro* raised plants by microbial inoculations and evaluation of field performance of tissue culture raised plants, and (iii) Estimation of secondary metabolite in tissue culture raised plants, callus and suspension cultures.

- Improvement in multiple shoot formation was achieved through MS media supplemented with hormones. Optimization of callus culture was carried out by subjecting calli to MS medium containing different concentrations of sucrose and antioxidants. MS medium containing 4% sucrose in combination with 5 µM (NAA) and 1 µM TDZ resulted in profuse callus growth. Calli grown on above medium were analyzed for podophyllotoxin and maximum level was detected in calli grown for four weeks.
- Field trials were carried out on seed raised plants grown at two sites (Institute's nursery and farmer's field at Basoli village in Almora Distt.). Over 90% seedling survival was recorded at both the sites. Biomass and podophyllotoxin analysis indicated low levels of the toxin from the rhizomes of these plants when compared to those collected from higher altitudes.

Field Evaluation of Microbial Inoculants for use in Mountains *(UCOST funded: 2006-2008)*

With a view to develop microbial fertilizers for application in the mountains, a long term study was undertaken to isolate, characterize and select suitable plant growth promoting microorganisms. The technology has been developed with emphasis on the selection of right organisms in appropriate formulations, suitable for use in the mountains. The project tends to establish a network of local farmers to adopt this technology for improving crop productivity. On farm demonstration trials have been initiated in collaboration with the local farmers, following an integrated approach using selected microbial inoculants, in addition of other organic inputs.

Core Programme

INSTITUTIONAL NETWORKING AND HUMAN INVESTMENT (INHI)

Networking of the existing institutional infrastructure in the IHR is critical for optimal use of the available scientific talent and for fostering conservation and achieving sustainable development. Through this Core Programme-the infrastructure, expertise, and scientific manpower available in the IHR is being supported effectively. The programme also helps in fulfilling broad mandate of the Institute. Furthermore, this programme supports Institute's role as a facilitator of R&D programmes in the IHR and establishment of institutional linkages. Outreach of this programme is also enhanced through on-site training programmes, dissemination of knowledge through library services and Environmental Information Centre of the Institute.

Creating Sacred Forest through People's Participation

In the IHR continued degradation of land and biological diversity is of serious concern. An approach of conservation by integration of sacred/ cultural value of the inhabitants for landscape restoration has been developed by blending science and religion for the protection of environment and biodiversity conservation. Identifying suitable plant species for plantation in the degraded land is a vital component of this programme.

- This programme was implemented in approximately 3 ha degraded land belonging to the village community of Kolidhaik village (Distt. Champawat, Uttarakhand). Site identification and need assessment for plantations was carried out by socio-economic survey in surrounding villages. In the hillside (Kail Bakriya Hilll) SWC measures (trenches along contours) were implemented and soil quality attributes were studied for analysis of changes in land quality status after restoration.
- A plant nursery near the plantation site was raised with 18,000 saplings of about 20 promising tree species. Plantation of over 6000 multi-purpose tree species was carried out through people's participation in religious ceremonies. Survival of the plants (Fig. 37) ranged from 50% for *Grewia optiva* (Bhimal) to 90% in *Quercus* spp. (Oak). Water harvested in the storage tanks significantly increased the survival rate of the plants.

Fig. 37. Kail Bakriya hill planted with multi-purpose tree species

Summary of the Completed Project

People and Resource Dynamics in Mountain Watersheds of the Hindu-Kush Himalaya

(SDC, IDRC, ICIMOD funded; 1997-2007)

This project was operated in Garur Ganga – Bhetagad watershed of Kumaun hills (Distt. Bageshwar) from January 1997 – June 2007 as a R&D project funded by the SDC, IDRC and coordinated by the ICIMOD, in response to the growing concerns regarding the biotic pressure on the resources and the people living in the middle mountains of the Hindu Kush Himalayas (HKH). PARDYP approached resource dynamics and research through a holistic methodology, adopting a nested approach to examine initial differences and subsequent changes in surface water flow, soil erosion and fertility, sedimentation, farming systems, land use/cover and potential livelihoods for the inhabitants of the region. The highlights of this project are summarized below:

- Framing methods for organizing and enabling community groups to identify the problems and needs in managing natural resources were experimented. Mobilization of the groups to undertake need-based pilot activities to conserve, manage and equitably use the natural resources was carried out.
- Activities ensuring strengthening of community institutions and transfer of appropriate technologies on water harvesting, storage, fodder production and utilization especially for lean period at household and community levels for decreasing women's workload were implemented. Community based natural resource management concept for long term sustainability was incorporated.
- Long term data base on dynamics of water resources, meteorology, soil erosion aspects, sediment transport and water quality under different land use and land cover practices was developed. In addition, off-season vegetable cultivation, vermi-composting and bio-composting, water harvesting combined with fish farming, rehabilitation of degraded community lands, participatory management of the natural resources, etc., were executed as the best options for improved livelihood of the people.

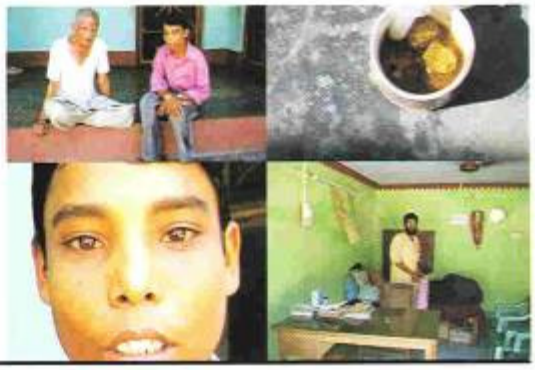
Integrated Eco-development Research Programme (IERP) in the IHR

The MoEF entrusted the responsibility of integrated action oriented research, development and extension programme (termed as Integrated Eco-development Research Programme - IERP) in the IHR to the Institute in 1992. Subsequently, the Institute identified two broad thrust areas, namely Technology Development and Research and Technology Demonstration and Extension, under this programme. The designated objectives of the programme are: (i) to provide extra mural funds to different Universities/ Institutions/NGOs/Voluntary agencies for the support of location-specific R&D activities in the IHR, (ii) to develop scientific capabilities in the IHR and strengthen infrastructure for environmental research, and (iii) to develop and execute coordinated programmes on the recommendations of the completed projects/ special theme(s)/R&D need(s) in the IHR with the help of identified network partners.

- During the year, funds for sixty four (64) ongoing/completed projects were released to different organizations. As many as 32

new project proposals received by the Institute from different organizations were scrutinized. Annual Progress Reports of 64 on-going projects were processed for evaluation by subject experts and the comments received were utilized for improving the project documents.

- A coordinated programme entitled "*Sacred values, eco-restoration and conservation initiatives in the Indian Himalayan region*" was strengthened in 5 Himalayan states (namely, Uttarakhand, Himachal Pradesh, Assam, Meghalaya and Arunachal Pradesh) under this programme.



Core Programme

INDIGENOUS KNOWLEDGE SYSTEMS (IKS)

Indian Himalayan region is the repository of rich indigenous knowledge systems. Under the pressures of market forces and globalization the rich diversity of indigenous and traditional knowledge systems of the Himalaya are gradually passing to oblivion. This programme seeks to identify, document, validate, and safeguard such knowledge base and intellectual property right interests of the rural societies and ethnic communities of the region.

Validation of Indigenous Knowledge and Uses of Medicinal Plants by the *Vaidyas*

Like other parts of the India, herbal therapy is a centuries-old tradition in the Himalaya. *Vaidyas*, the traditional herbal healers, have been providing this therapy to the local populace. These *Vaidyas* use different formulations to cure different diseases. Such formulations are mostly based on the locally available plant material and resources. This study aims to document the plants used for treatments, their prophylactic uses, the formulations developed by traditional healers, and the impact of traditional healing.

- Fifteen *Vaidyas* from Pauri, Tehri, Chamoli and Rudraprayag districts of Garhwal region were interviewed and their treatment fields were noted (Table 16). Most of the *Vaidyas* practice in 'child and woman related diseases'. The herbal treatments were very effective in bone fractures (Fig. 38), and for the treatment of jaundice.

Table 16. Medicinal herbs used in traditional *Vaidyas* system in Garhwal Himalaya

Field of herbal healing	% of practising *Vaidyas*	Species used/other ingredients in traditional formulations	Treatment impacts
Child and woman diseases	66.7	*Swertia chirayita, Tinospora cordifolia, Emblica officinalis, Ocimum sanctum, Centella asiatica, Withania somnifera, Terminalia chebula* and *T. bellerica*	
Specialist of bone fracture	26.7	*Juglans regia, Ricinus communis, Citrus spp.*, egg of local hen, mustard oil, resin, fresh cow dung	Very effective
Specialist of Jaundice	6.7	Wild small cucumber (about 2 cm size), *Carica papaya, Punica granatum, Raphanus sativus*, Live 52 (a standard ayurvedic drug), Livomin, multi-vitamins syrup and 3 months prevention of taking normal diet	Very effective

Figure 38. Fracture arm after resetting and treatment by traditional *vaidya*

- *Adhatoda vasica, Aegle marmelos, Azadirachta indica, Bauhinia variegata, Centella asiatica, Curcuma longa, Cynodon dactylon, Ficus benghalensis, Emblica officinalis, Ocimum sanctum, Piper nigrum, Psidium guajava, Raphanus sativus, Sapindus mukorosii, Swertia chirayata, Terminalia chebula, T. bellerica, Tinospora cordifolia, Trigonella foenum-graecum, Withania sominifera* and *Zingiber officinalis* were the most common plants used in herbal formulations.

Traditional Knowledge of Weather Indicators

Senior citizens of high altitudes of rural Himalayan regions have good understanding of indicators of local weather and agriculture. They have been using this knowledge for their various household decisions, especially those pertaining to agriculture – particularly for crop sowing, harvest, and assessment of production estimates. This study attempts to record such indicators for general approximation of crop yields. Approximately 120 senior citizens of 17 villages were interviewed for this purpose in Bageshwar district (Uttarakhand). Few examples of the compilation are stated as under.

- Snowfall in the month of *magha* (mid-January to mid-February) or south to north blowing winds during *magha* and *poush* (December and January) indicates good wheat crop, and snowfall during *poush* (mid December to mid January) indicate low yield of wheat.
- Mild quake tremors imply good crop yields during the year; and frequent lightening and thunder bursts in the atmosphere, signifies drought and subsequent crop failure. Proportionally higher rainfall during the year indicates less cold in that particular year.

Summary of the Completed Project

Indigenous Fermented Food and Beverages of Himalaya: Potential for Economic Development

Preparation and use of fermented food and beverages from local food crops is a common practice amongst the ethnic people of high altitude societies of the IHR. This practice is used to preserve food for the cold winter days, and to meet the requirements of the rituals and ceremonies. Some of these fermented products have also entered into the market, and cater good economic potential. This study tends to consolidate this indigenous knowledge from across the Himalaya.

- Based on cereals, legumes, vegetables, milk, beverages (non-distilled & distilled), meat, fish, and others - 8 categories of fermented foods and beverages are prepared and consumed in the high altitudes of the IHR (Table 17). From NW Himalaya - 26 types, Central Himalaya - 4 types, and NE Himalaya - 37 types of foods and beverages were documented.

Contd.....

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- Some cereals and legume based fermented foods such as *siddu, babru/babro, bhaturu, chilra* and *sepubari* in HP, and *kinema*, a soybean based fermented food in NE regions have already made their place in market and tourism sector.
- Dried mixture of finger millets /glutinous rice and varieties of local plant material containing natural yeast is used as a starter culture for preparing non distilled and distilled beverages. *Dheli*, a starter culture used in NW for preparation of *sura* (non distilled beverages) is a mixture of finger millet and 37 local herbs. In Central Himalaya *balam/balama*, a mixture of rice and *Amomum subulatum, Chinnamomum zeylanicum, Piper longum*, leaves of wild chillies, seeds of *Ficus religiosa* and old *balam/balama* powder is used as starter culture for preparation of cereals based food and beverages. While in NE regions the starters- *Marcha/ marchu, ranu dabai, mod pith* and *pham* are the mixtures of rice and varieties of local herbs.

Table 17. Number of indigenous fermented foods and beverages prepared and consumed in IHR

Fermented food categories	Regional number of food types		
	NW Himalaya	Central Himalaya	NE Himalaya
Cereal	15	1	1
Legumes	3	-	2
Vegetables	-	-	6
Milk	2	1	6
Beverages			
• Non-Distilled (mild alcoholic)	5	1	9
• Distilled (alcoholic)	1	1	1
Meat	-	-	2
Fish	-	-	9
Others	-	-	1
Total	26	4	37

Indigenous Post Harvest and Seed Storage Practices of Garhwal Himalaya

Local and indigenous knowledge about certain post harvest practices and seed storage technologies has contributed substantially in the continuance of traditional agriculture systems of the Himalaya. Such knowledge, which has been accumulated over the years, is fundamental for food production, as well as for development and adoption of cropping strategies in this region. The present study focuses on documentation and verification of the various post harvest and seed storage techniques that are being practised in the region. The results of a survey in Kedarnath valley of the Garhwal Himalaya, are stated below.

- The storage and post harvest techniques are used in the cultivation of a wide variety of crops (Fig. 39). Storage of food grains in metallic containers and their periodic exposure to sun is the most common storage practice.
- The people have well developed perceptions regarding the selection of crop/ crop stand

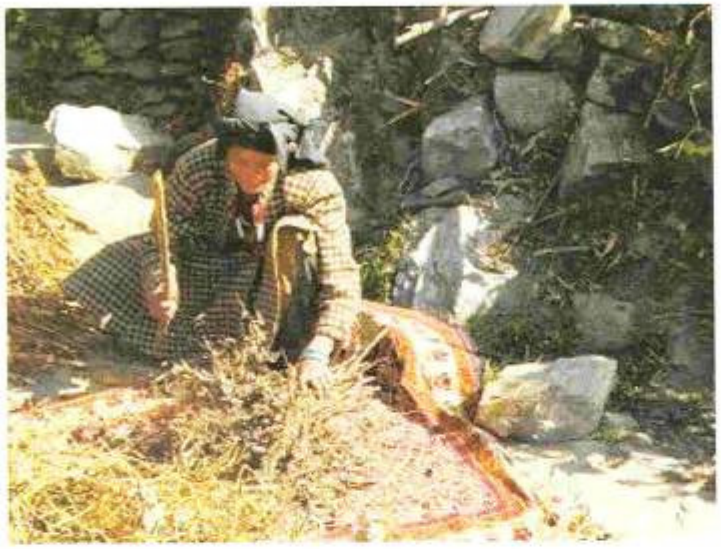

Fig. 39. Processing of produce for storage

for seeds. In case of potato the number of eyes in potato is a marker. The post harvest duties are mainly discharged by the women folks and practical demonstrations help transfer of this knowledge through generations.

Pastoralism and Transhumance in Kumaun and Garhwal Himalaya

The closure of trans-border trade between India and Tibet resulted in cultural transformation of the different sects of the pastoralist transhumant tribes of Bhotiyas, and their gradual naturalization into the cultural folds of this region. In this transition many of their cultural values and traditions were lost, yet some they managed to sustain through by adaptations. This study on Niti and Mana valleys of Garhwal Himalaya, examines the whole scenario with focus on their adaptive income generating activities, IKS of resource use, and relevance of their rituals and belief system in context of changes in social and economic system.

- The 'Transhumant Communities' of Central Himalaya have a rich traditional knowledge of making woollen products and also conservation of high altitude pasture land. In the carpets and other woollen items that are made by them sheep wool and natural dyes from various plants are used.
- Worship of local deity marks the most important feature of their belief system. They have different deity for different natural phenomena. These deities are considered more powerful than the Brahmanical Gods. Ghantakaran is their most powerful deity; its worship is considered a must for prosperity and sustenance of the tribe (Fig. 40).
- Use of fermented foods and beverages is common in rituals and festivals and are mass consumed and offered to guests; trade in medicinal plants and wild food for domestic use, are the new adaptations of the Bhotiyas of Niti-Mana (Table 18).

Table 18. Uses and parts of use of medicinal and wild edible plants of NDBR

Local Name	Botanical Name	Part used	Use
Pharan	*Allium wallichii*	Leaves	Medicinal & vegetable
Choru	*Pleurospermum angelicoidies*	Fruit/Leaves	Medicinal and vegetable (leaves used in flavouring)
Gucchi	*Morchella esculenta*	Fruiting Body	Medicinal and vegetable
Kenu	*Morus serrata*	Fruit	Fruit edible
Kutuki	*Picrorhiza kurrooa*	Root & Seeds	Medicinal
Amesh	*Hippophae rhamnoides*	Fruit	Medicinal
Thuner	*Taxus baccata*	Leaves & barks	Medicinal
Brahmkamal	*Saussurea obvalata*	Flowers	Worship/ medicinal
Ratanjot	*Onosema echioides*	Root Stem	Medicinal
Ban kakdi	*Podophyllum hexandrum*	Fruit, tuber	Medicinal
Dholu	*Rheum emodi*	Full plant	Medicinal
Chiphi	*Angelica glauca*	Seeds/ Root	Medicinal & leaves used for flavouring
Panger	*Aesculus indica*	Seed	Medicinal & food
Kut	*Saussurea costus*	Root	Medicinal
Hathajari	*Dactylorhiza hatagirea*	Tuber	Medicinal
Ghenu	*Viburnum cotinifolium*	Fruit and Seed	Medicinal & food
Balchari	*Arnebia benthamii*	Root	Medicinal

Fig. 40. Celebrations of Ghantakaran festival in Mana

Traditional Ecological Knowledge with Selected Ethnic Groups of Arunachal Pradesh

The entire North-Eastern region of India is one of the Mega Biodiversity Hot Spots' of the world. The process of adaptation to this bio-diversity rich regime has inculcated amongst the inhabitant tribal masses a good ecological understanding of the nature. The tribal people of the region have been using this knowledge efficiently for management of resource sustainability (Fig. 41). Under the study, NRM practices of Adi community of East Siang and West Siang districts- for traditional soil conservation, water conservation, and sustainable use of water and plant resources were studied.

- Case studies in Rengo, Pangin, and Rumgong villages of Adi community were carried out and their land use patterns were mapped. Shifting cultivation, terrace cultivation, and horticulture were three major land use types. The terraced type of agriculture was noticed to be the new development, suggesting switch towards settled agriculture (Table 19).

Table 19. Distributional pattern of agricultural practices among the tribal households

Village	No. of house-holds	Gender wise population		Distributional pattern (%)				
		Male	Female	SC	TC	SC+TC+H	SC+TC	TC+H
Rengo (1177 ft)	44	135	138	13.6(6)	9.1(4)	52.7(23)	11.4(5)	13.6(6)
Pangin (1704 ft)	82	222	200	1.2(1)	18.3(15)	18.3(15)	52.6(43)	9.8(8)
Rumgong (2632 ft)	104	321	329	23.1(24)	49.0(51)	2.9(3)	25.0(26)	0(0)

Values in parentheses is no. of households; SC=Shifting Cultivation, TC=Terrace Cultivation, H=Horticulture

Fig. 41. Terrace fields in Adi community area of Arunachal Pradesh

R&D HIGHLIGHTS OF THE REGIONAL UNITS

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

HIMACHAL UNIT

1. Database on soil physico-chemical characteristics, floristic inventory, community patterns, distribution pattern of native and endemic species and resource utilization pattern of the Kais and Manali Wildlife Sanctuaries, Lahaul valley was developed.
2. Periodical measurements on ambient air quality (total suspended particles, particulate matter, SO_2, NO_2, O_3) for establishing background values were taken at two important hill stations - Mohal (Kullu) and Kothi (Manali).
3. Physiological studies on some important MPTs suitable for wasteland plantation were carried out to understand their response when subjected to changes in atmospheric temperature and soil water stress. Seed germination protocols of *Angelica glauca* and *Saussurea costus* developed.
4. Base line information on various socio-economic attributes from eleven affected villages surrounding to Parbati II and III hydropower projects was collected. Conducted survey on people's perception regarding positive and negative impacts of hydropower projects.
5. State Level Workshop (01), Training Programmes (03), Awareness Camp on Biodiversity Act 2002 and Exposure visits (07) were organized and exposure of various demonstrations of the Institute (Herbal Gardens, Medicinal Plants Nurseries,

Arboretum, Agroforestry models, Vermicomposting, Bio-composting, Solid Waste Management, Pollution and Weather Monitoring) was given to > 500 different stakeholders.

GARHWAL UNIT

1. Socio-economic studies with special reference to indigenous farmers' practices and knowledge on soil fertility maintenance and below ground biodiversity were conducted in a range of land use/land cover types of Nanda Devi Biosphere Reserve.
2. In-depth studies on population dynamics, multiplication potential and biochemical and nutritional assessment of *Hippophae rhamnoides* were carried out. The findings have proved beneficial to develop a viable action plan for *Hippphae* resources and its bio-industrial potential.
3. A field station for demonstration, training and experimentation site for bioresource conservation and management and capacity building has been established at Triyuginrayan (Kedarnath valley). A strategy and action plan for eco-tourism promotion for Nanda Devi Biosphere Reserve (a world heritage site) was developed.
4. Four on-site training programme were organized at the Unit demonstration sites for different stakeholders on rural technologies i.e., biocomposting, protected cultivation, zero energy cool chamber, water harvesting etc. benefiting over 240 persons.

SIKKIM UNIT

1. A 'Rare and Threatened Plant Conservation Park' was established in collaboration with State Forest Department. In this 2 ha size park plantation of *Swertia chirayita* and *Saussurea costus* (> 90 % survival recorded) and Rhododendrons species was carried out.
2. A Regional level training programme on 'Comprehensive landslide risk management', in collaboration with National Institute of Disaster Management (MHA, Govt of India) and Land Revenue Disaster Management Department, Govt of Sikkim was organized.
3. Collaborations were developed with state forest department with a focus on "Sikkim-Biodiversity and environmental conservation and forest management'. Under a 'Memo of Agreement' with NABARD-Gangtok, training on biodiversity, plant propagation, nursery plantation, medicinal plant cultivation and farm-based technologies were imparted to 54 farmers' clubs and 5 NGOs.

NORTH EAST UNIT

1. Up scaling of technology dissemination and backstopping has been carried in five states of the NE region with the help of seven partner NGOs.
2. Major task force/commission study reports on shifting cultivation reviewed and analyzed. Success stories and best practices/examples in shifting agriculture were documented.

3. Documentation of (i) Fallow management practices among the Tangkhuls of Ukhrul District; (ii) Traditional pest management practices among three tribes (Hmar in North Cachar Hills district of Assam, Tangkhul in Ukhrul district of Manipur and Jaintia (Pnar) in Jaintia Hills district of Meghalaya); and (iii) Traditional soil and water conservation practices among the Nishyie tribe of Papumpare district and Adi tribe of East Siang and West Siang districts of Arunchal Pradesh.

APPLICATION OF R&D OUTPUTS IN DEMONSTRATION AND DISSEMINATION

A. Capacity Building

Rural Technology Center(s)-*Head Quarters*

This programme operates through a self sustaining Rural Technology Centre (RTC) set up at the Institute headquarters at Kosi (Uttarakhand). This centre with its demonstration establishments on simple low-cost technologies provides trainings to various stakeholder and trainer groups in different sets of packages. Demonstrations on 30 technologies have been established in the centre. Polyhouse cultivation, bio-composting, vermin-composting, bio-briquette, zero energy cool chamber, pisciculture, and mushroom farming are important technologies of interest.

- During the year 50 training/awareness programmes (8 -1 day,1 -2 days, 39 – 3 days, and 2 – 5 days) for different user groups were organized, in which 1580 persons (covering 261 villages from 8 districts of Uttarakhand) were trained. The stakeholders for trainings included: watershed managers (30%); haryali farmers (12%); NABARD nominees (7%); Students (28%); Agriculture Dept. officials (8%) and others (15%).
- Technical guidance/support for polyhouses, water harvesting tanks, fishpond and iron mould for bio-briquetting, etc. was extended to select SHGs. Also, strong linkages with various stakeholders and peer organizations/programmes of state of Uttarakhand were established (Fig. 42). Total revenue of Rs 11 lakhs was generated through RTC.

Fig. 42. Capacity building of various stakeholders at RTC, Kosi-Almora

Regional Units

- Demonstrations on appropriate eco-friendly rural technologies for capacity building and skill development were established at three locations (Maletha, Tapovan and Triyuginarayan) of Garhwal Himalaya. Four on site training programmes were organized and about 240 persons (160 farmers, 40 students and 40 NGOs representatives) were trained on different rural technologies (Fig. 43).
- The Miphu farm at NE campus of the Institute has been developed as a repository of eco-friendly rural technologies and the centre is being used for capacity building of various stakeholders. During the year demonstration and monitoring of selected low cost rural technologies such as liquid manuring, weed composting, vermi-composting, bio-briquotte, vegetable gardening using Trellis, multi-tier cropping, and contour hedgerow intercropping, were conducted.

Capacity Building for Disaster Management in Sikkim

Disaster Management Faculty (DMC) with the funding support from Disaster Management Division, Ministry of Home Affairs, GOI was inducted in the Sikkim Unit of this Institute in February 2003 with a mandate to contribute to the priority action programs in the areas of natural disaster management through capacity building of various target groups in Sikkim. During reporting period, training modules were developed and organized : (i) a State-level training-cum-workshop on disaster management (Fig. 44 a); (ii) a regional comprehensive landslide risk management training programme (Fig 44 b); and, (iii) training programmes for Sikkim Armed Police.

Fig. 43. Capacity building programme on different rural technologies.

Fig. 44. (a) State level training cum workshop on disaster management; (b) regional training programme on comprehensive landslide risk management

Capacity Building on Participatory Biodiversity Conservation

Realizing that proper understanding on conservation and sustainable use of resources facilitates participation of local people in conservation programes the Institute attempts to bring the target groups into the conservation movement by: (i) promotion of understanding on conservation science especially among students and teachers; and (ii) impart on-site training on assessment of biodiversity elements and collection, storage and propagation of important species.

- Focusing on development of capacity through Training of Trainers (ToT), so as to induce a multiplier effect, a seven days orientation course (December 04-10, 2006) was organized at GIC Talwari, Chamoli) for the selected teachers representing 18 eco-clubs from six districts of Kumaun and Garhwal (Fig. 45). Two three days training workshops (22 -24 May, 2006 at GIC Khirsu -Pauri Garhwal; and December 08-10, 2006 at GIC Talwari, District Chamoli) were organized for selected eco-clubs of Garhwal region. Representatives of 59 schools (179 participants - 60 teachers and 119 students) of six district of Garhwal and Kumaun participated in the workshop. Besides the deliberations of Resource Persons, the participants were exposed to various practical aspects, especially collection of biodiversity information. Towards building a biodiversity information network and to generate information on agribiodiversity, biodiversity assessment campaigns in a participatory manner were organized. Structured response sheets (in Hindi) were developed and distributed to the trained eco-club incharges during the workshop.
- Training (2 day each), under 'Memo of Agreement' with NABARD-Gangtok, imparted on biodiversity, propagation & nursery plantation, MP cultivation and farm based technologies were provided to 54 farmers' clubs and 5 NGO. On rating the level of field and campus demonstrations, over 50% considered them high level. Over 92% participants showed willingness to attend similar training programme in future. Besides, subject exposure was provided to 50 officers and Jawans of Sikkim Armed Police on biodiversity and plantation technique.
- Under the DST sponsored project Participation of youth in Real time/ field Observations to Benefit Education in Uttarakhand (U-PROBE), meteorological data were collected by students of identified schools (i.e. GIC Almora, GIC Pithoragarh,

GIC Kausani, GIC Hawalbagh, GIC Barechina, GIC Danya, GIC Kheti, GIC Lamgara, GIC Bhatkola and GIC, Binta) and database developed. The first and second issues of U-PROBE Newsletter were published by TRC-GBPIHED, to encourage and promote sharing of scientific knowledge among youngsters. Besides, U-PROBE Website has also been launched and can be accessed through following path **http://gbpihed.nic.in/uprobe/uprobewebsite.html).**

Fig. 45. Facets of conservation education programme. A – Orientation, B-C- Deliberations, D – Field assessment, E-F Post training sessions

Operation PARADE' (Participatory Action for Rural Area Environment & Development)

This programme, a joint venture of National Cadet Corps (NCC) of India and GBPIHED envisages implementation of village environment action plan (VEAP) and strengthening rural livelihood technologies in adopted villages involving the workforce of National Cadet Corps with our technical guidance. Initially the target area is Kumaun in Uttarakhand; subsequently it will be expanded to other areas of the region.

- VEAP was prepared for Railakot village (District- Almora, Uttarakhand) involving NCC Cadets and officials, which include development of resource maps (using geodetic GPS method), prioritizing the problems and strategies for their integrated solutions. Biological and physical interventions executed in this village include plantation of a community wasteland (2230 plants of 9 fodder species), digging water harvesting ponds, percolation tanks (Khal), construction of check-dams and trenches for water conservation. 50 NCC cadets (30 boys and 20 girls) of Kumaun region were trained for VEAP under this programme.

Institutionalizing Technology Backstopp-ing and Capacity Enhancement Within the Tribal Areas of North East

Under a DST funded programme this project envisages development and institutionalization of technology backstopping network in NE region. The GBPIHED NE Unit acts as a co-ordinating agency for the establishment of: (i) model demonstrations, (ii) capacity building of network partners and farmers in various technology packages, and (iii) technology improvisation as per area-specific needs and conditions.

- A consortium of seven NGOs from different states of the NE region has been established (Table 20). These partner NGOs have established technology demonstration parks in their respective areas and have been demonstrating, disseminating and establishing on-farm demonstration sites of relevant technologies in the villages. These centres established by the NGOs, are envisaged to serve as permanent technology

Table 20. Project partners and technologies demonstrated/ identified for the region

Name of the partner NGOs	Technologies demonstrated
Centre for Environment (CEP), Aizawl, Mizoram	Bio-composting, Polyfilm Technology, Legume mixed Intercropping, Contour Hedgerow Technology, Rain Water Harvesting, Zero Energy Cool Chamber, Bio-briquetting, Bamboo Propagation
Nature and Motivation-Rural Human Empowerment Network Association (NAMRHEN), Dawki, Meghalaya	Weed composting, Bio-briquetting, Vermi-composting, Polyfilm Technology, Green House, Trellises, Handi (pitcher) Irrigation Technology, Grafting and Budding, Bamboo Propagation
N.C. Hills Hmar Cultural Organization (NCHHCO), Halflong, Assam	Polyfilm Technology, Haandi (pitcher) Irrigation Technology, Bamboo Propagation, Bio-briquetting, Bio-composting, Contour Hedgerow Technology, Modified Jhum
St. Vincent's Welfare Society (SVWS), Kathalchera, Tripura	Bio-composting, Vermi-composting, Liquid Manuring, Polyfilm Technology, Cutting and Grafting, Bamboo Propagation, Trellises, Bio-briquetting, Contour Hedgerow Technology, Multi-Tier Copping
Institute of Integrated Resource Management (IIRM), Tezpur, Assam	Vermi-composting, Liquid Manuring, Polyfilm Technology, Green House, Trellises, Multi-tier Cropping, Trap Cropping, Bio-briquetting, Bamboo Propagation, Grafting, Budding
Society for Sustainable Rural Development (SSRD), Ukhrul, Manipur	Bio-briquetting, Vermi-composting, Bio-composting, Bamboo Propagation, Polyfilm Technology, Trellises, Zero Energy Cool Chamber, Liquid Manuring, Contour Hedgerow Farming, Rain Water Harvesting
Northern Integrated-Development Association (NIDA), Senapati, Manipur	Bio-composting, Vermi-composting, Green Manuring, Mixed Cropping, Rain Water Harvesting, Cutting, Grafting

demonstration and dissemination centres for the relevant state/district.

- A three day workshop-cum-training programme was organized for capacity building of the partner NGOs during March 16-18, 2007 at Multi-Technology Demonstration Site, Midpu.

Environmental Awareness and Training Programme

- A three day on-site training programme on nursery development, tree plantation techniques, natural resource conservation and management, and improved livelihood for the identified target groups was organized at village Chhulapai (Barakot, Lohaghat) in Champawat district of Uttarakhand from 20-22 March 2007 in collaboration with a Pithoragarh based NGO (NIDHI). The training was imparted to 85 trainees from 15 remote villages of the Barakot block including farmers, rural women, ex-army personnel, social workers, students, etc (Fig. 46). Training material on different themes was prepared and distributed to all the trainees. The participants felt the need to organize such trainings in other remote villages for increasing awareness on

Fig. 46. Institute scientist imparting training to the rural people at Chhulapain village

environmental conservation and providing technical know-how to the rural people to improve livelihood support system.

B. Field demonstrations

Participatory Management of Bhimtal Lake Catchment

Under this participatory programme funded by Lake Development Authority, Nainital strategies and measures for degraded land rehabilitation through bio-engineering measures, institutional interventions, and community participation were executed. The Phase I of the project envisage model development in 20 ha of van-panchayat lands of Sanguri and Songaun villages of Bhimtal lakke catchment.

- Four models, viz. multi-purpose species-7 ha, silvi-pasture -3.5 ha, aromatic plant- 5ha, and agro-horticulture- 5ha were developed considering community concerns and lake conservation priorities. For vegetation restoration, soil amendment and diverse planting techniques such as use of earthen pots, bags, soil-refilling in pits, etc., were taken up (Fig. 47), which significantly improved survival of planted saplings. Using bio-engineering measures 10 check dams, 14 gabion structures were constructed. In addition, 36 trenches, 10 water percolation tanks, 4 rainwater harvesting tanks, and 4 nurseries were made.

Fig. 47. Interventions for restoration of vegetation in Bhimtal lake catchment

- Fifteen community capacity building activities (on-site trainings on project related interventions- 7; low-cost technologies for improving livelihood- 2; consultation workshops- 3; and community awareness meets- 3) were organized. Data on demography and landuse pattern/changes, etc was collected for scoping of community based tourism. A 'village conservation fund' was initiated.

Improved Livelihood Practices in Mid Hills of the Central Himalaya

- This activity was aimed at: (i) Scaling up some of the land management technologies based on the R&D work of the Institute, and (ii) Developing capacities of the villagers and partner organizations (i.e., NGOs and line agencies) through improved networking and sharing of information. The land management activities undertaken were: Rehabilitation of community degraded land in Van Birkhet, Lawbanj and Punyamaphie villages (Kausani, Bageshwar Distt. Uttarakhand) by the introduction of fodder tree species and winter fodder grasses. Cash crop cultivation started by 36 farmers of 6 villages in the locality earned 8 times more income as compared from the traditional cropping practices. A number of farmers adopted vermi-composting and used the compost for crop cultivation replacing traditional use of FYM.
- Water harvesting and storage, linked with the fish farming and kitchen gardening, got highest popularity both in terms of cash earning and reduced work load. This activity adopted by more than 58 farmers of 26 villages. The availability of nearby market promoted these activities.

Network Programme on Bamboo Plantations in Uttarakhand

Bamboos constitute a group of highly sought after industrial raw material for use in pulp, paper,

mat board, handicraft industries, besides a source of quality fodder for cattle and numerous traditional uses. In view of the decreasing bamboo reserves of the country and its much relevance to the hilly region, field demonstration of maggar bamboo (*Dendrocalamus hamiltonii*), using the propagation protocols developed by this Institute were made under a programme funded by DBT. Plants raised through conventional (vegetative and seed) and through *in vitro* methods and so far over 5000 plants have been supplied to Uttarakhand Bamboo and Fiber Development Board, Dedradun. In addition, cutting raised plants of *D. hamiltonii* and more than 5000 seed raised plants of *D. strictus* were supplied for field plantation.

Improved Crop Cultivation in Sikkim

Under the broad objectives of Technology Vision 2020, Mission Mode Project on Agriculture the TIFAC Project in Sikkim supports this activity for the overall upliftment of the socio-economic condition of hill farming communities, through, (i) training and demonstration of protective cultivation technology of vegetables; (ii) plantation of disease-free cardamom and citrus plants, and (iii) training and demonstration of cultivation of disease-free ginger crop.

- Under this activity, improved cultivation technology along with specialized training of the farmers for vegetable crops and their seed production was carried out at Central Pandam village in East Sikkim district; Tarku and Chhamgaon villages in South Sikkim district (Fig. 48), and also on improvement of large cardamom cultivation and production of disease free mandarin planting material at I.A.R.I., Kalimpong. Disease free large cardamom seedlings (ca 5100) of variety SBLC 47, and mandarin propagules, Newseller (ca. 200) and grafted (ca. 100) obtained from I.A.R.I., Regional Station, Kalimpong (W.B.) were distributed to the progressive farmers are performing satisfactorily.

Fig. 48. Cultivation of cherry pepper and leaf mustard inside poly-house at Chamgaon, East Sikkim

Integrated Livestock-Fish-Crop Farming

For efficient management of available land and water resources with substantive economic and allied benefits, a tri-commodity approach of fishery, poultry/duck farming and vegetable cultivation coupled with assured supply of safe drinking water through slow sand filtration was adopted at two villages of Kumaun Himalaya under a project funded by DST (Fig. 49). Semi-intensive and intensive pond fish culture techniques were employed, which incorporates high-density stocking and fertilization mainly through integration of chick/duck and cow dung. Fingerlings of silver carp, grass carp and common carp stocked in ponds recorded substantially high fish yield (4269-6030 kg/ha/yr) over the three years of demonstration. The yield of chicken was recorded 55-65 kg/ha/yr. live weight and 2500-3000 eggs/ha/yr. The year-round vegetable cultivation on the pond dike and associated fields (600 m^2) using overflow of pond and storage tanks yielded 1.2-2.3 t/yr vegetables in the model villages. Enhanced vegetable production led to higher remuneration and generated additional income and adequate employment opportunities. On average, net gain of Rs 21,829 and 36,823 was obtained annually from integrated fish farming (IFF) with investment of Rs 8,109 and Rs 11,925 by the beneficiary families at Basoli and Manan villages,

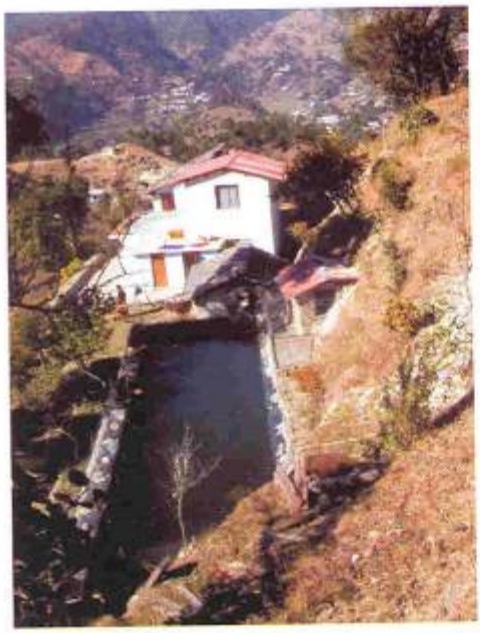

Fig. 49. Integrated poultry-fish-crop farming system with slow sand filtration unit

respectively. Training on this tri-commodity approach was imparted to over 300 women during three years of this project (January 2004-March 2007). The farming system has been found as an appropriate system for supplying diversified products, including inexpensive source of animal protein, safe drinking water and additional income to resource-poor small farmers, especially women. This technology needs to be further disseminated in the Kumaun Himalayan region.

Potential Fodder Trees for Silvi-Pasture Development

In the western Himalayan mountains people depend upon village common lands for fodder and fuelwood needs for subsistence living. Due to year-round biotic pressure many of these village commons have been turned into wasteland. A silvi-pasture demonstration and extension project funded by Ministry of Rural Development,was therefore launched in western Himalaya covering about 40 ha of village wastelands in Dobh-Srikot, Bhimli (Distt. Pauri-Garhwal) and Katarmal (Distt. Almora) villages in western Himalaya. This was a participatory project wherein the plantation of fodder trees (> 10,000 saplings of over 15 spp.) based on stakeholder priority carried out. Grasses, such as *Cassia tora, Cenchrus ciliaris, Trifolium alexandrium, Styloxanthus hamata, Prosopis juliflora, Crotolaria juncea, Panicum maximum* were sown in the demonstration plots at Katarmal site. Nursery for the desired plants was raised and plantation operations carried out in every monsoon season. Soil and water conservation measures (e.g., maintenance of bunds, trenches along contours, mulching) also implemented. In the polythene tanks about 7,500 L of rainwater - runoff was harvested that was used for irrigation of plants during summer

- Growth and survival monitoring of these plantations indicated that mean height attained by *Albizia leebek* (498.9± 37.4 cm), *Albizia stipulata* (250.0), *Dalbergia sissoo* (188.8± 11.9 cm), *Alnus nepalensis* (177.0 cm), *Morus alba* (135.6±16.2 cm) and *Bauhinia retusa* (120.3±10.0 cm), with over 60% survival are promising species for wasteland plantation in the degraded mid-hills of western Himalaya. The stakeholder community also derived fodder grass from these sites. In Dobh-Srikot site (10 ha area; Fig. 50) green fodder production in 2003 was recorded 100 Q. Next year about 500 Q fodder grass was harvested. At Katarmal site 150 Q green fodder in 2004 and 46 Q (dry wt.) in 2005 was harvested by the stakeholder community, thus saved 232 women labour days. One another community wasteland (H" 2 ha) at Katarmal village taken up for restoration by planting over 2000 saplings of 25 MPTs. In the 3 rainwater harvesting polythene lined tanks about 7,500 L of rainwater - runoff was harvested and used for irrigation of plants

Fig. 50. Luxuriant growth of *A. stipulata* at Dobh-Srikot village (Pauri-Garhwal)

during summer. The mean survival of plants at this was recorded 64% and mean height 103 cm after two years. This approach of wasteland restoration was spread among the community members through on-site trainings and teaching.

C. Dissemination

Development of Data Base on Himalayan IKS

The rural Himalaya is facing socio-economic transformation due to outmigration of male members to urban areas, switches towards cultivation of cash crops, and change in traditional food habits. As a result the perpetuity transfer of area specific IKS has suffered. Understanding the importance of such knowledge in present context and for the posterity, the IKS digital library of the institute attempts to document such cases with complete details.

- In the library, so far 536 information sets on IK pertaining to 329 medicinal plants, 24 socio-cultural practices, 6 religious cults, 58 – traditional NRM practices, and 119 sets of IKS related references have been compiled (Table 21). This information was also regularly updated during the year.

Table 21. Digitized data in digital library

Types of entries	Number of entries
Medicinal plants	329
Cultural & social	24
Religious	6
Traditional practices in NRM	58
IKS related references	119
Total entries	536

Library Facility of the Institute

The Central Library in the Institute was started in the year 1989. The library now contains a total of 13,648 books and 125 (77 foreign and 47 Indian) research journals. The objective is to cater the need of researchers of the Institute as well as outsiders working on various aspects of the Himalayan mountain environment and development. Article Alert, Current Awareness Services, Selective Dissemination of Information, Referencing, Indexing, Abstracting, Reprographic and Bibliographic services are provided by the library. The website address of the library <http://gbpihed.nic.in/library.htm>. Institute in-house publications, namely Hima-Paryavaran- a biannual newsletter and Institute Annual Report / Memorial lectures /Folders / Manuals, etc. are distributed through library to about 1500 individuals/organizations across the country.

ENVIS Centre on Himalayan Ecology in the Institute

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 of the MoEF; which is the nodal agency in the country to collate all the information from all the centres to provide national scenarios to the international set up INFOTERRA Programme of the UNEP. The ENVIS Centre of the Institute collects, collates, compiles and builds database related to various aspects of Himalayan ecology. Through print/electronic media, the Centre is regularly disseminating all available information, free of

cost, to various stakeholders/users including all the District Information Centres (operating in the Himalayan states of the country), ENVIS Centres/Nodes and other user agencies/groups. This year the centre published ENVIS Monograph No. 3 (*Resource Information Database of the Himalaya*), ENVIS Bulletin (Vol. 14 No. 1-2) and Volume 3 of the ENVIS Newsletter on Himalayan ecology. ENVIS Bulletin, Vol. 14 (1) was made online for wider use in the IHR through internet at http://gbpihed.nic.in/envis/HTML/vol14_1/vol14_1. The centre also maintains an ENVIS website: <http://gbpihed.nic.in/envis/envis.html>.

Dissemination through interactive forums

Forum/events	Venue/Date	Target groups
Consultative Brainstorming on Vision Document	GBPIHED, Himachal Unit, Kullu (11 September 2006) and Ministry of Environment & Forests, New Delhi (31 October 2006 & 5 January 2007)	Members of GB and SAC, Institute scientists
Biodiversity awareness campaign (Wild Life Week)	GBPIHED, Kosi-Almora (October 1-3, 2006)	Teachers and School children
Training workshop on conservation Education	GBPIHED, Kosi-Almora (May 22-24 & December 4-10, 2006)	Teachers and School children
Environmental awareness and technology exposure	GBPIHED, Pangthang (Sikkim) (June 5, 2006)	Women, NGOs, Farmers, etc.
Training programme on the "Data Generation, Prioritization and Conservation of Natural Resources including Medicinal Plants of the Indian Himalaya"	GBPIHED, Himachal Unit, Mohal-Kullu (June 6-10, 2006)	Ladakh Society for Traditional Medicines and Research Scholars of the Institute
State level Workshop on "R& D collaboration and dissemination of information packages	GBPIHED, Himachal Unit, Mohal-Kullu (September 29, 2006)	State Government Organizations, stakeholders of the Himachal Pradesh"
Exposure Visits for environmental awareness and resource conservation and sustainable utilization	GBPIHED, Himachal Unit, Kullu (March 26, September 26, October 11, 13, 17, November 11, December 27, 2006)	Students and Teachers
Interactive Meeting, 'Identifying R&D Priorities and Developing Collaborative Approaches amongst Allied Departments in Sikkim-Biodiversity and environmental conservation and forest management'	GBPIHED, Sikkim Unit, Pangthang (In collaboration with FEWMD, Govt. of Sikkim (March 7, 2006)	Different Govt. organizations of Sikkim
Awareness Camp on Biodiversity Act 2002	GBPIHED, Himachal Unit, Mohal-Kullu (March 26, 2007)	Govt. officials, Panchyat Members, Members of Zila Parishad, Block Smiti, Mahila Mandals and NGOs

Contd.....

Forum/events	Venue/Date	Target groups
Exposure on Biodiversity and other technologies	GBPIHED, Sikkim Unit, Pangthang (August 3, 8, 2006)	Students and Teacher
Exposure visit of 'Farmers and villagers for Technology and Nurseries' and inauguration of 'Experimental Medicinal Plants Nursery'	GBPIHED, Sikkim Unit, Pangthang (September 10, 2006)	Rural people
Training to farmers, 'Capacity Building for Adoption of Technology' (including medicinal plants cultivation and nursery technology)	GBPIHED, Sikkim Unit, Pangthang (January 16-17 & September 26-27, 2006)	Farmer's Clubs, NGOs and NCUI
Training Programme on Nursery Development, Plantation Techniques and Natural Resource Conservation and Management	Chulapain Village Champawat (March 20-22, 2007)	NGOs, Line Agencies, Farmer and Local People
World Environment Day	GBPIHED, Kosi-Almora (June 5, 2006)	Students
Raj Bhasha Karyashala	GBPIHED, Kosi-Almora (June 30, 2006)	Institute staff
Trainning course on Bamboo Craft Development	Loharkhet Village Bageshwar, Uttarakhand (August 5-20, 2006)	Bamboo and Ringal Entrepreneurs of Uttarakhand
"Training-cum-Workshop on Disaster Management" (in collaboration with Land Revenue and Disaster Management Department, Government of Sikkim	GBPIHED Sikkim Unit, Pangthang (Sikkim) (December 14, 2006)	State nodal officers for disaster management and other officials related to the subject
Interactive workshop on 'Shifting Agriculture: Issues and Options'	GBPIHED, NE Unit Itanagar (September 10, 2006)	Identified participants representing the State and Central Government Institutions, University faculty and others
Brainstorming on Increasing Outreach meeting	GBPIHED, Kosi-Almora (September 10, 2006)	Representatives of Govt. line departments, R&D Institutions, academicians, NGOs, decision makers and the key farmers
A State-Level Workshop on "R&D Collaborations and Dissemination of Information Packages to Different Stakeholders of Himachal Pradesh"	GBPIHED, Himachal Unit, Kullu (August 11, 2006)	Himachal Pradesh State Council for Science, Technology and Environment, participants from State and Central Government Departments and NABARD

MISCELLANEOUS ITEMS

1. SCIENTIFIC PUBLICATIONS

(I) Scientific Journals

Agnihotri, R. K., L. M. S. Palni & D. K. Pandey, 2006. Effect of salinity stress on seed germination and seedling growth in thirty landraces of rice from Kumaun Himalaya. *Ind. J. Plant Physiol.* 11 (3): 266-272.

Agnihotri, R. K., L.M.S. Palni & D.K. Pandey, 2007. Screening of various landraces of rice (*Oryza sativa* L) for osmotic stress on seed germination and seedling growth from Kumaun Himalaya. *J. Plant Biol.* 34 (1): 1-7.

Bisht, I.S., K.S. Rao, D.C. Bhandari, S. Nautiyal, **R.K. Maikhuri** & B.S. Dillon, 2006. A suitable site for *in-situ* (on-farm) management of plant diversity in traditional agrocosystems of western Himalaya in Uttaranchal state: a case study. *Gen .Res. Crop Evol.* 53: 1333-1350.

Bisht, A.K., A. Bhatt, **R.S. Rawal & U. Dhar,** 2006. Assessment of extraction pattern and restoration through propagation of *Angelica glauca*, a critically endangered Himalayan herb. *Inter. J. Biod. Sci. Manag.* 2:105-114.

Butola, J.S. & H.K. Badola, 2006. Assessing seedling emergence, growth and vigour in *Angelica glauca* Edgew. and *Heracleum candicans* Wall. under different growing media and environments. *J. Non-Timber For. Prod.* 13: 141-153.

Butola, J.S. & H.K. Badola, 2006. Chemical treatments to improve seedling emergence, vigour and survival in *Heracleum candicans* Wall. (Apiaceae): a high value threatened medicinal and edible herb of Himalaya. *J. Plant Biol.* 33(3): 215-220.

Butola, J.S. & H.K. Badola, 2006. Effects of growing medium on vegetative propagation of the Himalayan endangered medicinal plants, *Angelica glauca* and *Heracleum candicans*, using rhizome segments. *J. Hill Res.* 19 (2): 65-70.

Butola, J.S. & S.S. Samant, 2006. Physiological studies on seed germination of *Angelica glauca* Edgew. *J. Trop. Med. Plants* 7 (2): 205-212.

Butola, J.S. & S.S. Samant, 2006. Seed viability of *Saussurea costus*. *J. Trop. Med. Plants* 7 (2): 197-203.

Chandrasekhar, K., K.S. Rao, **R.K. Maikhuri** & K.G. Saxena, 2006. Ecological implications of traditional livestock husbandry and associated land use practices: A case study from the Trans Himalaya, India. *J. Arid Env.* 69: 299-314.

Das C.P. & **A. Pandey,** 2007. Fermentation of traditional beverages prepared by Bhotiya community of Uttaranchal Himalaya. *Ind. J. Trad. Know.* 6(1): 136-140.

Dhakarey, R., G. Upadhyay, D. Prakash, S. Kumar & **K.K. Singh,** 2005. Phenolic contents and antioxidant potential of Rhododendron species. *Ind. J. Agric. Biochem. 18 (1) 40-43.*

Dhyani, D., R.K. Maikhuri, K.S. Rao, **L. Kumar, V.K. Purohit, Manju Sundriyal** & K.G. Saxena, 2007. Basic nutritional attributes of *Hippophae rhamnoides* (Sea buckthorn) populations from Uttarakhand Himalaya, India. *Curr. Sci.* 92(8): 1148-1152.

Joshi, V. & K. Kumar, 2006. Extreme rainfall events and associated natural hazards in Alaknanda valley, Indian Himalayan region. *Jour. Mount. Sci.* 3 (3): 228-236.

Joshi, S.C. 2006. Photosynthetic response of *Thysanolaena maxima* (Roxb.) Kuntze, a multipurpose and monotypic plant to different levels of CO_2. *Physiol. Mol. Biol. Plants* 12: 241-245.

Kala, C.P., **P.P. Dhyani,** & B.S. Sajwan, 2006. Developing the medicinal plants sector in northern India: Challenges and opportunities. *J. Ethno-biology & Ethno-medicine* 2 : 32.

Kuniyal, J.C., P.S.P. Rao, G.A. Momin, P.D. Safai, S. Tiwari & K. Ali, 2007. Trace gases behaviour in sensitive areas of the north-western Himalaya: A case study of Kullu-Manali tourist complex, India. *J. Radio & Space Physics* 36 (3): 197-203.

Meena Joshi, **R.S. Rawal & U. Dhar,** 2006. Breaking seed dormancy of *Selinum wallichianum* – a medicinal plant of Himalaya. *Seed Tech.* 28:87-92.

Meena Joshi, **U. Dhar** & S. Manjkhola, 2006. Somatic embryogenesis and plantlet regeneration from encapsulated embryos of *Selinum tenuifolium* Wall. *J. Hort. Sci. & Biotech.* 81(4): 570-574.

Negi, G.C.S. 2006. Leaf and bud demography and shoot growth in evergreen and deciduous trees of central Himalaya, India. *Trees: Structure & Function* 20: 416-429.

Pandey, A, P. Trivedi, B. Kumar & L.M.S. Palni, 2006. Characteristics of a phosphate solubilizing and antagonistic strain of *Pseudomonas putida* (BO) isolated from a sub-alpine location in the Indian central Himalaya. *Curr. Microbiol.* 53(2): 102-107.

Pant, S. & S.S. Samant, 2006. Diversity, distribution, uses and conservation status of plants species of the Mornaula reserve forest, west Himalaya, India. *Int. J. Biod. Sci. & Manage.* 2: 97-104

Prakash, D., G. Upadhyay, B.N. Singh, R Dhakarey, S. Kumar & **K.K. Singh,** 2007. Antioxidant and free radical scavenging activities of Himalayan Rhododendrons. *Curr. Sci.* 92 (4): 526-532.

Purohit, V.K., P.C Phondani, D. Dhyani, L.S. Rawat & R.K. Maikhuri, 2007. *Ginkgo biloba*, a living fossil: Need conservation initiatives. *Natl. Acad. Sci. Lett.* 30(1 & 2): 1-5.

Samal, P.K. & P.P. Dhyani, 2007. Indigenous soil fertility maintenance and pest control practices in traditional agriculture in the Indian central Himalaya: Empirical evidence and issues. *Outlook on Agric.* 36(1): 49-56.

Samant, S.S., J.S. Butola & A. Sharma, 2007. Assessment of diversity, distribution, conservation status and preparation of management plan for medicinal plants in the catchment area of Parbati Hydro-electric Project Stage-III in Northwestern Himalaya. *J. Mount. Sci.* 4 (1): 36-54.

Satyal G.S., K. Kumar & K.D. Kandpal, 2006. Traditional practices of water scheduling in farmer managed irrigation systems in Central Himalaya, India. *Outlook on Agric.* 35 (4): 273-280.

Sharma, S. & P.S. Roy. 2007. Forest fragmentation in the Himalaya: A Central Himalayan case study. *Int. J. Sust. Dev. & World Ecol.* 14(2): 201-210.

Sundriyal Manju, 2006. Contour hedgerow inter-cropping and fertility management in shifting agricultural (jhum) fields in the North east India. *Technology Intervention for Mountain Ecosystem.* September, 14-15.

Trivedi, P., B. Kumar & A. Pandey, 2006. Conservation of soil microbial diversity associated with two hot springs in Uttaranchal Himalaya. *Natn. Acad. Sci. Lett.* 29 (5&6) 185-187.

(II) Chapter in Books/Proceedings

Bisht, B.S., **B.P. Kothyari,** S.K. Bhuchar & **S.S. Bisht,** 2006. Resource dynamics and promising livelihood options: A case study of the Bhetagad-Garurganga watershed, Indian central Himalayas. In: *Resource Constraints and Management Options in Mountain Watersheds of the Himalayas.* Proceedings of Regional Workshop (eds., R. White & S. K. Bhuchar), ICIMOD, Nepal. 69-76.

Bujarbarua P., M. Dollo & P. Sen, 2007. Medicinal and aromatic plant resources of NE India: Issues and concerns. In: *Biodiversity Conservation and Legal Aspects.* (eds., A.K. Kandya & A. Gupta). Aavishkar Publishers and Distributors, Jaipur, India. 1-25.

Chaudhury, S., M. Dollo & R.C. Sundriyal, 2006. Livestock linked rural economy of West Kameng and Tawang districts, Arunachal Pradesh. In: *Shifting Agriculture & Sustainable Development of North-Eastern India* (eds., P.S, Ramakrishnan, K.G Sexena & K.S. Rao). UNESCO-MAB series, Oxford & IBH Publication, New Delhi, India. 343-356.

Dhar, U., R. S. Rawal, I. D. Bhatt, G. Mahar, S.K. Joshi, K. S. Gaira, M. Pandey & B. S. Rawat, 2006. Himalay ki Jaiv Vividhta - Sanrakshan Shiksha Protsahan Main Harit Core Ki Bhagidari. GBPIHED Publication.

Dhar, U. 2006. Global biodiversity and megadiversity countries. An analysis for common approach. In: *Perspectives of Biodiversity,* (eds., D. D. Verma, S. Arora & R.K. Rai), Ministry of Environment & Forests, Govt. of India. 1-20.

Dollo, M. & D. Choudhury, 2006. Eco-cultural heritage of Arunachal Pradesh. In: *Interpreting the Heritage of North-East* (ed., R. Tondon), INTACH, India. 12-59.

Dollo, M., S. Chaudhury & R.C. Sundriyal, 2006. Traditional farming and land tenure systems in West Kameng district, Arunachal Pradesh. In: *Shifting Agriculture and Sustainable Development of North-eastern India: Tradition in Transition* (eds., P.S. Ramakrishnan, K.G. Saxena & K.S. Rao), UNESCO and MAB Series. Oxford &IBH Publication, New Delhi. 317-342,

Farooquee, N.A., M. Dollo & C.P. Kala, 2006. Traditional wisdom of Apatani community in the management and sharing of natural resources in North Eastern India. In: *The Relevance of Traditional Knowledge Today: Challenges and Opportunities.* (ed., K.K. Mishra), Pratibha Publications, New Delhi.110-126.

Ghosh, P. 2007. Technologies for restoration of degraded ecosystem. In: *Environmental Degradation and Protection.* (eds., K.K. Singh, A. K. Singh, A. Tomar & V. Singh), M. D. Publications, New Delhi, 113 - 143.

Jugran, A. L. Giri & I.D. Bhatt, 2006. Jav Vividhta ke Sarankchan Main Anwik Bidhiyan Evam Unaka Mahatwa. *In: Himalay ki Jaiv Vividhta - Sanrakshan Shiksha Protsahan Main Harit Core Ki Bhagidari* (eds., U. Dhar et. al.). GBPIHED, Publication. 18-25.

Kuniyal, J.C., A. Thakur, S. Tripathi, **H. Kumar, O. S. Sharma,** P. Pant, P. Hegde & U.C. Dumka, 2006. Aerosols characteristics at high altitude location of Kullu-Manali in the Northwestern Himalaya during ICARB. In: *First Post-Campaign Meeting of ICARB.* Space Physics Laboratory, ISRO, Thiruvanthapuram, 99-104.

Kuniyal C.P., G.S. Singh, **J.C. Kuniyal & S.C.R. Vishvakarma,** 2006. Utilization and conservation prospects of medicinal plant resources in high altitude of Himachal Pradesh. In: *Herbal Medicine Traditional Practices,* (ed., P.C. Trivedi), Aavishkar Publishers, Jaipur, 225-237.

Kuniyal J.C. 2006. Environmental impacts and remedial measures in expedition and trekking areas of the Biosphere Reserves: A case of the Pindari valley, central Himalaya, India. In: *Resources Appraisal, Technology Application and Environmental Challenge in Central Himalaya,* (ed., M.S.S. Rawat), Transmedia Publications, Srinagar-Garhwal, 144-162.

Mahar, G. 2006. Sudoor Sambedan Taknek dwara Jaib Vividhata ka Anklan. *In: Himalay ki Jaiv*

Vividhta - Sanrakshan Shiksha Protsahan Main Harit Core Ki Bhagidari (eds., U. Dhar et al.). GBPIHED Publication. 26-30.

Maikhuri, R.K. & K.S. Rao, 2006. Water resource management in the Central Himalaya: A case study. In: *Mountain Technology Agenda: Status, Gaps and Possibilities* (eds., A.P. Joshi, S. K. Agarwal & R. Kumar), Bishen Singh Mahendra Pal Singh Publ., Dehradun, 185-193.

Miral, M.S. & K. Kumar, 2006. Glacial lake outburst flood- a glacial hazard in the higher Himalayas. *Himalayan Geo-Hazards Science & Society,* (eds., K.K. Sharma, S.K. Bandooni & V.S. Negi), Research India Press, New Delhi, 229-234.

Palni, L.M.S., D.S. Rawat & M. Joshi, 2006. Rural resource centers: need for their establishment for enhancing livelihood opportunities and ecological health in the mountains. In: *Mountain Technology Agenda: Status, Gaps and Possibilities* (eds., A. P. Joshi, S.K. Agrawal & R. Kumar), Bishen Singh Mahendra Pal Singh Publ. Dehradun, 277- 284.

Pant M. C., K. Kumar, D. Pant & G. S. Satyal, 2007. *Neural networks sequence for surface interpolation using GPS data. In: Proceedings of* ICISTM, Gaziabad, India. 327-331.

Rao, K.S., S. Nautiyal, **V. K. Purohit, D. Dhyani, L.S. Rawat** & K.G. Saxena, 2006. Priority interventions for sustainable development of buffer zone villages of Nanda Devi Biosphere Reserve. In: *Resource Appraisal, Technology Application and Environmental Challenges in Central Himalaya (ed.,* M.S.S. Rawat), HNB Garhwal University, Srinagar Garhwal, 84-95.

Rawat, D.S., K. L. Tripathi & D.S. Bisht, 2006. Vegetable cultivation and sustainability under rainfed farming system: A case study from Indian Central Himalaya. In: *Resource Appraisal, Technology Application and Environmental Challenges in Central Himalaya* (eds., M.S.S. Rawat et. al.), HNB Garhwal University, Srinagar Garhwal, 16-22.

Saha, D., K. I. Singh & R.C. Sundriyal, 2006. Non-timber forest products linked rural livelihood in West Kameng district, Arunachal Pradesh. In: *Shifting Agriculture and Sustainable Development of North-eastern India: Tradition in Transition* (eds., P.S. Ramakrishnan, K.G. Saxena & K.S. Rao), UNESCO and MAB Series. Oxford & IBH Publication, New Delhi. 357-370.

Saxena, K.G., **R.K. Maikhuri** & K.S. Rao, 2006. Changes in agricultural biodiversity: implications for sustainable livelihoods in the Himalaya. In: *Small-Scale Livelihoods and Natural Resource Management in Marginal Areas of Monsoon Asia.* (eds., K.G. Saxena, L. Liang, Y. Kono & S. Miyata), Bishen Singh Mahendra Pal Singh Publ., Dehradun, 21 – 35.

Shimrah, T., K. Singh, **R.K. Maikhuri,** K.S. Rao & K.G. Saxena, 2006. Shifting agriculture in Central and Eastern Himalayas: A landscape ecology perspective. In: *Shifting Agriculture and Sustainable Development of North-Eastern India: Tradition in Transition.* (eds., P.S. Ramakrishnan, K.G. Saxena & K.S. Rao), Oxford & IBH Publ., New Delhi, 373-397.

Singh, K.I. & R.C. Sundriyal, 2006. Involving local communities in forest management in West Kameng district, Arunchal Pradesh. In: *Shifting Agriculture and Sustainable Development of North-eastern India: Tradition in Transition* (eds., P.S. Ramakrishnan, K.G. Saxena & K.S. Rao), UNESCO and MAB Series. Oxford &IBH Publication, New Delhi. 343-356.

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

Agrawal, D.K. 2006. Bio-engineering Measures for Hill Slope Stabilization- Concepts, Practices, Application and Performance Evaluation. GBPIHED Publication.

Bisht, Deepa, 2006. Samanwit Matsya Palan: Parvatiya Shhetron Hetu Rojgar Parak Vaywasay. (Training Manual in Hindi, 2006), GBPIHED Publication.

Dhar, U., R.S. Rawal & K. S. Gaira, 2006. U-PROBE (Participation of youth in real time/ field observations to benefit the education in state of Uttaranchal) GBPIHED Newsletter 2: 16.

Joshi, V., A.K. Sharma, A.K. Singh, H.K. Badola & K.K. Singh. 2006. Action Plan for Disaster Mitigation, Prevention and Preparedness-Building a Safer and Prosperous Sikkim. GBPIHED Publication. 44 p.

Maikhuri, R.K. 2006. Developing Eco-tourism in Nanda Devi Biosphere Reserve (World Heritage Site): Strategies and Action Plan (Brochure in English), GBPIHED Publication.

Nandy, S.N., P.P. Dhyani & P.K. Samal, 2006. Information Database of the Indian Himalaya. ENVIS Monograph No. 3, GBPIHED, Kosi-Katarmal, Almora, Uttaranchal, pp. 1-95.

Pandey, A., P. Trivedi, S. Singh & B. Kumar, 2007. Microbial Inoculants for Improving Plant Performance in Mountains. p. 14.

2. POPULAR ARTICLES

Agnihotri, R. K., N. Bag, **S. K Nandi**, & A. Kumar, 2006. Bamboo: Need for mass propagation and plantation in Uttaranchal. *Hima Paryavaran* 18(2): 13-15.

Agnihotri, R. K. 2006. Himalayi krishi prabandhan mein dhan ki paramparik prajatiyon ka yogdan. *ENVIS Bulletin* 14 (1): 81-83.

Agnihotri, R. K. & S. K. Nandi, 2006. Multiple node cuttings: an alternate method for clonal propagation of "maggar" bamboo. *ENVIS Newsletter* 3: 2-3.

Badola, H.K., K.K. Singh, G. Lepcha, **S. Kumar & B. Pradhan,** 2006. Rare and threatened plant conservation park in Gangtok-Sikkim. *Hima-Paryavaran* 18(2): 15-16.

Butola, J.S., S. Pant, & S.S. Samant, 2007. Diversity, distribution and indigenous uses of the *Hypericum* species in Indian Himalayan Region. *Ethnobotanical Leaflets* 1-9.

Dollo, M, 2006. National environmental protection laws and tribal societies. *The Arunachal Times* 17(150): 2.

Dollo, M. 2007. Traditional farmers groups supporting sustainable farming. *LEISA Magazine.* 23(1): 22-24.

Dollo, M., P.K. Samal, & K. Kumar, 2006. Traditional ecological knowledge in sustainable agricultural practices of the Apatanis in Arunachal Pradesh, *Hima-Paryavaran* 18(2):18-20.

Ghosh, P. 2006. Flame vines: potential plant for landscaping and apiculture in the hills. *Hima-Paryavaran* 18 (1): 15 –16.

Ghosh, P., A. Anthwal, & K. Kumar. 2006. Rehabilitation of degraded land through bio-energy block plantation for upliftment of rural economy in Dobh-Srikot watershed. *Hima-Paryavaran* 18(2):17–18.

Joshi S., Dumka R. & **K. Kumar,** 2006. Quaternary plant fossil from precambrian rocks of the lesser Himalaya. *Hima-Paryavaran* 18 (1): 10-11.

Joshi S., Dumka R. & **K. Kumar**, 2006. Erosion problem in lesser Himalaya: A case study in Chlathi, Kumaun Himalaya. *ENVIS Bulletin* 3: 4-5.

Joshi, S. & M. C. Pant, 2007. Information technology – A tool for forecasting, simulation and knowledge dissemination. *MoRe Expressions*, GBPIHED Researchers Newsletter 1:9-10.

Kimothi, M.M. & **V. Joshi,** 2006. High resolution IRS data for disaster monitoring and its management in Himalayan mountains. *ISG Newsletter* 12 (3-4): 71-78.

Maikhuri, R.K. & V.S. Negi, 2007. Paryavaran Sanrakshan Evam Satat Vikas Hetu Sahabhagita Evam Jan Sahayog. *Aparajita* 1: 33-35.

Maikhuri, R.K., V.S. Negi & L.S. Rawat, 2007. Global Warming Par Vishesh Rapat. *Aparajita* 3: 16-17.

Maikhuri, R.K., V.S. Negi & L.S. Rawat, 2007. Nanda Devi Biosphere Reserve Mein Ecotourism Ko Protsahan Hetu Rananiti Evam Niyojan. *Aparajita* 2: 22-25.

Miral, M.S. & K. Kumar, 2006. Jalyau Parivertan Ke Sanket: Uttarkhand Ke Simete Himalayee Glacier. *Him Uttarayni*, New Delhi. 31-33.

Nandi, S.K., S.C.R. Vishvakarma & U. Dhar, 2006. Intellectual property rights: Himalayan context. *Curr. Sci. 91(4):413.*

Nautiyal, S., A. Nautiyal, K.S. Rao & **R.K. Maikhuri,** 2006. Madhy Himalay Ke Paramparik Krishi Tantra Mein Adhunic Fasalon Ka Krishikaran: Ek Vaigyanik Adhyyan. *ENVIS Bulletin: Himalayan Ecology* 14(2): 85-87.

Negi, G.C.S. & D.K. Agrawal, 2006. Measuring and valuing ecosystem services: Himalayan mountain context. *Curr. Sci.* 91 (5): 573-575.

Pandey, A., P. Trivedi, B. Kumar, B. Chaurasia & **LMS Palni**, 2006. Soil Microbial diversity from the Himalaya: Need for documentation and conservation. *NBA Scientific Bulletin No. 5,* National Biodiversity Authority, Chennai, Tamil Nadu, India. 64.

Pant, S., J.S. Butola & A. Singh, 2007. Traditional food and beverages of Kullu valley, Himachal Pradesh. *MoRe Expressions*, GBPIHED Researchers Newsletter 1: 14-15.

Pant, M. & K. Kumar, 2006. Landslides: Introduction and meteorological effects. *U-PROBE Newsletter,* GBPIHED, Kosi-Katarmal Almora. 2 p.

Pande, G., **G.C.S. Negi**, P.D. Pant & C.S. Chauhan, 2006. Rock art in Uttaranchal: Some socio-cultural, geological and ecological aspects. *Hima-Paryavaran* 18 (2): 10-13.

Sen, P. 2007. Indian Noni (*Morinda citifolia* L.): The wonder plant. *Echo of Arunachal* 88: 8.

Purohit, V.K., Prakash C. Phondani & R.K. Maikhuri, 2006. Propagation of *Ginkgo biloba* Linn: Living fossil tree. *Hima Paryavaran* 18 (1): 13.

Rawat, Y.S., S.S. Oinam, S.S. & S.C.R. Vishvakarma, 2006. Willow (*Salix fragilis* L.): a multipurpose tree species under cold desert agroforestry system, northwestern Himalaya, India. *Him-Paryavaran* 17 (2): 10-12.

Singh, K.K., A.P Krishna, **L.K. Rai & Y.K Rai,** 2006. Farm based appropriate technologies for capacity building of mountain farmers and rural women: Case study from Sikkim Himalaya. *Mount. Tech. Agenda- Status, Gaps and Possibilities.* Science and Society Division, DST, Government of India. 100-115.

Sinha, S.K. & Samant, S.S., 2006. Climate change in the higher Himalaya-A case study in Lahaul valley. *ENVIS Newsletter* 3: 3-4.

Singh, V.K. 2006. Santulit Paryavaran Ke Liye Jaiwik Kheti (Hindi). *Hima-Paryavaran* 18 (1) : 16-18.

Sundriyal, Manju, 2007. Training on bamboo and ringal for women entrepreneurs of Uttaranchal. *MoRe Exressions- Newsletter*, Vol. 1: 7.

Participation of Institute Faculty / Project Staff in Different Events

Events	Units					Total
	HQ	NE	Sikkim	Garhwal	HP	
National						
• Symposia/Conference/ Workshops	34	21	14	14	21	**104**
• Training courses	11	01	06	03	09	**30**
• Meeting	35	02	17	03	28	**63**
• Participation as resource person	17	02	17	03	28	**67**
International	09	00	01	03	02	**15**

Singh K.V. Gupta & Co.
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Tel: 05962-233170, 233270

To
Members,
Govind Ballabh Pant Himalaya
Paryavaran Evam Vikas Sansthan
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)** as at 31st March 2007, the Income & Expenditure Account and the Receipt & Payment Account for the year ended on that date annexed thereto. These financial statements are responsibility of the Institute's management. Our responsibility is to express an opinion on these financial statements based on our audit.

We conducted our audit in accordance with auditing standards generally accepted in India. Those standards require that we plan and perform the audit to obtain reasonable assurance about whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation. We believe that our audit provides a reasonable basis for our opinion.

We report that:

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

II. In our opinion proper books of accounts as required by law have been kept by the Institute so far as appears from our examination of these books maintained at Head Office at Katarmal, Almora. Expenses at units have been verified from the vouchers received from Units time to time.

III. The Balance Sheet, Income & Expenditure Account and Receipt & Payment Account dealt with by this report are in agreement with the books of accounts except difference of Rs.190125.10.

IV. In our opinion and to the best of our information and according to explanations given to us, the said accounts read together with the notes and Significant Accounting Policies thereon give the information in the manner so required and give a true and fair view in conformity with the accounting principals generally accepted in India subject to that

1) Institute has not deducted tax on various payments covered under the provision of TDS.

2) Non provisions of sales tax liability for wrong issue of "D" form against purchases.

Contd.....

3) Non provisions of liability towards income tax of Rs. 48,43,744.00 for A.Y 2004-05. The Institute has filed appeal against above demand which are pending with the Appellate Authorities.

4) Non adjustment of outstanding entries in bank reconciliation statement since long time.

5) Non provision of liability for not getting registration with Provident Fund Department & not following the rules laid down under EPF Act.

6) Subscription paid in earlier years up to 31.03.2006 under the ENVIS Centre require capitalization.

7) Institute is not having any Internal Audit System at present which in our opinion it should have keeping in view its size and nature of activities.

8) Institutional Charges (Income) are shown after reducing expenses towards salary of temporary staff and other miscellaneous expenses.

9) There is a difference in books of Rs. 190125.10 lying under current assets. Efforts should be made to locate the difference in next year.

10)

S.No.	PARTICULARS	AMOUNT (IN RS.)	NATURE
1.	Salary & Wages under Various Projects	159254.00	Expenses
2.	Advertisement Expenses	24691.00	Expenses

11) Non - Provision of liability under Service Tax Act (Finance Act 1994) for late deposit & short deposit of tax & late filling of return.

12) Non- provision for write off of advances/ deposits outstanding since long in which recovery is doubtful.

13) Grant released under IERP project are treated as utilized on payment of grant irrespective of actual expenditure incurred by grantee organization during the year. Refund of unutilized grant if any, is credited under the said project on actual receipt basis.

i) In the case of balance sheet, of the state of affairs of the Institute as at 31st March, 2007.

ii) In case of Income & Expenditure Accounts of the excess of income over expenditure of the Institute for the year ended on that date.

iii) In the case of the Receipt & Payment Account, of the receipts & payments of the Institute on that date.

For SINGH K.V. GUPTA & CO.
CHARTERED ACCOUNTANTS

Sd/-

CA. RAKESH K. AGARWAL
(PARTNER)
M. NO. 85908

SEAL

DATED: 08-08-2007
PLACE: ALMORA

Singh K.V. Gupta & Co.
Chartered Accountants
07/38, Ansari Raod, Darya Ganj
New Delhi-110 002
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G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT
KATARMAL, KOSI (ALMORA) Uttarakhand

BALANCE SHEET AS ON 31ST MARCH 2007

PARTICULARS	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
CORPUS / CAPITAL FUND	1	27843878.66	24676825.59
RESERVE AND SURPLUS	2	363628399.51	354442521.97
EARMARKED / ENDOWMENT FUNDS	3	8256780.48	7659009.38
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	32701255.86	34007932.25
TOTAL		**432430314.51**	**420786289.19**
ASSETS			
FIXED ASSETS	8	361616089.53	355678760.97
INVEST. FROM EARMARKED/ENDOWMENT FUND	9	8256780.48	7659009.38
INVEST. OTHERS	10	0	0.00
CURRENT ASSETS , LOANS, ADVANCES ETC.	11	62557444.50	57448518.84
MISCELLANEOUS EXPENDITURE			
TOTAL		**432430314.51**	**420786289.19**
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES & NOTES ON ACCOUNTS	25		

AUDITOR'S REPORT
As per our separate report of even date annexed.
FOR: SINGH K V GUPTA & CO.
CHARTERED ACCOUNTANTS

Sd/-
(CA. Rakesh K. Aggarwal)
PARTNER
M No. 085908

DATED : 08-08-2007
PLACE : ALMORA

Sd/-
(DR.UPPEANDRA DHAR)
DIRECTOR

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

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

SEAL

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G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT

KATARMAL, KOSI (ALMORA) Uttarakhand

INCOME & EXPENDITURE A/C FOR THE YEAR ENDED 31ST MARCH 2007

PARTICULARS	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
INCOME			
Income from Sales/Services	12	71860.00	124985.00
Grants/Subsidies(net off exp)	13	72179450.19	84862681.46
Fees/Subscriptions	14	0.00	0.00
Income tfr from Fixed Assets fund		14531151.46	14934239.14
(to the extent of depreciation & WDV of asset sold)		0.00	
Income from Royalty,Income from Ins. Publication etc.	16	0.00	1000.00
Interest Earned	17	1771720.07	5790882.38
Other Income	18	1323473.00	3112704.23
Increase (decrease) in stock of Finished goods and work in progress)	19	0.00	0.00
TOTAL (A)		**89877654.72**	**108826492.21**
EXPENDITURE			
Establishment Expenses: a) Institute	20	19400235.00	28192724.00
b) Projects		8348665.00	7447602.00
c) F.C (Projects)		703409.00	2035787.00
Administrative Expenses : a) Institute	21	27560306.23	26899069.38
b) Projects (As per Annexure)		8335892.00	11317954.08
c) F.C (Projects)(As per Annexure)		466722.00	1844486.00
Expenditure on Grants, Subsidies etc.	22	7364220.96	7125059.00
Interest		0.00	0.00
Depreciation (Net Total at the year-end-as per Sch. 8)		14531151.46	14906118.96
TOTAL (B)		**86710601.65**	**99768800.42**
Balance being excess of Income over Expenditure (A - B)		3167053.07	9057691.79
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		**3167053.07**	**9057691.79**
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	25		

AUDITOR'S REPORT
As per our separate report of even date annexed.
FOR: SINGH K V GUPTA & CO.
CHARTERED ACCOUNTANTS

Sd/-
(CA. Rakesh K. Aggarwal)
PARTNER
M No. 085908

DATED : 08-08-2007
PLACE : ALMORA

SEAL

Sd/-
(DR.UPPEANDRA DHAR)
DIRECTOR

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

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

G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT

KATARMAL, KOSI (ALMORA) Uttarakhand

RECEIPTS & PAYMENTS A/C FOR THE YEAR ENDED 31ST MARCH 2007

Singh K.V. Gupta & Co.
Chartered Accountants
07/38, Ansari Raod, Darya Ganj, New Delhi-110 002
Tel: 011-23275713, 23260728
Branch Office: Mall Road, Almora-263 601
Tel: 05962-233170, 233270

RECEIPTS	CURRENT YEAR	PREVIOUS YEAR	PAYMENTS	CURRENT YEAR	PREVIOUS YEAR
I. Opening Balances			**I. EXPENSES**		
a) Cash in hand	45195.55	11984.05	**a. Establishment Expenses**	17783119.00	16262300.00
b) Bank Balances			**b. Administrative expenses**		
i) In current accounts	24520525.90	5749910.88	i) Institute	17282622.76	17360885.50
ii) In deposit accounts	15668574.00	0.00	ii) R&D(Rev) expenses	10277683.47	10170885.70
iii) Savings accounts	4516591.56	1342917.78	iii) Payments for current liabilities		20365266.09
c) Advances & Others	12037236.14	19382146.15	**c. Capital expenditure**		
(As per annexure Attached)			a) Purchase of Fixed Assets	11540788.00	17876118.00
F.C. ACCOUNT			b) Expenditure on Capital Work in Progress	7487690.00	9500000.00
a) Cash in hand	5818.33	125.00	**II. Payments made against funds for various proj.**		0.00
b) Cash in bank	654577.36	1394790.40	**Expenditure State govt. projects**		
c) FC Advances		525488.00	a) Capital	1437202.00	3165107.00
II. Grants Received			b) Revenue:		
a) From Government of India			Establishment exp	8348665.00	7447602.00
i) Institute	58000000.00	71900000.00	Administration exp	8335892.00	11315502.00
ii) IERP Projects	7500000.00	11300000.00	**Expenditure FC projects**		
b) From State Government	16977661.00	28801857.00	a) Capital	2800.00	564005.00
c) From other sources [from FC]	1116146.00	3680324.29	b) Revenue:		
III. Income on Investments from			Establishment exp	703409.00	1848787.00
a) Earmarked/ Endow.Funds	597771.10	427756.48	Administration exp	466722.00	1844486.00
b) Loans, Advances etc.		0.00	**IERP grant released**	7635305.00	7250779.00
IV. Interest Received			**III. Investments and deposits made**		
a) On Bank deposits savings a/c	152156.07	254538.71	a) Out of Earmarked/ Endowment funds	597771.10	0.00
b) On term deposits a/c	1324392.00	3901493.67	b) Out of own funds (Investments Others)		0.00
c) Loans, Advances etc.	295172.00	110959.00	c) General Fund		2602921.00
V. Other Income			**IV. Refund of Suplus money/Loans**		
(As per annexure Attached)	1395333.00	3261404.15	a) To the Government of India		317709.00
VI. Amount Borrowed		0.00	b) To Others/ security / caution money)		0.00
VII. Any other receipts.			**V. Other payments**		
b) Advance FC a/c		0.00	Current liabilities	19274836.08	68848.00
c) Receipts current liabilities	19153715.86	21877056.81	**VI. Closing balances**		
d) IERP grants refunded by grantee Org.	271084.04	125720.00	**a) Cash in hand**	12238.90	30354.72
e) Construction Fund	9500000.00	0.00	**b) Bank Balance**		
			i) In Current accounts	3263658.93	24520525.90
			ii) In deposit accounts	15894994.00	
			iii) In savings accounts	26408166.87	2618233.93
			c) Advances and others FC Project	16263220.11	18257760.84
			i) Cash in hand	13364.33	5818.33
			ii) Bank Balance	701801.36	654577.36
TOTAL	**173731949.91**	**174048472.37**	**TOTAL**	**173731949.91**	**174048472.37**

As per our separate report of even date annexed.
FOR: SINGH K V GUPTA & CO.
CHARTERED ACCOUNTANTS
Sd/-
(CA. Rakesh K. Aggarwal)
PARTNER
M No. 085908
DATED : 08-08-2007
PLACE : ALMORA

SEAL

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KATARMAL, KOSI (ALMORA) Uttarakhand

ANNEXURE FORMING PART OF BALANCE SHEET AS ON 31 MARCH 2007

ANNEXURE"B"

OTHER LIABILITIES

PARTICULARS	CURRENT YEAR
Electricity payable	113169.00
Salary Payable	1075070.24
GSLI Payable	5851.90
Security deposit	12519.00
EMD	1599641.17
EMD DST GCSN	1800.00
EMD LDA	20850.00
EMD MAP DASD	31500.00
Service tax payable	0.00
Expenses payable (POL)	0.00
Expenses payable (Contingency LDA)	0.00
Income tax payable	58800.00
Caution Money	33825.00
Dr.K.S. Rao F.C.(a/c)	1990.00
Security (F.C. a/c)	450.00
Caution Money (F.C.)	1750.00
Security Services payable	107541.00
Audit Fee payable	30337.00
Institutional charges payable	21050.00
Gratuity Payable(Dr H C Rekhari)	43598.00
EMD (Biotech-XIII) Project	28873.00
Telephone	39879.00
Dr Mukesh Joshi (Biotech-XII)	0.00
Salary payable(FC a/c)	0.00
Dr. G.S. Satyal (DST-KK-II GPS)	316.00
Sh. R.K. Dumka (DST-KK-II GPS)	173.00
HESCO Dehradun	11.00
Wages payable(LDA)	17584.00
Field Rent (LDA)	4000.00
SSLIC Payable	31497.00
C.P.F. Payable	246096.00
NTL Bank Loan	2400.00
Revenue Stamp	47.00
Wages payable(Instt.)	47268.00
POL Payable(FC)	1707.00
	3579593.31

SEAL

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

ANNEXURE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2007

ANNEXURE"C"

CURRENT ASSETS
FDR'S & L/C MARGIN MONEY

PARTICULARS	CURRENT YR.
General Fund FDR'S	13602921.00
Interest accrued on General fund	1553398.00
Institute	729517.00
Interest accrued om LC Margin money	8581.00
Biotech XI Project	577.00
	15894994.00

ANNEXURE"D"

CURRENT ASSETS
BANK BALANCES (SAVINGS A/C)

PARTICULARS	CURRENT YR.
S.B.I Almora A/C No. 01170003258	24291646.11
S.B.I Tandong A/c No. 01000050044	287607.59
S.B.I Kullu A/c No. 01100076038	533217.82
S.B.I Itanagar A/c 01100050337	215064.82
S.B.I Srinagar A/c No. 01100030433	1080630.53
S.B.I Almora A/c No.01170003257 (F.C)	701801.36
	27109968.23

ANNEXURE"E1"

DUE FROM STAFF

PARTICULARS	CURRENT YR.
Dr. Subrat Sharma (TTA)	0.00
Rec GU Staff	0.00
Rec NE Staff	21404.73
Recov Sikkim Unit Staff	(9993.82)
Dr. Varun Joshi (TTA)	65000.00
Sh. B.S. Mehra	10000.00
Sh. Somai Kant Joshi	70000.00
Ms. Sneh Joshi	700.00
	157110.91

SEAL

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

ANNEXURE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2007

ANNEXURE"E2"

DUE FROM OTHERS

PARTICULARS	CURRENT YR.
NRSA Hyderabad (ISRO GBP)	350000.00
M/s OTT Messchute	0.00
NICSI New Delhi	35106.00
CAPART North East	0.00
Security Deposit CET Sikkim	11000.00
M/sEmployment News	48287.00
Post Master GPO Almora	20601.00
Sigma Aldrich Chemicals	10590.00
NRSA Hyderabad (ISRO GBP)	29300.00
R K Nanada & Sons	28517.00
Siltap Chemicals Ltd.Biotech-III	408.00
NRSA Hyderabad(DST KK i)	7400.00
M/s Bio-Rad Laboratories,Australia	0.00
NIC Delhi	67147.00
CCU NEW DELHI	70898.00
M/s Hind Motors, Dehradun	1921.00
EMD (DST YS) M. Nadeem	4200.00
Security Deposit NE Unit	1750.00
INSA New Delhi	10000.00
M/S Elementar Analysis Sys. Germany	194145.00
M/S Varian B.V. Netherland	165398.00
Adv. Against land lease to State Govt.(G Unit)	2899715.00
Post Master Sikkim Gangtok	2154.00
	3958537.00

SEAL

G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT

KATARMAL, KOSI (ALMORA) Uttarakhand

SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2007

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

S NO.	DESCRIPTION	GROSS BLOCK				DEPRECIATION				NET BLOCK	
		Cost as at beginning of the year	Additions during the year	adj/deduction during the year	Cost at the end of the year	depreciation for prior periods	depreciation for current year	adj/deduction for previous years	Total up to the end of the year	As at the current Year end	As at the previous year-end
	A. FIXED ASSETS:										
1	LAND:										
	a) Freehold	75639.23	0.00	0.00	75639.23	0.00	0.00	0.00	0.00	75639.23	75639.23
	b) Leasehold	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	BULDING:										
	On Freehold Land	214751988.00	0.00	0.00	214751988.00	12182429.81	3500457.40	0.00	15682887.21	199069100.79	202569558.19
3	PLANT MACHINERY & EQUIPMENT										
	Scientific Equipments	122344005.11	8148167.00	0.00	130492172.11	40292083.08	6198378.18	0.00	46490461.26	84001710.85	82051922.03
4	VEHICLES	5035961.25	0.00	0.00	5035961.25	4009777.99	232461.67	0.00	4242239.66	793721.59	1026183.26
5	FURNITURE FIXTURES	16458427.40	412649.00	0.00	16871076.40	7879318.36	1004327.60	0.00	8883645.96	7987430.44	8579109.04
6	OFFICE EQUIPMENT	7083336.35	110919.00	0.00	7194255.35	4721456.88	528457.47	0.00	5249914.35	1944341.00	2361879.47
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	28956.95	2895.70	0.00	31852.65	29109.36	32005.04
9	LIBRARY BOOKS	55052071.50	5545294.00	0.00	60597365.50	17603815.41	2878374.86	0.00	20482190.27	40115175.23	37448256.08
10	TURE WELLS & W. SUPPLY										
11	OTHER FIXED ASSETS										
	GLASS / NET HOUSE	3911549.00	0.00	0.00	3911549.00	1794005.37	185798.58	0.00	1979803.95	1931745.05	2117543.63
	TOTAL OF CURRENT YEAR	**424773939.84**	**14217029.00**	**0.00**	**438990968.84**	**88511843.85**	**14531151.45**	**0.00**	**103042995.30**	**335947973.54**	**336262095.97**
	PREVIOUS YEAR	**403189462.84**	**56022659.00**	**(15021517.00)**	**444190604.84**	**73872984.73**	**14906118.96**	**(267259.82)**	**88511843.87**	**355678760.97**	**329316478.11**
	B. CAPITAL WIP	18180426.00	6500000.00	0.00	24680426.00	0.00	0.00	0.00	0.00	24680426.00	18180426.00
	ASSET UNDER INSTAL/ TRANSIT	1236239.00	987690.00	(1236239.00)	987690.00	0.00	0.00	0.00	0.00	987690.00	1236239.00
	TOTAL	444190604.84	21704719.00	(1236239.00)	464659084.84	88511843.85	14531151.45	0.00	103042995.30	361616089.54	355678760.97

SEAL

INSTITUTE SUPPORTING STAFF

HEAD QUARTERS

K.K. Joshi	Administrative Officer
Neena Kapoor	Finance Officer (Upto Nov. 26, 2006)
K.K. Pande	Account Officer
Surya Kant	Office Superintendent (A)
S. Higgins	Estate Manager
M. Anand	Library Assistant
Sarita Bagadwal	Stenographer
Jagdish Kumar	Stenographer
L.M.S. Negi	U.D.C.
Mamta Higgins	U.D.C.
Heera Singh	U.D.C.
K.K. Pant	U.D.C.
Hema Pandey	L.D.C.
S.K. Gurani	L.D.C.
Suraj Lal	L.D.C.
Jagdish Singh Bisht	L.D.C.
R.C. Bhatt	Driver
Chandra Lal	Driver
K.N. Pathak	H.K/Att.
Pan Singh	Peon
G.D. Kandpal	Peon/Mali
Nathu Ram	Peon/Mali
Ganga Joshi	Peon
Kashi Ram,	Chaukidar/Mali

SIKKIM UNIT

R.K. Das	L.D.C.
Sabita Krishna	L.D.C.
Musafir Rai	Peon
Shyambir	Peon
Jagnnath Dhakal	Field Assistant
P.K. Tamang	Peon

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

INSTITUTE FACULTY

HEAD QUARTERS

U. Dhar	Director	Plant Taxonomy; Conservation Biology
L.M.S. Palni*	Scientist-E	Plant Physiology; Biochemistry; Biotechnology
P.P. Dhyani	Scientist-E	Plant Physiology; Restoration Ecology
Kireet Kumar	Scientist-E	Environmental Engineering; Hydrology
Anita Pandey	Scientist-D	Microbiology
B.P. Kothyari	Scientist-D	Plant Pathology; Restoration Ecology
D.K. Agrawal	Scientist-D	Soil & Water Conservation Eng; Impact Assessment
D.S. Rawat	Scientist-D	Settlement Geography; Rural Ecosystems
R.C. Sundriyal	Scientist-D	Plant Ecology; Rural Ecosystems
S.K. Nandi	Scientist-D	Plant Physiology; Biochemistry
S.C.R. Vishvakarma	Scientist-D	Plant Ecology; Rural Ecosystems
G.C.S. Negi	Scientist-C	Forest Ecology; Watershed Management, EIA
R.C. Prasad	Scientist-C	Information System
R.S. Rawal	Scientist-C	High Altitude Ecology; Conservation Biology
I.D. Bhatt	Scientist-B	Plant Physiology, Phytochemistry
Subrat Sharma	Scientist-B	Agroecology, Remote Sensing/GIS
Rakesh Kumar Singh	Scientist-B	Information Technology
B.S. Majila	Technician-B	Forest Ecology; Restoration Ecology
Ranjan Joshi	Technician-B	Natural Resource Management; Econometrics
R.G. Singh	Technician-B	Applied Arts; Photography, Social Science

HIMACHAL UNIT

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

SIKKIM UNIT

H.K. Badola	Scientist-C & Incharge	Morphoanatomy; Conservation Biology
K.K. Singh	Scientist-C	Plant Physiology; Stress Physiology
Varun Joshi	Scientist-B	Environmental Geology
L.K. Rai	Technician-B	Plant Taxonomy
Y.K. Rai	Technician-B	Rural Ecosystems

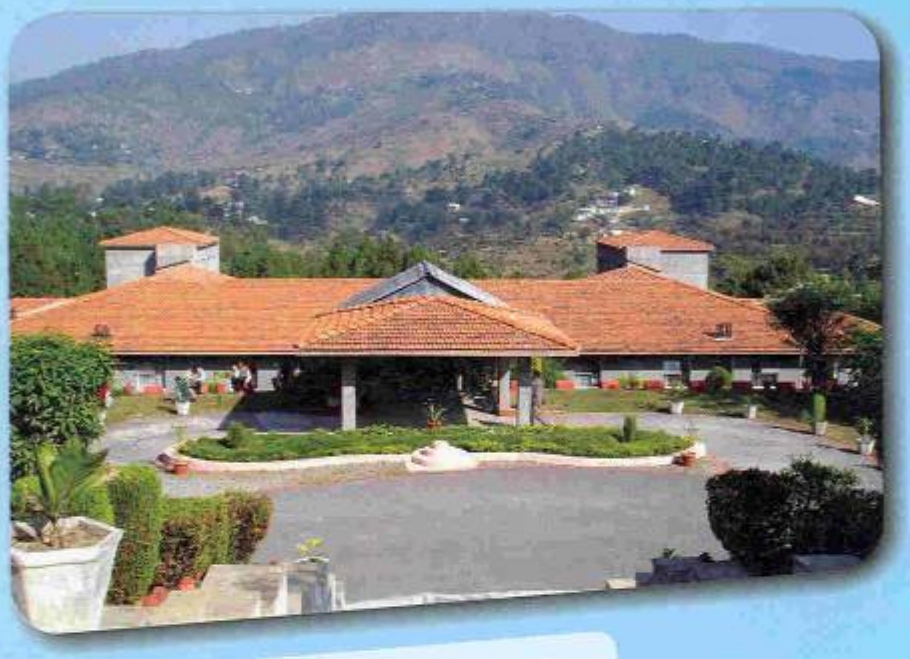
GARHWAL UNIT

R.K. Maikhuri	Scientist-D & Incharge	Plant Ecology; Rural Ecosystems
N.A. Farooquee	Scientist-C	Socila Science; Indigenous Knowledge Systems
Paromita Ghosh	Scientist-B	Plant/Soil Science

NORTH-EAST UNIT

P.K. Samal	Scientist-D & Incharge	Social Science; Anthropology
Gopi G.V.	Scientist-B	Wildlife Biology
S.C. Arya	Scientist-A	High Altitude Ecology

*(Arranged alphabetically within Positions; *Presently on Deputation)*



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