ANNUAL REPORT

2005-2006




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

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New Delhi

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Member Secretary

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Scientist E'/Scientist-in-Charge
IERP & INHI,
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Kosi-Katarmal, Almora-263 643,
Uttaranchal

Annual Report

2005 - 2006

G.B. Pant Institute of Himalayan Environment & Development
(An Autonomous Institute of Ministry of Environment & Forests, Govt. of India)
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CONTENTS

FOREWORD

The complexity of biophysical and socio-economic milieu of Indian Himalayan region (IHR) calls for in-depth understanding of interdisciplinary issues related to environment and development.

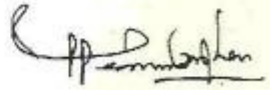
In order to address such issues, the R&D activities, during the reporting period, largely focused on strengthening and consolidation of datasets on water resources, land restoration, soil fertility maintenance, biodiversity and indigenous knowledge practices. Also, the Institute developed environmental management plans for selected hydropower projects, field demonstration trials on wasteland rehabilitation, water conservation and cultivation of medicinal plants. And the outreach was promoted through capacity building of a range of stakeholders on Training of Trainers (ToT) mode at the Rural Technology Complex of the Institute. Infrastructure in terms of instrumentation and other facilities were further strengthened to achieve the desired results.

Initiatives, such as, (i) implementation of village environment action plan (with National Cadet Corps); (ii) conservation education and biodiversity assessment campaign (with Eco-Clubs of Uttarakhand); (iii) conservation of Bhimtal lake catchment (with Lake Development Authority, Govt. of Uttarakhandl); and (iv) training on disaster management (with Govt. of Sikkim) were promoted to further increase the Institute's demonstration and outreach activities. New methodologies and approaches were refined through organization of seminars, symposia and workshops at Institute Headquarters and Units. In this direction, among others, the two brain storming sessions namely, "Ecosystem Services and Ecological Economics: Himalayan Mountain Context" and "Intellectual Property Rights: Himalayan Context", organized by the Institute were notable.

The Institute duly recognises the importance of application of research results in the field so that the societal needs are addressed. In this context the Institute, in consultation with stakeholders, reoriented the existing approach of conceptualizing and undertaking R&D activities. As a result of this exercise, the core priorities were identified to suit stakeholders' needs. Upscaling of R&D findings through various mechanisms was also felt inevitable during the course of introspection.

The R&D outcomes of the Institute is gradually finding place in the Government programmes and policies. The Institute will highly appreciate receiving periodic feedback from the user agencies and individuals engaged in adopting the best practices/technologies offered by us. We aim to serve the user groups better.

The Members of the Scientific Advisory Committee (SAC), the Governing Body (GB) and the G B Pant Society for Himalayan Environment & Development provided suggestions and directions for effective implementation of Institute programmes. Also, various experts and representatives of stakeholder groups provided inputs during reorientation of Institutes' R&D priorities. The Institute thanks them for continued co-operation and support.



(Uppeandra Dhar)

Director

Major Achievements

1. Rehabilitation of approximately 225 ha community wasteland through application of SWEET, sacred forest creation and silvi-pasture development. Integrated resource-use and conservation activities in Garurganga watershed, Kumaun Himalaya.
2. Strengthening of data-sets for developing area-specific Natural Resource Management (NRM) strategies through: (i) inventorization and development of biodiversity indices (6 states) and assessment of NTFPs (7 states) of NE region; (ii) investigation on dynamics of change in traditional farming systems and livelihood patterns of tribal communities in Arunachal Pradesh; (iii) promotion of medicinal and aromatic plant cultivation in the buffer zone areas of Nanda Devi Biosphere Reserve (Uttaranchal); and (iv) Kuhl irrigation studies in the Cold Desert areas of Himachal.
3. Expansion of research on: (i) glaciers, through establishment of two monitoring stations and data generation on glacial retreat using kinematic GPS survey in west Himalaya; (ii) assessment of biodiversity and resource utilization patterns in protected areas, including Cold Desert areas, of north-west Himalaya; (iii) nutrient-use optimization by improving soil biological processes in upland jhum farming systems in NE region; and (iv) *Lantana* mulching and reduced tillage in hill agriculture.
4. Execution of collaborative participatory action oriented programmes on: (i) conservation of Bhimtal lake catchment through wasteland plantation and cultivation of aromatic herbs (with lake development Authority, Nainital); (ii) implementation of Village Environment Action Plan (VEAP) through PARADE (with National Cadet Corps of India); and (iii) conservation education and biodiversity assessment campaigns (with Eco-clubs of Uttaranchal).
5. Improvement of seed germination and quantification of bioactive molecules (aconitine and pseudoaconitine) in tubers of medicinal herbs, such as *Aconitum heterophyllum* and *A. balfourii.*
6. Documentation of indigenous knowledge on – (i) post harvest practices and seed storage techniques of agricultural crops; (ii) weather indicators; and (iii) biodiversity and natural resource management in Arunachal Pradesh.
7. Environmental impact assessment studies of: (i) hydropower projects in central and west Himalaya; (ii) vehicular traffic on ambient levels of atmospheric gases in Himachal Pradesh; and (iii) socio-economic and environmental impacts of tea cultivation in Uttaranchal.
8. Improved outreach through: (i) capacity building trainings on cost effective and environment-friendly rural technologies across IHR (>3700 participants from different stakeholder groups); (ii) orientation course, training workshops and exposure visits on biodiversity conservation (Uttaranchal- 68 schools; 62 students, 68 teachers; NE region – 75 students, 37 teachers; Himachal Pradesh -102 beneficiaries); and (iii) trainings on disaster management (Sikkim Armed Police personnel – 190).

Publications:

Peer Reviewed Journals	National	-	22
	International	-	30
Book Chapters		-	26
Popular Articles		-	14

Fund Generation (externally funded projects): - 325 lakh (Rs)

EXECUTIVE SUMMARY

Research and Development Activities

The research and development programmes of the Institute are essentially multidisciplinary in nature. Through a holistic approach in R&D programmes, the Institute attempts to address the issues of sustainable development in the Indian Himalayan Region (IHR). The emphasis on interlinking of natural and social sciences is the major thrust of all the programmes. In this effort, special attention is placed on the intricate balance between fragility of mountains, indigenous knowledge and sustainable use and conservation of natural resources. A conscious effort is made to ensure the social acceptability and participation of stakeholder communities for the sustainability of various R&D programmes. A brief summary of R&D activities of the Institute during the reporting year 2005-2006 is as follows:

Land and Water Resource Management (LWRM)

- **Study of irrigation systems**
- **Studies on glaciers & watersheds**
- **Demonstration of wasteland restoration models**
- **GPS Geodesy for tectonic deformation**

The efforts of LWRM core during the current year were focused on research, demonstration and dissemination activities. Researches were focused on traditional land and water management systems (i.e., bench terrace systems of central Himalayan region, Jhum land in NE Himalaya and irrigated lands of cold desert in western Himalaya), water sustainability studies (water availability and use pattern), glaciology studies (retreat pattern, discharge and sediment yield) in Gangotri, Thelu, Dokriyani and Milam glaciers, Global Positioning System (GPS) geodesy with permanent and campaign mode surveys for quantification of tectonic deformation rate and landslide monitoring, etc. The work was initiated to strengthen the Institute's capabilities of GPS data generation through a network of permanent GPS stations. Under demonstration activities the Sloping Watershed Environmental Engineering Technology (SWEET) package for rehabilitation of community and private wasteland was executed and revised suitably. Based on the Village Environment Action Plan (VEAP) earlier developed by the Institute a joint project with NCC namely "*Operation PARADE*" was initiated in village Railakot (Distt. Almora, Uttaranchal), in collaboration with other core groups of Institute. Dissemination of Core findings through field trainings on soil and water conservation (SWC), nursery development, plantation under SWEET package, and publications was also carried out.

Sustainable Development of Rural Ecosystems (SDRE)

The SDRE Core activities documented resource dependency and use patterns for rural development planning in the Himalayan region. In addition, crop field soil fertility enhancing practices, such as the fallow management, pest

- Traditional practices of soil fertility management and pest control
- NRM studies for better efficiency
- Capacity building of rural people on income generation
- Location-specific appropriate models for improved livelihood options

control practice in the traditional societies of Manipur and NE region were studied. Strategies were devised for people-centered land use development in Arunachal Pradesh. Income generating activities such as cultivation of medicinal and aromatic plants (MAPs), value-addition in wild edibles and bamboo resources were also extended. Attempts were also made to understand the impact of global climate change on land use/cover. Lake catchment protection through execution of resource management models involving the catchment people and their capacity building was another focus. Strengthening the Rural Technology (RTC) and demonstration centers at Kosi-Almora, Garhwal and NE Units for training and extension of environment-friendly and cost-effective technologies among a range of user-groups continued to be one of the main activities. Through this activity 35 training programmes covering a total of 2914 people at HQs and 246 people in Garhwal were trained by SDRE core during the reporting period.

Conservation of Biological Diversity (CBD)

- Information consoli-dation on temperate plant endemics
- Biodiversity elements of protected & disturbed areas
- Enrichments of *ex situ* gene banks
- Participatory bio-diversity conservation through students, teachers & eco-clubs

This core group, while continuing with the umbrella activities, focused on: (i) consolidation of information on temperate plant endmics; (ii) biodiversity studies in protected areas (i.e., Cold Desert Biosphere Reserve and Manali, Kais and Khokhan Wildlife Sanctuaries); (iii) up-gradation of *ex situ* gene banks; and (iv) promotion of conservation education through participatory mechanisms. Analysis of temperate plant families of the region revealed richness of Himalayan endemics (> 57%) that increased with altitude. The database on Himalayan bioresources was further strengthened through: (i) updating information on plants from Trans, North West and West Himalaya; (ii) diversity assessment of pollinators, avifauna, and fishes; and (iii) biodiversity database for Himalayan Biosphere Reserves. Uninterrupted flow of information from protected and disturbed areas improved ecological understanding. The study completed for selected parameters of ecosystem functions at disturbed mid-altitude forest sites provided valuable datasets. The existing *ex situ* gene banks of the Institute [i.e. Arboretum (HQs & Sikkim Unit); herbal gardens (HQs, Sikkim & HP Unit)] were further strengthened through new introductions and area expansion. Up-gradation of genebank at HQs, as nature interpretation site, has been initiated. Experiments on seed germination (*Hypericum perforatum, Swertia angustifolia, S. chirayita*) and propagation protocols (*Hedychium spicatum; Malus sp.; Selinum tenuifolium*) complemented the initiatives of gene-bank establishment. Promotion of conservation education in school/college students and teachers through orientation courses and training workshops continued to be the most effective dissemination activity. Further, the participatory programmes, such as, biodiversity assessment campaigns for eco-clubs; development of school-campus conservation models; and involvement of youth in real time weather observations, improved the outreach of core group.

Ecological Economics and Environmental Impact Analysis (EE&EIA)

- Impact of urbanization and tourists influx on air quality
- EIA / EMP studies on hydropower projects in UA and HP
- Impact assessment of tea cultivation in UA
- Initiation of studies on ecosystem services and ecological economics

The core R&D activities during this year focused on two themes: 'Ecosystem Services and Ecological Economics' and 'Environmental Impact Analysis of Development Initiatives'. The major studies under these two broad umbrella themes were focused on impact of urbanization and tourism on air quality in selected destinations in HP, social and ecological considerations in EIA and formulation of environmental management plans for a few hydropower projects in UA and HP, impact assessment of tea cultivation in Uttaranchal hills and impact of soil amendments on soil fertility, soil and water conservation and crop yield, land use and land cover change on water yield of springs in western Himalaya. Valuable data set was generated on soil and water quality under different land use practices and cultivation trials. The study on the impact of vegetable cultivation was successfully completed and analyzed the factors those influence the spurt of this activity. Through externally funded projects wasteland restoration work aimed at soil and water conservation and enhancement in biomass production was also executed in different locations of Western Himalaya. To plan the systematic studies on ecosystem services and ecological economics a brainstorming session on "Ecosystem Services and Ecological Economics: Himalayan Mountain Context" was organized by the core and experts on the subjects were invited and useful points were drawn for further R&D work.

Environmental Physiology and Biotechnology (EPB)

- Development of microbial bio-inoculants for improved plant growth
- *In vitro* propagation & field demonstration of selected plant species
- Raising elite stock of bamboo and its plantation
- Training on hill- specific technologies

During the reporting period, R&D efforts of the core group continued to develop propagation protocols for selected economically important plants, some of these were adopted for large-scale multiplication and field demonstration. Understanding the impact of climatic factors and physiological and biochemical basis of plant's adaptation in relation to water stress deserved attention in order to screen suitable plants for field plantation programmes. Considering the need of improving plant growth and survival, focused studies on microorganisms were carried out. Several bacteria, isolated from various types of soil were developed as inoculants, which improved survival of *in vitro* raised plants and influenced plant growth. The microorganisms isolated from various sources are being maintained in laboratory for further investigations. Keeping in mind the importance of active ingredients of medicinal plants, such compounds were quantified for selection of elite stock plants, which are being maintained in a high altitude field station. The use of chemicals on improvement of root formation in cuttings and seed germination of *Podophyllum hexandrum* and *P. peltatum* has been realized and applied extensively for plant propagation. A bamboo network programme improved the outreach of the Core activities in terms of elite stock raising and its distribution to user groups and plantation.

Training and demonstration of different hill-specific technologies was also continued during this year.

Institutional Networking and Human Investment (INHI)

- Continued R&D funding through IERP
- Blending of science and religion for eco-restoration & conservation
- Strengthening of library and ENVIS facilities

The Core, through its R&D projects, focused on environmental management and socio-economic development by rehabilitating degraded lands and conserving biodiversity with the blend of science and religion and capacity building of the local communities. During this year, the impacts of the IERP became visible with receipt of hundreds of projects from prospective organizations all across the IHR, and funding of 34 new projects for execution of location-specific R&D activities. In all, 114 projects are currently on-going in 10 States of IHR. During the reporting period, the coordinated programme on "*Sacred values, eco-restoration and conservation initiatives in the Indian Himalayan region (IHR)*" was strengthened. Conducting IERP workshops to identify prospective PIs in the IHR and on-site training programmes are the regular activities of the Core. During the reporting year two IERP workshops were conducted, one at Palampur (Himachal Pradesh) and the other at Srinagar-Garhwal (Uttaranchal). 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 INHI Core.

Indigenous Knowledge Systems (IKS)

- Data base on indigenous crop diversity and weather change indicators
- Initiated study on IKS of Tribal communities of NE
- Updating digital library on Himalayan IKS

Well established indigenous knowledge (IK) of Himalayan people secures their survival in the Himalaya. Value addition in IKS through integration with modern scientific techniques will create enterprising potential of IK for economic upliftment of the indigenous people. To address these issues, the IKS Core has initiated: (i) documentation and analysis of indigenous practices of high altitude societies; (ii) analysis of people's perception of indigenous communities; and (iii) documentation of the traditional ecological knowledge on biodiversity management in selected ethnic communities of Arunachal Pradesh. The study on IKS of pastoralism documents preferred crops, crop yield and annual income from crops and highlights means of earning of transhumant women using their IK. The study documents traditional agro-biodiversity of different crops, fodder and fruit species of Mana and Niti valley areas of high altitude of Garhwal Himalaya. The perceptions regarding indigenous uses of selected plant species records the use preferences of medicinal herbs, wild edible fruits, etc. The study on traditional knowledge of understanding indicators of weather consolidates the vast indigenous knowledge of senior citizens, particularly about rainfall and snowfall in high altitude of Kumaun Himalayas. The study on documentation of the traditional ecological knowledge with reference to

biodiversity and natural resource management in an ethnic community of Arunachal Pradesh has been initiated to complement the objectives of the core programme. The IKS digital library has added more datasets based on published literature on IKS in the Himalayan region.

Completed Projects / Activities (Year 2005-06)

- People-Centered Landuse Development in the Biodiversity Rich Areas in West Kameng District of Arunachal Pradesh (Mac Arthur - UNESCO, funded)
- Commercial Utilization for Sustainable Rural Development and Conservation of Some Potential Wild Edible Oil Plants of Garhwal Region of Uttaranchal (CSIR, New Delhi funded)
- Assessment of NTFPs Potential and Harvests and Local Value System (In-House).
- Conservation and Management of Pollinators for Sustainable Agriculture, through Ecosystem Approach (FAO/GEF PDF-B funded)
- Studies on the Floristic Diversity of the Hamta-Jagatsukh Catchments in Himachal Pradesh (WPA, New Delhi funded)
- Management Plan for Medicinal Plants in the Catchment Area of Parbati Hydro Electric Project Stage - III (520 MW) in District Kullu, Himachal Pradesh (NHPC, H.P. funded)
- Dynamics of Structural and Functional Features of Biodiversity in Response to Disturbance Gradient in Forests of Kumaun Himalaya (DST, New Delhi funded)
- Centrally Sponsored Scheme- -Macromanagement of Agriculture Supplementation/Complementation of States' Efforts Through Work Plans-for Development of Medicinal And Aromatic Plants (DASD, Kerala funded)
- Assessment of Existing Stock and Scaling-up Productivity of Selected High Value Himalayan Medicinal Plants Through Biological and Biotechnological Approaches (NMPB, New Delhi funded)
- Vegetable Cultivation in Khairna Valley and its Impact on Environment (In-House)
- Genetic Profiling and Pilot Production of the Identified Elite Species and Quantification of the Active Biomolecules (DBT, New Delhi funded)
- Performance and Adaptability Analysis of Sloping Watershed Environmental Engineering Technology (SWEET) in the Hills of Kumaun Himalaya (DOLR, New Delhi funded)
- Community Wasteland restoration of Village Bantoli (Bageshwar, UA) (In-House)

1. INTRODUCTION

The year 2005-06 is seventeenth financial year of R&D activities being executed by the Institute at different locations of the IHR. All through these years Institute has made efforts to execute its mandate and provide environment-friendly, cost effective and locally acceptable solutions to mountain-specific environment and development problems. The Institute implements its R&D activities through the core funds provided by the Ministry of Environment and Forests (MoEF), Govt. of India, and the R&D projects funded by various external agencies (National and International). The Institute is also supporting activities of various partner Institutions in different Himalayan states through Integrated Eco-development Research Programme (IERP). The Scientific Advisory Committee (SAC) of the Institute reviews the progress of existing projects and provides guidance and help to develop new R&D programmes every year.

At present, the R&D activities of the Institute are centered on seven designated core programmes mentioned earlier. A number of activities/ projects were concluded during the reporting year. Summaries of these are included at appropriate places in the text. In due course detailed documents will be published and made available to the user groups / individulas. The progress made during the year 2005-2006 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 welcome critical comments, suggestions for improvement and for indication of shortcomings in our effort to achieve the target set by the MoEF, Govt. of India.

2. MILESTONE EVENTS

- **Annual Day Celebration & G. B. Pant Memorial Lecture**

The Institute celebrated its Annual Day on 118th birthday (September 10, 2005) of Bharat Ratna Pandit Govind Ballabh Pant, at its headquarters Kosi-Katarmal, Almora and all the four regional Units. Chief Guest, Shri Suresh Chandra, Special Secretary, Ministry of Environment and Forests, Govt. of India and Chairman Governing Body of the Institute inaugurated the function. At this occasion 11th Pandit Govind Ballabh Pant memorial lecture "Bamboo, Basket Weavers and Paper Mills", was delivered by Padmashri Prof. Madhav Gadgil of Indian Institute of Science, Bangalore. He stressed upon the need of establishing Biodiversity Management Committees at each gram Panchyat level to prepare People's Biodiversity Registers. Mrs. Veena Upadhayaya, Joint Secretary, Ministry of Environment and Forests, introduced the speaker.

Realizing the need to accelerate the process of establishing State Biodiversity Boards (SBBs) and Biodiversity Management Committees (BMCs) in the

- **State Biodiversity Board Worksop & Release of a Booklet**

Himalayan Region, the National Biodiversity Authority (NBA) and GBPIHED joined hands to organize a Zonal Workshop (September 11-12, 2005) at the Institute HQs. Prof. S. Kannaiyan, Chairman NBA inaugurated the workshop. Mrs. Veena Upadhayaya, Joint Secretary, Ministry of Environment and Forests, Prof. Madhav Gadgil, Indian Institute of Science Bangalore, Mrs. Vibha Puri Das, Principal Secretary, Govt. of Uttaranchal, Dr. Venkataraman, Member Secretary, NBA, and representatives of Himalayan State Government attended the workshop. Among others, the major recommendations included: (i) strengthen awareness programme on biodiversity conservation for different stakeholders; (ii) consider location/ region specific considerations of land resources while formulating BMCs and implementing PBRs; (iii) clearly define the role of different Govt. departments (for instance role of NBPGR can be highlighted in registering farmer's plant varieties) and NBA; (iv) develop a very strong framework to implement PBRs through participatory approach; (v) ensure flow of technical guidance from SBBs for the formation of BMC as well as PBRs. At this occasion a booklet "Facilitating Formation of State Biodiversity Boards and Biodiversity Management Committees in Indian Himalayan Region was released by Prof. Kaniyan.

- **SAC Meeting & Visit of SAC Members to R&D Demonstration Sites of the Institute**

XIII Meeting of the SAC of the Institute was held during December 22-23, 2005 under the chairmanship of Prof. K.P. Singh of Banaras Hindu University, Varanasi. Prof. J.S. Bali, Dr. Ramesh Chandra, Dr. P.S. Roy, Dr. U.C. Chaube (special invitee) were the other members present in the SAC meeting. At this occasion the Institute's R&D demonstrations/experiments and Rural Technology Complex of the Institute were visited by the SAC members. The SAC members provided inputs for improvement of output efficiency of Institute's R&D activities. The Chairman, while appreciating the efforts of the institute, since the last meeting of SAC (July 2004), mentioned that the Institute has created its special identity in national and international scientific community, which in turn has raised the expectations from the Institute.

- **G.B. Pant Society Meeting**

The XII Meeting of the G.B. Pant Society of Himalayan Environment and Development was held (14 February 2006) under the Chairmanship of Thiru A. Raja, Hon'ble Minister of Environment and Forests, Government of India. Among others, the Hon'ble Minister (Incharge) of Forest in States of Uttaranchal (Shri Nav Prabhat), Sikkim (Shri S.B. Subedi) and Mizoram (Dr. R. Lalthangliana) and Hon'ble Members of Parliament (Rajya Sabha – Shri Harish Rawat; Lok Sabha – Shri K.C. Singh 'Baba') attended the meeting. Shri J.C. Kala, Director General and Special Secretary, Ministry of Environment and Forests welcomed the President and all the members and representatives of the Society. In his opening address, the Hon'ble MEF and the President of the Society took note of the activities and initiatives of

the Institute during the reporting period. He exhorted the Institute to build up stronger linkages and strategic symbiotic partnerships with other Institutions and State Govts. to multiply its strength and to fulfill the expectations and aspirations of the people in the region and called upon the Institute to focus on: (i) sustainability of water resources including glacier's response to climate change; (ii) promotion of technologies aimed at upgrading the living standards of the people; (iii) promotion of biotechnological applications, and (iv) dissemination of traditional ethno-botanical knowledge. The society members provided useful suggestions and directions for further improvement in outreach of the Institute.

- **Training on Environmental & Social Management Framework**

Realizing the importance of integrated watershed management a best option for sustainable utilization and conservation of natural resources in the mountains a training programme was organized (20-22 February 2006) at the Institute HQs for the senior officials of Watershed Management Directorate, Govt. of Uttaranchal. Emphasis was to impart training on "Environmental and Social Management Framework", which was framed by the Institute. In this programme following aspects were covered: (i) watershed management: A methodological approach; (ii) social mobilization and community driven decision making; (iii) capacity building of *Gram Panchayats* and local community institutions; (iv) Source – centered approach for water resources management; (v) farming systems improvement and income generating activities for rural poor; (vi) management of arable lands, wasteland afforestation and silvipasture development; and (vii) medicinal plants for income generation.

- **Brain Storming on Ecosystem Services and Ecological Economics**

The increasing understanding of ecosystem services has begun to occupy the forefront of natural resource conservation programmes worldwide. To set out systematic R&D programmes in this direction and inviting viewpoints of the regional/national expertise the Institute organized a brain storming session at the HQs (24- 25 February 2006). Over 50 resource persons and delegates from different institutions attended the event. Three main ecosystems of the region (viz., forests, agriculture and water) were discussed in details for their goods and services. Approaches for valuation of these goods and services were elaborated. Resource persons from different Institutions, e.g., IISC Bangalore; JNU, New Delhi; IIFM, Bhopal; ISEC, Bangalore; ATREE, Bangalore and GB Pant University of Agriculture & Technology, Pantnagar delivered on theme areas. The action points emerged from deliberations included: (i) promote collaborative studies between active centers of learning on natural, economics and social sciences, particularly for standardization of methodologies for quantification and economic valuation of ES; (ii) develop expertise on ecological aspects of ES and their measurement / quantification; and (iii) use ecological science as a tool to better manage the environment.

- **Workshop on Intellectual Property Rights**

To safeguard the interests of stakeholder's communities and capacity building of user groups a workshop was organized at the Institute HQs (26-27 February 2006) with the objectives: (i) create awareness among researchers and other stakeholders of the IHR, and (ii) identify a mechanism for ensuring legal protection and benefit sharing in IPR related issues. Experts and participants from IISC, Bangalore; Patent Office, New Delhi; CSIR, New Delhi; Sher-e-Kashmir University, Srinagar; DBT, New Delhi; GBPUAT, Pantnagar; Dr YS Parmar University, Solan; Uttaranchal State Council for S&T, Dehra Dun and others deliberated on relevant aspects. The major recommendations included: (1) awareness campaigns be continued, with more emphasis on local people, students and other stakeholders; (2) formulation of projects should have inbuilt IPR component including prior art search from patent database; (3) GBPIHED should act as nodal agency for documentation on IKS in IHR; (4) CSIR model may be adopted for developing mechanisms for benefit sharing amongst the stake holders; (5) coordination amongst institutions involved in IPR related issues; (6) enhance knowledge base of the scientists for interpreting and analyzing the techno-legal information on patents; and (7) IPR and patent related information should be incorporated in University curriculum.

- **Satellite Symposium on Himalayan Biodiversity**

To join hands with National-level programmes to foster scientific activities the Institute contributed towards the Platinum Jubilee celebrations of National Academy of Science, India by organizing a two-day (March 27-28, 2006) satellite symposium. The goal of symposium was to gauge intensity and relevance of biodiversity researches being pursued in the IHR. The Chief Guest, Dr. D.R. Gautam, Director Horticulture, Uttaranchal, elaborated upon the importance of biodiversity studies for improvement of fruit and crop verities. Dr. G.S. Rawat of Wildlife Institute of India and Dr. Asha-Chandola Saklani from H.N.B. Garhwal University, Srinagar delivered the keynote addresses. The major issues flagged were: (i) biodiversity research needs improved interactions and interface; (ii) researchers should be alert about recent developments in the field of biodiversity; (iii) traditional curricula for teaching on subject require revamping through integration; (iv) socio-economic aspects and impact studies on biodiversity; and (v) improved understanding of behavioural ecology and human resource development.

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 and Water Resource Management, Sustainable Development of Rural Ecosystem, Conservation of Biological Diversity, Ecological Economics and Environmental Impact Analysis, Environmental Physiology and

Biotechnology, Institutional Networking and Human Investment and Indigenous Knowledge Systems. The achievement of goals and the progress made under various projects during the year have been placed under appropriate core programmes in the text. The project sites are spread over different parts of IHR and have been selected carefully keeping in view the biophysical heterogencity and location-specific needs of the inhabitants. All activities are need-based, target-oriented and time-bound. To meet the targets and to accomplish the objectives, the Institute HQs and the regional Units are well equipped with lab. facilities and support services. Research, demonstration and dissemination are underlying elements of all project activities to develop technology packages. During the reporting year 13 projects were completed and some new projects were initiated. Highlights of the progress made during the year 2005-2006, along with a brief, conceptual background, specific objectives and major achievements are summarized for individual projects.

CORE PROGRAME-I

LAND AND WATER RESOURCE MANAGEMENT (LWRM)

Himalayan region harbours rich biological and cultural diversity with prosperous land and water resource. Throughout human history the availability, distribution, use and access to these basic resources have been major drivers of civilizations and society development. As a consequence, management of land and water resources is becoming more important each day as human populations increase and natural resources and habitats become limited. Sustainable management of these resources aims to help balance the needs of people with the ability of ecosystems to support and maintain soil, water, forests and wildlife resources. It is increasingly recognized that land and water users have valuable knowledge of environmental sustainability themselves. There is also a need for appropriate valuation and promoting the use of the existing traditional knowledge. Ecosystem approach integrates ecological protection and restoration with human needs to strengthen the essential connection between economic prosperity and environmental well being. Therefore, the need for an ecosystem approach was felt to conduct long- and- medium term R&D studies focused on quantification of the resource use pattern. These attempts will help in developing strategies for sustainable use of land and water resources.

LWRM 1: Traditional Land and Water Management Practices in Himalaya and Critical Ecosystem Linkages

Background and Objectives

Study of region- specific traditional SWC practices

Himalayan region is well known for its traditional, time-tested and cost-effective land and water management practices. This study attempts to explore some of the region-specific traditional land and water management practices and its critical ecosystem linkages in Central, Western and North-East Himalayan region. The objectives of the study are: (i) identification and assessment of traditional SWC practices in Himalaya; (ii) quantification of soil loss in different land use practices with and without SWC measures.

A. Bench Terrace System of Central Himalaya

Background and Objectives

Study on natural boundary erosion plot concep

The bench terraces, specific trademarks of steep agriculture hillsides in the region are generally considered to constitute an excellent method of SWC and watershed management. For the quantification of resource linkages in bench terrace systems in Central Himalaya, Kuwagad micro-watershed, was selected and the study is conducted on the natural boundary erosion plot (NBEP) concept.

Results and Achievements

- Impact of slope on runoff & soil loss
- More runoff & soil loss from terrace risers

1. Plots with lower slope (< 3°) generated less runoff irrespective of its length. Whereas, outward sloping longer plots generated high runoff (coefficient ≈ 28%). Increase in the slope of terrace greatly influenced the runoff. Soil loss from the plots ranges from 0.1-2 t/ha, excluding the effect of riser. Terraces with greater slope generated more soil loss (≈ 4 t/ha) than gently sloped terraces.

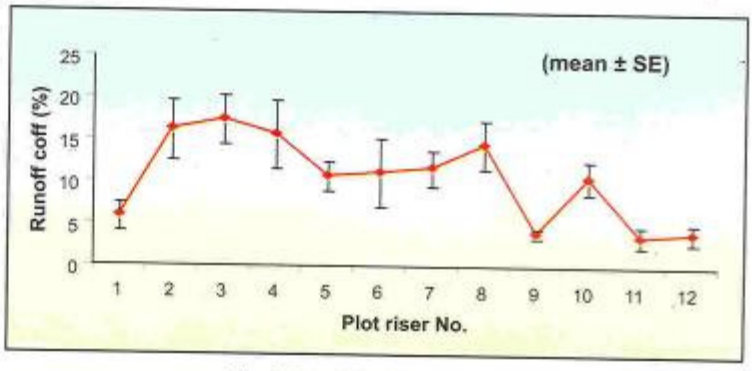


Fig. 1. Runoff coefficient of riser

2. The terrace risers contribute to a large part of runoff and soil loss in terrace cultivation (runoff coefficient up to 20% and total soil loss up to 0.26 t/ha) (Figs. 1 & 2). This suggested that specific attention should be paid to terrace riser protection in SWC programs in such areas.

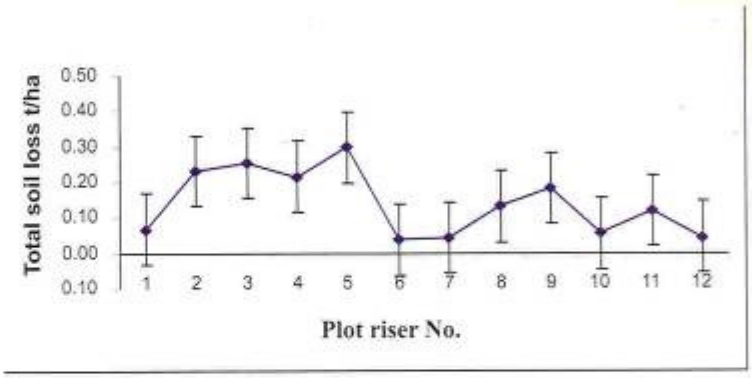


Fig. 2. Total soil loss from riser

B. Shifting Cultivation (Jhum Land) in NE Himalaya

Background and Objectives

Analyses of traditional SWC practices of Nyishi tribe

In the North-East region land is the vital component of all socio-economic activities and the soil and water losses from shifting cultivation remains a significant socio-environmental issue in the region. Tribal communities across the N-E States follow different types of indigenous SWC practices. This study envisages analyzing traditional SWC practices of Nyishi tribe in Senkhi watershed of Papum Pare district, Arunachal Pradesh.

Results and Achievements

- Study of *Phaik* & *Hade*
- Comparative assessment of current jhum fallow

1. Five villages having different socio-economic and ecological parameters across the Senkhi watershed were selected for detailed study (Table 1).

   In *phaik* system (an indigenous method of SWC), tree trunks, branches, bamboos and stones are used as barrier across the slope and weeds are put alongside. Besides this, there are different cropping systems such as *Hade*, that improves soil fertility through crop mixture.

2. Comparative soil loss and runoff studies (between 1st June and 30th September 2005) on current jhum fallow *(Nyibi)*, traditional SWC practice *(Phaik)* and control (control Jhum without SWC practice) revealed that soil loss (10.12 t ha^{-1}) in the traditional *Phaik* and current jhum fallow system was almost half of the control (Fig. 3). Surface runoff

was also higher in control, compared to current jhum fallow and *Phaik* system (Fig. 3). Total rainfall during the sampling period was 1154.3 mm.

Table 1. Agricultural plot size, slope and demographic profile of selected villages

Parameters	Village				
	Bhatt	Chimi	Ganga	Doria	Lobe
Altitude (m msl)	296	456	454	668	432
Cultivated plot size (ha)	0.2-3	0.2-3	0.3-1.21	0.2-1.68	0.2-2.45
Cultivated plot slope (Degree)	30.2	29.6	18.26	33.25	31.68
Total population	78	190	412	51	58
Households	12	23	48	8	10
Family size	7	8	9	6	6

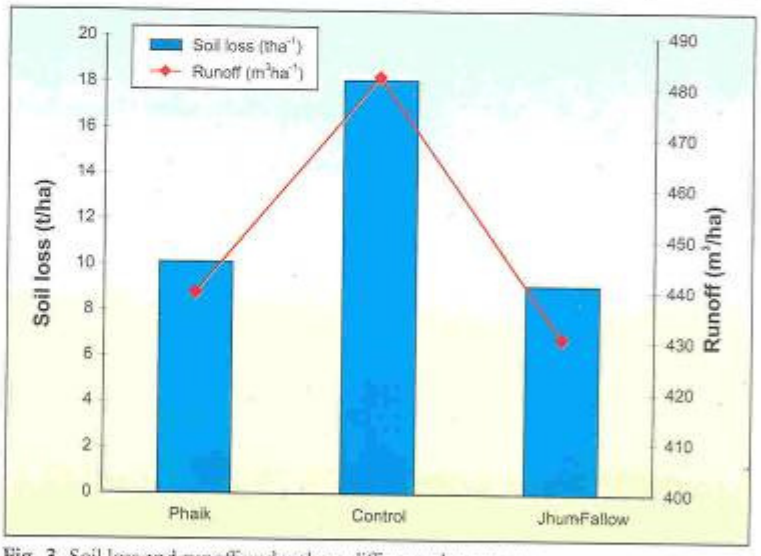


Fig. 3. Soil loss and runoff under three different plot systems

C. *Kuhl* Irrigated Land Management in the Cold Desert in Western Himalaya

Background and Objectives

Under prolonged severe winter, short xeric summer and very scanty or no rainfall conditions of cold desert of Lahaul valley, indigenous people have

standardized traditional off-take water channels (*kuhl)* to bring snowmelt from higher reaches of the hills to the agricultural fields. The *kuhl* is collectively constructed, repaired, managed and water shared among the village community. Cash crops like potato, pea and hops and traditional crops such as buckwheat, barley and beans are cultivated under such snowmelt irrigation during summers. The study focuses on flow of water and nutrients on watershed level and mapping of the landuse types of Jahlmanal watershed on the right bank of river Chenab that harbours six villages. Elevation of the watershed ranges from 2723 m to 6081m.

Results and Achievements

- Land use statistics of the watershed
- Correlation of seepage loss vs Kuhls length (r=0.71)

1. Out of 3300 ha area of the watershed only 6.6% is under possession of the villagers. Out of this 3.9% is agriculture land, followed by cultivated grass lands (2%), willow plantation (0.7%), cultivable waste (0.1%), kitchen garden (0.1%) and residential area (0.1%). Agriculture fields developed on glacial soil deposits in the valleys had > 200 cm depth, well drained, loamy skeletal soils.
2. Seepage losses among the *kuhls* varied from 69.2% to 14.4%. Longer length of *kuhl* and porous soil structure were main cause of higher water seepage from *kuhls.* Correlation between length of main *kuhl* and water seepage (r = 0.71). Under cement lined *kuhls* seepage was very less.

LWRM 2: People and Resource Dynamics in Mountain Watersheds of the Hindu-Kush Himalaya (*PARDYP*)

Background and Objectives

Participatory action research for improved livelihood options, database development & strengthening of community institutions

PARDYP, a regional collaborative programme, was initiated in January 1997 as a R&D project in the middle mountains of the Hindu-Kush Himalaya. In India, the project was taken up in Garurganga watershed in Bageshwar district, (UA). Due to its multidisciplinary approach and acceptability, the PARDYP has completed its three phases and is presently in its wrap up phase. Apart from generating long-term database on resource dynamics, strengthening of community institutions and farmers groups, adoption/adaptation of options ensuring improved livelihoods of the marginalized groups and families through participatory action research and skill improvement have been the major activities.

Results and Achievements

1. Integrated water harvesting linked with pisciculture has helped over 52 farmers of 25 villages with an income of Rs.1, 44,500.00 (Table 2). The water harvesting linked with off-season vegetables and cash crop cultivation, high-yielding agricultural crops, nursery development, etc.,

- Technology Adoption
  - Integrated water harvesting with pisciculture (Beneficiries- 52 farmers of 25 villages)
  - Integrated water harvesting with vegetables crop cultivation (Beneficiries-145 farmers of 39 villages).
- Rehabilitation of degraded community lands- 4 sites improved
- Hydrological monitoring of rehabitation site – significant reduction in soil loss & surface runoff

have been adopted by 145 farmers of 39 villages and earned Rs. 2,140-39,550 during the year. In addition, rehabilitation of degraded community lands at 4 locations significantly improved the ground cover and produced around 65 tonnes of fodder grass, costing Rs. 67,600.00.

2. The rating curve (Fig. 4a) for Lohari hydrological station shows significant variations in monthly as well as seasonal discharges. The minimum daily discharges (0.0010 m^3/sec) was recorded in June and maximum (13.27 m^3/sec) in September 2005. A similar trend was recorded for the monthly total water discharges at the outlet of the main station.

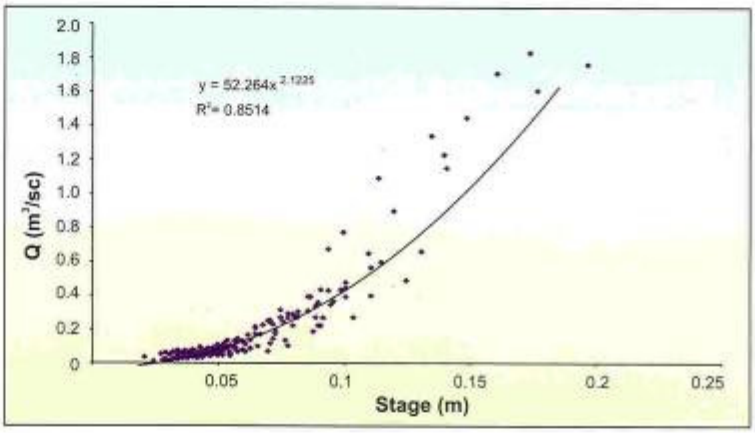


Fig. 4a. Rating curve for main hydrological station H4 (Lohari), 2005

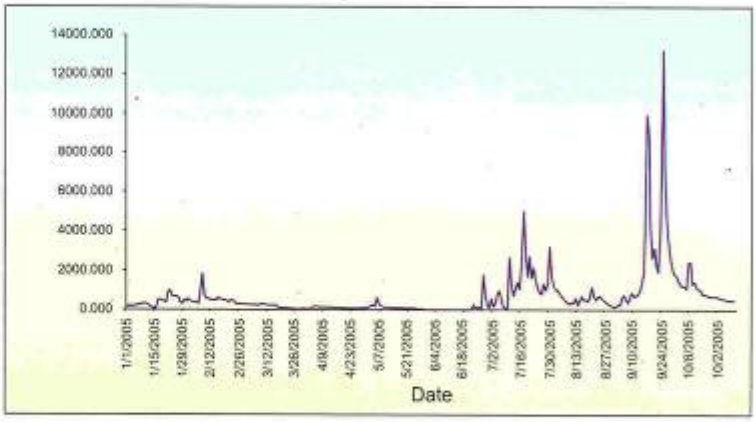


Fig 4b. Mean daily discharge for main hydrological station H4 (Lohari), 2005

3. The hydrograph for daily mean water discharge at Lohari station (Fig. 4 b) shows that during the dry season, mean daily water discharge remained < 2000 l/sec, and dropped to <100 l/sec during June. The peaks were observed during the rainy season. The erosion plot monitoring showed the highest surface runoff for bare land (155.17 m^3/ha), followed by pine forest (125.42 m^3/ha) and rainfed agriculture (17.39 m^3/ha). Rehabilitation site showed significant reduction both in terms of soil loss and surface runoff.

Table 2. Adoption of integrated fish farming and earning over a period of 6 years

Items	2000	2001	2002	2003	2004	2005
No. of farmers engaged	2	15	20	40	45	52
No. of villages covered	2	9	15	22	24	25
Total no. of tanks	3	22	35	61	67	70
Total inputs (Rs.)	2,900	18,300	32,800	43,200	44,500	46,000
Total income (Rs.)	6,200	67,700	97,620	178,370	183,700	190,500
Net income (Rs.)	3,300	49,400	64,820	135,170	139,200	144,500

LWRM 3: Water Sustainability Studies in Central Himalayan Region

Water resource management through demand supply assessment & ecosystem management

Background and Objectives

Water is the basis of life and development. Keeping in view the enormous spatial and temporal variations of precipitation in Himalayan region, knowledge of the amount of regional rainfall is essential for planning of land conservation strategies and water resources management. The perception of local inhabitants about the water availability, rainfall pattern, forest cover change, and water demand and water quality helps to investigate the critical linkages of land and water resources with socio-economic and environmental factors. The objectives of this study are: (i) assessment of availability, demand and consumption pattern of water; (ii) water budgeting at micro-catchment scale; (iii) selection of practices evolved mainly for coping with water stress through ecosystem management; and (iv) analyse cost- effective technical options for increasing the opportunity time for infiltration of water.

Results and Achievements

1. The preliminary assessment of water availability, water demand, rainfall change pattern, forest cover change and water quality was carried out in

- Reconnaissance of resource status and GIS map preparation
- Monitoring of meteorological parameters at selected sites

lower Kali valley of Central Himalaya. Digital GIS maps were prepared using Arcview and ERDAS Imagine to depict the patterns (Fig. 5).

2. Meteorological data and discharge measurements were taken regularly at 5 selected sites. Soil moisture patterns were studied in winter months to assess the water availability regime.

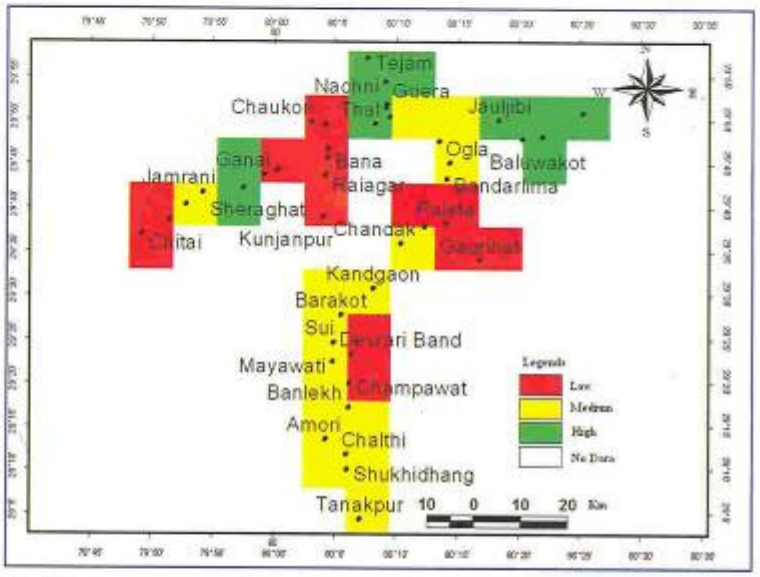


Fig. 5. Water availability pattern in lower Kali valley, Central Himalaya

LWRM 4: Geohydrological Studies and Quantification of Sediment Load of Thelu Glacier (Gangotri Glacier System), Uttaranchal Himalaya (*DST funded; Period: 2005-2008*)

Background and Objectives

Quantification of melt water discharge & SS load; role of tributary glacier & their recession monitoring

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 (June to September) large quantity of melt water flows down from the glaciers along with suspended sediment (SS). The seasonal variation in the amount of runoff derived from snowmelt, is however affected by meteorological parameters. The present investigation is focused on the discharge and SS transport pattern in the melt water stream draining the Thelu glacier (a tributary of Gangotri glacier). The objectives of the study are: (i) quantification of melt water discharge and SS load; (ii) role of tributary glacier in temporal

distribution of the SS load of Gangotri glacier; (iii) monitoring rate of recession of tributary glacier of Gangotri (i.e., Raktavarna, Thelu and Chaturangi glaciers).

Results and Achievements

- Area reconnaissance & finalization of the monitoring plan
- Melt water discharge and SS monitoring for Thelu & Gangotri

1. Preliminary survey of the study area was conducted for finalization of the monitoring sites and subsequently base camp was established at Thelu –Raktavarna valley (about 4500 m asl) for 24 hour flow monitoring and SS sampling.
2. Melt water discharge and SS was monitored during June to September 2005. The average seasonal discharge was recorded 0.37 and 38.31 m^3/sec for Thelu and Gangotri glacier, respectively. The average value of SS for Thelu glacier (0.29 g/l) was much lower than recorded for Gangotri glacier (1.58 g/l) (Fig. 6).

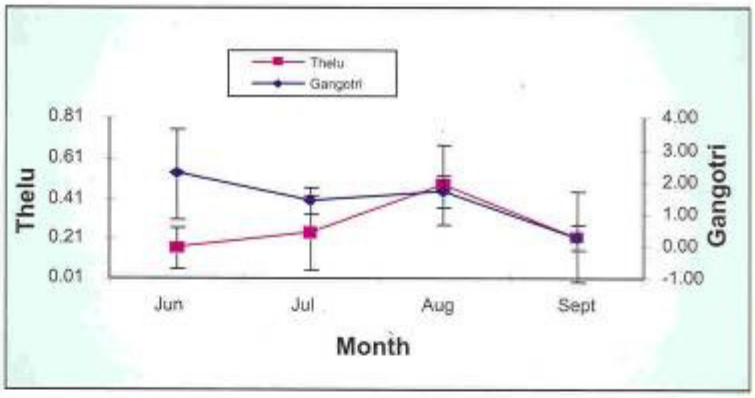


Fig. 6. Suspended sediment load (g/l) for Gangotri and Thelu glaciers

LWRM 5: Quantification of Tectonic Deformation Field in Kumaun Himalaya -A Basic Framework for Landslide Hazard Modeling Using sub-cm Precision GPS Survey *(DST funded;Period:2002-07)*

Background and Objectives

Study of N-S strain gradient & monitoring of temporal evolution of land slides & glaciers

In order to monitor the crustal motion along the two major N-S transects of Kumaun Himalaya i.e, Kali valley (Lipulekh to Tanakpur) and Gori valley (Dung to Almora), GPS monitoring networks have been set up since 2002, which include various GPS sites that are situated in each tectonic block along these transects. Data generated through annual GPS campaigns in these

transects since 2002, have been processed using GAMIT-GLOBK software. Study of active landslide of Balia Nala (Nainital) using GPS survey in static and kinematic mode is the another focus under this project. The objectives of the study are: (a) study of N-S strain gradient using high-precision GPS survey, to determine the annual strain rate field in Kumaun Himalaya; and (b) monitoring the temporal evolution of some landslides and glaciers using kinematic GPS survey.

- Field campaign at 24 stations & assessment of baseline shortening
- Landslide monitoring of Balia Nala (Nainital)

Results and Achievements

1. GPS field campaign was carried out covering 10 stations in Kali valley (Dharchula to Lipulekh) and 14 stations in Gori valley for monitoring the strain-rate accumulation for different physiographic zones and baseline shortening (Table 3). Baseline shortening is significantly larger in these valleys between GBPK (lesser Himalaya) and higher Himalayan sites, indicating differential movement between different zones.

2. Landslide monitoring was carried out in 1 Kmx1 Km area of Balia Nala landslide through kinematic survey at every 10x10 m grid area. The processed co-ordinates are used to generate the surface of the landslide region using programs like Surfer and GIS softwares (Arc view and ERDAS Imagine) with cm level accuracy (Fig. 7).

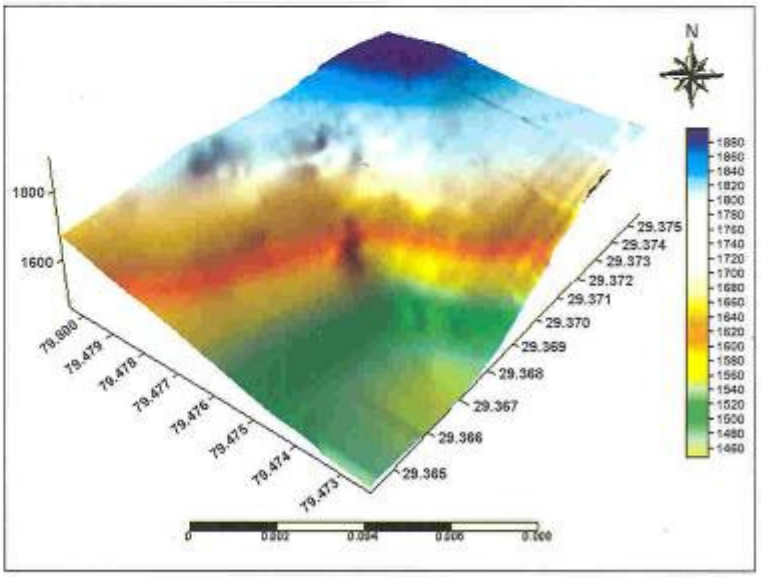


Fig. 7. Balia Nala landslide surface plot (2005)

Table 3: Zone wise strain rate and baseline difference in two sites of Kumaun Himalaya

	Kali Valley		*Gori Valley*	
	Strain (micro) ± SE (micro)	Shortening (mm)	Strain-rate ± SE (micro)	Shortening (mm)
GBPK-Higher Himalayan sites	0.109± 0.012	-11.275 ± 2.9	0.094 ± 0.022	-8.16 ± 2.04
GBPK-Tethys Himalayan sites	0.113± 0.005	-15.85 ± 2.4	0.117 ± 0.017	-11.9 ± 2.03

LWRM 6: Installation and Operation of Permanent GPS Station for the Quantification of Tectonic Deformation and Assessment of Stability of Himalayan Urban Centers

(DST funded; Period: 2005-2010)

Background and Objectives

Quantification of tectonic deformations along E-W Himalaya & its impact on the stability of urban areas

This study is focused on the quantification of the tectonic deformations and strain rates through continuously operating GPS receivers installed across five towns of IHR: Naini Tal (Kumaun Himalaya), Srinagar (Garhwal Himalaya), Gangtok (Sikkim Himalaya), Zero (Arunachal Pradesh) and Kullu (Himachal Pradesh). Two permanent GPS stations are already operating in the GBPIHED Campus, Kosi-Almora and Pangthang (Sikkim). These station cover the E-W transect of Himalaya and are part of the DST National Network of permanent GPS stations. The results of this study will help to reveal the total accumulation of strain across E-W Himalaya, and its effect on the stability of Himalayan urban centers to determine the areas vulnerable to natural hazard, and to identify areas for creating a minimum risk land use plan. The twin objectives of this study are: (i) quantification of tectonic deformation field by displacements of the above five fixed sites using GPS geodesy with high resolution; and (ii) measurement of slip rates across reported faults in the area towards improving assessments of the stability of different parts of the mountain urban centers.

Results and Achievements

- GPS results across three permanent stations
- Digitization of geological maps of the permanent GPS sites

1. Data generated from the permanent GPS stations, at Kosi-Almora, and Sikkim was rinexed, archived and processed using GAMIT/GLOBK software and also submitted to Survey of India. The precision of position solution is 2-5 mm for north component, 3-6 mm for east component and 10–40 mm in vertical component for the year 2005 – 2006 (Fig. 8).
2. Geological maps were digitized for all the areas where these permanent GPS stations are established (Fig. 9). The Srinagar station underlain by the Garhwal thrust is situated over the rocks of Chandpur phyllites and

will give the movement along the Garhwal Thrust. The Nainital GPS station will estimate the movement of the Main Boundary Thrust, while the Kullu station will estimate the movement over the carbonaceous slates, schists and phyllites. GPS stations at Zero falls above the Main Central Thrust and established over the schist and phyllites of Bomdila and Se-La group.

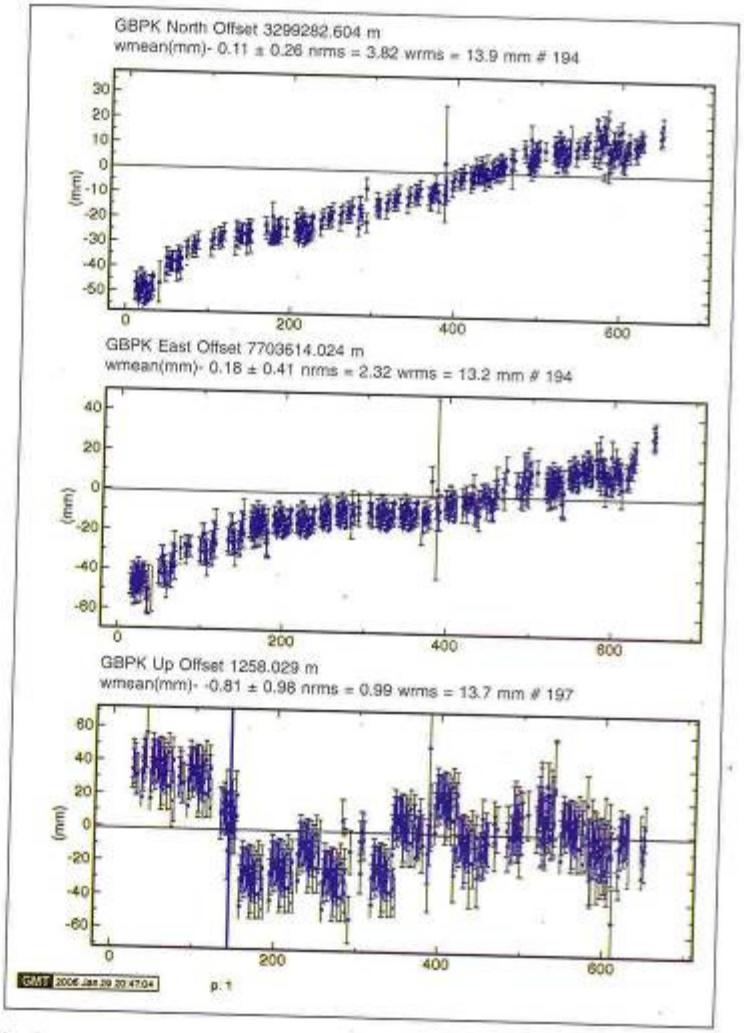


Fig. 8. North east and vertical components of repeatability for permanent GPS stations

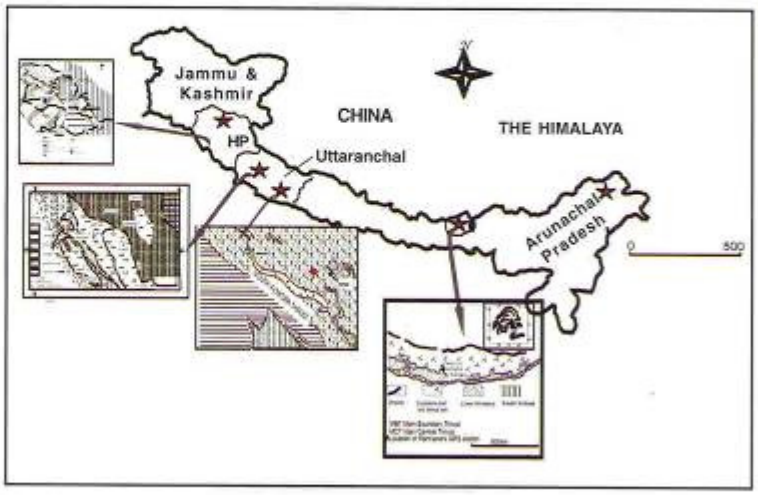


Fig. 9. Location map of permanent GPS stations with site geology

LWRM 7: Nutrient Use Optimization by Improving Soil Biological Processes Using Available Resources in a Marginal Upland Jhum Farming System on the North- East India *(CSIR funded; Period: 2004 - 2007)*

Background and Objectives

Assessment of farming system status & study of nutrient release synchrony

Shifting cultivation in Arunachal Pradesh has been practiced by majority of ethnic groups since time immemorial for their livelihood sustenance. There are many compelling scenarios where shifting cultivators have developed eco-friendly practices for sustainable management of agro-ecosystems. However, there is a need to better understand these best management practices and incorporate this knowledge with scientific technologies to optimize the resource utilization for better agronomic yields. This study carried out in the Senkhi watershed area inhabited by the Nyishi community of A.P. focuses on: (i) characterization of farming system and land and water quality in the subtropical region of A.P.; and (ii) to supplement farm yard manure through bio-compost and manipulate synchronization of nutrient release and crop uptake for efficient nutrient conservation in Jhum farming system.

Results and Achievements

1. Soil physio-chemical parameters for all the six villages in Senkhi watershed revealed that the forest soil was better than the soil of other land uses. The soils were characterized by low phosphorus (Table 4).

Table 4. Soil physico-chemical prpoperties of different land use systems in Senkhi watershed villages

Land use	Village	pH	Conductivity (mv)	Moisture (%)	TOC (%)	Nitrogen (%)	Phosphorus (%)	Pstassium (%)	Sodium (%)
Jhum	Chimi	4.346± 0.03	84.918± 5.83	14.67± 2.04	2.01± 0.01	2.31±0.07	0.06± 0.001	0.09± 0.00	0.002±0.0001
	Bahat	6.08± 0.02	73.554± 9.47	8.37± 1.58	1.62± 0.01	1.83±0.03	0.04± 0.001	0.07± 0.00	0.002±0.0001
	Doria	5.35± 0.40	105.69± 15.30	27.06± 1.66	1.32± 0.09	0.77±0.14	0.05± 0.01	0.08±0.002	0.003±0.0001
	Lobi	5.87± 1.29	79.320± 31.56	25.39± 2.33	1.31± 0.09	0.73±0.04	0.06± 0.01	0.09± 0.00	0.003±0.0001
	Lower Botum	5.47± 0.22	115.30± 16.69	32.36± 1.73	1.31± 0.13	0.75±0.13	0.05± 0.01	0.08± 0.00	0.002±0.0001
	Ganga	6.00± 0.48	86.530± 42.88	24.54± 2.42	1.13± 0.10	0.60±0.05	0.05± 0.01	0.07± 0.00	0.003±0.0001
Fallow	Chimi	3.75± 0.03	81.58±22.46	23.23± 0.18	1.53±0.01	2.62± 0.17	0.02± 0.001	0.06± 0.002	0.003±0.0002
	Bahat	5.51± 0.03	83.201± 9.27	10.67± 0.03	1.86±0.01	1.88± 0.01	0.05± 0.001	0.08± 0.00	0.028±0.0001
	Doria	5.83± 0.12	74.15± 8.27	23.31± 1.06	1.71±0.06	0.81± 0.01	0.11± 0.01	0.08± 0.00	0.003±0.0001
	Lobi	6.81± 0.22	75.68±16.05	25.81± 1.17	2.13±0.09	0.75± 0.01	0.09± 0.02	0.07± 0.00	0.002±0.0001
	Lower Botum	5.97± 0.12	80.89± 9.02	28.45± 1.10	1.60±0.07	0.79± 0.01	0.11± 0.01	0.08± 0.00	0.003±0.0001
	Ganga	5.94± 0.23	82.56± 5.67	31.06± 1.22	1.63±0.07	0.73± 0.01	0.08± 0.02	0.07± 0.00	0.004±0.0001
Forest	Chimi	4.54± 0.04	108.7± 15.737	17.97±0.03	2.90±0.01	2.34± 0.26	0.09± 0.001	0.08± 0.00	0.002±0.0002
	Bahat	5.24± 0.02	77.84± 16.51	14.43±1.86	1.67±0.01	1.96± 0.11	0.06± 0.001	0.08± 0.00	0.003±0.0001
	Doria	5.31± 0.40	107.90± 23.73	27.55±1.58	2.04±0.02	1.29± 0.02	0.07± 0.01	0.10± 0.00	0.004±0.0001
	Lobi	6.68± 0.19	119.27± 50.09	27.18±1.58	2.25±0.02	0.97± 0.01	0.09± 0.01	0.09± 0.00	0.003±0.0001
	Lower Botum	6.43± 0.41	117.71± 25.89	32.88±1.64	1.73±0.03	1.26± 0.02	0.06± 0.01	0.09± 0.00	0.004±0.0001
	Ganga	5.81± 0.19	130.11± 54.65	32.48±1.65	2.01±0.02	0.95± 0.01	0.09± 0.01	0.09±0.00	0.002±0.0001
WRC	Chimi	4.82± 0.03	118.59± 17.16	24.10±0.25	1.05±0.01	1.90±0.08	0.09±0.001	0.07±0.00	0.001±0.0002
	Bahat	3.92±0.04	89.002±24.10	11.00±0.06	1.69±0.01	1.84±0.06	0.02±0.001	0.09±0.00	0.022±0.0001
	Ganga	4.92± 0.03	76.260±8.50	23.56±0.255	1.02± 0.01	1.94±0.08	0.08± 0.001	0.07±0.00	0.001±0.0002

- **Land use characterization by soil quality attributes**
- **Identification of traditional soil enrichment practices**

2. The traditionally utilized important soil nutrient enhancement practices include: Crop residue left after harvest, use of common weeds (*Eupatorium odoratum*, *Ageratum conyzoides*, *Mikania scendences*, *Leeus aspera* and *Fimbristylis* spp.), Piggery wastes, bamboo and tree leaves, paddy husk and ash application in home gardens, wet rice cultivation and Jhum.

CORE PROGRAME-II

SUSTAINABLE DEVELOPMENT OF RURAL ECOSYSTEMS (SDRE)

The SDRE Core aims to address major issues in sustainable development of the rural areas of IHR through identification of development bottlenecks and formulation of R&D strategies for solving location-specific problems as well as providing inputs for policy formulation. Identification of problems, assessment of existing strategies, and devising of corrective approaches appropriate to economic, social and environmental needs are the basic perquisites for this. To achieve this, it is necessary that resource dependency and management strategies adopted by much of the communities in the IHR be assessed for their appropriateness. It is also necessary to be well acquainted with the issues influencing livelihood security in the IHR and the menu of options available to the mountain community in this regard. Appropriate strategies for resource management resulting in livelihood security can come about only when the above factors are well understood. Although factors influencing livelihood security are many; an important aspect where the SDRE Core can take a proactive action is technology development, demonstration, and the capacity building of the rural mountain populace by adapting them to these technologies. In the reporting period the core has taken up R&D works on following thrust areas/topics.

SDRE 1: Sustainable Resource Management Strategies for Rural Development in the Himalaya

A. Fallow Management Practices among the Tangkhuls of Manipur

Study of nutrient replenishment & crop yield

Background and Objectives

The cultivation phase of shifting agriculture as practiced by the Tangkhuls of Ukhrul district, Manipur is a three year cycle, sometimes stretching beyond. This prolonged cultivation phase is unique apart from normal shifting cultivation, which has a cultivation cycle of 1-2 years. The longer cultivation phase implies that the soil fertility levels of fields must be good enough to support crop yield for more than two years. The better fertility levels suggest that fallow management must be of a higher efficiency than in other parts of NE. This investigation was focused on soil fertility replenishment processes within shortened fallow periods and the resultant yield of crops with the objectives: (i) documentation of preferences of farmers for the species retained in the field during land clearing; (ii) assessment of crop yield under shifting cultivation fields; and (iii) estimation of optimum soil nutrient requirement of crops.

Results and Achievements

1. Based on field investigations, PRAs and interviews (386 farmers across eight villages) conducted for about 75 shifting cultivation plots and a total of 73 species were recorded those vary from village to village (Table 5).

Table 5. Species nurtured and retained in the shifting cultivation plots during plot clearing

Village name	Area sampled (acre.)	Species lopped/ thinned and retained		Trunk/stub species allowed for coppice/ re-growth	
		No. of species	Density (plants/ha)	No. of species	Density (plants/ha)
Kalhang	6.80	8	124.73	24	117.82
Nungbi Khullen	3.59	8	157.24	18	241.38
Longpi Kajui	2.42	12	108.16	19	201.08
L. Shimphung	2.24	7	35.16	20	292.31
Paorei	8.65	11	18.86	21	92
Paoyi	3.90	4	11.39	34	496.2
Phungcham	2.78	13	200.89	18	154.46
Total/average	30.38	34	82.83	61	196.83

- PRAs & interviews
- Identification of species left during cleaning
- *Alnus nepalensis* most preferred plant for soil enrichment
- Organic carbon estimates of cultivation phase

2. Based on the utility, *Alnus nepalensis* is the most preferred species and people assigned highest importance to it for its nutrient enrichment value. Other such species were: *Quercus pachyphylla*, *Kydia calycina*, *Albizia julibrisin* and *Ficus semicordata* etc.

3. Soil analysis (representative plots for 3 different cropping years) revealed highest organic carbon and nitrogen in 1st year that reduces with progressing cropping years. Highest phosphorus and potassium was found in 3rd year, and least in 2nd year of cropping.

B. Land Use Models for Himalaya

i) Case Study - Central Himalaya

Impact of rehabilitation on soil physico-chemical properties

Background and Objectives

Land degradation, in broader sense can result from any causative factor or combination of factors, which damage the physical, chemical and biological status of the land and its productive capacity. Stimulation of natural processes in favour of mankind in a long-term perspective, minimal possible dependence on the external inputs and interlinkages of the diverse subsistence needs of the human beings are the key considerations in ecological approaches of restoration. Biophysical interactions within and among the ecosystems, nutrient cycling and stability under varied disturbance regimes and management practices constitute the basis of formulating restoration strategies. This report deals with a detailed soil analysis at three points of time to assess the impact of rehabilitation on soil physico-chemical properties.

Results and Achievements

- Plantation resulted in improvement in soil properties at AAL & DFL
- Changes varied with species, site & management practices

1. At the time of plantation, and after 5 and 15 years of treatment, soil at the abandoned agricultural land (AAL) site had significantly higher concentration of organic carbon and cations at the degraded forest land (DFL). At both the sites, organic carbon, cations and nitrogen improved significantly after 15 years of plantation. Differences in pH and phosphorus between sites were not significant, however, phosphorus concentration had improved after 15 years at both the sites.

2. The degree of soil fertility changes induced by plantation may vary depending upon the eco-physiological attributes of plantation species, site characteristics and management practices. In the mixed plantation a significant improvement in soil nutrients was observed in both the sites, though the magnitude of change varied between sites (Table 6).

Table 6. Soil physico-chemical characteristics before and after 15 years of plantation at Banswara (Rudraprayag)

Parameters	Before plantation		5-years after plantation		15-years after plantation	
	AAL site	DFL site	AAL site	DFL site	AAL site	DFL site
pH	6.6±0.89	6.0±0.90	6.3±0.85	6.2±0.68	6.6±0.93	6.3±0.89
Organic carbon (%)	0.94±0.18	0.71±0.13	1.64±0.17	1.11±0.04	2.46±0.4	1.95±0.3
Total nitrogen (%)	0.15±0.05	0.10±0.02	0.25±0.05	0.25±0.05	1.39±0.0	0.95±0.25
Total phosphorus (%)	0.06±0.02	0.05±0.04	0.08±0.03	0.09±0.02	0.86±0.06	0.40±0.03
Exchangeable potassium (mg/100g)	3.7±0.89	2.0±0.45	6.43±1.45	4.3±0.4	12.2±2.1	7.30±0.8
Exchangeable calcium (mg/100g)	50.1±.±6.49	30.6±6.63	87.03±4.3	42.6±8.9	129.3±5.2	79.31±6.9
Exchangeable magnesium (mg/100g)	5.0±1.8	2.3±0.3	8.64±0.3	4.9±1.6	18.4±0.9	9.4±0.6

BOX - 1

Summary of the Completed Project

(2002-2005)

People-Centered Landuse Development in the Biodiversity Rich Areas in West Kameng District of Arunachal Pradesh

(Mac Arthur - UNESCO funded)

This study investigated the dynamics of change in traditional farming systems and livelihood pattern of the indigenous tribal communities in the western Arunachal Pradesh. It assesses potential of agricultural systems, livestock, forest and NTFPs with a focus to evaluate the crops and cropping patterns, and agronomic yield of settled and jhum practices, farm income and expenditure, changes in traditional farming systems, and the land use/cover change; role of livestock in local economy at high elevations and indigenous management of rangelands; impact of different forest management regimes on tree structure, species association, diversity, regeneration, along with economic benefits derived from them; and role of NTFPs in local socio-economies along with regeneration of selected over exploited species. The main findings were:

- West Kameng district of AP (area = 7422 km^2; population = 74,595 persons), inhibited by five major ethnic groups, viz. Monpa, Sherdukpen, Aka, Bugun and Miji that practice settled as well as shifting cultivation. Nearly 71% of total land area of the district is under forest cover, 9% degraded forest, 3.2% wasteland, 2.8% snow cover, 1.9% alpines, 3.8%

settled agriculture, 4.4% shifting cultivation, 2.6% jhum fallow, 0.8% horticulture, and 0.7% under settlements.

- Agriculture is the primary sector in which nearly 63% of total workforce is engaged. Use of high yielding and commercial crops, such as fruits (apple, kiwi, orange, and walnut) orchards and vegetables is gaining momentum in recent times and selected progressive farmers are procuring village community lands to cover such plantations.
- Livestock based economy studied in 9 villages (1400-3300 m amsl) and four pastures, viz., Lubrang (2500 m), Chander (2800 m), Baisakhi (3400 m), and Sela (4100 m) revealed that there is gross inconsistency in revenue earned from livestock. To get more benefit from this sector the veterinary facilities need to be extended to remote areas.
- There is a large variety of forest management regimes, i.e. Reserve Forest (RF), Anchal Reserve Forest (ARF) and Unclassed State Forest (USF), and all of them have different vegetation characteristics (Table 7). Most of the 'Unclassed State Forests' (USFs) are under shifting cultivation and regulated by local customary laws, however there is an increasing conflict of ownership for such land with the Forest Department. Diversity of USF and RF was much better compared to the ARFs. Since USFs occupy about 79% of the total geographical area of the district, tree plantation and timber forestry could be a better livelihood option and need policy focus.
- Out of a total of 257 NTFP screened from West Kameng district and its vicinity, 32 species had high local value while 14 species had high market demand. Species like *Taxus baccata*, *Pinus* spp, *Illicium griffithii*, *Swertia chiryata* and *Calamus* spp. were found to be most important commercial species generating high revenue. All tribal communities use different NTFPs for diverse purposes (Fig. 10).

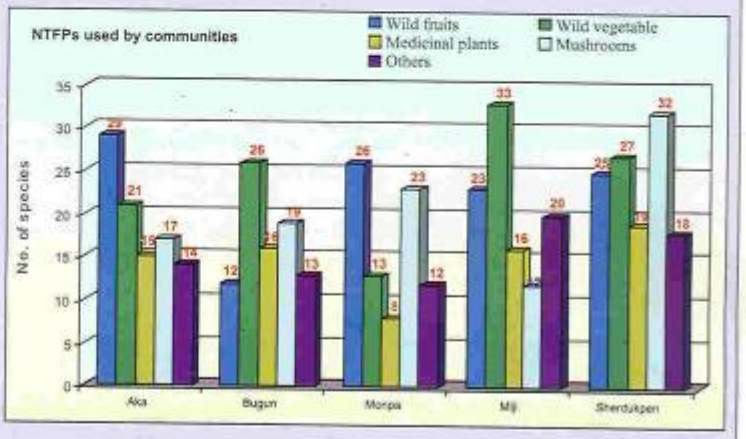


Fig. 10. NTFPs used for different purposes by the five major tribes of West Kameng district

Table 7. Some parameters of vegetation at five sampled forests

Category	RF	ARF-1	ARF-2	USF-1	USF-2
Area (km²)	736	1.40	3.10	4064	4004
Trees					
No. of species	85	6	3	122	61
Density of the stand (nos./ha)	411	254	341	605	575
Total basal area (m²/ha)	35.38	16.52	11.35	35.52	53.68
Saplings + Shrubs					
No. of species	130	11	9*	139	48
Density (nos./ha)	6900	7220	5236	11742	31100
Total basal area (m²/ha)	2.34	2.00	1.38	4.79	8.27
Seedlings + Herbs					
No. of species	79	21	18	30	50
Density (nos. of seedlings/ha)	51500*	344310	426500	22857	2323*

*Values for seedlings only.

SDRE 2: An Assessment of Agricultural Production and Strategy for Sustainable Development of Bioresources

Analyses of data on land & agricultural productions & base map preparation

Background and Objectives

The Himalaya constitutes a unique geographical and geological entity comprising a diverse social, cultural, agro-economic and environmental setup. In this region limited life supporting activities are available; land constitutes the most precious resource for its inhabitants as it is the main source of livelihood. The ever increasing population of human and livestock in this region, has made it imperative to assess the production of bioresources such as agricultural, fuel and fodder in the different geo-environmental conditions. With this in view, forty village of Hawalbagh development block of Almora district were studied across three altitudinal zones (i.e, less then 1400 m, 1400-1600 m and more than 1600 m). The main objectives for this year were: (i) to study the population pressure per unit of land; (ii) to study the agricultural production; and (iii) base map preparation.

- Zone wise assessment of market dependency to food supply
- RS data based land use/ land cover map

Results and Achievements

1. The middle altitude zone was found to be very poor in terms of food production and depended on market for about 50% of the food supply. The dependency for food on market was about 45% for third zone and only 15% for first zone (Fig. 11).

2. A map of land use /land cover based on remote sensing data revealed that the maximum cultivated land was present in the first altitudinal zone, maximum waste/ under utilized land was found in second zone and the maximum forest land in the third zone.

Fig. 11. Contribution of agricultural production to the total food requirement

SDRE 3: Conservation and Sustainable Management of Belowground Biodiversity in Two Altitudinal Windows of Garhwal Himalaya *(TSBF/GEF funded; Period: 2005 -2006)*

Identification of meso faunal diversity in agro ecosystems of NDBR & Kedarnath valley

Background and Objectives

Soil organisms are directly and indirectly responsible for the successful completion of pedological and nutrient cycling in any given ecosystem. The ability of these organisms to feed upon waste material and litter make them an important component in the cycling of nutrients. Soil faunal community shows a variety of reactions to changes induced by land management practices. Their abundance and diversity are indicators of the quality of soils and influence soil organic matter dynamics, nutrients contents and physical parameters. This study was focused on to identify the meso faunal diversity, particularly termites and ants in forests and major agroecosystems of Nanda Devi Biosphere Reserve (NDBR) and Kedarnath valley of Garhwal Himalaya.

Results and Achievements

- Termite population: High altitude-no termites
- Low altitude (max seasonal population – July with highest population in pine forest)

1. Population study on termites and ants at both the sites revealed that higher altitude was devoid of any termites population but at lower altitude, termites were found in all the land uses and forest types. The maximum population of termites was found during July, with highest population in pine forest and minimum in irrigated land.

- Ant population
- Lower altitude - maximum under rainfed conditions.
- Higher altitude-maximum under Cedrus forest

2. The ants population was found higher at lower altitude site with maximum number under rainfed conditions as compared to higher altitude with highest population under *Cedrus* forest. A seasonal comparison at both the altitudes indicates that across the season ants population was higher in April followed by July and October.

BOX - 2

Summary of the Completed Project (2002 – 2006)

Commercial Utilization for Sustainable Rural Development and Conservation of Some Potential Wild Edible Oil Plants of Garhwal Region of Uttaranchal

(CSIR funded)

This project aimed to prepare an inventory of wild edible oil plants, documentation of indigenous knowledge related to oil extraction, consumption pattern and uses, comparison of oil extraction from traditional and modern techniques, analysis of nutritional, physico and biochemical properties of oil and seed kernels, and propagation of these species for their large scale domestication and conservation. The project concluded with the following major achievements:

- A detailed survey in Pinder, Niti, Mana and Urgam valleys of the region revealed that important wild edible plant species such as *Neolitesa pallens, Prinsepia utilis, Prunus persica* and *Prunus armaniaca* are valued for their edible oil fruits, and medicinal properties.
- Indigenous uses of these four species were documented. The oil is used in body pain as well as massages (*P. persica*) in rheumatic pains (*P. persica, P. armaniaca*), and to cure the skin diseases of livestock/ human beings (*N. pallens*) etc.
- Unlike other species, *P. armaniaca* is a semi domesticated species extensively used for edible oil and for curing body ache. The fruit is either eaten raw or processed for preparing pickle, jam, jelly and many other indigenous cuisines.
- Physico-chemical studies of oil and seed kernels of these species revealed: oil of seed kernels of *P. utilis,* oil of *P. persica* comparatively rich in fatty acid composition, iodine, saponification and acid value followed by N. *pallens.*
- Multiplication studies by means of vegetative propagation (through stem cutting) in *P. utilis* were found quite promising. A strategy for the conservation and application through value addition in food, cosmetic and medicine industries were recommended for these species.

SDRE 4: Natural Resource Management – Seasonal Migration of Livestock in the Central Himalaya

Background and Objectives

Study of practices during seasonal livestock movement & temporary dwellings

Seasonal movement of village livestock in search of fodder and livelihood is an age-old phenomenon in the Central Himalaya. Livestock activities and various products of these seasonal dwellings were integral part of the village life and provide opportunities for additional income generation. Therefore studies on this livestock-based livelihood practices and functioning of temporary dwellings is important. The objectives of this study were (i) to document the seasonal livestock movement practices and temporary dwellings in the middle mountain region; and (ii) resource-use pattern (grazing lands) amongst different temporary settlements in the forest.

Results and Achievements

- Identification of grazing fields of selected *Thors*
- Study of grazing pressure

1. Along an altitudinal gradient (2200-3000 m) forest blanks and grasslands used as grazing lands for livestock of 15 temporary settlements (*Thor*) were surveyed in the Dudhatoli region (UA). In total 131 grazing fields were identified which were used for daily livestock grazing by different *Thors*.

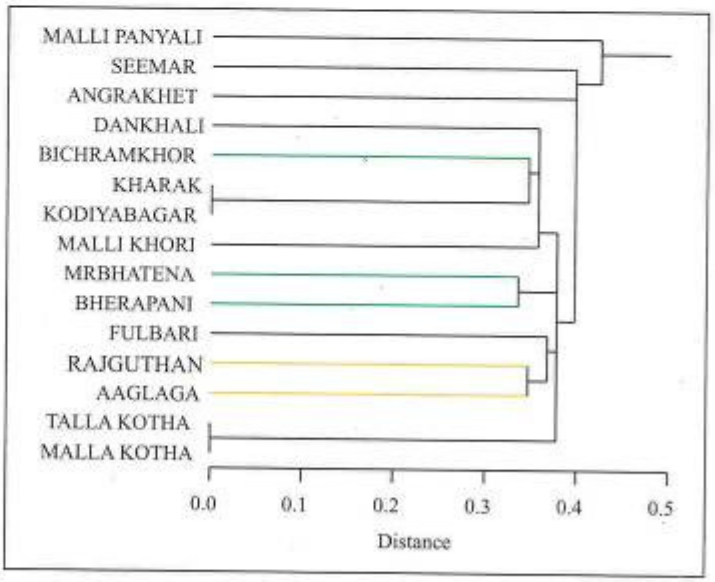


Fig. 12. Resource sharing by various *Thor* for livestock grazing in the Dudhatoli region

2. Along the elevation zone temporary settlements total number of grazing lands visited by livestock of different *Thors* of three elevation zone varied from 24 to 47, and usually with increase in elevation total numbers of grazing lands per elevation zone decreased. Individually for each *Thor* total number of grazing fields may vary from 8 to 18 different locations in the forests. The resource sharing by different *Thors* is depicted in Fig. 12.

SDRE 5: Global Climate Change Studies in the High Altitude Himalayan Ecosystems (*Department of Space funded; Period: 2003-2006*)

Background and Objectives

Study of responses of high altitude ecosystems, subsystems to climate change

As a consequence of the green house effect and global climate change, vegetation cover is expected to respond to changes in temperature and precipitation. There are continuing efforts worldwide to build a strong interagency focus on global change impacts on managed and natural ecosystems. However, there is a large gap between the Indian studies and the knowledge that exists in other parts of the world. Observations and monitoring from space of the changing landuse and landcover can be used effectively to collect and update information, and to devise corrective steps for more sustainable land use. The objective of this study therefore, is to advance our understanding of the structure and functioning of the high altitude ecosystems, subsystems of the Himalaya, their response to physical, biological and anthropological forces.

Results and Achievements

- Mapping of vegetation type & species distribution
- Classification of land use/ land covers of outer Himalayan region

1. Satellite image from LISS-III for regional mapping of entire Kumaun Himalaya, and LISS-IV images for higher elevations in outer, middle and inner Himalayan region were used for detailed mapping of vegetation types and species distribution.
2. Detailed classified map of outer Himalayan region reveals that in the areas above 1900 m elevation agriculture is very less represented landuse (0.1%), and oaks are predominant species in different landcover types. Among the different community types oak mixed conifers occupy 15.4% of the total area, while oak-mixed deciduous species and oak-mixed evergreen are spread in 14.6% and 13.1% of the total area, respectively. Exclusive dominance of Banj-oak, Tilonj-oak, and Kharsu-oak was observed in the 2.5%, 2.2%, and 3.2% of the total area, respectively (Fig. 13).

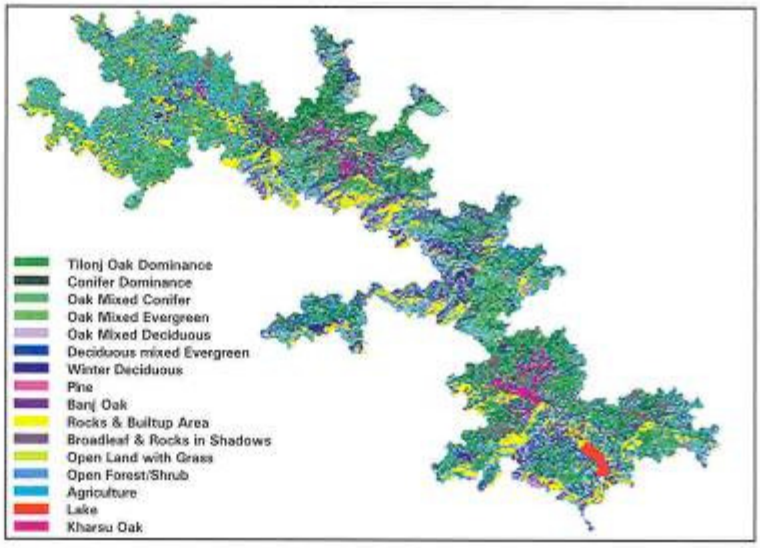


Fig. 13. Forest community association in outer Himalayan region

SDRE 6: Identification of Elite Genotypes of *Hippophae rhamnoides* for Multiplication and Large Scale Domestication in the Higher Himalayan Region of Uttaranchal *(DST funded: Period: 2003–2006)*

Background and Objectives

Vegetative propagation & awareness building on use & potential

Hippophae rhamnoides L. (Seabuckthorn), locally called 'Ames' is one of the few potential wild resource native of higher Himalaya that offers multipurpose benefits to the hill people. It can help to improve the degraded environmental conditions, as it has strong soil binding, water holding and atmospheric nitrogen fixing abilities. It provides firewood of high calorific value, and fruits, rich in vitamin C. In Uttaranchal this species still needs intensive screening and sustainable harvesting so that its full potential could be harnessed. The objectives of the study therefore were: (i) study of vegetative propagation potential of *H. rhamnoides*; and (ii) awareness building amongst local people about its potential, conservation, and management.

Results and Achievements

1. Rooting in stem cuttings of *H. rhamnoides* following treatment with growth hormones across four populations in Garhwal Himalaya revealed that 50 ppm of concentration of growth hormones i.e., Indole Butyric Acid (IBA), Naphthalene Acetic Acid (NAA) and Indole Acedtic Acid

- Impact of different concentration of growth hormones on rooting
- Awareness & training
- Documentation of indigenous/traditional uses of Ames fruit & fruit juice

(IAA), results in good percentile of rooting in stem cuttings as compared to 500 ppm. IBA has shown the best results followed by NAA and IAA (Fig. 14).

2. Indigenous/traditional knowledge about the uses of *Ames* fruits and fruit juice were documented. It is used to cure severe cold, cough, throat infections, and to reduce the poisonous effects of some plants grazed by livestock, mainly cattle, sheep and goat.

3. Awareness camps and training workshops organized in the study area. About 54 households in 11 villages in Niti and Mana valleys were trained in method of extracting Ames fruit juice.

Fig. 14. (A): Nursery of Ames; (B): Profuse sprouting and rooting of stem cuttings

SDRE 7: Technology Development, Demonstration, Training and Monitoring for Capacity Building in Rural Technologies

Demonstrations, development, monitoring & training of simple, local & cost efficient technologies

Background and Objectives

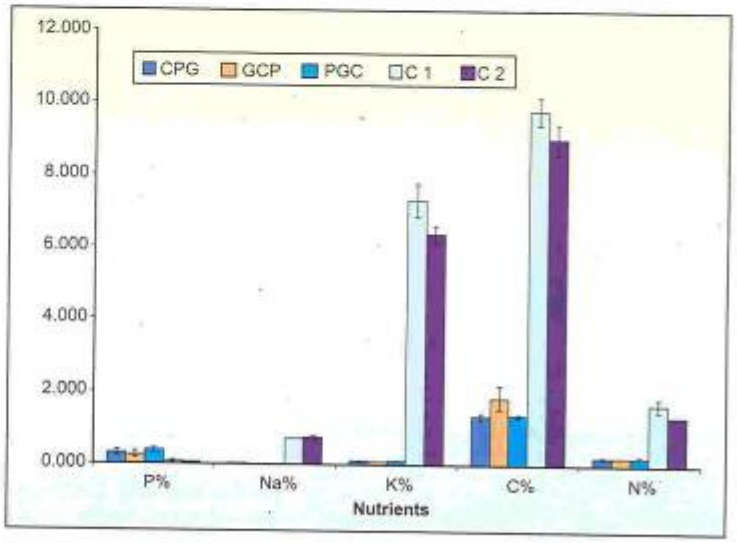
Agricultural development, globally, is moving towards organic farming with increasing awareness and consciousness about the deleterious effects of chemical fertilizers and pesticides. In the context of North East India, where most of the farmers are subsistence farmers, technologies and practices that are based on high external inputs, become inappropriate and inaccessible. Technologies, therefore, need to be adapted to local conditions and based on the principles of Low External Input for Sustainable Agriculture (LEISA). The inputs should also be based on locally available resources and be essentially simple, low cost as well as locally appropriate. The present activity aimed for maintenance and application of various rural technologies in the demonstration farm at Midphu and NE Unit campus; scientific monitoring of technologies and soil and water management models for their efficacy assessment in relation to physico-chemical parameters and production indicators, technology

upgradation/revision and their monitoring and assessments and technology demonstration and training to framers, NGOs and government officials.

- Demonstration of selected technologies & their assessment
- Technology experimentation
- SWC impacts of combination of bunding species

Results and Achievements

1. Selected technologies (weed composting, vermi-composting, liquid manuring, water nutrient management), irrigation technologies (*haandi* technology), moisture management and nutrient inputs (poly-filming, poly-tunnels, poly-pits), yield enhancing and maximizing returns per unit area technologies (trellies, modified jhuming, multi-tier cropping), fuel saving technologies (bio-briquetting) and bamboo propagation, etc. are being maintained, upgraded and scientifically monitored for their efficacy assessment.
2. The modified jhum plot showed increase in yield of *Curcuma longa* (turmeric), *Zingiber officinalis* (ginger) and *Cajanas cajan* (arhar). Other technologies also had significant impact on yield enhancement as well as improving nutrient release efficiency.
3. A study on the runoff, sedimentation and nutrient loss to see the impact of combination of bunding species in the modified jhum plot in the following combination: (i) Ginger, Colocasia, Pineapple (GCP), (ii) Pineapple, Colocasia, Ginger (PCG), and (iii) Colocasia, Pineapple, Ginger (CPG) indicated that runoff and sedimentation and nutrient losses were low in the plots treated with GCP (Fig. 15).



C= Colocasia P= Pineapple G=Ginger C1 & C2= Control

Fig. 15. Nutrient loss in modified jhum system during June to September, 2005.

SDRE 8: Traditional Pest Management Practices Among the Indigenous Tribes Practicing Shifting Cultivation in North East India: Documentation and Validation (*DST funded, Duration 2005-2007*)

Documentation & validation of traditional pest management practices of selected tribes

Background and Objectives

The importance of increased food grain production as well as protection from pests and diseases is of top priority to the resource poor farmers like the ones in upland areas of NE India. Agricultural productivity is constrained due to irregular rains, poor soil quality and loss due to pests and diseases. About 45% of the potential yield is lost to pests and diseases. As of now, the most common answer to this problem lies in the use of chemical (inorganic/ synthetic) pesticides. The consequences of pesticides use are well established. Therefore, the need of the hour is alternatives to chemical pesticides, which are environment-friendly and biodegradable. In this context, the traditional methods of pest management followed by the indigenous communities in NE India may be useful. The present study is an attempt to document such traditional pest management practices amongst the selected ethnic communities of north- east India along with validation of the same.

Results and achievements

- Documentation of pests & disease control practices
- Examples of practices based on biological means

1. Five villages were selected for in-depth investigation in the Harangajao block of North Cachar Hills district in Assam and Amlarem Block of Jaintia Hills district in Meghalaya where the average fallow period for shifting cultivation was recorded 5.1 years.
2. Regular cleaning and weeding, complete drying of terraces in case of worm infestation are some of the cultural practices. Manual picking of slowly moving insects like caterpillars, beetles; use of kitchen smoke for post-harvest storage, use of different types of traditional traps to catch larger pests like rats and monkeys were some of the mechanical methods employed for pest control.
3. Some biological pest control practices are- Use of crabs to attract *Leptocorisa* sp. in wet terraces; use of 'Thing Sapu' to control termites and other insects; use of 'Ar' to control chilly pests and use of tobacco leaf extract for repelling kitchen garden pests as well as stored grain pests were recorded.

SDRE 9: Augmenting Economic Security of Rural People Using Indigenous Bamboo Resources in the Indian Central (Uttaranchal) Himalaya (*DST Women Scientist Project; Period 2005-2007*)

Background and Objectives

World over bamboo is slowly but steadily gaining importance as a raw

Documentation of indegnous users and pactices of bamboo resource management, and capacity building on bamboo based livelihood options

material for cottage industries and other products. Bamboo plays an important role in the socio-economy of tribal and rural people and has been intimately associated with mankind since ancient time. The Planning Commission, Government of India has launched a massive programme 'National Mission on Bamboo Technology and Trade Development'. Accordingly the Govt. of Uttaranchal has also initiated a program on bamboo and taken step for plantations of selected species by establishing the Uttaranchal Bamboo and Fibre Development Board. The traditional knowledge on the use of bamboo by artisans and the constraints they are facing to improve the trade remains largely undocumented, which if done properly could make a useful compendium of information and development of this sector. Therefore the present study focuses on: (i) to document local practices bamboo resources management; (ii) the current and past utilization patterns along with regeneration and propagation practices of selected species; (iii) capacity building of local people and possibility of development and introduction of bamboo-based livelihoods for small-scale craft industries.

Results and Achievements

- Inventory of bamboo species across IHR
- Reconnaissnce on bamboo use in Hawalbaag block
- Bamboo harvest patterns of Landsdowne forest divison

1. An inventory of bamboo species of Uttaranchal (8 spp. with 5 genus) as well as other Himalayan states was prepared (79 spp and 22 genera). Survey in 5 villages in Hawalbagh block (Almora distt.) revealed that bamboo and ringal articles made by the local people and sold in nearby villages/towns and earning (range= Rs. 1200-3000) monthly/artisan. The prices of the items are not fixed and maximum profit is earned by middlemen.

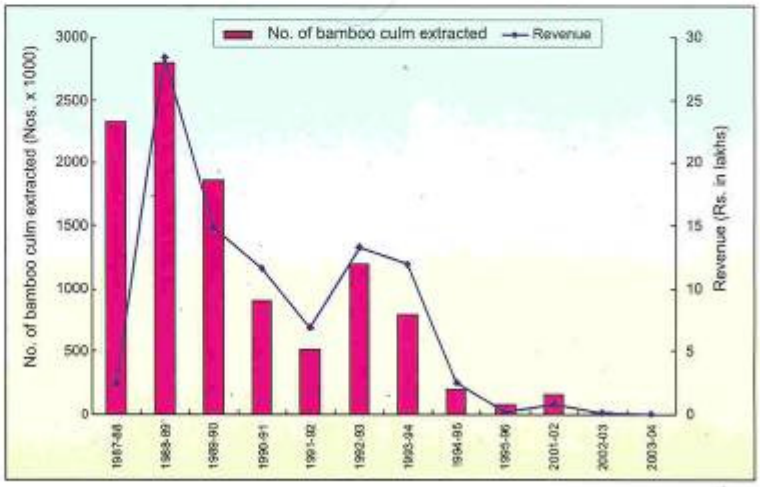


Fig. 16. Quantum of bamboo harvested and annual revenue generated in the Lansdowne Forest Division, Uttaranchal state

2. Secondary data collected on quantum of harvests and revenue earned from bamboo in Lansdowne Forest Division (Pauri-Garhwal) indicate that the maximum felling was done in 1988-89 when nearly 2.8×10^6 culms were harvested that generated a net revenue of Rs. 28.4 lakh; the quantum of harvest and income declined in the following years (Fig. 16).

BOX – 3
Summary of Completed Projects

Assessment of NTFPs Potential and Harvests and Local value System (In House)

North-east region of India is of exceptional biogeographic interest with high floral and faunal diversity. The region is also home to over 100 tribal communities, majority of whom are dependent on various types of NTFPs for their day-to-day needs as well as income generation. NTFPs have also wide potential to be commercially exploited to meet the industrial demands. In this investigation efforts were made (i) To screen out important NTFPs of North-east region that have got wide market potential; (ii) To assess distribution, utilization and natural status of selected species; (iii) To analyse composition of selected species; and (iv) To identify conservation strategies for the selected NTFPs so that their natural status can be known and suitable strategies can be formulated for their conservation along with scientific exploitation.

- Inventorization of the NTFPs was carried out through review of forest revenue records of seven states or North-east India, three Autonomous District Councils of Meghalaya and one district council of Assam; local market survey at Tura, Garo Hills, Meghalaya and Haflong, N.C. Hills, Assam; and from government agencies, viz. NEDFI, APEDA.
- The review of forest records from 1993-2003 of seven states revealed that 55 NTFP items are being marketed from different states. Manipur has the highest (31 numbers), followed by Arunachal Pradesh (26 nos.), Assam (9 nos.), Nagaland (5 nos.), Meghalaya (4 nos.), Tripura (3 nos.) and Mizoram (2 nos.).
- The NTFPs collected from the region can broadly be classified as bamboo and canes, medicinal plants, spices, resin, fibre, edible products, thatch, dye, broom grass, agar, katha, sandal wood, honey, etc. Of the 55 marketed species, the whole plant (12.7 %) or plant-parts such as stem (9.1 %), bark (9.1 %), leaves (30.9 %), flowers (5.5 %), seeds/ fruits (16.4 %), roots (3.6 %), rhizome (1.8 %), resin (3.6 %) and other parts (7.3 %) are used for diverse purposes (Fig. 17). Apart from these NTFPs, items such as stone/ boulders, sand, earth/clay that are equally important forest resources fetch considerable amounts of revenue in all the seven states.
- Local market survey for NTFPs in Tura, Garo Hills, Meghalaya revealed that 28 items are being marketed mostly for use as food. All these items are collected from jhum fields, home and kitchen gardens.

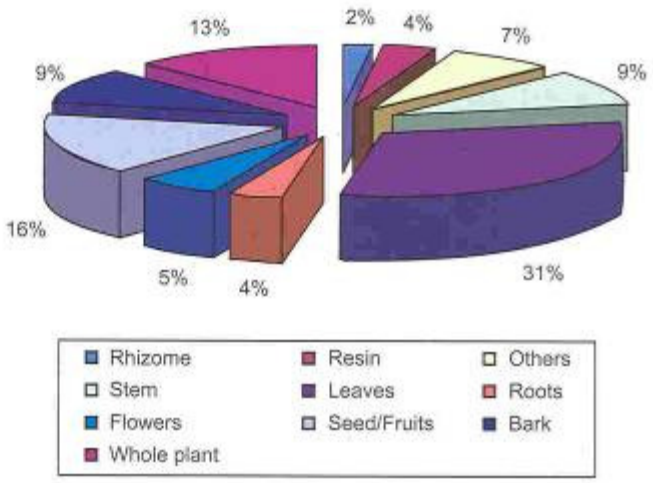
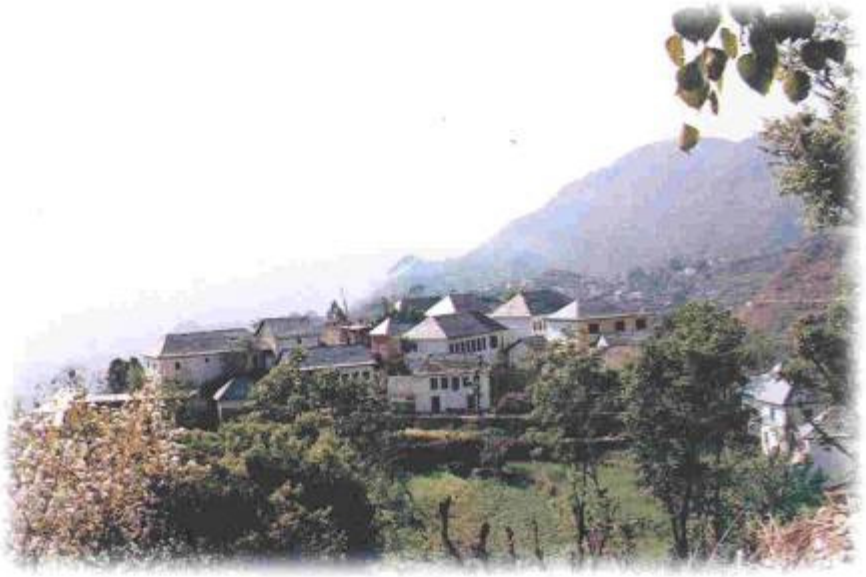


Fig. 17. Plant part/components contributing to the NTFP economy in Northeast India.



CORE PROGRAME-III

CONSERVATION OF BIOLOGICAL DIVERSITY (CBD)

The importance of maintaining Himalayan Biodiversity for human well-being not only in the region but across the world is well recognized. With this understanding, CBD is strengthening its activities in IHR through location-specific as well as cross cutting programmes. The activities are responsive to contemporary global thinking, especially the provisions pertaining to Mountain Biodiversity, under Convention on Biological Diversity. The aim is to harness potential bio-resources and minimize the pressure on biodiversity assets. The umbrella programmes include: (i) Bioresource inventory of the Himalaya , which focuses on documentation and prioritization of important components of biological diversity; (ii) Studies on Biodiversity, which includes in-depth assessment and monitoring of the important components of biodiversity and the processes responsible for depletion of biodiversity; (iii) Establishment of gene-banks - to complement in situ conservation with the help of ex situ methods; and (iv) Peoples' Participation in Biodiversity Conservation - to promote participatory mechanisms for Himalayan biodiversity conservation.

CBD 1: Bioresource Inventory of the Himalaya

Background and Objectives

Development of inventory for bio-resource database

Realizing the fact that adequate baseline information on biological resources at different levels (i.e. species, population, community, habitat, ecosystem, etc.) can help in identification of priorities for conservation and ensuring sustainable use, the secondary datasets available from different published and unpublished sources are being compiled and analyzed for development of an authentic database. In this context, preparation of inventory of Himalayan bioresources (family, group and area wise) has been initiated to: (i) develop systematic database of native/endemic species and their habitats; (ii) draw information about various attributes of specific habitats/species; and (iii) prioritize species and sites for conservation.

Results and Achievements

A. Floral Inventories

- Status of endemics across temperate dicotyledons
- Endemic richness
- Inventory of angiosperms and woody species

1. The temperate dicotyledonous families were analyzed for the diversity (3333 species, 532 genera) and distribution of endemics, which revealed 57.7% endemism (endemic 13.0%, near endemic 44.7%). Proportionately endemics in temperate families increase towards high alpines (Table 8).

Table 8. Altitudinal representation of endemics in temperate plants

Altitude zone(m asl)	Endemics (%)	Near endemics (%)	Others (%)
Subtropical (<1500)	31(3.7)	229 (27.1)	584 (69.2)
Temperate (1501-3000)	201 (10.5)	894 (46.7)	818 (42.8)
Alpine (3001-4500)	244 (13.8)	1046 (59.3)	473 (26.8)
High Alpine (>4500)	48 (9.4)	336 (65.8)	127 (24.9)

2. Across life forms, endemic richness is more in herbs, followed by shrubs and trees (Fig. 18). Among biogeographic provinces, in Trans/Northwest, West and Central Himalaya the majority of endemics are represented by herbs. On the contrary, in East Himalayan province tree and shrub endemics are prevalent.

3. Inventory of angiosperms (4,300 species) of the Trans, North-West and West Himalaya was prepared, which includes information on over 3000 species from the Himachal Pradesh. Also, information on 600 woody species of Sikkim was compiled.

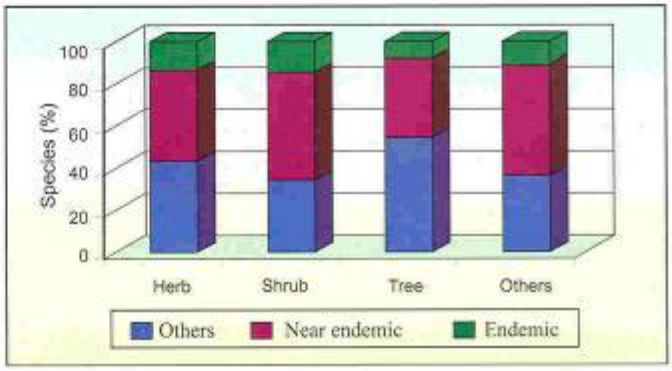


Fig. 18. Distribution of temperate endemics in life form categories

B. Faunal Inventories

- Icthyo-faunal study of streams in NE
- Inventory of birds across HBR and their threat status

1. A study on ichthyo-faunal population and diversity in Senkhi stream, Papum Pare district, Itanagar, (AP revealed presence of 47 species (16 families, 32 genera) of fishes and 2 species of crustaceans [i.e., prawn-Macrobrachium sp. and crab-*Barytelphusa (Maydelliathel phusa) lagubris lagubris*]. The families showed an even pattern of distribution except that of dominant family Cyprinidae comprising 49% of total ichthyofauna.

2. *Barilius bendelisis*, a column feeder, dominated in population. The scattered graph plotted for *Barilius bendelisis* (2702), with respect to length and weight and breadth and weight showed significant relationship (Fig. 19 a & b). Similar relationships were observed for *Psilorhynchus balitora* (607), a dominant bottom feeder (Fig. 19 c & d). The enumeration of ichthyo-fauna, has confirmed two new records for the State (*Glyptothorax telchitta* and *Balitora brucei*).

3. An inventory of 738 species of birds (64 families and 20 orders) has been prepared across the Himalayan Biosphere Reserves (HBR). Of these, 209 species fall under different IUCN categories of threat [critically endangered - 11; endangered - 4; vulnerable - 29; low risk near threatened - 20; low risk least concern - 30 and data deficient - 135].

CBD 2: Studies on Biodiversity

Background and Objectives

Study of distribution of bioresources, their use pattern and dynamic

Need for in-depth studies, to understand the patterns and processes at different levels of biodiversity, is being stressed across the world. In the IHR, a region representing richness and uniqueness of biodiversity elements, such needs assume greater significance. However, lack of authentic datasets at different levels has emerged as major impediment in formulation and

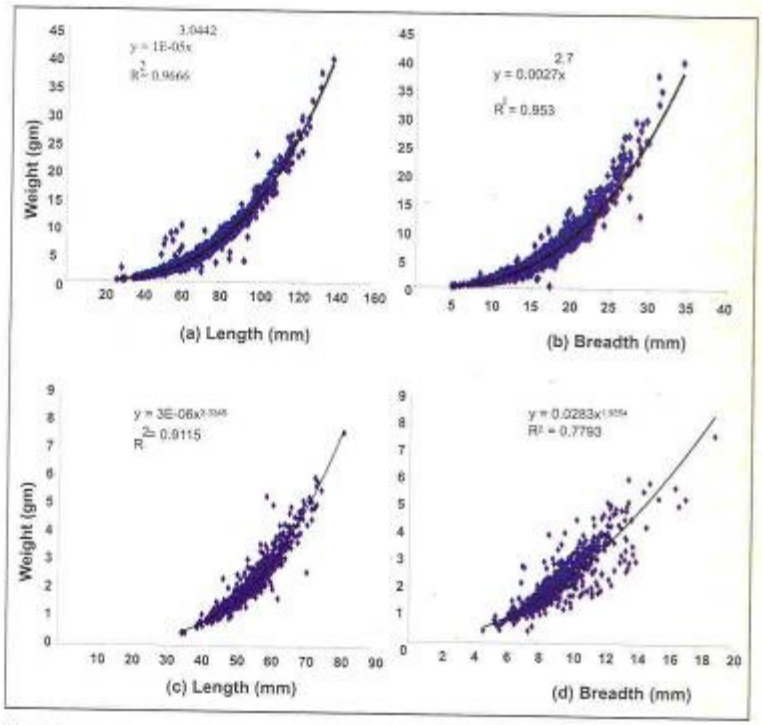


Fig. 19. Length-weight relationship of (a) *B. bendelisis*, (c) *P. balitora;* Breadth-weight relationship of (b) *B. bendelisis*, (d) *P. balitora;*

implementation of appropriate strategy/plan for optimal use and maintenance of biodiversity. In view of this, the study focuses on: (i) investigating distribution of bioresources and their use patterns in biodiversity rich areas, (ii) studying dynamics and functional features of biodiversity in response to disturbance, (iii) assessment of diversity of important (ecologically and economically) species across altitude and disturbance gradient.

Results and Achievements

(a) Biodiversity Rich Areas - Protected Areas

Khokhan Wildlife Sanctuary (KhWLS)

- Delineation of forest communities
- Uses of plant resources

1. Data generated from 65 sites (between 1640-2400m) revealed presence of 17 forest communities. *Cedrus deodara* with maximum representation in sites (n= 19), followed by Quercus leucotrichophora (7), *Abies pindrow* (6), *Quercus semecarpifolia* (5) are most frequent forests.

BOX - 4

Summary of the Completed Project

(September 2004- March 2006)

Conservation & Management of Pollinators for Sustainable Agriculture, through and Ecosystem Approach

(FAO/GEF PDF-B funded)

- The Institute, as National Implementing Agency, completed the PDF-B phase of the project. The major output of the PDF-B for India (focus area - IHR) was the Stocktaking Report on following components of the project (i) *Knowledge base*: (a) description of agroecosystems/ farming systems (b) Information on crops and their pollinators, (c) information on insect diversity and distribution; (d) general status of pollinators in relation to crops; (e) declining populations of natural insect pollinators; (f) information on pollinators interaction; (g) best management practices; (ii) *Capacity building and awareness raising*: (a) Government departments and research organizations; (b) farmers associations, khadi mission, etc., (c) support programmes; (iii) *Sharing experiences and dissemination of results*: (a) means of sharing experiences among experts, (b) conveying with farmers and public, (c) Interdisciplinary and inter-regional exchange, (d) existing data base and other information networks.
- The stocktaking report was an outcome of two stocktaking workshops - (i) National Stakeholders Workshop (Oct. 8-9, 2004) and (ii) National Partners Workshop (Nov. 29 - Dec. 1, 2004), and extensive review of existing information.
- The major signals of PDF B Stocktaking include: (i) relatively poor data base on trends of population decline and causes of decline; (ii) inadequate efforts to promote indigenous pollinators (e.g. *Apis. cerana*) populations; (iii) fewer investigations on availability, conservation and management of non-*Apis* pollinators; (iv) fragmentary data sets on proportionate contributions (pollination service) of pollinators to different crops; (v) lack of ecological data sets *on crop-pollinator-wild* habitat interlinkage; (vi) inadequate taxonomic information on pollinators and their food base (flora); (vi) relatively poor knowledge base on pollinators and their services in central/eastern Himalaya; (vii) lack of user friendly (multi stakeholder) data base on pollinators/pollination services.
- Considering the inputs of partners and field visits by the representatives of executing agency three sites have been identified as potential STEP sites for Global Full Size Project: (i) Upper Kosi watershed (Distt. Almora, Uttaranchal); (ii) Upper Kullu Valley (Distt. Kullu, Himachal); (iii) Mamlay watershed (Sikkim).
- Based on the information generated and documents prepared during PDF-B phase, Institute participated in the process of development of full size global project that has been endorsed by the Government of India.

2. Among plant resources, 68 species (35 trees, 9 shrubs, and 24 herbs) fall under different use category (medicine-23, fuel- 24, wild edible/food-20, fodder-22, timber- 4, religious-7, agricultural tools (3), and other purposes (15 spp.). Probability of use and resource use index of highly preferred fuel species has been analyzed (Table 9).

Table 9. Mean collection, probability of use and resource use index of preferred fuel species in KhWLS

Species	Mean collection (kg household-1 year -1)	Probability of Use (PU)	Resource Use Index (RUI)
Abies pindrow	1138.0	0.51	601.00
Cedrus deodara	756.0	0.31	455.06
Cornus macrophylla	432.0	0.23	117.24
Desmodium elegans	474.0	0.27	147.45
Picea smithiana	1204.8	0.52	806.64
Pinus wallichiana	1357.5	0.43	720.38
Pyrus malus	244.8	0.16	52.80
Quercus floribunda	1593.0	0.46	897.75
Quercus glauca	1392.0	0.55	765.60
Q. leucotrichophora	1812.0	0.49	998.70

Kais Wildlife Sanctuary (KaWLS)

- Delineation of PU and RUI
- Demographic structure of Abies pindrow community

1. Survey revealed presence of 9 forest communities (*Abies pindrow* community is most frequent) and 400 species of vascular plants. Of the total plant species, 37 are used as fuel. *C. deodara* (PU=0.60; RUI=792.08), *P. smithiana* (PU=0.52; RUI=742.05), *Pinus wallichiana* (PU=0.61; RUI=642.68), *Alnus nitida* (PU=0.44; RUI=404.03); *Aesculus indica* (PU=0.40; RUI=291.90), Berberis lycium (PU=0.36; RUI = 231.48), *Celtis australis* (PU = 0.34; RUI = 145.69) and *D. elegans* (PU=0.33; RUI=114.30) were among most preferred fuel species.

2. Demographic structures of A. pindrow, the most frequent community, are presented (Fig. 20).

Manali Wildlife Sanctuary- MWLS

- Identification of forest communities
- Regeneration patterns of (*Cedrus deodara*)

1. Sampling across 34 sites (2218-3500 m) resulted in identification of 9 forest communities. Of which, *Picea smithiana* and *C. deodara* are most frequently distributed. Tree density of forests ranged between 70-1160 ind. ha-1

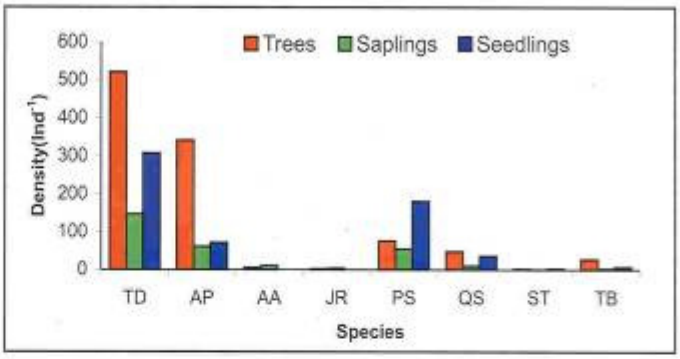


Fig. 20. Population structure of *Abies pindrow* community in Kais Wildlife Sanctuary (TD=Total density; AP=*A. pindrow*; AA=*Acer acuminatum*; JR=*Juglans regia*; PS=Picea smithiana; QS=*Quercus semecarpifolia*; ST=*Salix tetrasperma*; and TB= *Taxus baccata* subsp. *wallichiana*)

2. Regeneration patterns of *C. deodara* communities are presented (Fig. 21).

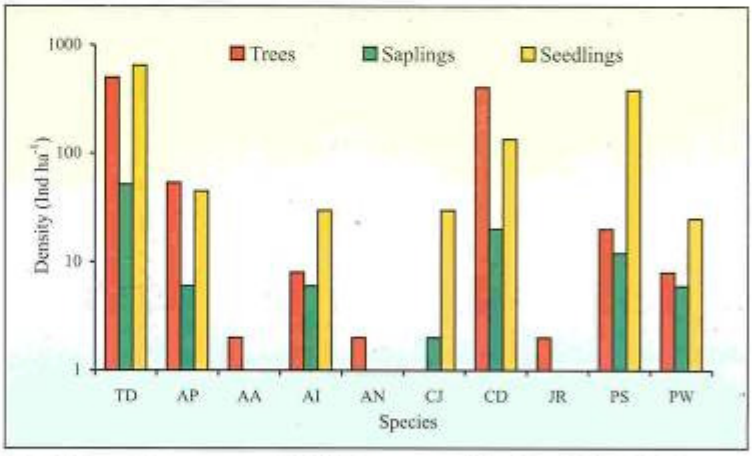


Fig. 21. Population structure of *C. deodara* community in Manali Wild Life Sanctuary (TD=Total density; AP=*Abies pindrow*; AA=*Acer acuminatum*; AI=*Aesculus indica*; AN=*Alnus nitida*; CJ=*Corylus jacquemontii*; CD=*Cedrus deodara*; JR=*Juglans regia*; PS=*Picea smithiana*; and PW=*Pinus wallichiana*)

Proposed Cold Desert Biosphere Reserve (MoEF funded)

1. Resource utilization pattern of the reserve showed use of plants as: fuel-42 spp., fodder -27; medicine-84; wild edible-44; religious-14; timber-

11, and miscellaneous-34. Fuel extraction trends in 13 villages were assessed.

- Enumeration of plant use.
- Regeneration patterns and successional changes in population composition.

2. Regeneration patterns of trees in *A. pindrow*, *C. deodara*, *P. smithiana*, and *Betula utilis* communities indicated changing trends in structure due to possible replacement of dominants by co-dominant species (i.e., *A. pindrow* by *P. wallichiana*; *C. deodara* by *Juniperus polycarpous* and *Pinus wallichiana*; *P. smithiana* by *J. polycarpus*; and *Betula utilis* by *A. pindrow*).

(b) Biodiversity patterns along disturbance gradient

Study on structural and functional features of vegetation diversity across different intensities of canopy disturbance in three forests of Kumaun (west Himalaya), has been completed. The outcome of the study is summarized (Box 5).

(c) Studies on sensitive species

- Investigation into distribution and demography of *S. chirayita* in W.Himalaya

1. Eleven natural populations of Swertia chirayita were investigated in Sikkim. Non-significant correlation ($r = 0.1997$; $p<0.05$) obtained between altitude and average plant density. Identification of 14 micro-habitats revealed rock crevices support maximum plant density (57 ind/m2). Stem height ($r = -0.464$; $P< 0.01$) and collar diameter ($r = 0.272$; $P< 0.01$) significantly correlated with altitude.

2. Study in west Himalaya on *S. chirayita* (5 populations) revealed density of plant ranging between 1.65 to 2.35 ind. m^{-2} (Fig. 23). The frequency of occurrence was high (90-95%) in all the populations and either matched or exceeded the frequency of other dominant species in the plot. It was noticed that the species performs better on a southwest slope under conifer mixed broad-leaved forest. Specific populations, Kanchula locality in present case, with highest biomass (above and below) and maximum density exhibit plus attributes for consideration for mass multiplication.

CBD 3: Establishment of Gene-Banks Across the Himalaya

Background and Objectives

Enrichment of germplasm at institute HQs units cross IHR

In order to develop a germplasm bank of Himalayan plant species and ensure ex situ conservation of rare-endangered, endemic and economically important species, enrichment of germplasm in arboreta (HQs, and Sikkim Unit), herbal gardens (HQs, Sikkim and HP Units) and demonstration sites (Lata - Distt-Chamoli, UA) have been developed. The activity focuses on: (i)

establishment of ex situ gene bank of Himalayan species including economically important ones; (ii) development of propagation protocols for locally acceptable plants; and (iii) large scale multiplication of important species and making the saplings available at local level.

BOX - 5

Summary of the Completed Project
(2005- 2006)

Studies on the Floristic Diversity of the Hamta-Jagatsukh Catchments in Himachal Pradesh
(WPA, New Delhi funded)

Considering the need of having detailed inventory of biodiversity resources in a potential hydropower project areas for assessment and prediction of the loss of biodiversity due to construction of dam, tunnels, etc., this short term study was initiated with the objectives to: (i) assess the floristic diversity; (ii) assess the communities of the potentially high project impact areas; (iii) assess the human dependence on biodiversity; (iv) identify the rarity of the species; and (v) assess the current impact of local communities on floristic diversity of the catchment. Major findings of the project are:

- A total of 619 species (trees- 44; shrubs- 86; herbs- 438; ferns- 51) belonging to 258 genera and 116 families of the vascular plants were recorded.
- Sampling across 54 sites resulted in identification of 23 communities (Forests: 14; Shrubs: 2; Alpine Scrubs: 4; and Alpine Herbs: 3). Amongst the identified communities, *Picea smithiana* with presence in 12 sites revealed maximum frequency of occurrence. Communities in the potentially high impact area were assessed (14 communities: Forests- 12; Shrubs- 2).
- Of the total, 441 species are being used by inhabitants as medicine, wild edible, fodder, fuel, house building, making agricultural tools, religious and various other purposes.
- Considering IUCN threat categories, 27 species have been identified under different threat categories.
- Current impact of local communities on floristic diversity assessed. Floristic diversity at different levels discussed and appropriate strategy and action plan suggested for the conservation of floristic diversity of the high project impact areas.

BOX - 6
Summary of the Completed Project
(2005- 2006)

Management Plan for Medicinal Plants in the Catchment Area of Parbati Hydro Electric Project Stage - III (520 MW) in District Kullu, Himachal Pradesh
(NHPC, H.P. funded)

The Stage III of the Parbati H.E. Project is a run of the river scheme on river Sainj downstream of Power House of Parbati H.E. Project Stage II. The catchments harbour unique biodiversity including medicinal plants (MPs). Due to development of tunnels and reservoir, the biodiversity of the area is being affected. Therefore, the project has been initiated to: (i) prepare an inventory of MPs of the dam submergence area; (ii) identify status and habitat preference of the MPs; and (iii) develop management plan for the MPs. The outcomes include:

- The catchment harbours 104 species of MPs [i.e., trees (23), shrubs (22), herbs (57) and ferns (2)]. Of the identified species, 30 (29%) are Himalayan native; 9 species native to Himalayan Region and adjacent countries. Among natives, 9 species are near endemic.
- Amongst the MPs, Zanthoxylum armatum has been categorized as endangered and Valeriana wallichii as vulnerable. The other species i.e., Rhus javanica, Thalictrum foliolossum, Salvia lanata, Rubia cordifolia, Bergenia ligulata and Hedychium spicatum may also be considered as threatened due to their over exploitation for trade.
- Considering the mode of propagation, over 86% species propagate by means of seeds, 7.7 species by seeds and rhizomes/roots/tubers, and 2.9 species by seeds and cuttings, and a fewer species (2) by sori.
- Management plan for the cultivation and conservation of the MPs of Dam submergence area and commercially viable MPs of the catchment area has been suggested, which includes ex situ conservation of species of the dam submergence zone, prioritization of species for cultivation and conservation, provision for MPs nurseries, capacity building plans, etc.

Results and Achievements

A. Enriching Gene Banks

Arboreta & Herbal Garden (HQs; Sikkim & HP Unit)

1. The *ex situ* gene-bank site of HQs (arboretum, herbal garden) and nursery was enriched with expansion of infrastructure. The site is being upgraded

BOX - 7

Summary of the Completed Project
(2002- 2005)

Dynamics of structural and functional features of biodiversity in response to disturbance gradient in forests of Kumaun Himalaya
(DST, New Delhi funded)

The study focused on assessment of responses against increasing level of disturbance in three different oak forests. Attempts were made to (i) assess biodiversity patterns (structure/composition) across various disturbance intensities of identified forests, (ii) analyze impact of disturbance on selected ecosystem properties (i.e. litter fall, decomposition and nutrient release etc.) and (iii) examine the relative role of forest disturbances on recovery and maintenance (regeneration) of species diversity in different forest ecosystems. The outcome of the study include:

- Development of a matrix for characterizing disturbance level in *Quercus leucotrichophora* and *Q. floribunda* forests of Kumaun Himalaya on the basis of different anthropogenic disturbance attributes (i.e. lopping, grazing, and practices of management, etc).
- Across disturbance intensities compositional patterns in three oak forests varied considerably. (i) in banj-oak (*Q. leucotrichophora*) forest, mean tree density, total basal area (TBA), shrub density and sapling density in degraded stands was significantly low ($p<0.05$) as compared to protected site. Whereas, the herb density increased from protected (4813 ind. ha-1) to degraded (83666 ind. ha-1) but increase was not significant ($p>0.05$); (ii) in case of moru-oak (*Q. floribunda*) forest, tree density and TBA declined towards the semi-degraded thereafter showed an increase towards degraded stands. Seedling, sapling, shrub and herb density did not show specific patterns; (iii) for kharsu-oak (*Q. semecarpifolia*) forests significant decline from protected sites to degraded sites was observed for tree density and herb density. On the contrary significant increase was recoded in shrub density.
- The demographic patterns showed variation towards high disturbance sites of *Q. leucotrichophora* forests. The dominant, *Q. leucotrichophora*, exhibited accumulation of individuals in young tree class. The co-dominants Myrica esculenta in semi-degraded unprotected and Lyonia ovalifolia in degraded sites was responsible for change in overall demographic profiles. For *Q. floribunda* forest, the dominant species showed change in patterns in semi-degraded unprotected site where a greater accumulation of sapling was revealing. Characteristically declining population (with absence of recruits) of dominant species in high disturbance site of *Q. semecarpifolia* forest was recorded.
- Across disturbance level, in all the studied oak forests, litter fall was recorded highest in protected sites, which decreased towards the higher

disturbance sites. The decomposition data revealed highest rate of decomposition in protected site of *Q. leucotrichophora* and *Q. floribunda* forests.

- The specific investigations on mistletoe infestation across disturbance gradient revealed that Taxillus infestation on banj-oak forest is associated with higher lopping intensity. On an average, across lopping intensity, the infestation on *Q. leucotrichophora* varied between 21.6% (low lopping) to 45.6% (high lopping). Results revealed that infestation is affected significantly ($p<0.01$) not only by lopping intensity but also by the size of trees. Mean infestation was significantly ($p<0.01$) more in high lopping sites (45.6%) as compared to moderate lopping (29.9%) and low lopping (21.6%) sites (Fig. 22).

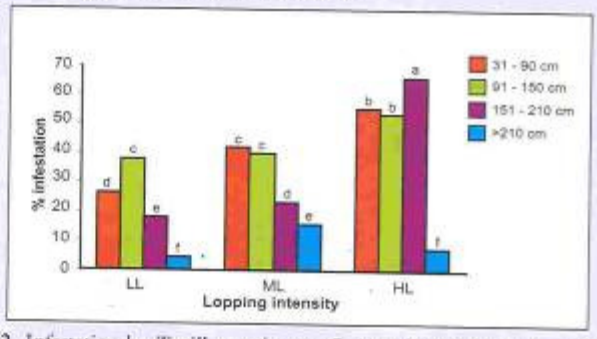


Fig. 22. Infestation by *Taxillus vestitus* on *Quercus leucotrichophora* at different lopping intensities and across different CBH classes. Bars with different lower case letters are significantly ($P<0.05$) different

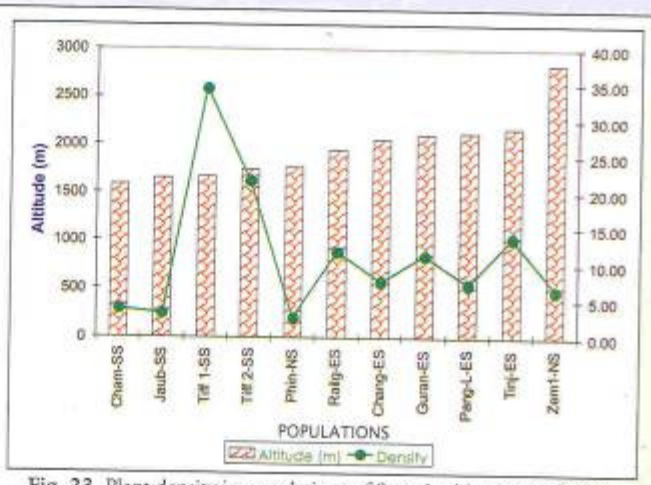


Fig 23. Plant density in populations of Swertia chirayita in Sikkim

- Enrichment and up gradation of gene banks
- Cataloguing and assessment of woody taxa, and establishment of Pt G.B. Pant Smriti Vatika at Sikkim campus
- Land acquision for the arboretum at HP unit

as nature interpretation site. The nursery remained a major source for ensuring planting material availability to various eco-restoration sites of the Institute. Over 7500 saplings were made available for internal use in the Institute and over 2000 saplings of multipurpose trees (MPTs) were distributed among the schools and other stakeholders in the region.

2. At Sikkim Unit (Pangthang), in view to catalogue and monitor the existing woody gene resource in campus, all taxa > 10 cm dia, have been targeted to map, measure and tagging. Over 1725 individuals covering >50 taxa were tagged and assessed. A 'Smriti Vatika' (area, 0.6 ha) in the memory of Pt. G.B. Pant was initiated (Fig. 24).

Fig. 24. Smriti Vatika at Sikkim Unit campus, Pangthang

3. The HP Unit took possession of the 1.94 ha land for the establishment and maintenance of the functional arboretum. Herbal gardens at different locations (Kosi-Katarmal, Almora; Pangthang - Sikkim and Mohal - Kullu) were further enriched with new accessions (over 40 spp.).

B. Propagation protocols and cultivation packages

Medicinal Plants (HQs)

- Experimentation on germination response of *S. angustifolia*

1. At HQs, experiments to improve germination of *Swertia angustifolia* (family Gentianaceae) revealed variation in germination responses among populations in controlled condition (16-32%). KNO3 (200 mM) significantly improved germination (Sa1-81.3: Sa2-80.0%) as compared to control. However, in other three populations KNO3 (100 mM) improved germination (Table 10). The treatments also significantly reduced mean germination time (MGT).

Table 10: Effect of different concentrations of KNO3 on germination of S. angustifolia seeds from different provenances

Population	Treatments (mM)				LSD (P<0.05)	F
	Control	100	200	400		
Sa1	31.33	72.66	81.33	53.33	13.21	33.92
Sa2	22.66	73.33	80.00	35.33	13.16	55.31
Sa3	18.66	58.66	24.66	44.00	16.92	13.72
Sa4	32.00	67.33	23.33	29.33	17.55	15.41
Sa5	25.33	76.00	37.33	30.00	13.97	32.79
LSD (P<0.05)	7.65	10.62	17.49	17.10		
F	5.48	4.46	29.56	3.75		

- Study of germination response of *H. perforatum* and monitoring of seed germination of potential species

2. At HP Unit, seed germination experiments were conducted on *Hypericum perforatum*. Among different treatments (i.e., GA3, Indol Acetic Acid, KNO3, Thiourea, and Sodium Hypo Chloride) highest germination was observed in GA3 (70.0%), followed by KNO3 (71.1%) and Sodium Hypo Chloride (44.4 %) (Fig. 25). Seed germination of *Trichosanthes tricuspidata*, *Hedychium spicatum* and *Hyoscymus niger* was monitored in the germinator at 25°C. *H. niger* showed highest germination (i.e., 93.3%), followed by *H. spicatum* (90.7%) and *T. tricuspidata* (62.2%).

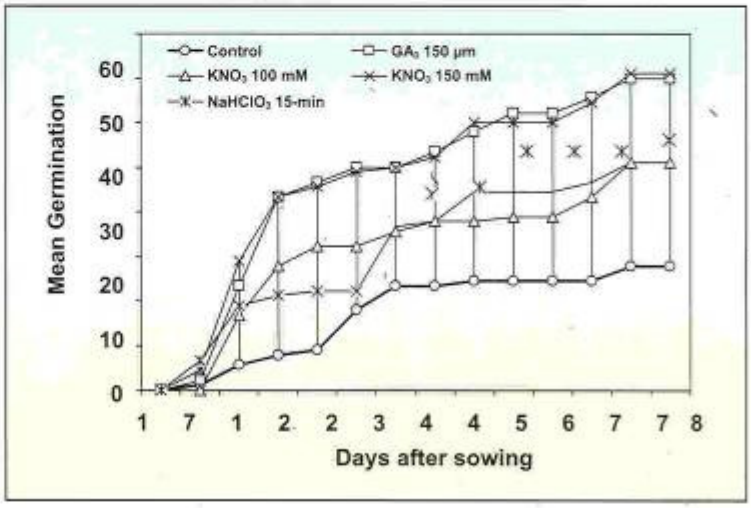


Fig. 25. Germination performance of seeds of *Hypericum perforatum* in different treatments

Seed germination of *Dioscorea deltoidea* showed highest germination (i.e., 78%), followed by *Heracleum candicans* (43.50%), *Grewia oppositifolia* (40%), and *Artemisia parviflora* (15%) in the nursery beds.

• Development of protocol for somatic embryogenesis and synthetic seed.

3. Under a CSIR Scheme at HQs, protocol for somatic embryogenesis and synthetic seed production in *Selinum tenuifolium* was developed. Mature leaf explants induced 87% callus in MS medium containing 3 µM 2,4-D. Maximum production of globular structure, their differentiation into embryos and germination occurred with a combination of 2 µM BA and 2 µM IBA. The addition of MS medium to the alginate capsules (3% Sodium alginate and 100 mM calcium nitrate) improved their germination rate to 77.8% as compared to control (57.8%). Over 66% plantlets survived under nursery condition (Fig. 26).

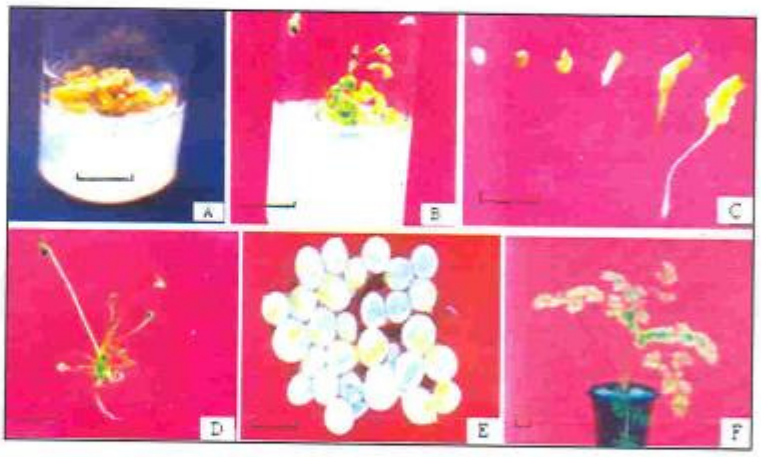


Fig. 26. Somatic embryogenesis and plantlet regeneration via synthetic seed in S. tenuifolium. [A- embryogenic callus, B- different stages of somatic embryos, C- encapsulated somatic embryos, D- germination of synthetic seed, E- plantlet from synthetic seed, F- acclimatized plantlet]

High Value Trees

In vitro propagation of apple cv. Green Sweet and survival monitoring of transplantations

1. While attempting propagation and improvement of apple root stock (under DBT Funded project), in vitro propagation of cv. Green Sweet has been achieved. Well rooted shoots (plantlets) taken out from rooting medium transferred to the pots containing a potting mixture of vermiculite: perlite: soil (2:1:1). In spite high mortality, the survived plantlets remained healthier till 8 weeks of transplantation (Fig. 27).

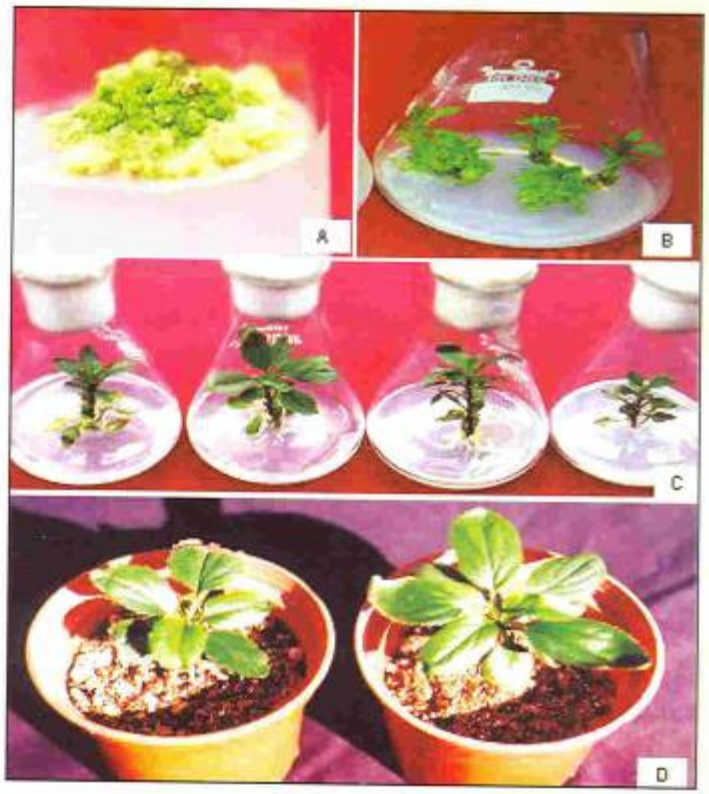


Fig. 27. In vitro propogation of apple cv. Green Sweet. A- Callus, raised through nucellus; B- Shoot induction and multiplication; C- *In vitro* rooting; D- Six weeks old *in vitro* raised plantlets

BOX - 8

Summary of the Completed Project
(2002- 2006)

Centrally Sponsored Scheme- Macromanagement of Agriculture Supplementation/Complementation of States' Efforts Through Work Plans- for Development of Medicinal and Aromatic Plants
(DASD, Kerala, funded)

This project envisaged to: (i) establish and maintain medicinal and aromatic plants (MAPs) in the herbal gardens at different altitudes of Uttaranchal, Himachal Pradesh and Sikkim, (ii) develop nurseries for distribution of planting material of selected high value medicinal and aromatic plants in Uttaranchal and Himachal Pradesh, (iii) promote transfer of technology through national, state and district level seminars and farmers training, and (iv) establish a regional analytical laboratory for quality testing. The major outcomes of the study are:

- Established herbal garden in 3.5 ha area (1.0 ha at Doharnala, HP; 0.5 ha at Pagthang, Sikkim and 2.0 ha at Kosi-Katarmal, UA). Over 120 species being maintained in these gardens. Production of MAPs and distribution of planting material was ensured from these gardens.

- Established a Regional Analytical Laboratory (RAL) at Kosi- Katarmal, with updated infrastructure including analytical equipments i.e. Gas Chromatography, Clevenger apparatus (essential oil extraction/ aromatic oil extraction), microwave extraction system etc. The laboratory is fully functional and provides analytical support to the different stakeholders.

- RAL has started generating authentic datasets for high value medicinal plants of the region. For example, analysis of different species of Berberis was conducted to estimate Berberine alkaloids across altitude and forest types. The study revealed that the lower altitude populations have better quantity of the alkaloids and pine forest is the best habitat for optimal berberine contents.

- Two state- levels Seminar on *Mainstreaming Medicinal Plants for the Development of the Region* organized for States of Uttaranchal and Himachal Pradesh and one district level meeting on *Aushdhiya Padapon Ki Vikas Mein Bhumika: Sambhavanyea Evam Kathiaiyan* was organized in Champawat district (Uttaranchal).

BOX - 9
Summary of the Completed Project
(2002- 2006)

Assessment of Existing Stock and Scaling-up Productivity of Selected High Value Himalayan Medicinal Plants Through Biological and Biotechnological Approaches
(NMPB, New Delhi funded)

The project was initiated with the objectives to: (i) quantify the availability of identified species in selected representative sites of Uttaranchal Himalaya, (ii) develop propagation protocols through conventional and *in-vitro* approaches, (iii) develop herbal garden of propagated plants for *ex -situ* conservation and demonstration, (iv) inventories of selected medicinal plants of Uttaranchal, (v) maintain a herbarium, and (vi) organize State-Level Seminar. The project outcome includes:

- Population assessment of target species in selected sites (Picrorhiza kurrooa - 11; *Aconitum balfourii* -6) of Uttaranchal was conducted. *P. kurrooa* populations occupy an altitude range between 3340-3880 m asl and prefer moist slopes. Density ranged from 1.43 ind. m-2 (Valley of Flowers) to 5.35 ind m-2 (Bhujanikhan). *A.balfourii* prefers moist slopes between 3300-3700 m and density of species varies from 0.48-5.55 ind m-2.
- Datasets generated on morphological variability (i.e. plant height; root length and diameter; leaf number, length and width; below and above ground biomass, etc.) of these two selected species.
- Improvement in seed germination achieved using various plant growth regulators. For both the species maximum improvement (*P. kurrooa*-42.5%; *A. balfourii*-41.6%) was achieved under GA3 (200µM) treatment and response was best in agropeat substrate. Vegetative propagation protocol through stolon cutting in case of *P. kurrooa* and through tuber cutting for *A. balfourii* was also achieved.
- In-vitro propagation protocol for *P. kurrooa* using epicotyl segment and mature explant and *A. balfourii* using epicotyl segment was achieved.
- Herbal garden (1.5 ha) and demonstration plot has been established at Lata (District- Chamoli) for ex situ conservation of high altitude medicinal plants. Accessions of 22 high value medicinal plants have been maintained.
- Prepared detailed inventory for 22 selected high value medicinal plants and developed herbaria of selected important medicinal plant of Uttaranchal at Kosi-Katarmal (Almora).

CORE PROGRAME-IV

ECOLOGICAL ECONOMICS AND ENVIRONMENTAL IMPACT ANALYSIS (EE&EIA)

In the Indian Himalayan region the people's need and aspirations press the policy makers and Government implementing agencies to continue developmental activities despite several undesirable environmental impacts. Hydropower projects, expansion of road network, commercial cropping that entails introduction of hybrid crop varieties, monocultures and fertilizers and biocides, increased urbanization and vehicular traffic, etc. are some of the examples. There has been a continual conflict between man and nature in the functioning of the developmental projects that grossly disregard the nature's law. Symptoms of such an approach are encountered as, soil erosion and landslide triggering, water and air pollution, loss of forest vegetation and biodiversity, migration of people etc. Every year Government puts lot of funds and efforts for mitigating the ill-effects of these developmental projects. Therefore, there is a need to analyze the environmental and socio-economic impacts of these developmental activities to come up with remedial measures for mitigation of the negative impacts. Further, the cost-benefit analysis also need to be worked out considering the cost of ecological and non-tangible benefits and losses accrued from such projects to facilitate the decision-making in an environment-friendly way. During the reporting period the Core activities were focused on EIA of hydropower projects, impact analysis of tourism induced vehicular traffic and air pollution and alternative land use practices (tea and vegetable cultivation) and other crop management interventions.

EE& EIA 1: Tourism: Impacts on Ecosystem and its Ecological Economics

Assessment of tourist influx, infrastructure & impacts

Background and Objectives

By some estimates, tourism is now the world's largest industry. It is the only economic area where developing countries consistently run a trade surplus. But the industry's rapid growth has placed a heavy burden on local economies, cultures, and environments. Uncontrolled tourism development is stressing many of the planet's most sensitive locations. The Himalayan region presents a paradox. While it is one of the richest regions in the world in terms of biodiversity resources, it is also home to some of the world's poorest people. There are immense opportunities for tourism in the IHR; nature, wildlife, adventure, religious and leisure tourism are some of the options. Therefore, tourism sector needs urgent attention to reap the benefits of sustainable tourism which includes revenue generation as well as sustainable livelihood for the locals. Studies were therefore focused on solid waste management, tourist influx and infrastructure, air quality monitoring (TSP, SO_2, NO_2 and surface ozone in Kullu (H.P.) and Almora town (Kumaun Himalaya).

Results and Achievements

- Data development on tourist & vehicular traffic
- Air quality monitoring for TSP, SO_2, NO_2 & surface ozone

I. Changing Behaviour of Ambient Air Quality and Surface Ozone in Hill Spots: A Case Study of Kullu-Manali Tourist Complex (KMTC), Northwestern Himalaya *(partially funded by DST; Period: 2003-2006)*

1. The per day incoming visitors, based on 12 hourly census (6 AM-6 PM) on an alternate day for ten months, ranged from 14,377-23,578 in Kullu and 888-8,558 in Rohtang Pass (Fig. 28). The number of plying vehicles ranged from 1,632-2,927 at Kullu and 128-1,273 Rohtang Pass.

2. The highest total suspended particles (TSP) concentration at Mohal was 267.1 $\mu g\ m^{-3}$ in June 2005 and 247.4 $\mu g\ m^{-3}$ at Kothi in April 2005. PM^{10} at Mohal was 112.7 $\mu g\ m^{-3}$ in January 2006 and 75.0 $\mu g\ m^{-3}$ at Kothi in April 2005.

3. Among the gaseous pollutants, SO_2 concentration in April 2005 at Mohal was 12.3 $\mu g\ m^{-3}$ and 14.5 $\mu g\ m^{-3}$ at Kothi. NO_2 concentration at Mohal was 22.1 $\mu g\ m^{-3}$ in February 2006 and 7.9 $\mu g\ m^{-3}$ at Kothi in June 2005. On an average, O3 concentration at Mohal was 30.4 ppb, while the highest was 67.3 ppb on May 6, 2005 (Fig. 29).

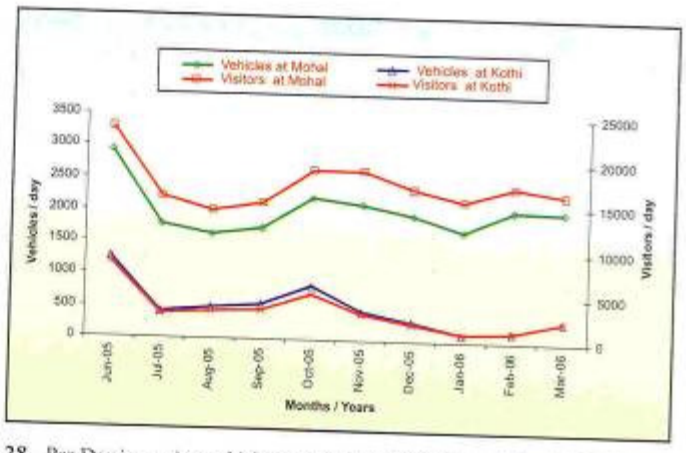


Fig. 28. Per Day incoming vehicles and visitors to Mohal and Kothi, HP (June 2005 to March 2006)

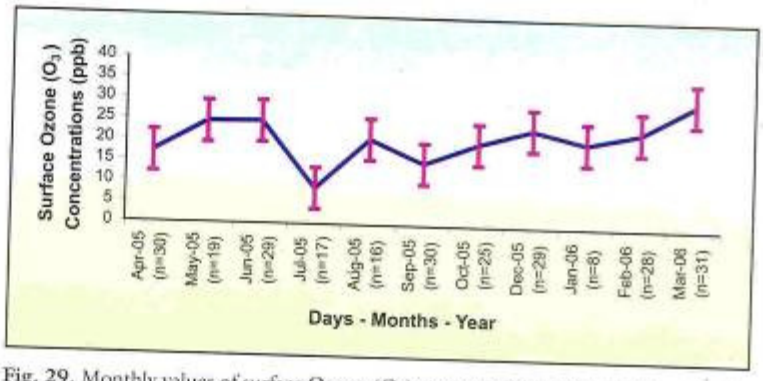


Fig. 29. Monthly values of surface Ozone (O_3) concentration at Mohal during April 2005-March 2006

II. Impact of Urbanization and Tourism Development in Almora Town

- Compilation of tourist statistics
- Imitation of work on solid waste management & air quality monitoring

1. Secondary database on number of Indian and Foreign tourist influx (1997 to 2005; Fig. 30) and the number of registered resorts, hotels and guest houses in different price segments along with their capacities in and around Almora town was compiled.
2. Methodology for conducting primary surveys and sampling locations in Almora town was finalized and field work was initiated on categorization and quantification of municipal solid waste, air quality monitoring (SPM, RSPM, NOx, SOx), vehicle pressure and water availability.

Fig. 30. Tourist inflow in and around Almora city

EE& EIA 2: Environmental Impact Analysis of Hydropower Projects

ESA & EMP proposed & upcoming hydropower projects

Background and Objectives

The Himalaya carries tremendous potential for development of irrigation and hydropower. Development of hydropower in terms of mini or micro-hydel projects, and through large and small dams, is an untapped area that has potential to revolutionize the economy of the Himalayan States. While the development of mini and micro hydel projects is always eco-friendly, the large or small river valley projects have widespread implications that include loss of agricultural land and bio-diversity, displacement, alienation, structure failure and risk of flash floods etc. Besides the choice between large and small dams, which shrouds in controversy, the rehabilitation and inter-boundary disputes are the other debatable issues. Experiences of upcoming hydro-power projects in Himalaya can better elucidate the subject and help finalizing the priorities. The major objectives of this study are therefore to undertake EIA/ EMP studies on already proposed or upcoming projects and suggest suitable remedial measures.

Results and Achievements

- Impact-development of road network, water crises, natural hazards, noise pollution, crop damage
- Air quality- Increase is TSP over permissible limits

1. People surrounding Parbati II (100%) and Parbati III (14%) perceived new road network as one of the major positive impacts of hydropower projects. More than 60% respondents acknowledged financial benefits through compensation and possibilities for future tourism development.
2. Among the negative impacts, >75% respondents outlined water crises, occurrence of natural hazards, noise pollution, air quality deterioration, crop damages and tree felling due to the hydropower projects (Fig. 31). People suggested preventive measures such as, prohibition of

blasting in the vicinity of residential areas, afforestation, proper disposal of muck as well as debris and water sprinkling to control the blowing dust.

3. TSP from July 2005 onwards showed that during winters TSP concentration crosses its permissible limit. The highest ever values so far recorded was 184.7 µg m^{-3} (Fig. 32).

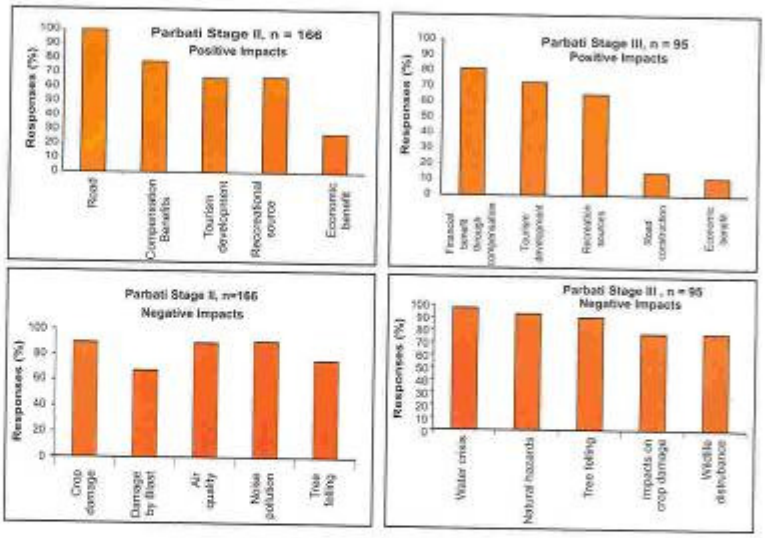


Fig. 31. Positive and negative impacts perceived by the local communities surrounding to hydropower projects

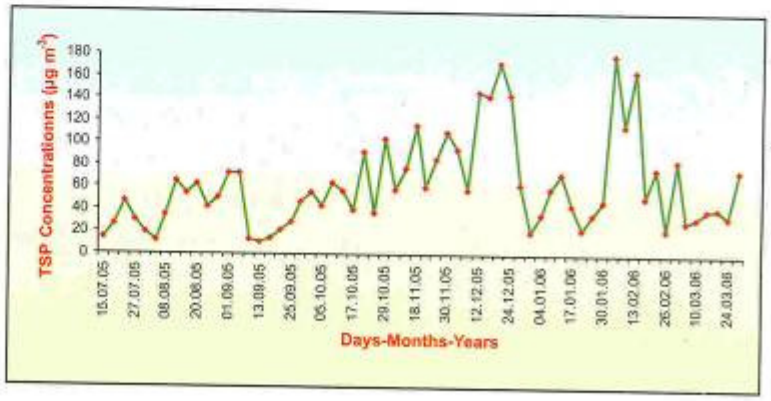


Fig. 32. Ambient air quality near power house site, Parbati II and dam construction site at Suind, Parbati III

III. Comprehensive EIA and Formulation of EMP for Nandprayag-Langasu & Tamak-Lata Hydro-Electric Projects *(Uttaranchal)*

(UJVNL funded; Period: May 2005 - April 2007)

Results and Achievements

- Compilation of base work for LR plan & RR plan

1. Socio-economic survey of the villages and landslides falling in the project area were conducted to develop landslide restoration plan and reservoir rim treatment plans. Based on the RS-GIS data, a composite catchments area map of the project site is shown in Fig. 33.

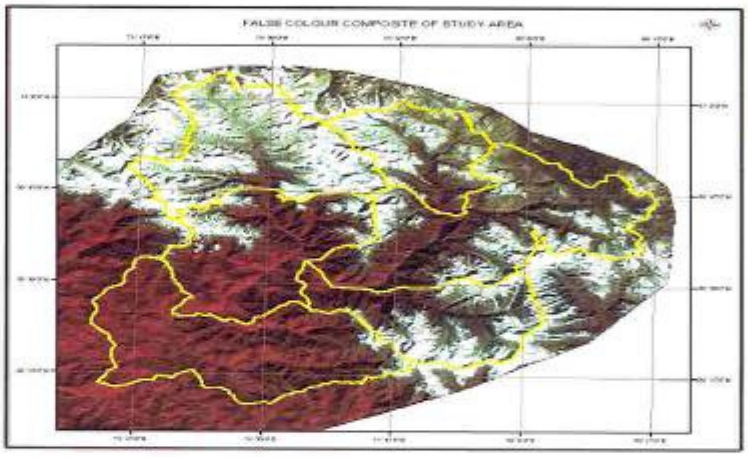


Fig. 33. False color composite map of the study area (Tamak-Lata HE project).

Table 11. Phytosociology of influence zones of two hydroelectric projects

Vegetation parameters	Abundance	Density	Frequency	Total Basal Cover (m2)
Nandprayag-Langasu HEP				
Tree	446	4.556	163.889	2659.750
Saplings	46.153	2.139	108.333	54.140
Seedlings	20.532	1.167	50.000	----
Herbs	424.532	21.431	448.611	----
Shrubs	130.194	5.361	131.944	----
Tamak-Lata HEP				
Tree	143	1.597	38.889	3808.77
Saplings	94	0.986	31.944	60.39
Seedlings	58	0.556	25	----
Herbs	404	4.750	86.111	----
Shrubs	816	9.472	186.111	----

2. Survey of flora and fauna of the project sites have been completed involving 77 sampling points in Nandprayag-Langasu hydro-electric project site and 67 sampling points in Tamak-Lata HE project site (Table 11).

IV. Comprehensive EIA and Formulation of EMP for Lakhwar-Vyasi HE Project *(NHPC funded; Period: March 2006 - August 2006)*

- Compilation of land records of affected families, & data on flora, fauna, soil, and water & air quality
- Preparation of RS/ GIS layers

1. Detailed information was procured about the land acquisition under the Lakhwar-Vyasi HEP. Land acquisition data collected was verified through the land record officer (*Patwari*) for identifying partially and fully affected families. Out of the 212.7 ha private land required for construction, 98.8 ha is irrigated and 113.7 ha is non-irrigated.

2. Fields surveys were conducted for listing flora and fauna across the project area. The list of fauna found in the project area during early 2006 is given in Table 12. For the vegetation surveys more than 83 sampling points in project influence zone were sampled falling under different vegetation types (Fig. 34). Data on soil, water quality and aquatic life have also been collected from the project sites.

3. All the required RS/GIS layers and data base has been created for the catchments area and influence zones of the Lakhwar-Vyasi HEP for erosion intensity classification.

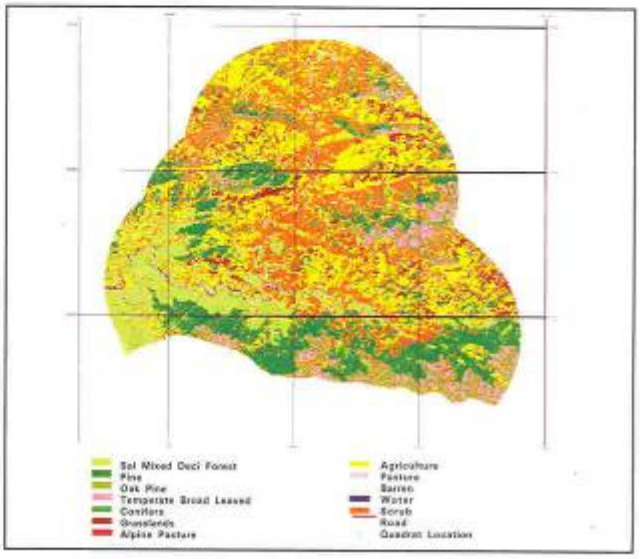


Fig. 34. Quadrate study map for influence zone of Lakhwar-Vyasi HE project

Table 12. Wild animals present in Lakhwar-Vyasi project site

Common name	Zoological name	Status
Mammals		
Black bear	*Selenaractos thibetanus*	Rare
Common langur	*Presbytis entellus*	Common
Spotted dear	*Axis axis*	Vulnerable
Fox	*Valpus valpus*	Vulnerable
Himalayan goat antilope	*Nemorahaedus goat*	Vulnerable
Samber	*Carvus unicolor*	Vulnerable
Leopard	*Panthera pardus*	Vulnerable
Common mongoose	*Herpestes edwardsi*	Vulnerable
Monkey	*Macca mulata*	Common
Porcupine	*Hystrix indica*	Common
Indian hare	*Lepusnigricollis*	Common
Wild bore	*Susscrofa cristus*	Vulnerable
Leopord cat	*Felis begalensis*	Vulnerable
Wolf	*Canisaures indicus*	Vulnerable
Reptiles		
Diard's	*Typhlops diardi*	Common
Karite	*Bungarus caeruleus*	Common
Kobra	*Naja naja*	Common
Pit viper	*Viper russelli*	Common
Lizards		
Common lizard	*Agame tuberculata*	Common
Great lizard	*Varanus bengaleusis*	Common
Girgit	*Calotes versicoler*	Common

EE&EIA 3: Impact Assessment of Alternative Land Uses

Background and Objectives

Assessment & improvement of alternate land use practices

In the Himalayan mountains cultivable land is a precious resource. The traditional agri-silvi-pastoral mode of livelihood of the local inhabitants is gradually shifting to alternative land uses, such as cultivation of cash crops (e.g., tea, floriculture, vegetables, cultivation of medicinal plants and high yielding crop varieties etc.) under the influence of efforts put under various Government programmes and market economy. The implications of these changes may be seen on nutrition and health, loss of traditional crop varieties, soil and water pollution, land use and land cover change, socio-economic milieau etc. Similarly, the changes in land use/cover taking place in the

cold desert areas are affecting the surrounding ecosystems. Therefore, the impact of these changes needs to be analyzed from the standpoint of ecological and socio-economic cost and benefits. Agricultural practices those are favourable with regards to soil fertility management and SWC need to be investigated. Efforts are also required to find out the mitigation measures to enhance the efficiency of the alternative land use practices and reduce the ill-effects of these changes on the environment. During the reporting period studies were focused on the following.

(I) Impact Assessment Studies on Tea Cultivation in Uttaranchal Hills

Results and Achievements

- Comparison of soil quality attributes of selected tea garden sites and adjacent non- tea garden sites of Kausani
- Parameter compared pH, organic carbon, total Nitrogen, total Potassium, Lead, Copper, Arsenic, Iron etc.

1. Mean annual pH, organic carbon and total nitrogen in the soils of selected tea gardens of Kausani (Kumaun hills, Uttaranchal) were found significantly low as compared to adjacent non-tea garden soils (control). Total phosphorus was found significantly high in tea garden soils as compared to control. Total potassium was found almost the same in both the conditions (Table 13).

Table 13: Mean annual concentration of different soil quality parameters in tea gardens of Kausani (UA). The range of values across the year is given in parentheses

Parameters(n = 126)	Tea garden (Treatment)	Adjacent non-tea garden area (Control)	Level of Significance
pH	5.09±0.04 (4.01-6.05)	5.59±0.04 (5.02-8.57)	t=16 P< 0.001
Organic Carbon (%)	1.21±0.03 (0.53-2.4)	1.45±0.04 (0.71-2.42)	t=4.8 P< 0.001
Total Nitrogen (%)	0.25±0.01 (0.14-0.30)	0.28±0.01 (0.22-0.36)	t=2.14 P< 0.05
Total Phosphorus (%)	0.06±0.001 (0.01-0.08)	0.05±0.002 (0.01-0.10)	t=7.14 P< 0.001
Total Potassium (%)	1.32±0.06 (0.46-2.11)	1.27±0.05 (0.39-2.04)	t=0.64 < NS >

2. Mean annual concentration of lead (Pb) in the water (treatment) draining tea gardens (0.19±0.02; range= 0.0-0.45 ppb) and the water (control) collected from adjacent non-tea garden area (0.18±0.02; range= 0.0-0.61 ppb) was similar (Fig. 35 A). Copper (Cu) in the treatment (0.50±0.20; range= 0.0-5.51 ppb) was markedly low than the control (0.92±0.42; range= 0.0-14.63 ppb) water (Fig. 35 B). Similarly,

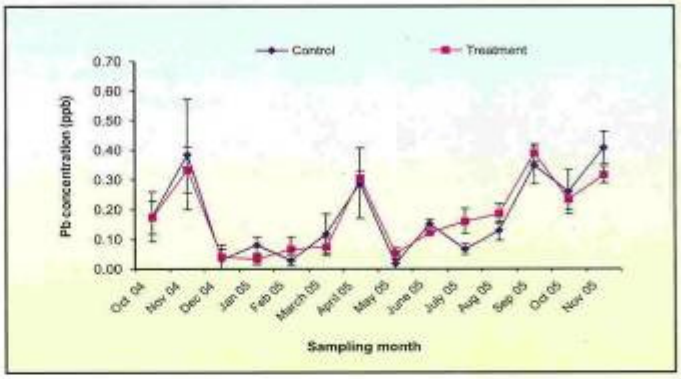


Fig. 35 A. Lead in water of Kausani tea gardens

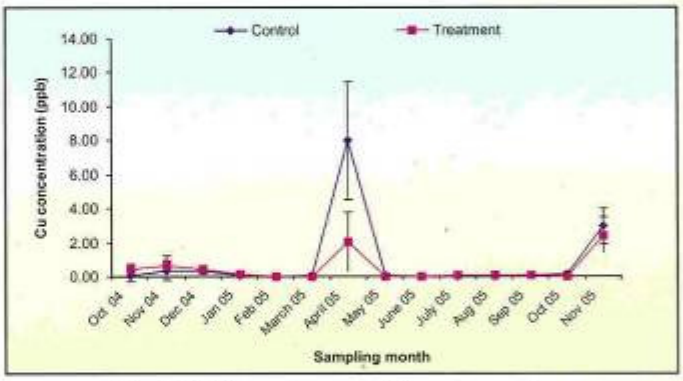


Fig. 35 B. Copper in water of Kausani tea gardens

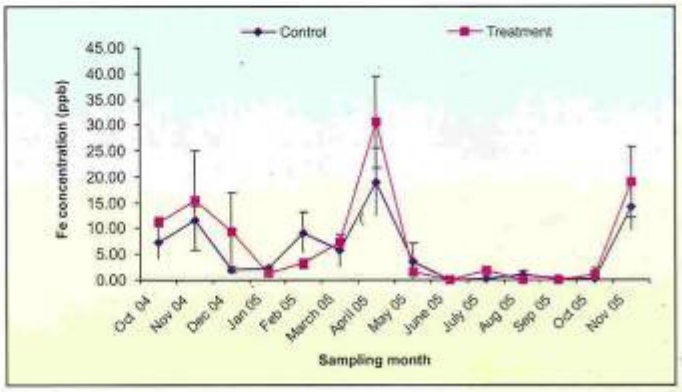


Fig. 35 C. Iron in water of Kausani tea gardens

Arsenic (As) in the treatment (0.19±0.07; range= 0.0-0.68) was low than the control (0.27±0.07; range= 0.0-0.71). Iron (Fe) in the treatment water (7.51±1.88; range= 0.0-40.95) was found high than the control (5.46±1.19; range= 0.0-29.16) (Fig. 35 C).

3. Mean annual concentration of chloride and nitrite was significantly high ($t = 2.18$; $P<0.05$) in the treatment water than the control; whereas pH, nitrate, sulphate, total hardness and phosphate in both the conditions were alike (Table 14). In the treatment water, the concentration of phosphate (1.25±0.04; range= 0.9-1.6 ppm) was lower than the control (1.28±0.04; range=1.0-1.7 ppm).

Table 14: Mean annual concentration of different water quality parameters in tea gardens of Kausani (UA). The range of values across the year are given in parentheses

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

(II) Impact of Reduced Tillage and Mulching in the Central Himalayan Cropfields *(funded by DST; Period: 2005-2008)*

- Laying out experimental design; 13 treatments of tillage & 3 types of mulch on wheat crop
- Study of soil quality & runoff impacts

Results and Achievements

1. In an abandoned cropfield (Kosi-Almora, 1152 m asl) 39 experimental plots (size 5x5 m^2; slope <5°) prepared for 13 treatments of tillage and mulching (replicated thrice in a RBD design), Oak, Pine and Lantana leaf litter was mulched after sowing wheat in early November (Fig. 36). The initial soil physico-chemical characteristics (0-15 cm depth) revealed: soil texture (19.7% sand, 61.4% silt,18.6% clay), soil

moisture (17.1%), water holding capacity (52.4%), soil OC (0.44%), soil pH (5.6), total N (0.14%), P (0.07%) and K (0.77%).

Fig. 36. A bird eye view of experimental site of the project

2. Among the 13 different treatments mean soil moisture ranged from 9-11.6% and mean soil temperature (range = 16.7-18.2°C) across wheat crop cycle (November-May). Available N (NO_3-N and NH_4-N), P (PO_4-P), NPK, rate of C and N mineralization and microbial biomass (C and N) were determined in all the 39 plots (Fig. 37 A-B).

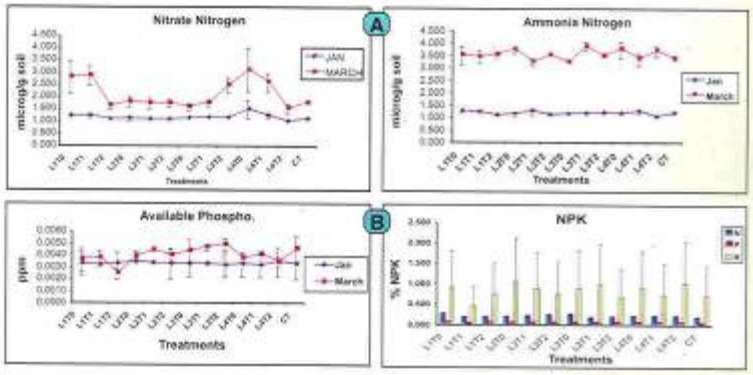


Fig. 37. (A). Ammonium nitrogen and nitrate nitrogen in soil of different treatment plots (B). Available phosphorus and total NPK in soil of different treatment plots

3. Out of the total 10 rainy days (rainfall 50.4 mm) during the wheat crop cycle, runoff (L/plot) was found (range = 0.66-2.1 L/plot) and silt loss (range = 7.68-18.08 g/plot). Rate of panicle initiation (range = 98-224x107/ha) and grain yield of wheat (range = 1105-1494 g/plot) was recorded variable across the treatment plots.

(III) Land Use Changes and its Environmental Impacts in Cold Desert Environment: A Case of the Lahaul Valley, Northwestern Himalaya
(ICSSR funded; Period: 2004- 2007)

Results and Achievements

- NSC application & its impacts
  - Quantum of NSC use
  - Crops raised under NSC

1. In the cold desert of Lahaul valley night-soil compost (NSC) preparation using human excreta, tree leaves and grass, ash and dung from cattle, sheep and goats is an age-old practice. Annually the quantity of NSC was computed about 25 MT in Hinsa and 17 MT in Jahlma villages. The per ha use of NSC was 8.0 and 7.2 MT in Jahlma (in 6.4% of the cropped area) and Hinsa (in 15.4% of the cropped area) villages, respectively. Out of the four villages surveyed, two villages do not practise NSC.

2. The important cash crops and traditional crops where the NSC used are: pea (*Pisum sativum*), potato (*Solanum tuberosum*), barley (*Hordeum himalayense*), wheat (*Triticum aestivum*) and hops (*Humulus lupulus*) (Fig. 38).

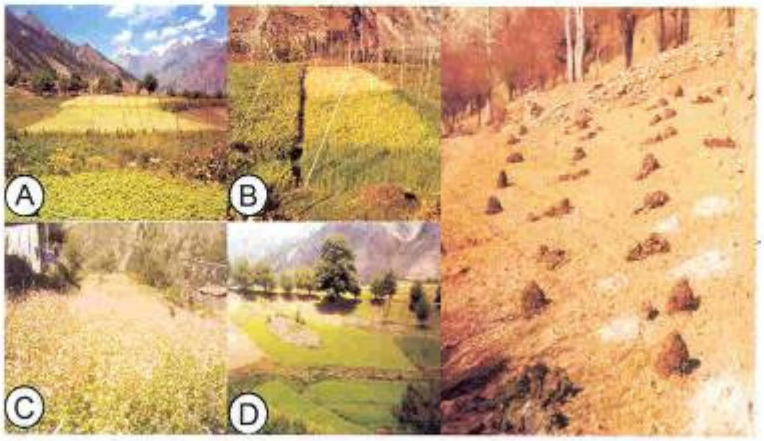


Fig. 38. Some valuable traditional crops: (a) buckwheat, mustard oil, (b) maize, (c) buckwheat, (d) barley, and (e) use of night-soil compost in crop fields in the Lahaul valley

(IV) Impact of Geology and Land Use / Land Cover on Spring Discharge in Western Himalaya *(MoWR funded; Period: 2004-2007)*

- Preparation of geological maps of recharge zone- 14 springs
- Monitoring of WHC, water discharge & heavy metals

1. Geological maps (lithology, landuse/cover, slope and aspect, soil profile) of the recharge zones for 14 springs located in different geological conditions in the Western Himalayan region were prepared. The mean water holding capacity (across 0-15 cm and 15-30 cm soil depths) of the recharge zone soil of these springs varied from 34-60% (Table 15). Water discharge of all the 14 springs was monitored at monthly intervals.

2. Water quality analysis of the springs for Cu, Pb, Fe and As (ppb) for summer and winter seasons using Atomic Absorption Spectrophotometer (Make: Varian, Model AA 280 Z) revealed that the concentration of Fe was highest (range =2.83-26.63) followed by Cu (range =0.22-0.96) and Pb (range =0.51-0.71). As was absent in most of the water samples. In the water samples of winter 2005, the pH ranged from 7.4 -7.9 across the springs.

Table 15: Soil water holding capacity (WHC) at two depths for the selected springs

Name of Spring	Soil depth (cm)	WHC (%)	Mean WHC (%)
Batula	0-15 15-30	39 41	40
Maithana	0-15 15-30	54 60	57
Karas	0-15 15-30	47 44	46
Kamera	0-15 15-30	38 40	39
Teendhara	0-15 15-30	53 41	47
Charwapipal	0-15 15-30	52 47	50
Joshimath	0-15 15-30	57 53	55
Bhatoli	0-15 15-30	58 47	53
Kothar	0-15 15-30	42 35	39
Bhaktiyana	0-15 15-30	35 33	34
Bidakot	0-15 15-30	52 45	49
Gulabrai	0-15 15-30	66 56	61

BOX - 10

Summary of Completed Projects
(2002-2006)

***Vegetable Cultivation in Khairna Valley and its Impact on Environment** (In-House)*

The study area, Khairna valley is a rural regime located in Uttaranchal (Kumaun Himalaya). It includes Khairna market i.e., a place at nearly 30 kms distance from Naini Tal town and 190 settlements distributed over an altitudinal range of 900 to 2000 m asl. In the last few decades the valley has witnessed a sudden spurt in vegetable cultivation. The study, therefore, was conducted to know the underlying reasons, driving forces, adoption, and the impacts of this activity. Nineteen representative villages in the study area were surveyed to probe different scenarios based on distance from the road-head, altitude (agro-climatic situations), irrigation facilities, administrative unit etc. The major findings of the study are:

- A household survey (N=777) revealed that average household size in the valley is 7.16 and average landholding is 0.54 ha. Nearly 88% of the households grow vegetables and the average gross area under vegetables per household is 39.6% of the landholding. Only 17.1% of the agricultural land is irrigated, and irrigated holding per household is merely 0.092 ha. Agriculture is predominantly rainfed, and most of the vegetable cultivation is confined to rainy season, however small scale off-season cultivation is also practiced.
- The average yield of vegetables worked out on the basis of household responses, for tomato, pea, cauliflower, capsicum, bean, and chilly were found to be 91.28, 152.5, 306.67, 197.3, 24.9, 17.1 and 64.67 q/ha, respectively.
- Analyses of vegetable cultivation in the valley in terms of three categories of distance from road head i.e., < 2 km, 2-5 km, and > 5 km, did not indicate a linear trend in vegetable production with the distance. Yet, the vegetable cultivation was found to be most intensive in villages within 2 km range from the road (gross area under vegetable to landholding size = 51.9%). Also, the adoption (number of vegetable cultivating farmers) was maximum 88.8% in the zone, suggesting road connectivity up to 2 km distance a prompting factor for vegetable cultivation.
- Similarly, different agro-climatic conditions did not exhibit a trend with vegetable production. The middle altitude areas i.e. 1200-1500 m altitude, seemed to be the most preferred sites for vegetable cultivation (adoption = 90.2%; gross area to landholding size - 41.53%).
- The analyses of people's perception revealed that easy cash and easy and maximized use of land as the two most important reasons for spurt / adoption of vegetable cultivation. The total affirmations received in support of these reasons (easy cash - 54.76%, easy and maximized use of land - 41.64%) were over 95%.
- People perceived both positive and negative impacts of vegetable cultivation. Increase in workload for women, less time available for them for childcare/ household chores, nutritional impacts as result of switch from cereals to vegetables, loss of traditional landraces are the main negative impacts. However, easy cash income, employment, nutritional benefits and production related agricultural solutions were some of the positive impacts.

CORE PROGRAME-V

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. Over the past decade the research activities of this core group has focused on studies related to understanding of different factors that govern the productivity and functioning of plants. Microorganisms are known to play a significant role in influencing plant growth, and therefore activities continued on microbial diversity in Himalayan soil, plant growth promoting rhizobacteria, and mycorrhizal associations in Himalayan trees. A number of bacteria,. isolated from soil, have been used as inoculants which resulted in improvement of plant growth and seed germination. The microorganisms isolated from various sources are being maintained under lab conditions and being characterized for biotechnological applications. There has been an overwhelming demand for high quality plant propagules and continuous efforts are underway to develop propagation protocols, using both conventional as well as *in vitro* techniques, for economically important species. Large scale multiplication of selected species, particularly 'maggar' bamboo and *Rhododendron madenii*, has been taken up; field plantation and subsequent growth performance based on physiological, biochemical and molecular parameters have been initiated. In view of the increased biotic pressure that has threatened the survival of several important high value medicinal plants of the region; elite clones have been selected based on content of active biomolecules and been conserved in the high altitude field stations. Due to harsh climatic conditions and erratic rainfall pattern in the Himalaya, plants are subjected to various types of stresses affecting the overall growth and productivity, and such investigations leading to understanding of mechanism of adaptation is in progress. The relevance of hill-specific technology transfer in the hilly region has been realized and attempts have been made to impart trainings to villagers, farmers, marginal growers, etc. for long term benefit and economic upliftment of the rural people.

EPB 1: Rhizosphere Microbiology of Himalayan Plants

Isolation & characterization of microorganisms and microbial diversity in Himalaya

Background and Objectives

With a view to study the microflora in Himalayan soils studies have been initiated based on the isolation and characterization of three groups of microorganisms, i.e., bacteria, actinomycetes and fungi (including mycorrhizae). While the temperate and alpine locations have been explored for enumerating the diversity of free-living bacterial, actinomycetes and fungal communities, the symbiotic associations between selected trees and the AM (arbuscular mycorrhizal) fungi have also been investigated. These investigations mainly include the microbial diversity, plant-microbe and microbe-microbe interactions with special reference to their applications. The studies carried out in the reporting year were focused on: (i) microbial diversity in Himalayan soil; (ii) plant growth promoting rhizobacteria; and (iii) mycorrhizal associations in Himalayan trees.

Results and Achievements

- Isolation of microbial diversity in Mana hill soils
- Characterization of different strains of *Pseudomonas putida* B0

1. Microbial diversity in Mana hill soils (near Badrinath; Chamoli-Garhwal, Uttaranchal), characterized by sub-zero temperatures due to snowfall during winter was examined, and 33 species of bacteria, actinomycetes, fungi and yeasts were raised in the form of pure isolates. Isolations were conducted on selective as well as non-selective media at different temperatures.

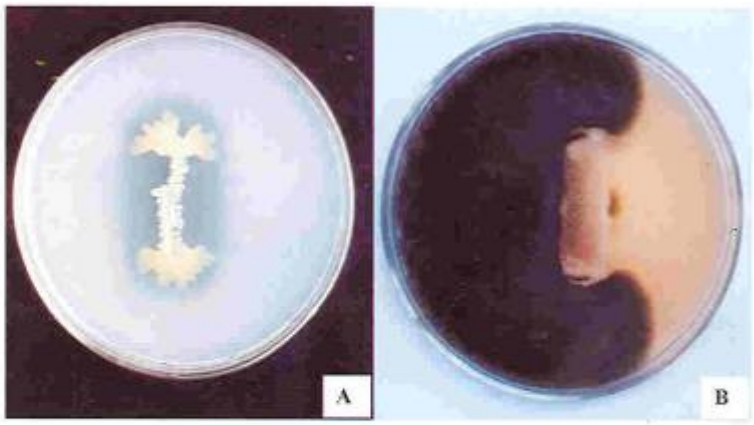


Fig. 39. Phosphate solubilization (A) and antifungal (B) potential of *Pseudomonas putida* B0.

2. Characterization of a fluorescent, psychrotrophic, phosphate solubilizing and antagonistic strain of *Pseudomonas putida* B0, isolated from a sub-alpine Himalayan location has been completed. The morphological, physiological, biochemical and molecular properties of this strain is presented (Table 16). The isolate showed maximum similarity with *Pseudomonas putida* based on 16S rRNA analysis and also exhibited several properties of biotechnological importance (Fig. 39).

Table 16. Characteristic features of Pseudomonas putida B0

Patameters	Morphological, biochemical, physiological and molecular characteristics
Colony morphology	Fluorescent, yellowish colonies (2-3 mm dia) on Pseudomonas isolation agar at 25 °C after 48 h incubation
Microscopic features	Gram –ve, single, motile rods, 0.6-0.8 X 1.2-1.8 µm
Extra and intracellular enzyme activity	Positive for Catalase, Citrate utilization, Gelatin hydrolysis, Cytochrome oxidase; Negative for Casein, Starch and Urea hydrolysis, Nitrate reduction
Utilization of carbon sources	Positive for Arabinose, Dextrose, Fructose, Galactose, Mannitol, Mannose, Trehalose, Xylose and negative for Adonitol, Cellobiose, Dulcitol, Inositol, Inulin, Lactose, Maltose, Raffinose, Rhamnose, Salicin, Sorbitol
Temperature tolerance	0-35 °C, Optimum temperature 25 °C (psychrotrophic)
pH tolerance	3-12, optimum pH 8.0
Salt tolerance	upto 4% (w/v)
Antibiotic sensitivity (µg ml^{-1})	Ampicillin 1500, Carbenicillin 1500, Chloroamphanicol 50, Gentamycin 5, Kanamycin 5, Nalidixic acid 200, Penicillin 1500, Rifampicin 200, Streptomycin sulphate 10, Tetracycline 200.
16S rRNA analysis and gene sequences	Maximum similarity with *P. putida* (gi/62003358/gb/AY958233.1); other closely related 16S rRNA gene sequences are (1) *Pseudomonas* sp. SF4c (gi/58618858/gb/AY880843.1); (2) *Pseudomonas* sp. E2.2 (gi/51235025/gb/AY625608.1); and (3) *P. putida* strain PC 16 (gi/60202562/gb/AY918067.1)
Characteristics of biotechnological applications	
Biocontrol properties and production of secondary metabolites	Suppression of phytopathogens, e.g. *Alternaria alternata* and *Fusarium oxysporum*; Production of chitinase, β-1,3-glucanase, salicylic acid, siderophores and hydrogen cyanide
Phosphate Solubilization	247 mg ml^{-1} of P after 15 days of incubation at 21 °C

EPB 2: Large Scale Propagation of Location-Specific Elite Plants Using Conventional and Biotechnological Methods

Large scale in vitro multiplication & performance evolution of D.hamiltonii, R. maddenii, etc. elite plants

Background and Objectives

Large quantities of quality planting material are required for afforestation, commercial cultivation and rehabilitation programmes. The conventional methods of propagation involving seeds and vegetative/clonal techniques have been quite successfully adopted under this activity. In addition the methods of plant tissue culture has been gainfully utilized for developing propagation protocols, and using the developed protocols large-scale *in vitro* multiplication of *Dendrocalamus hamiltonii* and *Rhododendron maddenii* is being carried out for field transfer; subsequent performance evaluation is underway on the basis of physiological and biochemical parameters.

Results and Achievements

- Performances statistics of *D. hamiltonii* (70% survival & 3- fold increment in plant height during the 1st year)
- Multiplication status of *R. maddenii* & *A. racemosa*
- Maintenance of *in-vitro* culture of species

1. Field transfer of *in vitro* raised plants of *D. hamiltonii* indicated over 70% survival and 3-fold increment in plant height during the 1st year. Increases in chlorophyll content (1.6-1.82 mg/g fresh wt. for Chl a and 0.70-1.23 mg/g fresh wt. for Chl b), leaf area (21.7-36 cm2), net photosynthesis rate (3.55-5.44 µmol/m2/s) and transpiration rate (1.12 -1.70 mmol/m2/s) was recorded for these plants following field transfer.

2. Over 1800 *in vitro* produced *R. maddenii* plants were transferred for hardening and acclimatization in green house conditions at Sikkim (Fig. 40). More than 10,000 multiple shoots are ready for root induction. Field transfer of 50 in vitro raised plants in the Institute's Arboretum resulted in cent percent survival and growth in the first four months. Fresh nodal explants of *Arundinaria racemosa*, an important bamboo, produced more shoots (3.9 shoots per node) on MS medium when supplemented with the cytokinin, BAP.

Fig. 40. In vitro shoot multiplication in *A. balfourii* **(A)**, and hardened in vitro raised plants of *R. maddeni* ready for field transfer (B).

3. In vitro cultures of various plant species, namely *Podophyllum hexandrum, Picrorhiza kurrooa, Aconitum balfourii, Thamnocalamus spathiflorus, Gladiolus* sp., Orchids, and *Sinningia speciosa* are being maintained.

EPB 3: Impact of Environmental Changes on Growth Performance of Plants

Study of water stress conditions in plants for identification of multi purpose tree species for revegetation of rainfed area

Background and Objectives

Among a variety of environmental factors, water is one of the most important variable that influences not only growth and productivity of plants but also their geographical distribution. Plants growing in the rainfed areas are generally exposed to natural cycles of water deficit and water sufficiency. Although plants growing under rainfed areas can be considered to be well adapted to drought, little is known about the water relations of these multipurpose plants, which support sustained agriculture production and meet fuelwood, fodder and minor timber requirement of locals. In view of this, there is a need for evaluation, screening and identification of multipurpose tree species (MPTs) that could be successfully used for revegetation of rainfed degraded lands. Studies were therefore, initiated to evaluate: (i) effect of water stress on growth and morphology; (ii) effect on biochemical processes; and (iii) effect on relative water potential, water potential and osmotic potential of important MPTs of west Himalaya.

Results and Achievements

- Analyses of water content relation in leaves of different species & changes in soil attributes

1. Leaf dry matter content, relative water content, water saturation deficit, water content at saturation and contents of proline and total soluble carbohydrate in the leaves of different populations of *Ficus glomerata, F. roxburghii, Grewia optiva* and *Boehmeria rugulosa* plants were found to be different. The soil of various population sites showed variation with respect to organic carbon, soil pH, nitrogen, phosphorus and potassium contents.

- Comparison of water potential & SPAD meter values of multipurpose species

2. Twenty three MPTs of Himachal Pradesh were assessed with respect of water potential and SPAD meter values during winter season (Nov - Feb). Significant differences in water potential and SPAD meter values (an indirect assess of nitrogen/chlorophyll status of plants were recorded among the species). Differences were also recorded amongst the species of the same genera (Table 17).

3. Measurements of water potential and SPAD meter values on 9 important plant species prior to, during and after rain revealed marked difference with respect to the lowest water potential values as well as their recovery pattern.

Table 17. Water potential and SPAD meter values of three Quercus species during winter season. Values are mean ±S.E. of 6-12 observations.

Species	Water potential (?w)	SPAD values (chlorophyll content)
Q. leucotrichophora	-6.46 ± 0.56	50.36 ± 1.48
Q. glauca	-5.24 ± 0.27	47.15 ± 1.20
Q. floribunda	-5.81 ± 0.32	43.28 ± 0.85

EPB 4: *In vitro* Approaches Towards Commercial Cultivation of *Podophyllum* spp. *(DST funded; Period 2004 -2007).*

Standardization & improvement of existing in-vitro protocols & estimation of secondary metabolites

Background and Objectives

Podophyllum spp. is important due to the presence of podophyllotoxin, used in the preparation of drugs for treatment of different types of cancer. *P. hexandrum* has become critically endangered due to indiscriminate collection from the natural habitat. Therefore, conventional and biotechnological approaches have been applied for propagation, conservation and production of podophyllotoxin. The activity focuses 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.

- Optimization of callus culture & assessment of podophyllotoxin contents
- Field trial of seed raised plants

Results and Achievements

1. Improvement in multiple shoot formation occurred on MS supplemented with plant growth regulators. Optimization of callus culture was carried out by subjecting calli to MS medium containing different concentrations of hormones, sucrose and antioxidants. MS medium containing 4.0% sucrose in combination with 5.0 µM NAA and 1.0 µM TDZ resulted in profuse callus growth (Fig. 41). Calli grown on above medium were analyzed for podophyllotoxin and maximum level was detected in calli grown for four weeks.
2. Field trials were carried out on seed raised plants grown at two sites (Intitute's nursery and Basoli village farmer's field, Almora). Over 90% seedling survival was recorded at both the sites.

Fig. 41. *In vitro* multiplication (A) and optimization of callus production (B) in *Podophyllum* spp.

EPB 5: Characterization and Improvement of Tea through Biotechnological Tools - Phase –II (*Funded by DBT; Period 2005- 2007*)

Background and Objectives

Development of bacterial & VAM formulation as biofertilizer.

This is a multi-institutional project where the defined objective with this Institute is development of bacterial and VAM formulation as biofertilizer for tea. The three major objectives under this activity are: (i) microbial diversity in tea rhizosphere (isolation and characterization); (ii) development of bacterial and VAM inoculants; and (iii) formulation and product development.

Results and Achievements

- Assessment of microbial diversity of tea rhizosphere
- Evaluation of soil based consortium to growth performance

1. Microbial diversity (free living- bacteria, actinomycetes and fungi, and symbiotic associates- arbuscular mycorrhizal fungi) of tea rhizosphere has been worked out.
2. A soil based consortium developed using tea associated mycorrhizae was evaluated through bioassays for growth promotion properties under green house conditions. Field trials have been established at Kausani, Uttaranchal.

BOX - 11
(Summary of the Completed Project)
(2003-2006)

Genetic Profiling and Pilot Production of the Identified Elite Species and Quantification of the Active Biomolecules (DBT funded)

This activity is the 2nd phase of a project "Bioprospecting of Biological Wealth Using Biotechnological Tools", and focused on selection of elite populations of some MPs based on their active biomolecule content, multiplication, and conservation and set up demonstration plots of these species. The objectives were: (i) quantification of biomolecules from *Podophyllum hexandrum*; (ii) setting up of demonstration plots for *P. hexandrum, Picrorhiza kurrooa, Aconitum heterophyllum* and *A. balfourii* in a high altitude field station; and (iii) imparting training to farmers on medicinal plants cultivation. The major findings include:

- A wide variation in podophyllotoxin was found in *P. hexandrum* collected from different locations of Himalaya. Rhizome samples collected from various populations of Kumaun and Garhwal region indicated a range of 0.007-5.45% (on dry wt. basis). Podophyllotoxin detected in leaf and stem samples from the same region also indicated a wide variation (0.004-0.106 and 0.001-0.486 %, respectively). Another study carried out in 22 populations of HP revealed a range of 0.0045-4.133%.
- In the demonstration plots set up at high altitude field stations Khaljhuni and Jhuni villages (2450 m amsl) in Bageswar district, Uttaranchal, plants of *P. kurrooa, P. hexandrum* and *A. balfourii* collected from various locations were multiplied (via seed, vegetative and in vitro methods) and grown in about 1 ha land (Fig. 42).
- Marked improvement (60-70% germination VS 30-35% control) in seed germination of *A. balfourii, P. kurrooa* and *P. hexandrum* following pre-soaking treatment with GA_3, KNO_3 and thiourea was obtained. Chemical treatments have also been used to excise tubers/rhizome to induce rooting and enhance plant multiplication.

Fig. 42. Demonstration plots at Khaljhuni and Jhuni villages

CORE PROGRAME-VI

INSTITUTIONAL NETWORKING AND HUMAN INVESTMENT (INHI)

Networking of the existing institutional infrastructure in the Himalayan region is critical for optimal use of the available scientific talent. Through Integrated Ecodevelopment Research Programme (IERP) of the Institute, the infrastructure, expertise and scientific manpower available in the IHR are being effectively complemented. This programme is also complementing in achieving the mandate of the Institute and in the fulfillment of its broad objectives. The programme also supports Institute's role as a facilitator of R&D programmes in the IHR and in establishment of institutional linkages. Besides this, the INHI Core is also actively involved in capacity building of the people all across the IHR through on-site training programmes, Central library services and ENVIS Centre of the Institute.

INHI 1: Creating Sacred Forest/Hill for Eco-Restoration and Biodiversity Conservation in the New Millennium

Achievement of eco- restoration by using human reverence for religion

Background and Objectives

In the IHR continued degradation of land and biological diversity is a matter of serious concern. One of the basic reasons for ineffectiveness of the interventions adopted for land rehabilitation and biological conservation could be non-integration of sacred/spiritual/cultural values. Keeping the above in mind, the Core (INHI) executed 'Badrivan Restoration Programme' at Badrinath in the past that illustrated the importance of blending science and religion for the protection of environment and biodiversity conservation. The present project at Kail Bakriya (Lohaghat, Uttaranchal) adopting the above mentioned innovative approach, envisages to: (i) create environmental awareness among the local people for eco-restoration and biodiversity conservation; (ii) screen/identify promising plants for rehabilitation of degraded lands; and (iii) develop a model for eco-restoration and biodiversity conservation (with peoples' participation) by creating a sacred forest and developing a multipurpose tree model.

Results and Achievements

- Preliminary soil status assessment
- Development of two plant nurseries & three water harvesting tanks
- Hosting of plantation ceremonies. (16000 plants raised, 700 saplings planted)

1. Soil collected from two project sites in the months of June 2005 and October 2005, revealed that the soil is very poor in plant available nitrogen (NH_4^+ and NO_3^-), organic carbon, and soil moisture contents.
2. At Kail Bakriya Hill project site (Fig. 43) in the Kolidhaik village (Champawat district, UA) 345 trenches and 3 water harvesting tanks were constructed. Two 'Plantation Ceremonies' were organized at this site in which almost 700 well-established saplings of 10 promising forest/horticultural trees were planted with people's participation. The survival was recorded >75%.

Fig. 43. Kail Bakriya Hill project site at Kolidhaik village in Lohaghat.

3. Two plant nurseries were established, and 16,000 seedlings of 23 promising tree species were raised. Seed germination in the nurseries ranged from 50-59% for *Quercus leucotrichophora* and *Sapindus mukorossi*, respectively.

INHI 2: Development of a Strategy for Capacity Building of Rural People: A Case Study in the Central Himalayan Region in the Context of Culture, Resources and Development

Development of policy prescription on poverty and status of poverty alleviation measures in Uttarkashi & Pauri districts, UA

Background and Objectives

In the Central Himalayan region research and policy recommendations are desired on: (i) situation of poverty and its ramifications and poverty alleviating measures; and (ii) relevance, adequacy and performance of existing infrastructure, including social infrastructure and rural credit based on assessment of the problems, needs and priorities of the people living in diverse socio-economic and ecological setting. Therefore this study in two hill districts of Uttaranchal; Uttarkashi and Pauri with 68.71% and 26.74% of their population below poverty line (BPL), respectively, was initiated to investigate: (i) current situation of the poverty, policy and implementation issues associated with poverty and poverty alleviation measures, rural infrastructure including credit, and their further development, (ii) poverty vis-à-vis social infrastructure, cultural institutions, value systems, and social exclusion; and (iii) relationship between poverty and gender focusing on role of women to optimise the management options for effective reduction in poverty.

Results and Achievements

- Status of poverty along altitude
  - Poverty increases with altitude
  - No relation between per capita cultivated land and poverty
  - Percentage of bovine population bears inverse relation with poverty
  - 77% loaning of BPL families in livestock purchase

1. Linkages of poverty with various resources along vertical gradients (through study of 2962 households in 25 villages within altitudes of 1100-2150 m amsl) revealed that poverty increased with the increase in altitude. Marginal farmers dominated in all the altitudinal zones. The largest percentage was found in 500-1800 m amsl zone. No distinct correlation between classes of land holding along vertical gradients and poverty was found (Fig. 44).
2. Percentage of cultivated land and irrigated land varied in different altitudinal zones. Higher percentile was found in the zone < 1500 m (Fig. 45). Per Capita cultivated land was highest in the zone 1800-2100 m, followed by 1800-2100 m zone. Per capita availability of cultivated land did not show any correlation with poverty.
3. Per capita livestock holding gradually decreased from lower to higher zones with exception to the last zone (i.e., > 2100 m) and did not show any correlation with the poverty (Fig. 46). Categories of livestock varied in different altitudinal zones. It was observed that higher percentile distribution of cows and buffaloes in the zone 1500-1800 m had a direct

bearing on poverty as the occurrence of poverty was lesser in this zone (Fig. 47) as compared to other zones.

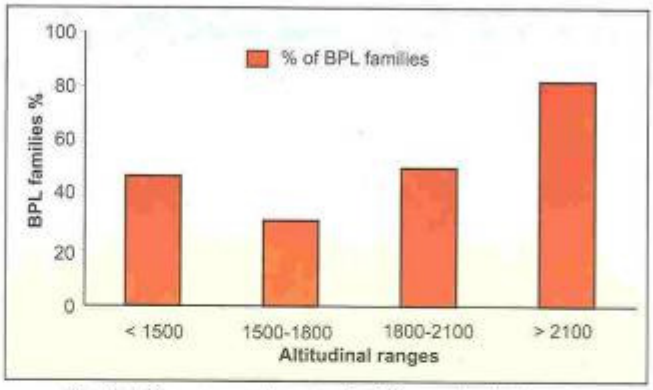


Fig. 44. Occurrence of poverty in different altitudinal zones

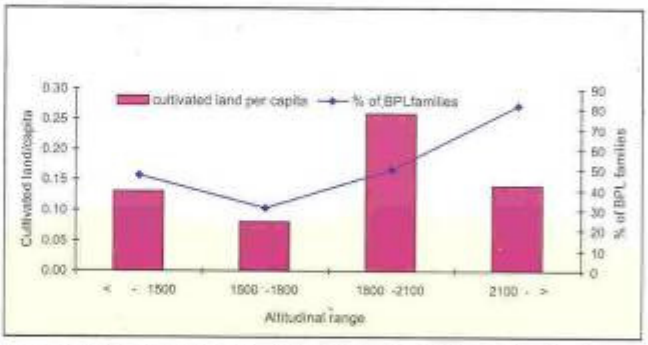


Fig. 45. Per capita cultivated land vs poverty in different altitudinal zones

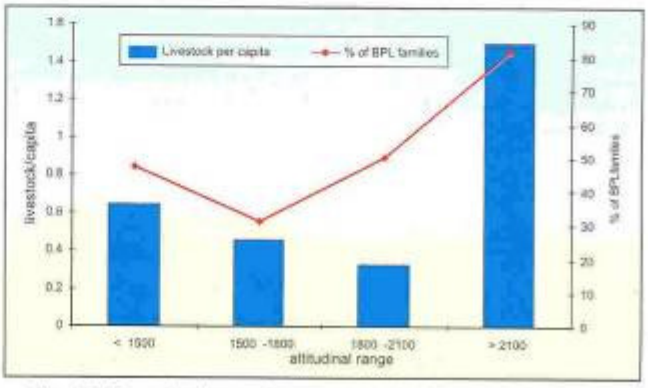


Fig. 46. Per capita livestock vs poverty in different altitudinal zones

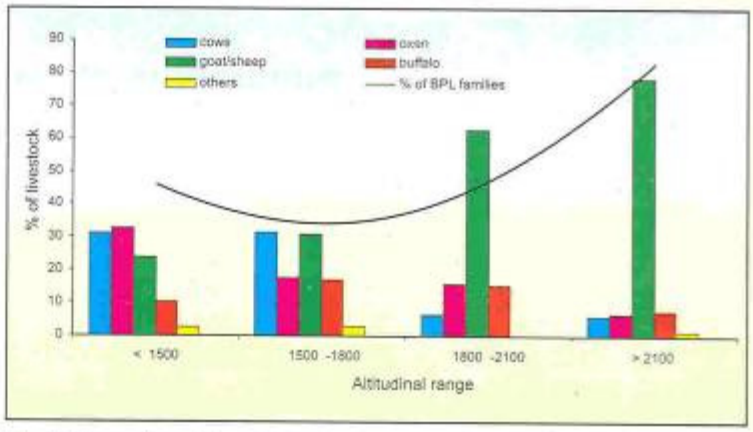
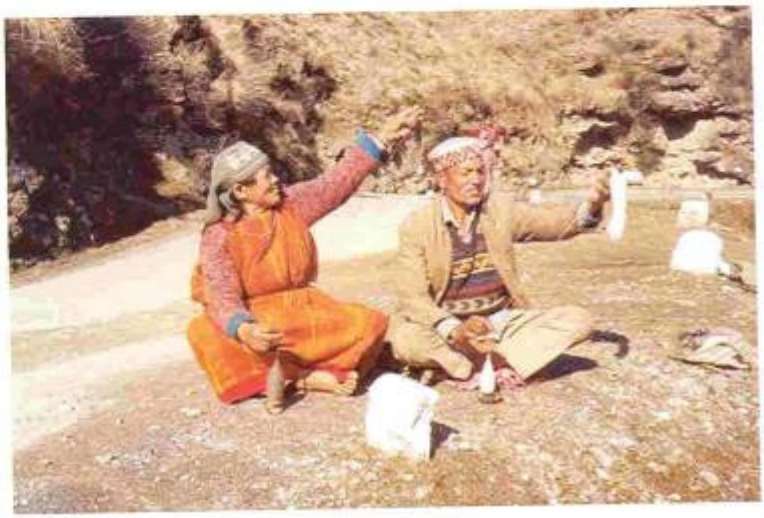


Fig. 47. Categories of livestock distribution vs. poverty in different altitudinal zones

4. Analysis of the functional aspects of the credit system through investigation of types and nature of loans given to 191 BPL households revealed that as much as 77% of the beneficiaries received loans for the purchase of livestock.

CORE PROGRAME-VII

INDIGENOUS KNOWLEDGE SYSTEMS (IKS)



Indigenous knowledge systems and cultural heritage play significant role in sustainable use, management and conservation of resources. Restrengthening of culture and indigenous knowledge base should lead to enhanced conservation practices. Well established IKS of Himalayan people secured their survival in difficult terrain of the Himalaya for generations. Integration of IKS with modern techniques will lead to value addition. Value addition and validation of indigenous and traditional knowledge will create potential for enterprises, which, in turn should lead to economic upliftment of the local people. To address these issues, the IKS Core has initiated documentation and analyses of indigenous knowledge and management practices of high altitude societies, people's perception on indigenous use of selected medicinal plants, wild edible fruits and plants of religious importance, and people's knowledge about forecasting of local weather using climatic indicators. This integration will be one of the approach for development of Himalayan societies.

IKS 1: Indigenous Knowledge and Practices of Pastoralism and Transhumance in Kumaun and Garhwal Himalayan Region

Analyses of resource use IKS of high altitude villages in Darma, Byans, Mana and Niti valley

Background and Objectives

Amongst the high altitude transhumant pastoral communities of Kumaun and Garhwal region, women have been traditionally playing a major role in the decision making for livestock management and subsistence agricultural activities. With no viable alternative in sight, the search to reduce the workload of women has assumed a critical urgency. However, women have managed to cope up with the new situation without losing their traditional knowledge base. Over the last few decades, the pressure on such women groups has increased, due to the huge amount of male out migration to the urban areas in search of employment. In addition, now market forces have penetrated to the remote high altitudes, which has begun to disrupt the traditional practices, and has thus marginalized the pastoral and transhumant communities. The present study focuses on: (i) identification of the traditional institutions, their resource-use IKS, and its economic, cultural and environmental determinants; (ii) analyses of the process of gradual disruptions of IKS in relation to changes in economic and social systems; and (iii) verification of the findings through group discussions and empirical observations. Six high altitude villages of Darma and Byans valleys in Dharchula in Pithoragarh districts of Kumaon, and six villages in Mana and Niti valleys in Chamoli district of Garhwal were investigated under this study.

Results and Achievements

- Identification of processed crops, spices & condiments that were marketed
- Status of local handicrafts

1. In Mana valley, only three crops Patato (*Solanum tuberosum*), Phaphar (*Fagopyrum tataricum*) and Rajma (*Phaseolus vulgaris*) were preferred for cultivation (Table 18).
2. The indigenous method of processing and marketing of available resources was yet another method of survival of high altitude pastoral communities. They collect around 20 types of wild and cultivated condiments, spices and herbs; give them minimum treatment, and sell them to the local sedentary villages of lower altitudes (Fig. 48).
3. With integration of traditional designs of wool weaving/knitting with Ludhiana made yarn the transhumant woman make local woollen products such as *Dan*, *Thulma*, *Asan*, *Pankhi*, sweater and socks and earn about Rs. 34000 to 47100 per year (Table 19).

Table 18. Average crop production in Mana village in 2005 (kg/ *Nali*)

Crops	Seed input (kg/ *Nali*)	Manure input (one time) (kg/ *Nali*)	Fertilizer input (one time) (kg/ *Nali*)	Yield (kg/ *Nali*)	Total Production (kg/ household)
Patato	20-30	30-50	10-15	200-240	2000-2600
Phaphar	2-5	30-50	10-15	100-150	20-35
Rajma	2-5	30-50	10-15	90-140	20-25

One *Nali* = 0.02 ha or 200 m^2

Fig. 48: Sun drying of *Jambu* (*Allium* sp.) and garlic (Left) and packaging of raw wool for colouring (Right).

Table 19. Average income from woollen products / family in Mana valley (2005)

Products	Numbers produced	Wool consumption (kg.)	No. of man days	Number of pieces sold/ a year	Price per piece (Rs.)	Average income (Rs.)/year
Dan	4-8	5.5	25	5-7	1800	10000-12600
Thulma	3-6	7.5	17	3-6	1200	5000-7500
Asan	20-30	1.5	2	20-30	150	3000-5000
Pankhi	10-25	2.5	3	20-25	350	5000-8000
Sweater	10-30	1.5	2	20-30	375	10000-12000
Socks	10-40	0.25	1	20-40	50	1000-2000

IKS 2: Documentation and Analysis of Indigenous Post Harvest Practices and Seed Storage Technologies in Garhwal Himalaya

Identification of appropriate IKS sites & practices, & process verification

Background and objectives

The traditional agriculture has proved to be productive, sustainable and ecologically sound, especially under extraordinarily difficult conditions of the Himalayan region. Most farmers in the Garhwal region rely on a wide range of local crops well adapted to the local environment. In this way they are able to secure a diverse food supply and sustain their livelihoods by minimizing the risk of crop failure. Local and indigenous knowledge about seed storage and post harvest practices has contributed substantially in the continuance of their traditional agriculture systems. Such knowledge, which has been accumulated over the years, is fundamental for food production and cropping strategies in this region. The present study focuses on: (i) identification of appropriate villages/sites for documenting the post harvest practices; (ii) identification of various seed storage techniques; and (iii) verification of findings through group discussion and interviews in selected villages of Ukhimath (District-Rudraprayag) and Mana and Niti valleys of Chamoli- Garhwal, Uttaranchal.

Results and Achievements

- Identification of species preserved
- Listing of most common crops

1. Agriculture is the main source of livelihood and the farmers have preserved around 80 species belonging to food grains, pulses, oilseeds, vegetables, cash crops, fodder and fruit species in the study areas.
2. The most common food crops grown in the area were rice (*Oryza sativa*), wheat (*Triticum aestivum*), maize (*Zea mays*), potato (*Solanum tuberosum*) Amaranths (*Amaranthus caudatus*), pigeon pea (*Cajanus cajan*) and horse gram (*Macrotyloma uniflorum*). Jowar (*Sorghum bicolor*), white mustard (*Brassica alba*), black mustard (*Brassica nigra*), barley (*Hordeum vulgare*), fox tail millet (*Setaria italica*), black soyabean (*Glycine max*) and barnyard millet (*Echinochloa frumentacea*) were less preferred crops by the high altitude peasants.

IKS 3: Documentation of Perceptions Regarding Indigenous Uses of Selected Plant Species of Uttaranchal Himalaya

Documentation of values of plants & spread of related ethno-botanical knowledge

Background and Objectives

The indigenous communities of the Uttaranchal Himalaya hold a great deal of knowledge that is accumulated through generations about traditional uses of various plant species. The information on valuable species will give a strong manifestation of people's preference on useful plant resources. The

present study focuses on: (i) what makes a plant species important from local people's perspectives? and (ii) assess how ethnobotanical knowledge is distributed among the population with respect to age, gender and village.

- Identification of important plants
- Listing of preferred species for different uses

Results and Achievements

1. A total of 32 species of medicinal plants, 15 species of wild edible fruits, 15 plant species of religious importance and 22 timber yielding species were told important by 65 respondents across different district of Uttaranchal.

2. Of the 32 medicinal plant species, *Swertia chirayita*, *Phyllanthus emblica*, *Picrorhiza kurrooa*, *Aconitum heterophyllum* and *Ocimum sanctum* were most preferred species (Table 3). These medicinal plants were used for curing a number of ailments.

Table 20. Preferences of medicinal plant species by indigenous people of Uttaranchal

Species	Vernacular name	People's prefrence (%)
Swertia chirayita	Chiraita	48
Phyllanthus emblica	Awala	45
Picrorhiza kurrooa	Katuki	42
Aconitum heterophyllum	Ateesh	41
Ocimum sanctum	Tulsi	33
Dactylorhiza hatagirea	Salampanja	27
Xanthoxylum armatum	Timur	25
Curcuma domestica	Haldi	22
Cinnamomum tamala	Tejpat	22
Rheum australe	Dolu	15

3. *Rubus ellipticus*, *Berberis* spp. and *Myrica esculenta* were preferred by over 80% respondents. *Benthamidia capitata*, *Ficus palmata*, *Carissa* spp., *Ficus auriculata*, *Aegle marmelos*, *Musa* spp. and *Ziziphus mauritiana* were other important wild edibles in descending order of preferences.

4. *Ocimum sanctum*, *Pyrus cerasoides*, *Ficus religiosa*, *Cynodon dactylon*, *Aegle marmelos*, *Ficus bengalensis*, *Saussurea obvallatta*, *Rosa* sp., *Musa* sp. and *Nelumbo nucifera* were the important plants used for religious activities.

IKS 4: Traditional Knowledge of Understanding Indicators of Weather

Documentation of IKS on indicator of weather & its distribution

Background and objectives

Senior citizens of rural Himalaya have good understanding of their natural systems including indicators of local weather, agriculture and pastoralism. Historically, the natural environment, particularly physiographic and climatic constraints, has strongly influenced their settlement pattern and their resource-use pattern. Their proximity with the natural systems led them to understand the indicators of weather that have particular significance to the agrarian societies. This study is an endeavour in this direction to understand and document their knowledge of weather indicators. The main objectives of the study are: (i) investigation of traditional knowledge of indicators of weather; and (ii) understanding the distribution of knowledge among the population with respect to age, gender and village.

Results and Achievements

- Compilation of perceptions by age
- Documentation of perception on temperature-humidity- rainfall link and snowfall

1. A total of 333 persons from 42 villages of Bageshwar and Pithoragarh districts of Uttaranchal responded about the weather indicators (Table 21). If the temperature rises gradually and atmosphere becomes suffocating due to humidity, it is a sign of rainfall. If the weather is cloudy and wind blows, it is assumed that rainfall will not occur, as the clouds will be cleared by wind.

2. When yak stops chewing cud it indicates beginning of snowfall soon. If snowfall starts in the evening and stays and freezes on tree branches it is believed that snowfall will occur for few more days. When snow looks slightly bluish in colour it indicates the continuation of heavy snowfall.

Table 21. Age group wise distribution of respondents for indicators of weather in the high altitude of Kumaun Himalaya

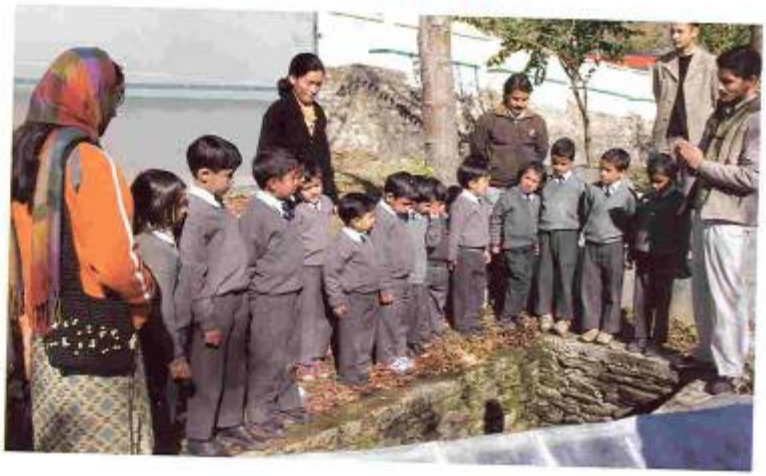
Age group (years)	Respondents (%)
20-40	14 (4.2)
41-60	114 (34.2)
61-80	159 (47.7)
81-100	46 (13.8)
Total	333 (100)

R&D HIGHLIGHTS

REGIONAL UNITS

The Institute manifests its outreach through its four regional Units, at Mohal-Kullu (Himachal Unit), Srinagar-Garhwal (Garhwal Unit), Pangthang (Sikkim Unit) and Itanagar (North-East Unit). Adequate infrastructure has been created at these Units to conduct the R&D work following the Institute mandate. The following five pages presents some major highlights of these Units during the reporting period. However, the details of the R&D work carried out at these Units appear in the main text of this Annual Report.

HIMACHAL UNIT



- Medicinal plant management plan
- Base-line information on impact of dam
- Biodiversity elements & resource use of CDBR & wild life sanctuaries
- IKS of cold desert environment
- Ambient air quality database
- Plant water relationship & seed germination protocol
- Arboretum, herbal garden strengthening

- Inventorization and status assessment of medicinal plant species i.e. their number, nativity, endemism, rare, endangered and threatened status was carried out in the submergence zone and catchment area of the Parbati Hydro Electric Project Stage – III, Kullu district and a medicinal plant management plan for their cultivation and conservation prepared.
- For generation of baseline information on impacts of dam construction as perceived by the affected community, air quality changes etc., for suitable EMP suggestions and futuristic planning, survey of 25 villages and monitoring of air quality was conducted in the influence zone of Parbati II and Parbati III hydropower projects; also impacts of dam construction on floristic diversity was assessed in Hamta Jagatkush catchments.

- Inventory of Angiosperms (> 4,300 species, 3000 species listed from HP, 1100 native to HP) for Trans, North West and West Himalaya was prepared and assessment of bio-diversity elements, resource use pattern, and preference of species for fuel use was recorded for Kais, Khokhan, Manali wildlife sanctuaries and in the proposed CDBR in Lahul and Spiti district.
- The soil fertility management through use of night soil compost and traditional *Khul* irrigation system practiced in the Lahul valley was documented; also efficacy assessment of Khul system in terms of flow in channels, and nutrient and seepage losses etc., was carried out.
- Background database on various ambient air quality parameters was further strengthened through monitoring of TSP, PM_{10}, O_3, SO_2 & NO_2 in selected spots in Kullu-Manali region.
- Water stress tolerance studies on important species of NW Himalaya was conducted through measurement of water potential and SPAD-502 meter values; species of genera *Quercus* and *Ulmus* were studied. Seed germination protocol for *Hypericum perforatum*, a vulnerable high value medicinal plant with GA_3 (70.00%), KNO_3 (71.11%) and $NaHClO_3$ (44.44 %) was achieved.
- Medicinal plant nurseries at Mohal and Kasol and herbal gardens at Mohal and Dhoranala strengthened, and 1.94 ha of land for arboretum acquired.

GARHWAL UNIT

- Reconnaissance on traditional institutions, their resource use IKS and its economic, cultural and environmental determinants carried out at high altitude villages in Darma, Byans, Mana, and Niti valleys; information

on indigenous methods of processing, and marketing of available resources collected.

- Pastoralism & trans humance
- Indigenous post harvest practices & seed storage
- Impact of recession of Himalayan glaciers.
- Cultivation of aromatic, medicinal and wild edible plants
- Below ground diversity
- Rural technology trainings

- Preliminary work on identification of various seed storage techniques was verified through group discussions and vegetable species preserved have been identified.
- In Dokriani Bamak Glacier, CO_2 monitoring at base camp (near snout), Bhatwari, and Srinagar was conducted, and compositional changes in vegetation, population attributes, IVI etc. were studied.
- Impact of protected cultivation and biocompost application yielded 4 - 5 times below ground biomass yield increment for *A. glauca* and *A. benthamii*. Seedlings (1.4 lakh of *P. Kurrooa*, 30 thousand of *S. costus*, and 10 thousand of *L. angustifolia)* of MAPs were raised at village Ginothi (Uttarkashi) for large scale cultivation.
- Indigenous uses of wild edible plant species viz, *N. pallens, P. utilis, P. persica*, and *P. armaniaca* which are valued for their edible oil fruits, and medicinal properties, were documented, multiplication experiments carried out, and conservation strategy through value addition in food, cosmetics, and medicinal uses recommended.
- In order to understand the link between soil quality attributes and belowground biodiversity population attributes of termite and ant populations were recorded for two altitudinal windows of Nanda Devi Biosphere Reserve and Kedarnath Valley areas.
- Experiments on impacts of growth harmones on rooting in stem cuttings of *H. rhamnoides* were conducted and awareness camps and training workshops about its multiple use values and economic potential organized in the Niti and Mana valleys.
- Five training-cum-demonstration programmes on packages of rural technologies comprising of vermiculture, vermicompost, vermiwash, *Azolla* culture, zero energy cool chamber etc. organized; 246 persons benefited.

SIKKIM UNIT

- Conventional propagation method was developed for *S. chirayita*, and maximum seed germination (70%) was observed with $NaHClO_3$ under substrate trials - natural soil, clay soil, and CS+FH+Sand, all yielded >90% germination. Also, *in vitro* mass multiplication of rhododendron spp.- particularly, *R. maddeni*, and *R. dalhousiae* continued, multiple shoots and rooted plantlets produced, field transferred and growth performance of rhododendron plantations monitored.

- Plant propagation research
- Biodiversity elements & database
- GPS study for tectonics
- Lead BR coordination
- Gene Bank
- Training

- Efforts for preparing systematic database of species and habitats, and to prioritize taxa for conservation continued; about 600 woody taxa and 420 MPs inventoried. Eleven populations of *S. chirayita* were explored and assessed for availability over 14 micro-habitats and their correlation with physiographic attributes studied.
- Detailed GPS field campaigns were conducted in Sikkim and Darjeeling Himalaya and data from reference GPS station at Panthang recorded for study of tectonic deformation and isolation of zones of high displacement and strains.
- The institute was identified as the Lead Bisosphere Reserve coordinating institution for Khangchendzonga, Manas, and Dibru Saikhuwa biosphere reserves in the NE region; compilation of research based information on these BRs initiated.
- Gene bank in the Institute campus strengthened, 1725 individuals (>50 taxa) assessed for stem girth; Smriti Vatika in the memory of Pt. G. B. Pant established in 0.6 ha land and one experimental medicinal plant nursery also established in the campus.
- Eleven technology exposure trainings organized, 442 persons benefited; disaster mitigation trainings imparted to students, teachers, and Sikkim armed police personnels.

NORTH-EAST UNIT

- NTFP potential of NE
- Traditional practices under Jhum
- Inventorisation of Lead BR floristic diversity
- Follow management of Tangkhuls.

- Inventorization of the Non Timber Forest Products (NTFPs) for seven states of NE India completed; 55 NTFP items marketed from NE and Manipur owns the highest (26 nos.) of NTFPs.
- Digitization of the floristic elements of six states – Assam, AP, Manipur, Meghalaya, Mizoram and Tripura and inventorisation of rare, endangered, threatened, and endemic elements of NE India carried out.
- Traditional pest management practices among the indigenous tribes practicing shifting cultivation were documented for three states of NE, and traditional SWC practices (Phaik and Hade) and nutrient enrichment practices of under jhum farming system of Nyishi tribe studied; resources used for nutrient enhancement identified.
- Soil nutrient dynamics and management practices under the fallow period of shifting cultivation, and crop yield under 3 year or above cultivation phase is being studied; preference of species during ground clearing for fallow recorded.

APPLICATION OF R&D OUTPUT IN DEMONSTRATION & DISSEMINATION

Capacity Building

The Institute executes its mandate through research, demonstration and dissemination activities across the IHR with the involvement of a range of stakeholders. During the reporting period the application of R&D output was ensured through following main demonstration and dissemination activities.

(a) Livelihood Options

1. Farmers Field School-Cum- Training Programme

Demonstration, training, implementation support and fine tuning of hill - specific technologies to capacity building

A critical constraint in rural development is access to technology, particularly for productivity enhancement and income generation. Demonstration of technologies and training of users were identified two crucial steps in the transfer of technology to remote rural areas where it is most needed. With this rationale Rural Technology Complex (RTC), those can act as nodal points to collect information from various agencies, institutions, individual experts and to disseminate this knowledge to target groups in the region were established at the Institute HQs and at the Garhwal Unit in the past. At these sites environment-friendly and cost-effective technologies have been demonstrated, and these are also continually upgraded through feedback from other Institutions. Capacity building through trainings, demonstrations of technology packages and field exercises of target groups are carried out at these centers with the main objectives of (i) Capacity building of user groups towards technology adoption, management and development of resources; (ii) Guidance and support for field implementation of technology packages; and (iv) Technology fine-tuning based on the feedbacks of the user groups. The achievements of this activity were:

- Major technological packages under RTC
- Trainings imparted (30 nos.; 2914 people)
- Technology dissemination through other forums & capacity building

1. Information on about 30 known, available and tested practices/ technologies were collected, modified, and demonstrated under major groups as: yield increasing, income generating, life supporting and value adding.

2. Trainings (30 nos.; total 2914 people) were imparted on protected cultivation, bio-composting, mushroom cultivation, vegetable cultivation, agroforestry, horticulture, multipurpose tree plantations, cash crop cultivation, water harvesting, fish cultivation, bio-briquetting, soil conservation, watershed management, waste land development, etc. to officials of different Government organizations (1200), NGOs (209), farmers, women (842) students (18), etc. (Fig. 49). Through these trainings a total of Rs. 5, 18,475.00 were generated.

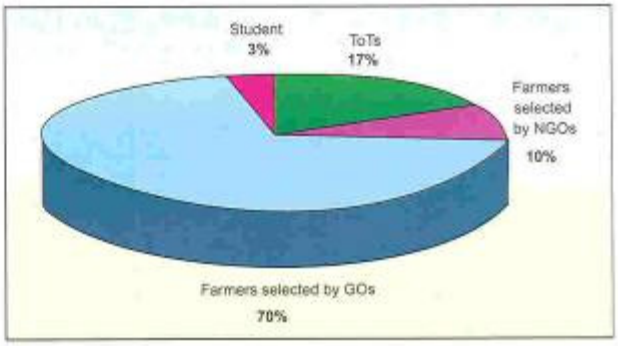


Fig. 49. Trainings organized for different user groups at RTC

3. Technology packages were also distributed among the people during various meetings, *Kisan Melas* at Block Head Quarters, trainings and field visits. In addition technical and infrastructural help was also provided to selected farmers. Raising of multipurpose tree species and its distribution on nominal cost generated Rs. 30,215. A number of stakeholders/user groups visited the RTC during this year (Fig. 50).

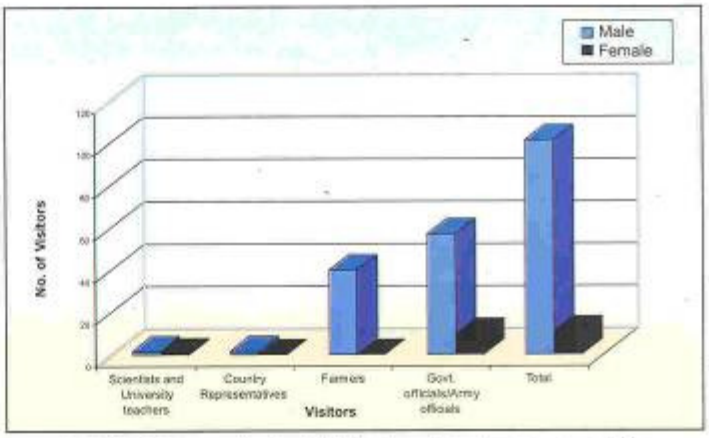


Fig. 50. Visitors to the Rural Technology Complex, Institute HQs

2. Demonstration and Dissemination of Appropriate, Cost-Effective Hill-Specific Technologies for Sustainable Rural Development of Garhwal Region (UA)

Technology change is an important element in the process of development and lack of it is the main cause of poverty, which is common

Technology development, demonstration & training through Rural Technology Centers

in the rural sector of the Central Himalaya. The region is rich in bio-resources but it is felt that the potential of science and technology has not been adequately harnessed in overcoming the development constraints. Therefore, development of technologies and the requisite training of target groups/users are two important aspects required in the transfer of technology. The achievements of this activity were:

1. Demonstrations on different composting (vermicompost, biocompost, and farm manure) on selected crops and vegetables on yield.
2. Five trainings-cum-demonstration programmes were organized and 246 persons (155 farmers and students) were trained (Fig. 51) on different rural technologies. In these trainings feedback from academicians were also sought.

Fig. 51. Capacity building of the farmers/students/other user groups at demonstration site inviting the subject experts

3. Promoting Cultivation of Medicinal and Aromatic Plants in the Nanda Devi Biosphere Reserve and Other Areas of Garhwal Himalaya

The IHR is a storehouse of unique and rich floral and faunal diversity with high economic potential. The use of herbal plants in medicine and for other purposes in Himalaya represents a long history of human

interaction with the environment. However, over-harvesting of variety of valuable MAPs has resulted in resource degradation, loss of biodiversity, loss of indigenous knowledge and traditions. Therefore, there is a need to emphasize upon selected MAPs with economic potential for large-scale cultivation. Under this activity impact of different treatments on belowground biomass yield, raising planting materials of few selected species, and awareness creation among the rural people for large scale domestication/ cultivation was attempted. The achievements of this activity were:

- 4-5 fold yield increase by protected cultivation & biocompost
- Mass multiplication of *P. kurrooa*, *S. costus*, & *L. angustifolia*

1. Impact of protected cultivation (shade net, polyhouse) and application of biocompost resulted into 4-5 fold higher biomass yield of *Arnebia benthamii*, *Angelica glauca*, *Rheum emodi* and *Pleurospermum angelicoides* as compared to control (Fig. 52). *A. glauca* and *A. benthamii* exhibited greater belowground biomass.
2. About 1.8 lakhs of seedlings of three species i.e. *Picrorhiza kurrooa* (1.4 lakhs), *Saussurea costus* (0.30 lakhs) and *Lavendula angustifolia* (0.10 lakhs) were raised at Ginothi village (Distt. Uttarkashi) so as to meet the growing demand for large scale MAPs cultivation of the motivated people of the region.

Fig. 52. Large-scale cultivation of MAPs at Ginothi (Uttarkashi)

4. Capacity Building and Economic Upliftment of Rural Women through Livestock- Fish- Crop Farming

This activity addressed the complex issues of sustainable development, employment generation, poverty alleviation and improvement in quality of life of rural folk, primarily women and children through: (i) Optimal utilization of wastewater and underused land resources through integration of fishery with livestock, poultry and vegetable cultivation; (ii) Motivation and capacity building of local people; (iii) Monitoring of physico-chemical, biological parameters of water and management of fish health; and (iv) Income generation by the sale of extra produce. The achievements of this activity were:

- Establishment of models in three villages
- Yield results under different models

1. In three models demonstrated at village Basoli and Manan (Distt. Almora) and Haigad (Distt. Bageshwar) on tri-commodity approach of fishery, poultry/duck farming and vegetable cultivation coupled with assured supply of safe drinking water through slow sand filtration about 140 women were trained.

2. Intensive fish culture incorporating high density stocking of silver carp (*Hypophthalmicthys molitrx* Valenciennes), grass carp (*Ctenopharyngodon idella* Valenciennes) and common carp (*Cyprinus carpio* Linnalus), and fertilization mainly through integration of chick/duck and cow, a yield level of 4621 and 5650 kg/ha/yr was realized at Manan (Fig. 53) and Basoli, respectively.

3. From a small poultry (30 birds) and duckery (6 ducks) unit, 2287 and 900 eggs were obtained in a year. Besides diversified farm output (fish, chicken, eggs and fresh vegetable) for household use, gross income of Rs. 22,936 and Rs. 29,360 was generated from integrated fish farming system at Basoli and Manan, respectively.

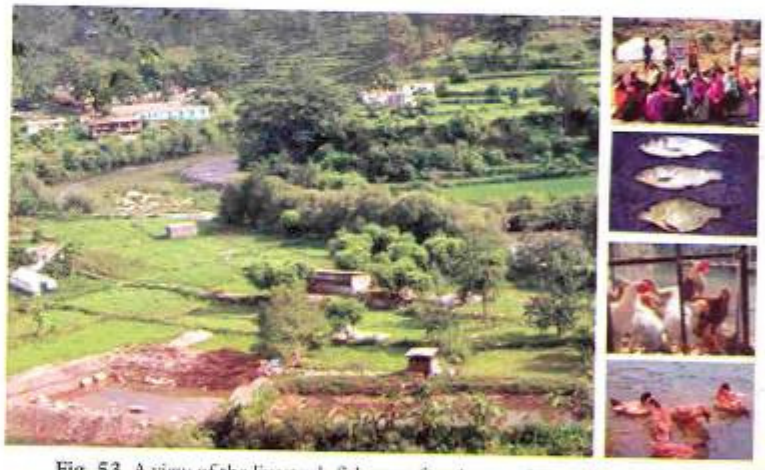


Fig. 53. A view of the livestock-fish-crop farming model at Manan Village

5. Vegetable Cultivation (Technology Vision 2020 Mission Mode Project on Agriculture) in Sikkim

Economic upliftment of hill farmers communities through technology demonstration & training

Under the broad objectives of Technology Vision 2020 Mission Mode Project on Agriculture, the TIFAC Project in Sikkim executed by the NE Unit has focused on socio-economic upliftment 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 on cultivation of disease-free ginger crop. The achievements of this activity were:

- Better yield & growth results through simple techniques & treated/ superior varieties

1. Adopting the technique of solar sterilization of ginger (pre-sowing) using organic manure, the farmers of three villages (Tarku, Central Padam and Cham Gaon, Sikkim) reaped yield higher than that reaped in previous five years. Similarly, higher yields of vegetables were also obtained at these three villages adopting polyhouse and simple technologies (Fig. 54).

2. Performance evaluation of 150 mandarin propagules (Central Pandam village) and 9,100 propagules of disease free cardamom (Lingdok and Tumin villages) distributed to the farmers indicated no report of insect or disease infestation in these plants during one year growth.

Fig. 54. Cabbage cultivation in polyhouse (A) and a self built polyhouse (B), both at Central Pandam village, East Sikkim

6. Demonstration of Silvi-Pasture Model for Wasteland Restoration in Western Himalaya

Wasteland restoration for fodder production and soil and water conservation

In the western Himalayan region culturable wasteland is increasing with the mounting pressure on forest vegetation in the want of resources such as, fodder, fuelwood, wood for agricultural implements, minor timber and NTFPs for subsistence livelihood of the rural populace. Large chunks of wastelands around the villages are available for revegetation with suitable mix of plants that could cater to the need of the above resources. Silvi-pasture development is one such approach that involves the plantation of MPTs suiting to the demand of local people and adapted well to the local agroclimatic conditions. In this demonstration 41 ha village wastelands across three localities of UA were put under MPTs plantation and suitable cultural practices that allowed the regeneration of fodder grasses.

- Survival and growth records of fodder plants
- Production of grass from wastelands enhanced

1. At the Katarmal (Distt. Almora) site (5 ha) mean height of plants was recorded 42.0 ± 7.2 cm; and the average survival 49% after two years of plantation in March 2006 (Table 22). The maximum survival was recorded for *Bauhinia retusa* (90%) and *Quercus leucotrichophora* (82%) and the minimum for *Salix alba* (20%).

Table 22: Growth of plants after 2 years at Katarmal Village wasteland

Vernacular name (No. of live plants)	Botanical name	Mean height (Cm) (Height range)
Banj Oak (165)	*Quercus leucotrichophora*	63.2 (14 – 151)
Phalyant (40)	*Quercus glauca*	30.7 (8 - 68)
Utis (7)	*Alnus nepalensis*	21.6 (14 – 41)
Pomegranate (4)	*Punica granatum*	70.8 (66 - 83)
Kwairal (35)	*Bauhinia variegata*	26.7 (10 – 89)
Harar (6)	*Terminalia chebula*	12.0 (9 - 14)
Shisham (27)	*Dalbergia sissoo*	61.6 (7 - 180)
Siris (5)	*Albizia lebbeck*	19.4 (14 – 26)
Bitun (24)	*Melia azedarach*	72.9 (19 – 210)
Bhimal (10)	*Grewia optiva*	13.8 (9 - 21)
Walnut (23)	*Juglans regia*	15.1 (6 – 25)
Kharik (19)	*Celtis australis*	30.8 (8 – 54)
Reetha (18)	*Sapindus mukorossi*	53.5 (10 – 122)
Bains (7)	*Salix alba*	95.7 (50 – 180)
Total Plants = 390	14 Species	42.0 ± 7.2

2. At the Katarmal site 46 Q (dry wt.) fodder grass was harvested by the stakeholder community, thus saved 232 women labour days (Fig. 55). At the Dobh-Srikot site (Pauri-Garhwal) the grass at the silvi-pasture site (10 ha) was purchased by people of weaker section from the stakeholders and later sold it at higher prices. Earlier these sites did not produce fodder to be harvested by the village people.

Fig. 55. Silvi-pasture sites developed at Katarmal and Dobh-Srikot (UA)

7. Community Wasteland Development in Katarmal Village (Kosi-Almora)

- Plantation of multipurpose trees in community wasteland
- Soil & water conservation measures
- Rain water harvesting in poly-ponds

1. A community wasteland (= 2 ha area) of Katarmal village that was severely grazed was taken up in summer 2005 and planted with fodder/ fuel wood species (1478 saplings of 25 spp.), polythene lined ponds (3 nos.) and contour trenches for rainwater harvesting were dug out seeking community participation (Fig. 56).

2. After 9 months in March 2006, plant survival was recorded 64%. Promising growth (= 1.5 m high) was recorded for *Alnus nepalensis* and *Grevillea robusta*. In the polyponds about 7,500 L of rainwater-runoff was harvested for irrigation of plants. The trenches also harvested water to supplement the growth of plants. Protection and SWC measures revived the grass cover leading to 61 Q harvests till March 2006, thus saving about 76 women days, otherwise spent for collection of grass from distant areas.

Fig. 56. Katarmal village community wasteland restoration through rain water harvesting and MPTs plantation

8. Community Wasteland Rehabilitation: Village Bantoli, Bageshwar, UA

In this activity a community degraded grazing land by applying SWEET and planting with MPTs (a total of 7630 plants preferred by the village community) were planted. The average survival was recorded over 84% after

- Plantation of village grazingland with multipurpose tree species, and improved grass
- Community participation for protection of plants

an initial mortality due to termites. The area was fenced and soil moisture was increased through contour trenches, plugging of gullies and introduction of grasses etc. Plant species like *Q. leucotrichophora, Q. glauca, Bauhinia variegata, Dalbergia sissoo,* and *Alnus nepalensis* performed well. Broom grass and Napier have been adopted by the villagers for growing on the terrace margins and risers. The site is formally handed over to the Village *Van Panchayat* (Forest Council) for future management. As a result of complete protection against grazing, the revived grass lots has been harvested and distributed to all stakeholders under the rules formulated jointly by the *Van Panchayat* and *Mahila Mangal Dal* (women self help group).

Community Wasteland Restoration through Sloping Watershed Environmental Engineering Technology (SWEET) in Kumaun Himalaya

SWEET package developed by the Institute was demonstrated at four representative sites (113 ha community and 55 ha private wastelands) in 5 villages of Almora district in 2001. These sites experience a wide range of land degradation caused by soil erosion from sloping community land, heavy grazing by domestic animals, abandoned agriculture land, acute water shortage and out-migration of land owners. Measures on in-situ SWC, site protection through fencing, water harvesting through low-cost polythene lined tank, and selection of tree species based on multipurpose benefits were implemented. After 5 years of growth, Alnus nepalensis, Prunus cerasoides, Cassia nilotica, Albizzia leebeck, Dalbergia sissoo, Quercus leucotrichophora performed better and can be promoted for waste land restoration. The annual increment in fodder yield of these sites is presented in Fig 57. The cost of treatment per ha (Rs. 14,500) include cost of fencing and site protection (38%), biological interventions (30%), physical interventions (15%) and other costs. Cost can be reduced if social and biological fencing are adopted. A minimum of 5-7 year's support is necessary at initial stage for successful establishment of model and getting land in terms of fodder and other biomass. Adaptability of SWEET has been very encouraging.

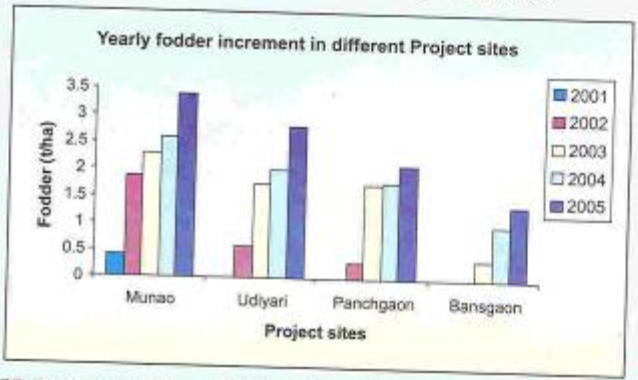


Fig. 57. Yearly increment and fodder yield at different sites in the hills of District Almora (UA)

(b) Natural Resource Conservation and Management

1. Impact of Different Fertilizers on Survival, Leaf Growth and Soil Quality of Tea Plantation

Alternative land use practices' impact on environment

Growth trials of tea under different fertilizers

The Government of Uttaranchal motivated the local people for tea cultivation and as a result a number of small tea gardens have come up in the region recently. Mostly abandoned rainfed croplands and culturable wasteland of local inhabitants have been put under tea plantations. To make this activity environment-friendly the possibility of using bio-fertilizer and locally made FYM was experimented as compared to chemical fertilizer, that could be adopted by the tea growers. An experimental plantation was therefore, established to determine the impact of fertilizer (NPK), traditional FYM and bio-fertilizer on tea plant survival, number of leaves (two leaves and a bud), leaf mass and soil quality. A total of 432 cutting raised plants of UPASI-9 variety of tea were planted in 18 plots in a RBD design in September 2003 and periodical observations were taken on different plant growth parameters (Fig. 58).

Fig. 58. Experimental tea plantation developed at Kosi-Katarmal

- FYM treated plants yield more leaf crop
- Plant mortality highest under fertilizer treated plots

1. Phenological studies revealed that during the growing period (April – October 2005), FYM treated plots produced greater number of leaves per bush (124.9) followed by bio-fertilizer (119.6) and NPK treated plots (113.2). Dry weight of leaves per bush was obtained maximum for bio-fertilizer (24.4 g), followed by FYM (17.5 g) and least by NPK treated plots (16.5 g). Two peaks in leaf production and leaf dry weight per bush were recorded for all the treatments (Figs. 59 A - B). The

cumulative plant mortality for NPK treated plots was recorded significantly higher as compared to FYM (t=3.16; P<.01), and bio-fertilizer (t=3.49; P<.01) treated plots (Fig. 59 C).

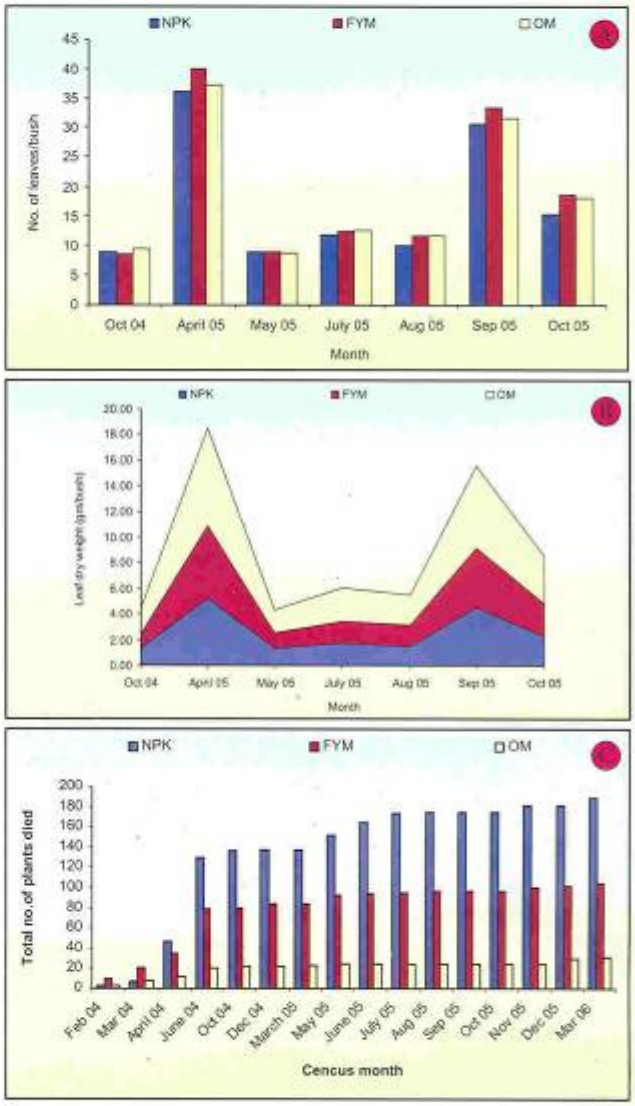


Fig. 59. Number of leaves per tea bush (A); Leaf dry wt. per bush (B) & Cumulative mortality under different fertilizer treatments (C)

2. Soil analysis of the experimental plots revealed that both organic carbon and organic matter were more in FYM treated plots as compared to other two treatments. Soil moisture and water holding capacity was found higher for bio-fertilizer treated plots as compared to the other two treatments (Table 23).

Table 23: Impact of different fertilizers on soil quality parameters under experimental tea plantation (October 2004-March 2006)

Parameters	NPK	FYM	Bio-fertilizer
pH5.	23±0.10	5.45±0.11	5.51±0.12
OC (%)	0.65±0.07	0.69±0.06	0.59±0.04
OM (%)	1.12±0.12	1.20±0.10	0.97±0.10
Moisture (%)	20.00±4.34	16.34±2.91	20.43±4.61
WHC (%)	55.38±1.88	55.10±3.22	57.47±1.91

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

Implementation of VEAP & strengthening of rural livelihood technologies through involvement of NCC

This programme is a joint venture of National Cadet Corps (NCC) of India and GBPIHED. The programme envisages implementing village environment action plan (VEAP) and strengthening rural livelihood technologies in adopted villages with the technical support of GBPIHED and involvement of the workforce of NCC. Initially the target area is Kumaun in Uttaranchal, subsequently it will expand in other areas of the region. The objectives of the programme are: (i) To train the NCC cadets and officials of the region in training of trainers (ToT) mode on VEAP; (ii) Extension and awareness camps organization by NCC cadets/officials in respective rural areas for training the farmers/ villagers to foster this programme; and (iii) Implementation of VEAP demonstration models in adopted villages across the region. The main activities were:

- **Preparation and implementation of village environment action plan for Railakot village**
- **Training of trainer women's on livelihood technologies (45 master trainer trained)**

1. VEAP was prepared for Railakot village (District Almora, Uttaranchal) involving NCC Cadets and officials, which include resource maps, priority problems and strategies for their integrated solutions. Biological and physical interventions were initiated in this village that include plantation of a community wasteland (1780 plants of 9 fodder species), construction of ponds (3), *Khal (2)*, check-dams (2) and 580 trenches for water conservation (Fig. 60).

2. 45 women of Railakot village (master trainer) were trained for various livelihood options. They will be promoted to develop field models for farmer-to-farmer trainings.

Fig. 60. Demonstration of poly-pond construction in Railakot village

3. Participatory Management of Bhimtal Lake Catchment, Kumaun Himalaya

Participatory management of lake catchments through interventions, institutions building & policy dialogues

The Govt. of Uttaranchal has prepared a Lake Conservation and Management Plan for four lakes including Bhimtal lake (Distt. Naini Tal) with a goal of soil conservation and watershed management. The GBPIHED has been identified the implementing agency for Bhimtal lake on a mutually agreed scheme on "Participatory Management of Bhimtal Lake Catchment". The project has introduced and supported interventions that sustainably improve the degraded areas of Bhimtal catchment vis-à-vis livelihood, capacity building of the stakeholders and promotion of village-level institutions in order to develop an enabling environment for sustainable management of the *Van-Panchayat* lands. The project aims to develop a few prototypes of land rehabilitation for upgrading management of natural resources in the lake catchment area (Fig. 61). The main activities executed were:

- **Restoration of degraded community land by four model approach**
- **seedlings of multipurpose species planted**
- **Development of aromatic plant model with women participation**
- **1338 seedlings of fruits planted**

1. To restore the degraded community lands four models (viz. MPTs, silvipastoral, aromatic plant, and agri-horticulture) an area of 7, 1.5, and 2.5 ha was treated for these respective models in two villages of the lake catchment. Four community interaction meetings were organized to identify work elements, responsibilities and monitoring of the activities. Trainings on contour making and hedgerow plantation were also done for local stakeholders.

2. In the MPTs model, 4326 seedlings of Alnus *nepalensis, Albizia chinensis, Cedrus deodara, Bauhinia variegata, Quercus leucotrichophora,* and *Grevillea robusta* were planted. In silvipastoral

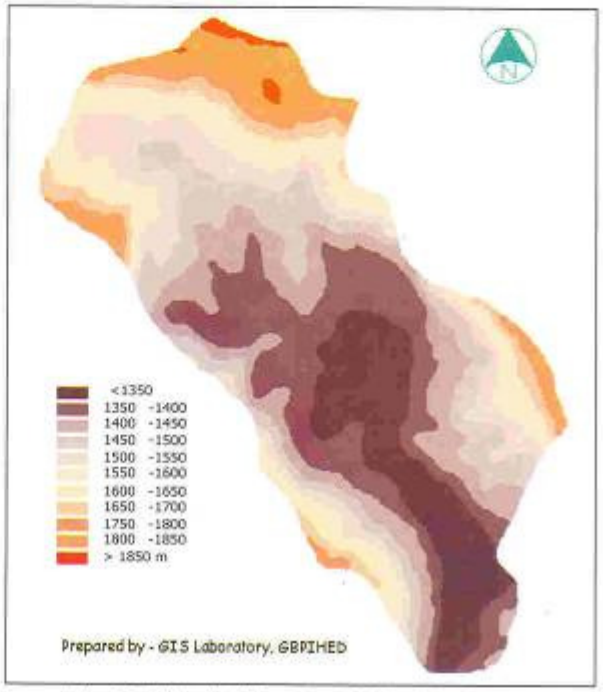


Fig. 61. Altitudinal Zonation of Bhimtal Catchment
(Based on survey of India Toposheet 1964-1965)

model grasses like *Pennisetum purpureum*, and *Thysanolaena maxima*, and fodder trees such as *B. retusa*, *Q. leucotrichophora*, and *Morus alba* were planted.

3. The aromatic plant model is being developed seeking participation of mostly BPL women farmers groups. In this Lemon and Citronella grasses (33000 slips/ha) and 500 seedlings of Tejpatta, Amla, Harar and Bahera were planted. At agro-horticulture model 1338 seedlings of fruit-trees were planted.

4. Network Programme for the Establishment of Demonstrations of Bamboo Plantations in Uttaranchal

Large scale multiplication and field demonstration of bamboo

Besides a source of quality fodder particularly during winter, and numerous traditional uses, Bamboos constitute a group of highly sought after industrial raw material for use in pulp, paper, mat board, and handicraft industries. In view of the decreasing bamboo reserves in the country and its much relevance to the hilly region, this project on field demonstration of 'maggar bamboo', *Dendrocalamus hamiltonii*, has been initiated in which the propagation protocols developed at GBPIHED are being used. This

activity focuses on: (i) Large scale multiplication by conventional and *in vitro* methods; and (ii) Setting up of demonstration plots.

- Multiplication through nodal explants, vegetative propagation & seeds
- NAA - an effective rooting agent

1. About 2000 plants of *D. hamiltonii* raised from nodal explant of an elite bush and 1000 plants were supplied for field plantation and another 1000 are being hardened. In addition more than 5000 seed raised plants of *D. strictus* were supplied for plantation (Fig. 62).
2. Vegetative propagation using culm cuttings (about 1.5 m in length containing 3-5 nodes) was carried out and the effect of two auxins (IBA and NAA) and a systemic fungicide (Bavistin) was found effective for NAA (60% rooting compared to nil in control) for root induction.
3. Seed germination improved (90%; control 60%) following pre - soaking treatment with Bavistin and was subsequently used for large scale propagation.

Fig. 62. Mass multiplication of bamboo plants for field plantation.

5. Peoples' Participation in Biodiversity Conservation

Biodiversity conservation by awareness and training of students and teachers

It is now well established that proper understanding on conservation and sustainable use of resources facilitates participation of local people in conservation programes. This has prompted various organizations to take initiatives in this direction. However, the initiatives in the Himalayan region are not adequate. In view of this, the Institute has initiated a programme to bring the target groups into the conservation movement. This activity was executed through the GBPIHED HQs and Units to: (i) Promote understanding of conservation science especially among students and teachers;

(ii) Impart on-site training on assessment of biodiversity elements and collection, storage and propagation of important species; and (iii) Obtain and analyze response of different target groups with respect to location-specific conservation option/priorities. The main achievements were:

- Linking of programme with eco-clubs
- Organization of orientation course & workshop
- Generation of field information on agro biodiversity

Institute Head Quarters

1. The ongoing initiative to promote outreach through conservation education was further strengthened by linking it with the existing eco-clubs. An orientation course on conservation education was organized at GIC Didihat, Pithoragarh (July 25-31, 2005). Representatives of eco clubs (38) were imparted extensive training (theoretical & practical) on the various aspects of biodiversity conservation (Fig. 63). Orientation course was followed by a three day (July 29-31, 2005) training workshop at GIC Narayan Nagar, Pithoragarh. Workshop was attended by 98 participants (36 teacher and 62 students) representing 36 schools of Uttaranchal.

Fig. 63. Various events of orientation course and training workshop at Didihat and Narayan Nagar A: Inagural session of course; B: Introductory session of workshop; C: Teachers resource prsons imparting training; D: Field demonstrains

2. As a follow-up of above events, the trained participants of different eco-clubs were involved in field information generation through structured questionnaire on agro-biodiversity. A total of 725 response sheets from 178 villages in various localities of Kumaun region were received. Seeds

of a total of 18 varieties of Wheat, and 60 varieties of Paddy were also collected and being maintained in the laboratory of GBPIHED.

- Collection and dissemination of weather data under U-PROBE

3. As a technical resource center under "U-PROBE" (participation of youth in real time/field observation to benefit the education programme), weather data from identified 9 schools were collected and compiled. For proper dissemination of information among different stakeholders U-PROBE Newsletter was published and distributed.

Himachal & Sikkim Unit

- Organization of exposure visits
- Training and exposure programs on labs, nurseries, technologies and habitat trek

4. Exposure visits / training programmes of students, teachers, farmers and government officials were organized in herbal garden/nursery site of HP Unit.

5. At Sikkim Unit participatory training/exposure sessions were organized for: (i) Villagers (28 male and 12 female), covering 4 villages (East Sikkim), students and teachers (73), local folks (>100) and 'Police Jawans' (18) and field staff (40) of Forest Department with a focus on exposure to herbal garden/nurseries, low-cost technological interventions; 'habitat trek' (Fig. 64); biodiversity conservation, medicinal plants and plantation at newly formed '*Smriti Vatika*' was also carried out with the participation of the trainees.

Fig. 64. Habitat trek for school students in Sikkim

6. Environmental Awareness and Short-Term On-Site Training Programme

Dissemination of Institutes action-oriented R&D activities for environmental awareness

In this programme capacity building of rural inhabitants/identified target groups was achieved by imparting on-site trainings on natural resource conservation and management. To achieve this a three-day on-site training programme on nursery development, tree plantation techniques, and natural resource conservation and management was organized at village Kumrora (Bageshwar district, UA), in collaboration with a local NGO (Fig. 65). The training was imparted to 120 participants (of 12 villages) including farmers, rural women, ex-army personnel, students and representatives of the NGOs, etc.

Fig. 65. Training programme at Village Kurmora on NRM

7. Training Programme on Medicinal Plants Cultivation

- **Organization of one day training on medicinal plants cultivation at Kapkot village Bageshwar**

Two one-day Farmer's trainings on medicinal plant propagation and cultivation were conducted in Kapkot, Bageshwar (UA). About 60 persons participated in both the trainings, which were attended by medicinal plant growers, farmers, villagers, Gram Pradhans, NGOs and researchers. It included deliberations on newer methods of plant multiplication, use of chemicals to promote rooting, knowledge about pre-soaking treatment of seeds to improve and synchronize germination and methods of storage of plant materials. Lectures were delivered by resource persons and discussion on various problems and issues were held (Fig. 66).

Fig. 66. Farmers training on medicinal plants cultivation in Kapkot, Distt. Bageshwar.

Dissemination through interactive forums

Forum / Event	Place & Dates	Target Groups
Workshop on Agroecosystem Management	Tapovan-Chamoli (UA), 18 May 2005	Researchers, Local people
Workshop for Farmers and Line Agencies from UA & HP	Kausani, Bageshwar, UA, 19-20 May 2005	Researchers, Line Agencies' Farmers, Local people
Training on Medicinal Plant Propagation and Cultivation	Kapkot, Bageshwar (UA), 8 June 2005	Farmers, Local people
Workshop on Facilitating Formation of State Biodiversity Boards and Biodiversity Management Committees in IHR	GBPIHED, Kosi-Katarmal, Almora, 11-12 Sept. 2005	Academicians, NGOs, Researchers, Line Agencies, Farmers, Local people
Conference on Arunachal Pradesh: Tradition in Linking Ecology, Economics and Ethics, Organized by NERIST, Itanagar- collaboration GBPIHED	13-16 Sept. 2005. Itanagar.	Academicians, NGOs, Researchers, Line Agencies, Farmers, Local people
Workshop on Development and Scope of Disaster Management	Itanagar, 26-27 Oct. 2005	Academicians, NGOs, Line Agencies
Training on conservation through Cultivation of High Altitude MAPs	GBPIHED, Kosi-Katarmal, Almora. 18 Nov. 2005	Academicians, NGOs, Researchers, Farmers, Local people
Training on Low-Cost Technological Interventions	Sikkim Unit, Pangthang, 28 Dec. 2005	Armed Police
Workshop on Garmin Khetron mai Vikash ki Sambhawanaein evam Tikau Vikash Suchak	GPIHED, Kosi-Katarmal, Almora. 28-29 Dec. 2005	NGOs, Line Agencies, Farmers, Local people
Workshop on Environmental and Social Management Framework for Uttaranchal Decentralized Watershed Management Project	GBPIHED, Kosi-Katarmal, Almora, 20-22 Feb. 2006	Executives of Watershed Management Directorate, Govt. of UA
Brainstorming Session on Ecosystem Services and Ecological Economics: Himalayan Mountain Context	GBPIHED, Kosi-Katarmal, Almora. Feb. 24-25, 2006	Academicians, NGOs, Researchers

Forum / Event	Place & Dates	Target Groups
Workshop on Intellectual Property Rights: Himalayan Context	GBPIHED , Kosi-Katarmal, Almora. Feb. 26-27, 2006	Academicians, NGOs, Researchers
Training pegramme on Demonstration and Dissemination of Rural Technologies	Maletha, Tehri-Garhwal, 27-28 Jan., 15-16 Feb. & 6-7 Mar. 2006	NGOs, Line Agencies, Farmers, Local people
Training Programme on Nursery Development, Tree Plantation Techniques, and Natural Resource Conservation and Management	Kumrora Village, Bageshwar, UA, 22-24 March 2006	NGOs, Line Agencies, Farmers, Local people
Symposium on Himalayan Biodiversity: Issues and Options for Priority Research	GBPIHED , Kosi-Katarmal, Almora, 27-28 March, 2006	Academicians, NGOs, Researchers

MISCELLANEOUS ITEMS

1. SCIENTIFIC PUBLICATIONS

(I) Scientific Journals

Badola, H.K. & J.S. Butola, 2005. Effect of ploughing depth on the growth and yield of *Heracleum candicans*: a threatened medicinal herb and a less-explored potential crop of the Himalayan region. *Journal of Mountain Science* 2: 173-180.

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Bhatt, A., R.S. Rawal & U. Dhar, 2005. Germination improvement in *Swertia angustifolia*: a high value medicinal plant of the Himalaya. *Current Science* 89 (6): 1008-1011.

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Chettri, S.K. & K.K. Singh, 2005. Status of Khangchendzonga Biosphere Reserve Fringes. *Journal of Hill Research* 18 (20): 113-115.

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Joshi, B.K. 2006. Traditional knowledge and land use management in Indian Central Himalayas. *Indian Journal of Traditional Knowledge* 5(1): 34-40.

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3. PARTICIPATION OF INSTITUTE FACULTY /PROJECT STAFF IN DIFFERENT EVENTS

Events	HQs	Units				Total
		NE	Sikkim	Garhwal	HP	
National • Symposia/Conference/ Workshops	10	11	03	08	07	39
• Training Courses	03	03	02	01	00	09
• Meetings	25	01	23	07	03	59
• Participation as a Resource Person	07	01	04	08	02	22
International	06	04	00	01	00	11

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Chartered Accountants
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To
Members,
G.B. Pant Institute of Himalayan
Environment & Development,
New Delhi.

We have audited the attached Balance Sheet of **G.B.Pant Institute of Himalayan Environment & Development (A Institute of Govind Ballabh Pant Himalaya Paryavaran Evam Vikas Samiti)** as at 31stMarch, 2006, the Income & Expenditure Account and the Receipt & Payment Account for the year ended on that date annexed thereto. These financial statements are the 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.

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 provision of sales tax liability for wrong issue of "D" form against purchases.
3) Non provision of liability towards income tax, if any.
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 for various magazines for library under ENVIS Centre Rs. 1,24,354/- charged to revenue instead of capitalizing the same under Fixed Assets. Subscription paid in earlier years under the ENVIS Centre also 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) Attention is invited to not given in schedule No. 8 of fixed assets regarding capitalization of subscription paid Rs. 89,55,053.00 towards library books in earlier years & depreciation Rs. 9,91,313.46 charges thereon during the year.

9) Institutional charges (Income) are shown after reducing expenses towards salary of temporary staff & other miscellaneous expenses.

10) Project expenses which were being accounted for on payment basis till last year now being accounted for on accrual basis from this year. Effect on Income:-NIL

11) Following income/ expenses of the Institute pertains to earlier year.

S.No.	PARTICULARS	AMOUNT (IN RS.)	NATURE
1.	R&D(R) Institute Expenses	32,500.00	Expenses
2.	Intt. On Term Deposits	25,92,755.00	Income
3.	Institutional Charges (DPAP Training)	2,76,404.00	Income
4.	Provision for Gratuity & leave encashment	Amount not ascertainable	Expenses

12) Non provision of liability under Service Tax Act (Finance Act 1994) for late deposit of tax & late filing of return.

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

14) Grant released under IERP projects 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, 2006.
ii) In the 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 receipt & payments of the Institute of that date.

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

Sd/-
(C.A. RAKESH K. AGGARWAL)
(PARTNER)
M.NO.085908

DATED: 22nd August,2006
PLACE: ALMORA

SEAL

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

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

BALANCE SHEET AS ON 31ST MARCH 2006

PARTICULARS	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
CORPUS / CAPITAL FUND	1	24676825.59	15619133.80
RESERVE AND SURPLUS	2	354442521.97	329316478.11
EARMARKED / ENDOWMENT FUNDS	3	7659009.38	7231252.90
SECURED LOANS & BORROWINGS	4	0.00	0.00
UNSECURED LOANS & BORROWINGS	5	0.00	0.00
DEFERRED CREDIT LIABILITIES	6	0.00	0.00
CURRENT LIABILITIES AND PROVISIONS	7	34007932.25	31528095.70
TOTAL		420786289.19	383694960.51
ASSETS			
FIXED ASSETS	8	355678760.97	329316478.11
INVEST. FROM EARMARKED/ENDOWMENT FUND	9	7659009.38	7231252.90
INVEST. OTHERS	10	0.00	0.00
CURRENT ASSETS, LOANS, ADVANCES ETC.	11	57448518.84	47147229.50
MISCELLANEOUS EXPENDITURE			
TOTAL		420786289.19	383694960.51
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES & NOTES ON ACCOUNTS	25		0.00

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

Sd/-
(C.A. RAKESH K. AGGARWAL)
(PARTNER)
M.NO.085908

SEAL

DATED : 22.08.2006
PLACE : ALMORA

Sd/-
(DR. UPPEANDRA DHAR)
(DIRECTOR)

Sd/-
(DR. S.K. NANDI)
(D.D.O)

Sd/-
(NEENA KAPOOR)
(FINANCE OFFICER)

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

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

INCOME & EXPENDITURE A/C FOR THE YEAR ENDED 31ST MARCH 2006

PARTICULARS	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
INCOME			
Income from Sales/Services	12	124985.00	132488.00
Grants/Subsidies (equal to exp)	13	84862681.46	72141906.63
Fees/Subscriptions	14	0.00	0.00
Income tfr from Fixed Assets fund (to the extent of depreciation & WDV of asset sold)		14934239.14	73872984.73
Income from Royalty,Income from Inv. Publication etc.	16	1000.00	345.00
Interest Earned	17	5790882.38	746233.16
Other Income	18	3112704.23	997546.00
Increase (decrease) in stock of Finished goods and work in progress)	19	0.00	0.00
TOTAL (A)		108826492.21	147891503.52
EXPENDITURE			
Establishment Expenses: a) Institute	20	28192724.00	14508935.00
b) Projects		7447602.00	6597174.00
c) F.C (Projects)		2035787.00	2465325.00
Administrative Expenses : a) Institute	21	26899069.38	27014913.13
b) Projects (As per Annexure)		11317954.08	8083983.00
c) F.C (Projects) (As per Annexure)		1844486.00	2849300.50
Expenditure on Grants, Subsidies etc.	22	7125059.00	10622276.00
Interest		0.00	0.00
Depreciation (Net Total at the year-end-as per Sch. 8)		14906118.96	73872984.73
TOTAL (B)		99768800.42	146014891.36
Balance being excess of Income over Expenditure (A - B)		9057691.79	1876612.16
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		9057691.79	1876612.16

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/-
(C.A. RAKESH K. AGGARWAL)
(PARTNER)
M.NO. 085908
DATED : 22.08.2006
PLACE : ALMORA

SEAL

Sd/-
(DR. UPPEANDRA DHAR)
(DIRECTOR)

Sd/-
(DR. S.K. NANDI)
(D.D.O)

Sd/-
(NEENA KAPOOR)
(FINANCE OFFICER)

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

RECEIPTS & PAYMENTS A/C FOR THE YEAR ENDED 31ST MARCH 2006

Singh K.V. Gupta & Co.
Chartered Accountants
07/38, Ansari Road 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	11984.05	30308.05	a) Establishment Expenses	16262300.00	13512417.00
b) Bank Balances			b) Administrative Expenses		
i) In current accounts	5749910.88	1744153.85	i) Institute	17360885.50	15312390.13
ii) In deposit accounts	0.00	0.00	ii) R&D (Rev) expenses	10170885.70	10334216.00
iii) Savings accounts	1342917.78	17200639.70	iii) Payments for current liabilities	20365266.09	19272381.05
c) Advances & Others	19382146.15	18228774.22	c) Capital Expenditure		
(As per annexure attached)			i) Purchase of Fixed Assets	17876118.00	17155264.00
F.C. ACCOUNT			ii) Expenditure on Capital Work in Progress	9500000.00	9000000.00
a) Cash in hand	125.00	406.00	**II. Payments made against funds for various proj.**	0.00	0.00
b) Cash at bank	1394790.40	1051207.84	Expenditure State govt. projects		
c) FC Advances	525488.00	0.00	a) Capital	3165107.00	5959878.00
II. Grants Received			b) Revenue:		
a) From Government of India			Establishment exp	7447602.00	6597174.00
i) Institute	71900000.00	63000000.00	Administration exp	11315502.00	8083983.00
ii) IERP Projects	11500000.00	7000000.00	Expenditure FC projects		
b) From State Government	28801857.00	14581024.00	a) Capital	564005.00	100714.00
c) From other sources (from FC)	3680324.29	5498970.06	b) Revenue:		
III. Income on Investments from			Establishment exp	1848787.00	2465325.00
a) Earmarked/ Endow.Funds	427756.48	427825.43	Administration exp	1844486.00	2849300.50
b) Loans, Advances etc.	0.00	0.00	IERP grant released	7250779.00	10694383.00
IV. Interest Received			**III. Investments and deposits made**		
a) On Bank deposits savings a/c	254538.71	871184.98	a) Out of Earmarked/ Endowment funds	0.00	0.00
b) On term deposits a/c	3901493.67	108473.18	b) Out of own funds (Investments Others)	0.00	0.00
c) Loans, Advances etc.	110959.00	261995.00	c) General Fund	2602921.00	0.00
V. Other Income			**IV. Refund of Suplus money/Loans**		
(As per annexure Attached)	3261404.15	1130231.00	a) To the Government of India	317709.00	5856.00
VI. Amount Borrowed	0.00	0.00	b) To Others/ security / caution money)	0.00	0.00
VII. Any other receipts.			**V. Other payments**		
a) Advance FC a/c	0.00	190073.00	Suspense a/c	68848.00	0.00
b) Receipts current liabilities	21877056.81	18308914.63	**VI. Closing balances**		
c) IERP grants refunded by grantee Org.	123720.00	72107.00	a) Cash in hand	30354.72	11984.05
d) Suspense a/c FC	0.00	68848.00	b) Bank Balance		
			i) In Current account	24520525.90	5749910.88
			ii) In deposit accounts		
			iii) In savings accounts	2618233.93	1342917.78
			c) Advances and others	18257760.84	19382146.15
			FC Project		
			i) Cash in hand	5818.33	125.00
			ii) Bank Balance	654577.36	1394790.40
TOTAL	174048472.37	149225155.94	TOTAL	174048472.37	149225155.94

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

Sd/-
(C.A. RAKESH K. AGGARWAL)
(PARTNER)
M.NO. 085908
DATED : 22.08.2006
PLACE : ALMORA

SEAL

Sd/-
(DR. UPPEANDRA DHAR)
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G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT
KATARMAL, KOSI (ALMORA) UTTARANCHAL

ANNEXURE FORMING PART OF RECEIPT/PAYMENTS A/C AS ON 31ST MARCH 2006
STATEMENT OF OPENING & CLOSING BALANCES

PARTICULARS	OPENING AMOUNT	CLOSING AMOUNT
Cash & Bank Balances		
Cash In Hand :		
Srinagar	5.85	2376.85
Sikkim	0.00	624.10
Kullu	1236.36	218.36
Itanagar	19924.27	11621.52
Remittance in transit Sikkim Unit	0.00	255000.00
Grant in aid in transit MOWR GCSN	0.00	250000.00
Grant in aid in transit ISRO GBP	0.00	300000.00
Cash at Bank Balances		
SBI Almora A/c No.01170003256 (Endo)	36920.98	38224.54
SBI Tadong A/c No 01000050044	590315.92	42805.08
SBI Kullu A/c NO.01100076038	122195.82	1135809.82
SBI Itanagar A/c No 01100050337	66392.10	408995.27
SBI Srinagar A/c No 01100030433	914568.80	310747.46
Advances		
House Building Advance	3167235.00	2743423.00
Motor cycle/Car Advance	509017.00	475364.00
Festival Advance	21750.00	19800.00
C.P.F	36.00	36.00
Income tax deducted at source	0.00	119998.00
Units of Institute:		
Sikkim Unit	331907.10	0.00
HP Unit	32527.00	0.00
Garhwal Unit	(226665.59)	0.00
NE Unit	48972.62	0.00
FC Advances:		
ET & NT Delhi (INDO SUMMER)	0.00	2880.00
NRSA Hyderabad (PARADYP)	0.00	258720.00
Pant Nagar UNIV. (PDF GEF)	0.00	40000.00
Fixed Deposit		
With SBI Endowment Fund	6464718.00	6464718.00
Interest Accrued on FDR (Endowment Fund)	729613.92	1156066.84
Interest Accrued on FDR (General Fund)	0.00	787762.00
Asset under installation	0.00	1236239.00

SEAL

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FDR (Margin Money/LC A/C)		
Institute	4283412.00	1268743.00
BIOTECH -XI	577.00	577.00
BIOTECH -XII	0.00	0.00
DST MN	184000.00	0.00
Due Staff/ other IC A/c		
Dr.Mukesh Joshi (Bitech-XII)	(1000.00)	(1000.00)
Post Master G.P.O Almora	2.00	12629.00
M/s Bio-rad Laboratories, Australia	81344.00	81344.00
Employment News 48287.00	48287.00	
Sigma Aldrich Chemicals	10590.00	10590.00
Siltap Chemicals Ltd (Biotech -III)	408.00	408.00
NRSA Hyderabad 158400.00	8400.00	
R.K.Nanda & Sons 28517.00	28517.00	
NICSI New Delhi 0.00	390068.00	
NRSA Hyderabad (MOE & F-KSR)	11500.00	0.00
CAPART 0.00	31114.00	
Security Deposit CET Sikkim Unit	0.00	11000.00
M/s OTT Messachute	0.00	4500.00
Recov Sikkim Unit Staff (Lead BR)	0.00	1160.00
NIC New Delhi 67147.00	67147.00	
Sh. Chander Lal (LTC)	838.00	0.00
Dr Subrat Sharma (TTA)	0.00	13000.00
Dr. Varun Joshi (TTA)	0.00	65000.00
NRSA Hyderabad (ISRO GBP SSS)	0.00	25000.00
NRSA Hydrabad (DST-KK-I)	7400.00	7400.00
Recov NE Unit Staff 0.00	32433.00	
Recov GU Staff 0.00	14695.00	
F.C.Inter A/C 2500.00	2500.00	
DST U-PROBE : Principal GIC Danya	6000.00	0.00
Principal,GIC Kheti	6000.00	0.00
Principal GIC Lamgara	6000.00	0.00
Principal , GIC Barechina	6000.00	0.00
Principal GIC Hawalbagh	6000.00	0.00
DST NB Pantnagar Univ.grant tfr	221298.00	0.00
M/s TERI New Delhi	150000.00	0.00
M/s CCU New Delhi	790000.00	70898.00
Mr P S Bhakuni 1440.00	0.00	
M/s Spectronics Corpn.	48000.00	0.00
M/s Hind Motors Dehradun	368815.00	1921.00
M/s Atto Corporation	58000.00	0.00
TOTAL	**19382146.15**	**18257760.84**

SEAL

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G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT
KATARMAL, KOSI (ALMORA) UTTARANCHAL
SCHEDULE FORMING PART OF BALANCE SHEET AS ON 31ST MARCH 2006

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

S N.	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	190351696.00	24400292.00	0.00	214751988.00	8681972.41	3500457.40	0.00	12182429.81	202569558.19	181669723.59
3	PLANT MACHINERY & EQUIPMENT										
	Scientific Equipments	108232820.11	14111185.00	0.00	122344005.11	34480997.92	5811085.16	0.00	40292083.08	82051922.03	73751822.19
4	VEHICLES	4922632.25	408709.00	(295380.00)	5035961.25	4007713.04	269324.77	(267259.82)	4009777.99	1026183.26	914919.21
5	FURNITURE FIXTURES	15591729.40	866698.00	0.00	16458427.40	6898742.50	980575.86	0.00	7879318.36	8579109.04	8692986.90
6	OFFICE EQUIPMENT	6807308.35	276028.00	0.00	7083336.35	4171762.25	549694.63	0.00	4721456.88	2361879.47	2635546.10
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	26061.26	2895.70	0.00	28956.96	32005.04	34900.74
9	LIBRARY BOOKS	40873510.50	5223308.00	8955053.00	55052071.50	13997528.56	3606286.86	0.00	17603815.42	37448256.08	26875981.94
10	TUBE WELLS & W. SUPPLY										
11	OTHER FIXED ASSETS										
	GLASS / NET HOUSE	3911549.00	0.00	0.00	3911549.00	1608206.79	185798.58	0.00	1794005.37	2117543.63	2303342.21
	TOTAL OF CURRENT YEAR	370827846.84	45286420.00	8659673.00	424773939.84	73872984.73	14906118.96	(267259.82)	88511843.87	336262095.97	296954862.11
	PREVIOUS YEAR	313542595.84	57285251.00	0.00	370827846.84	61695405.93	12177578.80	12177578.80	73872984.73	296954862.11	313542595.84
	B. CAPITAL W I P	32361616.00	9500000.00	(23681190.00)	18180426.00	0.00	0.00	0.00	0.00	18180426.00	32361616.00
	ASSET UNDER INSTAL/TRANSIT	0.00	1236239.00	0.00	1236239.00	0.00	0.00	0.00	0.00	1236239.00	0.00
	TOTAL	403189462.84	56022659.00	(15021517.00)	444190604.84	73872984.73	14906118.96	(267259.82)	88511843.87	355678760.97	329316478.11

Note:- In earlier years, subscription paid for Library books charged to revenue expenditure which has now been changed & capitalised during this year. Consequent upon the addition during the year under Library books includes Rs. 89,55,053.00 & depreciation for the year includes Rs. 9,91,313.46 on Library Books which pertains to earlier years.

INSTITUTE SUPPORTING STAFF

HEAD QUARTERS

Capt. K.K. Joshi	Administrative Officer
Neena Kapoor	Finance Officer
K.K.Pande	Account Officer
Suryakant Langyan	O.S. (A)
Sanjeev Higgins	Estate Manager
Mritunjay Anand	Library Assistant
L.M.S. Negi	U.D.C.
Sarita Bagdwal	Steno Gd III
Jagdish Kumar	Steno
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-Cum F.A.
Pan Singh	Peon
K.N.Pathak	H.K./Att.
G.D.Kandpal	Peon/Mali
Nathu Ram	Peon/Mali
Ganga Joshi	Peon
Kashi Ram	Peon/Mali

SIKKIM UNIT

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

HIMACHAL UNIT

S.P. Maikhuri	O.S.
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
K. 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 Systems
R.S. Rawal	Scientist-C	High Altitude Ecology; Conservation Biology
I.D. Bhatt	Scientist-B	Plant Physiology, Phytochemistry
S. Sharma	Scientist-B	Agroecology, Remote Sensing / GIS
B.S.Majila	Tech-B	Forest Ecology; Restoration Ecology
Ranjan Joshi	Tech-B	Natural Resource Management; Econometrics
R.G.Singh	Tech-B	Applied Arts; Photography, Social Science

North East Unit

D. Choudhury	Scientist-D	Animal Biology; Entomology
P.K.Samal	Scientist-D	Social Science; Anthropology
S.C. Arya	Scientist-A	High Altitude Ecology

Sikkim Unit

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

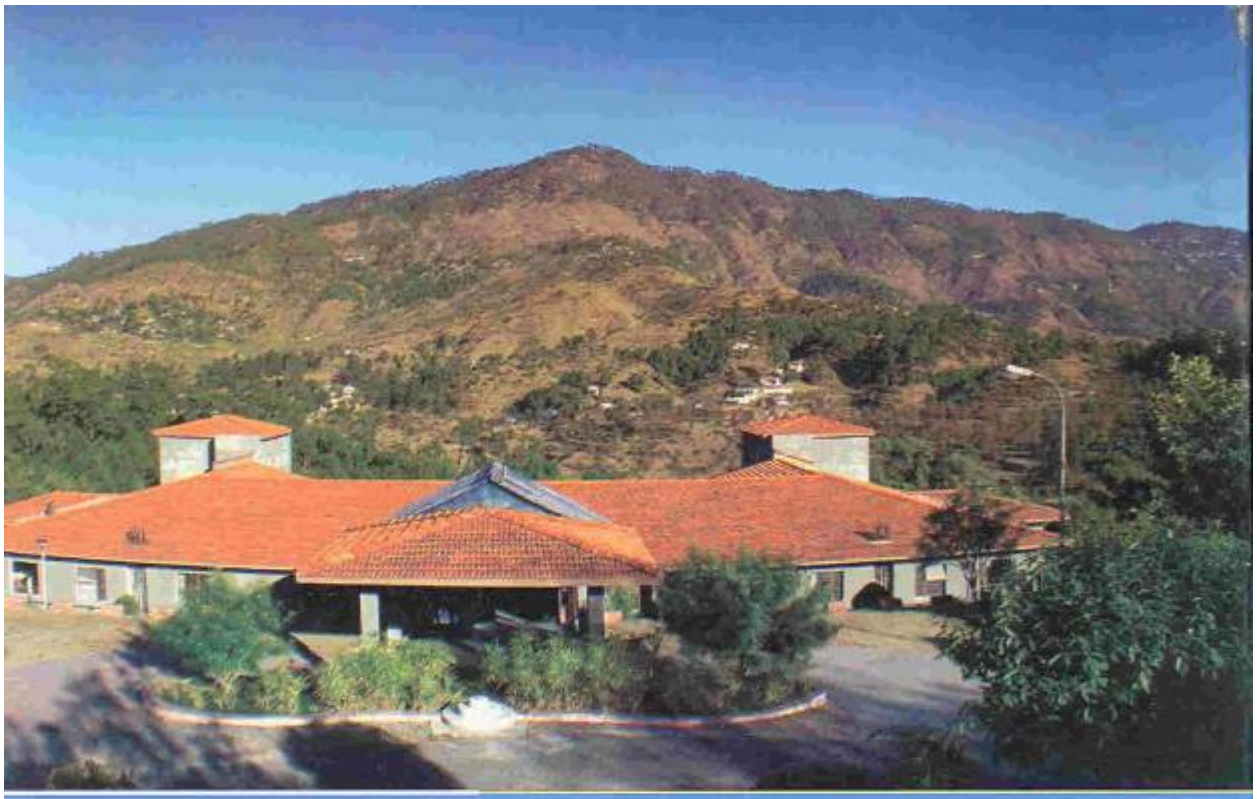
Garhwal Unit

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

Himachal Unit

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

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



HEAD QUARTERS
KOSI-KATARMAL, ALMORA
PH: 05962-241041/241015/241154
FAX : 05962-241150, 241014

HIMACHAL UNIT
MOHAL, KULLU
PH : 01902-225329
FAX : 01902-222720

SIKKIM UNIT
PANGTHANG, SIKKIM
PH : 03592-237328
FAX : 03592-237415

GARHWAL UNIT
UPPER BHAKTIYANA,
SRINAGAR, GARHWAL
PH: 01346-252603
FAX : 01346-252424

NORTH-EAST UNIT
VIVEK VIHAR, ITANAGAR
PH : 0360-2211773
FAX : 0360-2211773

Designed & Printed at Silver Offset Press, Dehradun Ph: 0135-2715348