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2004-2005






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

Annual Report
2004 - 2005

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

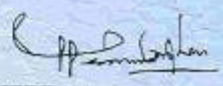
As we are all aware, the issues of environment and development in the Indian Himalayan Region (IHR) are complex and need to be addressed in interdisciplinary and integrated manner. In this context the Institute is making significant strides to better understand complexities of the subject matter through its R&D programmes, which are having inbuilt research, demonstration and dissemination components.

The reporting year (2004-05) witnessed further augmentation of in-depth R&D pursuits to apply our research outputs in the field. The research themes were reviewed, restructured and systematized. Among major highlights of the year, Institutes' initiative for organizing a brainstorming session on Retreating Himalayan Glaciers helped in conceptualizing frame work for developing state-of the-art 'Center of Glacier Studies' in the Institute. Among others, the Institute conducted studies on eco-hydrological aspects of selected watersheds, installed Global Positioning System (GPS) for studying tectonic deformations, and demonstrated models for wasteland restoration. It has undertaken case studies related to resource use and dependency by tribal communities, capacity building for rural population including women, and developed location specific appropriate models for improved livelihood options. In biodiversity conservation sector, the focus has been on the development of user-friendly biodiversity database for biosphere reserves, ecosystem functions of climatically sensitive timberline zones, and establishment of conservation models. The Institute also took a lead in Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP) of development initiatives, which include selected hydropower projects. A good beginning has been made in the context of documenting indigenous knowledge systems of the Himalayan communities. Attempts were made to upgrade rural livelihoods through development of medicinal plant (MPs) sector in the form of: (i) cultivation and strengthening researches on selected high value MPs; (ii) establishment of herbal gardens; and (iii) organization of policy workshops for Uttaranchal and Himachal Pradesh. The Institute also provided platform for deliberating upon some pertinent issues such as watershed management, high altitude pastoralism, technology backstopping and several other related subjects.

The Rural Technology Complex (RTC) of the Institute gained widespread popularity among rural populace and line departments. A collaborative venture - PARADE (Participatory Action for Rural Area Environment and Development), with NCC has opened new avenues for technology transfer and participatory action research. These programmes have been instrumental in developing interface between the Institute and the developmental agencies, and building local capacity on cost-effective technologies. The feed back on capacity building programs of the Institute is encouraging. The Institute further strengthened its network with other regional Institutes in IHR by supporting location specific eco-developmental activities under Integrated Eco-development Research Programme (IERP). At national level, the institute has been identified as a executing agency for a Global Pollination Project.

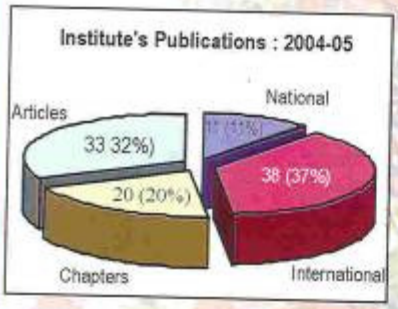
We believe that the Institute will play a pivotal role to achieve the goal of developing sustainable environmental management strategies for IHR. In this context, continued acceptance of Institutes' R&D results in peer reviewed international scientific journals is the testimony of its high standard research output. And the institute will continue to maintain the international standards.

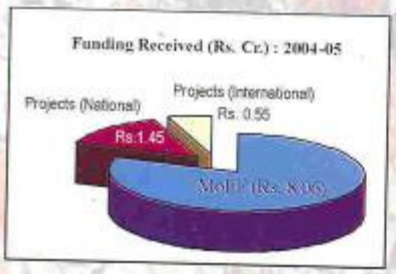
The Members of the Scientific Advisory Committee (SAC), the Governing Body (GB) of the Institute and the G. B. Pant Society for Himalayan Environment and Development provided valuable suggestions and directions for implementation of Institutes' progrmmes. We thank them for their continued support and encouragement.



(UPPEANDRA DHAR)
Director

Major Achievements





- Setting-up of a field station for geo-hydrological studies at Thelu (Gangotri glacier system) and campaign stations at Gangotri and Milam glaciers for studies on glacier retreat in west Himalaya.
- Adoption of Institute's approach on technology demonstration and dissemination in five States of NE through a network of NGOs, supported by DST, Govt. of India.
- Generated information on effect of forest disturbances on selected functional parameters in climate sensitive timberline zone of west Himalaya.
- Strengthening of activities for Global Project on 'Conservation and Management of Pollinators for Sustainable Agriculture, Through an Ecosystem Approach': (i) National stocktaking report; (ii) Organization of national stakeholders and national partners consultation workshops.
- Promoted activities for development of medicinal plant (MPs) sector in the Himalaya through: (i) In-depth research on selected high value MPs; (ii) Establishment / maintenance of herbal gardens at Pangthang, Sikkim (0.5 ha), Kullu, H.P. (1 ha) and Kosi-Katarmal (2 ha); (iii) Organization of state-level workshops for Uttaranchal and HP; and (iv) Establishment of Regional Analytical Laboratory for MPs.
- Rapid environmental impact assessment and formulation of environmental management plans for Lakhwar-Vyasi (Yamuna River) and landscaping and restoration plan for Dhauliganga hydroelectric projects in Uttaranchal.
- Completion of studies on: (i) Vesicular Arbuscular Mycorrhizae (VAM) in important tree species; (ii) Assessment and improvement of tea clones through (a) use of simple physiological method for early selection; (b) *in vitro* protocols for large-scale multiplication; and (c) trap cultures for identification of VAM fungi associated with tea rhizosphere.
- Implementation of R&D projects under integrated eco-development research programme to evolve and replicate packages for environmental restoration through blend of science and religion. The coordinated programme on " Sacred values, eco-restoration and conservation initiatives" was further strengthened with IERP funding.
- Establishment / strengthening of Rural Technology Park at Maletha village (Tehri-Garhwal) and Kosi-Katarmal (Almora) and promotion of capacity building and skill development activities through (i) Training on rural technologies (1389 persons – 734 male, 655 female) and contour hedgerow-farming (30 women); (ii) Demonstrations on SWEET and silvi-pasture models; (iii) Training on conservation education (93 students and teachers from 41 schools); and (iv) Training on disaster management for Sikkim State.
- Launched a collaborative programme 'Participatory Action for Rural Area Environment & Development' with National Cadet Corps, aimed at environmental restoration of hill villages (Railakot, Almora).

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 of natural resources. A conscious effort is made to ensure the social acceptability and participation of stakeholder communities for the success of various programmes. A brief summary of R&D activities of the Institute during the reporting year 2004-05 is as follows:

Land and Water Resource Management (LWRM)

- Geo-hydrological studies of glaciers & watersheds
- Demonstration of wasteland restoration models
- GPS Geodesy for tectonic deformation

The research activities of the LWRM core revolved around the central theme of land and water management practices of the eastern, western and central Himalaya, and their critical linkages with various geo-environmental processes prevalent in different altitudinal zones of the region. Some of the project mode studies undertaken during the year include: people and resource dynamics for mountain watersheds, hydrometry and sediment study of Gangotri glacier, environmental change studies in Dokriani glacier, global change study for environment management and sustainable development, quantification of tectonic deformation rate using GPS geodesy, etc. A technology demonstration project on SWEET model for rehabilitation of community and private wasteland was successfully executed. The concept of source centered catchment area conservation and management study was initiated for Uttaranchal Govt. Based on the village environment action plan, a joint project with NCC, namely "Operation PARADE" was initiated in village Railakot (Uttaranchal) in collaboration with other core programmes of the Institute.

Sustainable Development of Rural Ecosystems (SDRE)

- Resource use and dependency studies
- Capacity building for rural population, including women
- Location specific appropriate models for improved livelihood options

The integrated utilization of natural resources by indigenous communities to fulfill their subsistence needs of food, fuel, fodder, fiber, timber, NTFPs, medicines, implements, housing and income generation is an essential part of rural livelihoods in the Himalaya. The SDRE Core activities continued to document resource dependency and use patterns in the Himalayan region. In the eastern Himalaya during the reporting year the information was generated on role of customary laws and its efficacy in management of natural resources among selected tribal communities,

while in the central Himalaya assessment of bioresources was continued with particular reference to agricultural production and strategy for sustainable development, and base map preparation for natural resource management (NRM). Besides, study on seasonal migration of livestock in high hill areas was continued. Integrated management of watershed based on natural, social and development aspects for prioritizing a research action plan was done for Upper Kosi region in Kumaun Himalaya. Strengthening the Rural Technology Centre at Kosi-Almora, establishment of a Rural Technology Park at Maletha village in Tehri district in the central Himalayan region, and continuation of demonstration model at Midphu, Itanagar in the north-east for demonstration and dissemination of simple, cost-effective and appropriate rural technologies also got momentum in the reporting period. Forty trainings comprising a total of 1389 persons at HQs, 290 persons in Garhwal and 27 women entrepreneurs from the 5 states of north-east were trained for their capacity building by SDRE core during the reporting period.

Conservation of Biological Diversity (CBD)

- User friendly biodiversity database for biosphere reserves
- Ecosystem functions of climatically sensitive timberline zones
- Establishment of conservation models

Continuing with the umbrella activities, the core, during reporting period, maintained a balance of research, demonstration and dissemination activities. Detailed floral inventories and analyses of endemism for selected families/groups strengthened the database on Himalayan bioresources. User-friendly biodiversity database, developed for Himalayan Biosphere Reserves (BRs), is first of its kind to address management issues of BRs. The newly started activity on pollinators for sustainable agriculture, under FAO global project initiative, helped in development of database on diversity, status and conservation of pollinators in IHR. Uninterrupted flow of information from biodiversity rich areas further improved the ecological understanding of such areas. The study completed for selected parameters of ecosystem functions at climate sensitive ecotone – timberline zone of west Himalaya, is important first hand information with wide ranging implications. Studies to understand impact on ecosystem processes along disturbance gradient continued for selected mid-altitude forests of the region. The activities for establishment of gene banks across the Himalaya were further strengthened through R & D interventions in arboretum (HQs & Sikkim Unit) and herbal gardens (HQs, Sikkim & HP Unit). These sites were used extensively for teaching, training and demonstration for different target groups. The experiments on seed germination of several selected high value plants complemented the initiatives of gene bank establishment. Promotion of Conservation Education in school/college students and teachers through seven-day orientation course continued to be the most effective dissemination activity. Involvement of target groups was ensured through initiation of activities for: (i) Developing school-campus conservation models, and (ii) Participation of youth in real time weather observations.

Ecological Economics and Environmental Impact Analysis (EE & EIA)

- Initiation of studies on ecosystem services
- Rapid EIA of hydropower projects
- Impact assessment of development initiatives

The core R&D activities during the reporting period continued to focus on two themes: 'Ecosystem Services and Ecological Economics' and 'Environmental Impact Analysis of Development Initiatives'. Some of the studies under the two broad umbrella themes were focused on: comparative studies on ecosystem services of oak and pine forests in central Himalaya, impact of tourism on ecosystem with particular reference to air quality in selected destinations in HP, social and ecological considerations in EIA of hydropower projects in UA and HP, impact assessment of alternative land uses (vegetable and tea cultivation in Uttaranchal hills) and impact of land use and land cover on water yield of springs in western Himalaya. Successful completion of activities relating to rapid EIA and formulation of environmental management plans and landscaping and restoration plans for hydropower projects, mission project on agriculture potential and a GPS based project on landslides in Sikkim Himalaya also took place during the reporting period. 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.

Environmental Physiology and Biotechnology (EPB)

- Development of microbial bio-inoculants for improved pant growth
- *In vitro* propagation & field demonstration of selected plant species
- Training on hill- specific technologies

During the reporting period, the core activities were focused on understanding the factors that govern the overall productivity and functioning of plants. Continued efforts resulted in development of propagation protocols for selected economically important plants, some of these were adopted for large-scale multiplication and field demonstration. Gaining basic information on physiological and biochemical basis of adaptation in relation to water stress deserved attention in order to screen suitable plants for field plantation programmes. Considering the need of improving plant survival and increasing production, the role of microorganisms remained a focus of investigations. Several bacteria, isolated from various types of soil were developed as inoculants, which improved survival of *in vitro* raised plants and influenced plant growth. Cold tolerant bacteria have also been isolated from higher altitudes. The microorganisms isolated from various sources are being maintained under laboratory conditions 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 has been realized and applied extensively for plant propagation. Training and demonstration of different hill-specific technologies continued on a regular basis and core staff contributed significantly as resource persons.

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

The Core, through its R&D projects, focused on developing/replicating packages/strategies for sound environmental management and socio-economic development by rehabilitating degraded lands and conserving biodiversity with the blend of science and religion and also by capacity building of the local communities through alleviation of poverty. During the reporting year, the functional impacts of the Integrated Eco-development Research programme (IERP) have become widely visible with receipt of hundreds of projects from prospective organizations distributed all across the IHR, and funding of 34 new projects to various Universities/ Institutions/NGOs for the execution of location-specific R&D activities. In all, 114 projects are currently on-going in ten 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 by funding three new projects in the States of Himachal Pradesh and Uttaranchal. 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

The R&D activities of the Core, during the reporting year continued to focus on understanding and documenting indigenous practices relating to the natural resource management. The detailed practices relating to traditional processing practices of vegetable drying and traditional environment knowledge of weather have been documented. The verification of such knowledge through group discussions with target groups has confirmed the authenticity of the collected information. The studies on indigenous knowledge of pastoralism and transhumance has generated database on different types of knowledge of the pastoral communities spread across foothills to alpine meadows. Two new studies have been initiated, one on the preferences regarding indigenous knowledge and uses of selected plant species of Uttaranchal Himalaya, the other on the resource dynamics, role of Institutions and conflict resolution in Arunachal Pradesh in Northeast Himalaya. The IKS digital library has added more datasets based on published literature on IKS in the Himalayan region.

Completed Projects / Activities

(Year 2004-05)

- Global Change Impact Assessment for Himalayan Mountain Region - Environmental Management and Sustainable Development *(APN funded)*
- Impact of Contour Hedgerow Farming System Technology on Land Capability Restoration in Upland Agriculture System and Capacity Building for Technology Dissemination in North Eastern India *(ICAR - NATP funded)*
- Impact of Multipurpose Contour Hedgerows Intercropping on Crop Productivity and Soil Fertility in Shifting Agricultural (jhum) Fields in the North East India *(DST funded)*
- Lead/ Coordinating Institution for Nanda Devi, Manas, Dibru-Saikhowa, Dehang-Debang and Kangchendzonga Biosphere Reserves *(MoEF funded: Phase-I)*
- Studies on Responses of Functional Features of Communities to Habitat Alterations in Timberline Zone of West Himalaya *(in-house, sub activity)*
- Rapid EIA and Formulation of EMP for Lakhwar Vyasi HE Project in Yamuna valley *(NHPC funded)*
- Landscaping and Restoration Plan for Dhauliganga HE Project - I in Uttaranchal *(NHPC funded)*
- Technology Vision 2020 Mission Project on Agriculture Potential- Sikkim *(TIFAC, DST funded)*
- Geometry Kinematics and Deformation Mechanisms in Darjeeling-Sikkim Himalaya *(DST funded)*
- Selection of Plant Growth Promoting Microbes for their Potential Use in Mountains *(CSIR funded)*
- Establishment of Biotechnology Complex for Capacity Building and Economic Upliftment with Particular Reference to Women of the Indian Himalayan Region *(DBT funded)*
- Characterization and Improvement of Tea Through Biotechnological Tools - Phase I *(DBT funded)*
- Gene pool Preservation and Mass Propagation of Sikkim Himalayan Rhododendrons Using Biotechnological Tools *(DBT funded)*
- Demonstration and Capacity Building of Mountain Farmers and Rural Women on Farm Based Simple Technologies in Sikkim *(DST funded)*

INTRODUCTION

The year 2004-05 is sixteenth financial year of R&D activities being executed by the Institute at different locations of the Himalaya. All through these years Institute has made efforts to provide practically feasible and locally acceptable solutions to mountain specific environment and development problems. The Institute implements its activities through the programmes supported through the core funds provided by the Ministry of Environment and Forests (MoEF), Govt. of India, and the projects financed by external funding 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 Science Advisory Committees of the Institute reviews the progress of existing projects and provides guidance and help to develop new R&D programmes.

At present, the R&D activities of the Institute are centered on seven designated core programmes. Various 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 public. The progress made during the year 2004-2005 on various ongoing and newly initiated projects and a brief account of the academic and other activities, along with the statement of accounts, have been presented in this report. Institute would be most grateful for critical comments, suggestions for improvement and for indication of shortcomings in our effort to achieve the target set by the MoEF, Govt. of India.

MILESTONE EVENTS

- **National Workshop on Watershed Mangement**

The Institute, organised a National workshop on "Resource Dynamics in Watershed Management: Emerging Challenges and Options" during June 2225, 2004. Deliberations covered the following major themes: Ecosystem and ecological services, (ii) Farming systems and livelihood options, (iii) Intergration, managrment and modeling, and (iv) Policies and planning. Over 70 participants covering academics, bureacrats, researchers, NGOs, line agencies and farmers, attended the workshop. the recommendation of the workshop included: (i) Multi objective decision suuport system, (ii) Exchange of information on the success stories, problems, etc., for mutual benefit , (iii) Remuneration for the ecosystem services provided to other areas including sediments, supply of quality water, conservation of bio-diversity and carbon sequetration and strengthening research and develoment for quantification these services, (iv) Encouragement for cultivation of medicinal plants and other high- value low - volume crops by farmers and ensuring marketing support through farmer driven cooperatives, and (v) Popularization of nutritional and medicinal values of traditional crops (organic food).

- **Brainstorming Session on Receding Glaciers**

A brainstroming session on "Receding Glaciers in the Indian Himalayan Region: Environmental and Social Implications" was organized on September 11, 2004. Dr. P. Ghosh, Secretary, MoE&F, GOI inaugurated the session and Padmshri Shri Sundarlal Bahuguna was the chief Secretary Uttaranchal, Dr. R. Mandal, Advsior Planning Commision, Mrs. Veena Upadhyaya, Joint Secretary, MoE&F, Shri N. Pant, Joint secretary & Finance Advisor, MoE&F, . Among subject experts, Dr. B.D. Acharya, Dr. V.K. Raina, Dr. Mukherjee, Dr. K.D. Sharma, Dr. A.V. Kulkarni, Dr. P.C.S. Devara, Prof. V.K. Gaur, Dr. Ramesh Chandra, etc., contributed during the session. The contents of deliberations on various aspects and the subsequent panel discussions on these aspects are supposed to form a baseline for developing a strategy and action plan on receding Himalayan glaciers.

- **Consultation Workshops for Global Pollination Project**

Institute as National Agency for global project on "' conservation and Management of Pollinators for Sustainable Agriculture, Through an Ecosystem Approach", organized the first National Stakeholders Consultation Workshop at the Institute HQs(8-9 October 2004), the workshop focused on: (i) introduction of the concept and components of the project, (ii) review of the expertise and information available on the project, (iii) identification of the partners and their responsibilities, and (iv) components of stocktaking exercise for status report preparation. Subsequently, the National Partners Consultation workshop focused on- review of the stocktaking reports, development of matrices for important crops, identification of priorities and finalization of national activities for inclusion in the full size project.

- **Regional Workshop on High Altitude Pastorism**

A regional Workshop 'Analysis of contemporary Issues Related to Carrying Capacity of Pastoralism in Higher Himalaya" was organized in the Institute (7-8 December 2004) in collaboration with Department of Human Ecology, Lund University, Sweden under joint research planning grant by Swedish Research Council (SIDA). The presentations in the workshop covered the entire Himalaya from Ladakh to Arunachal Pradesh including Bhutan.

- **Project Formulation Workshop on Technology Backstopping in NE**

Recognizing that development of the rural agarian sector is based on three critical imperatives- access resources, credit and technology backstopping, and that the agricultural development of NE India, particularly the uplands, requires a concerted technology backstopping, the north-east Unit of the institute, on the request of the Science & Society Division of the Ministry of science & Technology, GOI has formulated a coordinated programme by organizing a Project Formulation Workshop, which was sponsored by DST, at the Assam Administrative Staff College, Guwahati (17-19 January 2005). The Workshop was held to help the NGO partners to formulate proposals on technology backstopping. The programme, as conceptualized process mechanism using NGO partners

and lead farmers to set up demonstration centers and on-farm demonstrations for technology dissemination and capacity building.

- **State level workshops on development of Medicinal Plant sector**

A workshop on "Mainstreaming Medicinal Palnts for Development of the region- Uttaranchal Case in Point" was organized at Masi, Almora, in collaboration with regional environmental NGO, INHERE (28-29 January 2005). This was followed by yet another Workshop on the same subject organized for Himachal State at Himachal Unit of the Institute at Kullu (March 12-13, 2005). The main thrust of these Workshops was on group discussions to identify: (i) Major issues and constraints in cultivation and marketing/trade; (ii) Development of interface between farmers and R&D Institutions; and (iii) Institutional arrangements and support (Laboratories, quality assurances and mechanism of market support, etc.).

- **PARADE- Collaboration with National Cadet Corps**

A collaborative programme aimed at environmental restoration of the hill villages was launched jointly by GBPIHED with National Cadet Corps (NCC) at the Institute HQs. Lt. Gen. M.C. Bhandari, AVSM & BAR, Director General, NCC inaugurated the programme on 23 February 2005 at GBPIHED, Kosi- Katarmal, Almora. To begin with this activity, a resource map of identified village Railakot (Almora) was generated involving field work and interaction with village people. R&D intervention relating to wasteland development, water management, cash crops, health and hygiene and environment education are proposed under this programme. Institute scientists held several interactive meetings with the village people in collaboration with NCC to find out the priorities for action. Under the capacity building programme 40 Complex at GBPIHED, on environment-friendly rural technologies for income generation and resource conservation.

In addition to the above, following regular events were organized by the Institute.

- **SAC Meeting**

The 12th meeting of Science Advisory Committee (SAC) of the Institute was held (July 16-17, 2004) at the Institute HQs, Kosi-Katarmal under the Chairmanship of Prof. K.P. Singh, Banaras Hindu University, Varanasi. The committee members appreciated Institutes' efforts and offered following suggestions: (i) Focus on some priority issues such as, medicinal plants, watershed management, dissemination of rural technologies, global climate change; (ii) Network with other Institutes / Universities in terms of joint projects and publications on areas of mutual interest; (iii) Integration of socio-economic and ecological aspects; and (iv) Ecosystem approach for restoration, conservation and resource-use.

- **Annual day and G.B. Pant Memorial lecture**

Annual Day Function of the Institute was celebrated on the 10th September 2004 at its HQs (Kosi- Katarmal, Almora), Which coincided with the 117th birth anniversary of Bharat Ratna Pt. Govind Ballabh Pant. Chief

guest of the function and Dr. R.S. Tolia, Chief Secretary, Uttaranchal presided over Prof. J.S. Singh, FNA, Professor Emeritus, Banarus Hindu University, Varansi delivered the X th Pt. Govind Ballabh Pant memorial lecture "Sustainable Development of the Indian Himalayan Region: Linking ecological an Economics Concerns". At the occasion, Dr. Ghosh released Institute folder and a book " Tourism in Kullu Valley: an Environmental Assessment", authored by Institute scientists was released by Dr. Tolia.

• GB Meeting

The 27th meeting of the Governing Body (GB) of the Institute was held at the Institute HQs on September 10, 2004. Dr. Pradipto Ghosh, Secretary, MoEF and the Chairman GB of the Institute welcomed the members (Prof. H.Y. Mohan Ram, Dr. M. Sanjappa, Prof. R.S. Tripathi, Dr. R.S. Tolia, Ms. Veena Upadhyaya). Dr. Uppeandra Dhar, Director of the Institute made a brief presentation on the progress of the Institute and vision for the future. In the discussion that followed the presentation the members offered suggestions for improvement of the Institute's R&D efforts. The members expressed satisfaction on overall progress of the Institute during the reporting period.

• Society Meeting

The 11th meeting of Govind Ballabh Pant Society of Himalayan Environment & Development was held on April 13, 2005 at MoEF, Paryavaran Bhavan, New Delhi under the Chairmanship of Thiru A. Raja, the Hon'ble Union Minister, MoEF, GOI. Among other dignitaries the meeting was attended by Sri Harish Rawat, Hon'ble MP (Rajya Sabha); Shri Thakur Ram Lal, Hon'ble Minister of Forests, HP; Shri Nav Prabhat, Hon'ble Minister of Forests, UA; Shri Kailash Sharma, Hon'ble MLA, UA; Shri Suresh Chandra, Special Secretary, MoEF; Dr. R.S. Tolia, Chief Secretary, UA; Ms Veena Upadhyaya, JS, MoEF; Shri S.S. Shokeem, Joint Director, Ministry of HRD, GOI; Shri Srikanta K. Panigrahi, Nominee, Planning Commission; Shri R.K. Bhargava, Additional Secretary, Ministry of Mines, GOI and Shri V.K. Chaurasia, Ministry of Urban Development, GOI; Dr. D. Bandhopadhyay, Director, IIFM, Bhopal; Dr. M. Sanjappa, Director, BSI, Kolkata; Shri G.K. Prasad, DG, ICFRE, Dehradun; Shri P.R. Sinha, Director, Wildlife Institute of India, Dehradun. Shri Sunil Pant and Capt. M.S. Kohli attended the meeting as non-official members. At the outset, Shri S. Chandra, SS, MoEF welcomed the Hon'ble President of the Society, members and nominees, and briefly introduced the mandate of the Institute. Director of the Institute made a brief presentation on the R&D activities of the Institute. During discussions the committee members emphasized upon: cultivation and market linkages for medicinal plants, inter-institutional collaboration with other institutes of Ministry, initiate publieprivate partnership, strengthening eco-tourism as a development option and wider replication of R&D based demonstrations in the field.

RESEARCH AND DEVELOPMENT PROGRAMMES

- 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
- Indigenous Knowledge Systems.

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.** Institute's project implementations sites are spread over different parts of IHR and have been selected carefully keeping in view the biophysical heterogeneity and location-specific needs and aspirations of the inhabitants. All activities are need-based, target-oriented and time-bound. Efforts are made to provide practicable solutions rather than theoretical prescriptions. The Institute HQs and the regional Units are well equipped with facilities and services, especially the well-equipped laboratories and computation facilities. Research, demonstration and dissemination are underlying elements of all project activities that lead to development of technology packages. While a number of projects were completed during the year, a few new projects have been initiated. Highlights of the progress made during the year 2004-2005, 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)

Life on earth is dependent on availability of water, which is the most valuable produce of land and atmospheric processes. The availability distribution, use and access to land and water resources have been major drivers for civilizations and human development. With ever-growing requirement of rising population, management of land and water resources is becoming more critical as the availability of these natural resources is limited. Proper management of land and water resources must aim at achieving a balance between the needs of people and the ability of ecosystems to support and regenerate its resources. Within the fragile ecosystems of the Himalaya, the dynamic geological and geomorphological processes, ever growing human population and recent global change vitiate the resource degradation. As a consequence, serious problems related to sustenance of ecosystem services provided by land and water resources have arisen. Considering these points the core activities are focused on long-and medium-term R&D studies in the field of spatial and temporal pattern of resource availability and critical linkages it possess with other geo-environmental factors. These attempts will help in developing suitable strategies for management of land and water resources in the region.

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

Natural boundary erosion plot concept for LWRM

Documentation of traditional SWC practices

Background and Objectives

In different parts of Indian Himalayan region (IHR), the role of traditional land and water management practices is well recognized. In central Himalaya, the bench terraces that cover many steep agriculture hillsides are widely adopted as an excellent method of soil and water conservation (SWC). Dominated by terrace agriculture, Rikhey village in Kuwagad watershed (a micro watershed of Nana-Kosi catchment) of Kumaun region has been identified and studied using the natural boundary erosion plot concept. In this approach, the natural plots made by farmers were monitored. In the case of NE Himalaya, traditional communities follow different management practices for SWC in shifting cultivation areas and thus a study was conducted in Senkhi watershed representing the shifting cultivation in Arunachal Pradesh. The objectives of the study are: (i) Identification and documentation of traditional SWC practices in the Himalaya; (ii) Quantification of soil loss in different land use practices with and without SWC measures; (iii) Development and dissemination of technology packages for environmentally sustainable and socially equitable management of land and water resources in the region.

Results and Achievements

- Soil physico-chemical attributes of study sites
- Average total nitrogen of terrace soil was low

(a) Studies in Central Himalaya

1. Representative sampling plots with runoff collectors were maintained in Rikhey village (Fig.1). Mean soil moisture before Rabi crop sowing

Fig. 1. Natural boundary erosion plots in Kuwagad watershed, Distt. Almora (Uttaranchal)

was found to be 15.8% (Table 1) that was considered favourable for crop germination while the average water holding capacity was 40.8%.

2. Average **total N content of the terrace soil was quite low (0.096%) at the time of crop sowing (Table 1).** Soil poor in N will not support enough microbial population responsible for decomposition and release of nutrients for the organic matter applied in the crop fields at the time of crop sowing.

Table 1. Physico-chemical properties of soil

Parameters	Rikhey site
Soil moisture (%)	15.79±0.29%
Water holding capacity (%)	40.8±0.78%
pH	5.98±0.01
Electrical conductivity (ms)	0.035±0.0001
Particle size (%)	Sand = 28.07±0.57% Silt = 65.90±0.56% Clay = 4.36±0.21%
Organic carbon (%)	1.41±0.02
N	0.096±0.002%
P	0.043±0.001 ppm
K	0.82±0.03 ppm

(b) Studies in North-East Himalaya

- Land use/cover in study site was higher than in the state
- Varying cropping patterns adopted to protect soil & water loss

1. Analysis of land use/cover in Senkhi watershed in Arunachal Pradesh (AP) using the SOI toposheet and satellite imageries (1997) revealed that the spatial distribution of shifting cultivation is generally observed in hilly slopes (>25°). Comparative analysis of land use/cover in AP and for the study site showed that the forest cover is less in State (62%) compared to 87% in study site. Settled cultivation occupy 3% of the study site, and 1% in State, while shifting cultivation cover was 4% and 14% in study site and State, respectively.

2. **There are 11 distinct types of indigenous land use practices across the study sites** (Table 2). Here the shifting cultivation is locally known as *Rongo. Phai,* an indigenous system of SWC has been identified for detailed analysis of its effectiveness. Besides this, there are different cropping systems, such as, *Hade* to protect soil and water loss, and improve soil fertility through fertility enhancing crop-mixture which need further investigation.

Table 2. Traditional land use classification of Nyishis

Land use type	Description
Moro	Forest
Oming-Olang	Clan land
Atu-Olang	Individual land
Eeh-Nyumra	Bamboo forest
Nyibi	Fallow land
Nengken-Rongo	1st year jhum field
Nyengnyi-Rongo	2nd year jhum field
Sapiya	Terrace rice field
Bolu	Home garden
Nam-Olang	Household
Dolu	Village settlement

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

(SDC, IDRC and ICIMOD funded; Period: 1997-2005)

Better livelihood options adopting low-cost technologies

Generation of data base on resource dynamics

Capacity building

Background and Objectives

People and Resource Dynamics in Mountain Watersheds of the Hindu-Kush Himalayas, a regional collaboration programme, was initiated in January 1997 as a R&D project in the middle mountains of the Hindu Kush Himalayas (HKH). In India, the project area is Garur Ganga watershed located in Bageshwar district of Uttaranchal. Due to its multidisciplinary approach and acceptability, the PARDYP has completed its two phases and is presently in its third phase of operation. Apart from generating long-term database on resource dynamics, activities ensuring improved livelihood conditions of the marginalized groups and families through demonstrations, adoption/adaptation of tested low-cost technologies and skill improvement, have been the major interventions of the project. Synthesis, modeling, dissemination of the results / information, skill development and strengthening of community institutions, are the major activities of the present phase of this project.

- Beneficiaries- 155 farmers in 58 villages
- Rehabilitation of wasteland improved fodder crisis and reduced erosion

Results and Achievements

1. **Rehabilitation of degraded community lands at 4 locations in the watershed has eased the fodder crisis, improved water percolation and ultimately reduced erosion of soil and nutrients.** Improved fodder production of around 54 t, costing Rs. 62,000, is a direct benefit to the community during the year.

2. Estimated reference evapo-transpiration (ET) for the Lawbanj area. Daily minimum ET (1.6 mm) on 185th day and daily maximum (3.9 mm) was estimated on 127th day of the year (Fig. 2). The erosion

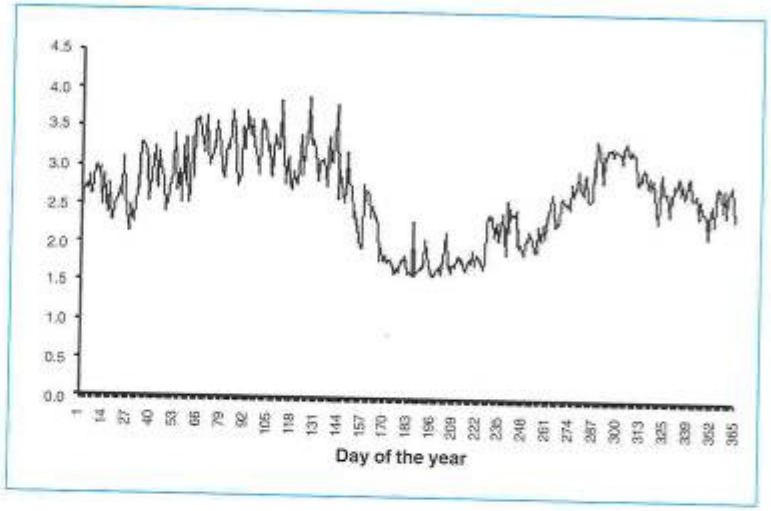


Fig. 2. Reference Evapo-transpiration for Lawbanj, Distt. Bageshwar (Uttaranchal)

plot monitoring showed the highest surface runoff generated by bare land (1542 m^3/ha) followed by pine forest (1389 m^3/ha) and is least for rain fed agriculture (49.28 m^3/ha).

Application of SWEET for rehabilitation of degraded community land

Performance assessment and environmental awareness activities

LWRM 3 : Rehabilitation of Degraded Community Lands: Village Bantoli- Bageshwar- Uttaranchal Central Himalaya

Background and Objectives

The consequences of increasing anthropogenic interferences on the natural recourses and the resulting ecological imbalance are of serious global concern. Symbiotic relationship between man and the environment, as a key to the sustainable development, has been weakened because of the fact that man has been continuously transforming the natural components of the system and manipulating the elements of the bio-physical environment. As the population increased, so did the cultivated area and the number of cattle, placing more demand on resources, particularly for fodder and fuel wood. Keeping in view the fragmented land holdings, increasing demand of fodder, dependency on already deteriorating forest base, increasing womens work load, rehabilitation of community degraded land has been identified as a potential R&D area in this region. Sloping watershed environmental engineering

technology (SWEET) approach applied to rehabilitate a piece of community land at Bantoli village in Bageshwar district with active participation of community stakeholders. The main objectives were: (i) Improvement of productivity of degraded lands by application of SWEET; and (ii) Performance assessment and adaptability studies, promotion of environmental awareness through capacity building, exchange visits ensuring adoption/ adaptation of such activities.

- Plantation for rehabilitation
- Interventions for water conservation

Results and Achievements

1. After a series of formal and informal meetings with the village community plantation of plant species preferred by the women was done in August 2004. **A total of 6700 saplings were planted and the survival rate of the plant species was recorded over 90% during initial stage**, which was subsequently reduced to 84% due to termite infection on roots of *Quercus glauca*.
2. The area has been fenced and water conservation measures have been initialized through contour trenches, plugging of gullies and introduction of grasses in the site.

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

Geohydrological studies & quantification of sediment load

Monitoring recession rate of tributary glaciers

Background and Objectives

About 17% of the total area in Himalaya is occupied by approximately 10,000 glaciers. Snow and glacier ice of these mountains serve as the major water source for Indian rivers. Glaciers have long been recognized as significant agents of erosion and deposition. The concentration of suspended sediment (SSC) in the melt waters of Himalayan glaciers is highly variable. This is generally due to variability in sediment sources, rock type, relief, weathering state, tectonic setting, climatic influences, the ice flux, thermal conditions and the debris entrainment processes. The case of Gangotri glacier system is not different. Numerous small glaciers join the main glacier, from all side and form the Gangotri group of glaciers. The rate of flow of water and sediment and its quantification is of great importance to evaluate role of a tributary glacier i.e. Thelu glacier. The objectives of the project were: (i) Quantification of discharge and sediment load of melt water stream of Thelu glacier; (ii) Identify role of tributary glaciers in temporal distribution of the suspended sediment load of Gangotri glacier and its relationship with melt water discharge; and (iii) Monitoring rate of recession of tributary glaciers of Gangotri, i.e., Raktavarna, Thelu and Chaturangi glaciers.

Results and Achievements

- Establishment of a field station at Thelu glacier
- Observations on receding rate, sediment source

1. **A field station was set up at Thelu glacier** for detailed study at an altitude of 4600m above msl.
2. Observations on receding rate of tributary glaciers, sediment source area, production mechanism and transport pathways of the sediment load of the glacier etc. are continuing.

LWRM 5 : Quantification of Tectonic Deformation Field in Kumaun Himalaya- A Basic Framework for Landslide Hazard Modeling Using Sub-cm Precision GPS Surveys *(DST funded; Period: 20022005)*

Background and Objectives

Landslide hazard modeling using precision GPS geodesy

Determination of N - S strain gradient

The continuous movement of the Indian landmass towards Asia is building up stresses and strains, which in turn is accumulating in the fractural framework of the Himalaya and contributing to the natural hazards in the mountains. Landslide monitoring with kinematic GPS survey is attempted to model slope evolution. In recent years, the GPS measurements in the Himalaya and adjoining regions have led to the conclusion that the plate motion or convergence along the strike of the entire Himalaya is not uniform rather the entire belt can be subdivided into small blocks, which are marked by transverse features. These transverse features seem to control the tectonics, plate motion and geodynamics of the region. The objectives of the study were: (i) Study of N-S strain gradient using high-precision GPS surveys, to determine the annual strain rate field in Kumaun Himalaya from Dung to Almora and Kalapani to Tanakpur; and (ii) Monitoring of the temporal evolution of some potentially damaging landslides using kinematic GPS surveys.

Results and Achievements

- Monitoring sites along Gori and Kali valleys
- Campaign stations established at Gangotri and Milam glaciers

1. Investigations carried out at Balia Nala (Naini Tal) using more than 100 grid points to expand the study towards the active landslide area. Data were collected in static mode and kinematic mode. The recorded data were processed using SKIPRO software and the processed co-ordinates were used to generate the surface of the landslide region using GIS software (Arc view and ERDAS Imagine).
2. Along with data collection from 14 sites along Gori valley and central Himalaya, data collection and processing from 15 new GPS sites along the Kali valley transects was carried out. **The velocity and precise position (ITRF 2000) for Gori valley sites were determined (Table 3).** The result depict non-uniform distribution of plate motion in N-S transect.

Table 3. Azimuth and velocity results (2002-04) for Gori valley

Station	Azimuth (degrees)	Velocity (mm/year)
Dung	69.37	4376 ± 4.21
Milam	45.93	3774 ± 441
Burfu	45.10	33.50 ± 378
Belju	43.90	29.09 ± 4.29
Laspa	4734	20.33 ± 3.29
Martoli	44.67	2845 ± 478
Lilam	47.68	36.04 ± 542
Bugdiyar	4845	3456 ± 4.37
Railgad	4947	3646 ± 645
Bala	44.19	35.28 ± 4.56
Khalia Top	43.29	3546 ± 5.16
Munsyari	35.91	3784 ± 4.9
Chokouri	53.61	39.63 ± 443
Pithoragarh	43.88	5216 ± 5.30
Kosi	46.28	4643 ± 3.60

3. **Campaign stations at Gangotri and Milam glaciers were established for glacier retreat studies.** GPS data in a rapid, static and kinematic mode were collected along and near the snout and processed with SKIPRO software with respect to the reference station.

LWRM 6 : Performance and Adaptability Analysis of Sloping Watershed Environmental Engineering Technology (SWEET) in the Hills of Kumaun Himalayas (*DOLR funded; Period: 2001-2006*)

Adaptability of SWEET package for reclamation of wastelands

Generation of awareness and skill amongst local populace

Background and Objectives

The project on performance and adaptability analysis of SWEET was initiated in Almora district of Uttaranchal on community and privately owned wasteland. The SWEET package developed by the Institute, is being used for regenerating such degraded wasteland. The technology includes site protection through fencing, water harvesting through low-cost polythene lined tank, selection of tree species based on multipurpose benefits like fruit, fodder, fuel wood, fiber and timber. The objectives of the project were: (i) To test the performance and adaptability of SWEET through field demonstrations and to generate awareness and skill among the farmers / extension workers for reclamation of wastelands through

field training; and (ii) To modify and suggest appropriate technology packages for future application in wasteland restoration.

Results and Achievements

- Physical & biological treatments associated with better plant growth and fodder yield

1. **After physical and biological treatment in degraded wastelands, soil moisture slightly increased resulting in better growth of vegetation and higher fodder yield.** Fodder yield at three different sites is presented in Fig. 3.
2. In terms of growth, plants like *Alnus nepalensis*, *Prunus cerasoides*, *Cassia nilotica*, *Albizzia lebbek*, *Dalbergia sissoo* and *Quercus leucotrichophora* were found more suitable than other species (Table 4).

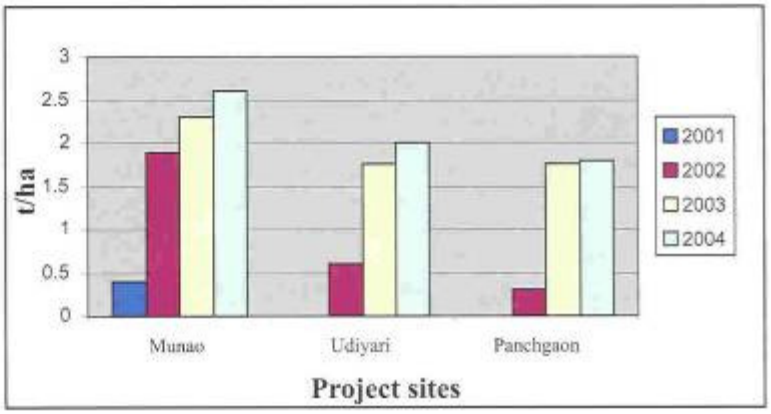


Fig. 3. Yearly increment in fodder yield at different sites in the hills of Distt. Almora (Uttaranchal)

Table 4. Details of survival and height of plant species

Village	Year of plantation	No. of species	No. of plants	Average survival(%)	Average height of plants (cm)
Munao	2001	17	3761	75.88 ± 0.92	146.65 ± 2.19
Udiyari	2002	11	3920	76.55 ± 1.31	126.00 ± 3.90
Katarmal	2002	18	5144	69.94 ± 0.69	121.94 ± 2.16
Panchgaon	2002	16	3790	6471 ± 1.02	103.0 ± 1.30
Bansgaon	2003	13	3565	60.00 ± 0.57	73.84 ± 1.38

LWRM 7 : Environmental Impact of Recession of Himalayan Glaciers: A Case Study of Dokriani Bamak *(DST funded; Period: 20022005)*

Determination of land use and land cover change

Monitoring diurnal and seasonal variations in CO_2 level

Successional patterns in microsites by glacial retreat

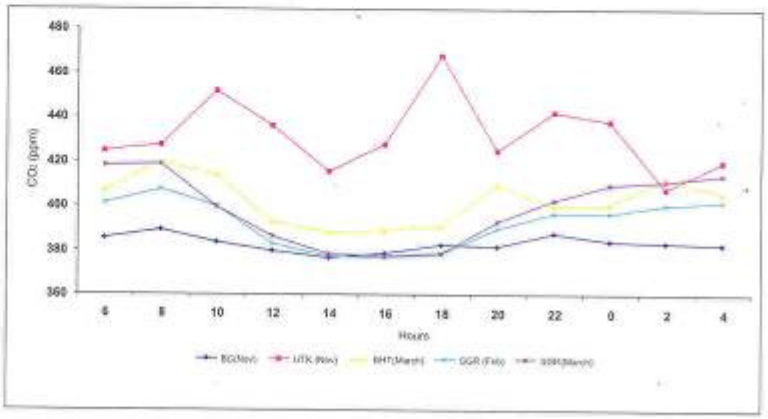
Background and Objectives

The Himalaya constitutes one of the most important glacier systems in the world. These glaciers contribute to fresh water to main river systems of Indian sub-continent. It has been estimated that 38221 sq. km of Himalayan ranges are glaciated. Updated Glaciers inventory (Geological Survey of India) has identified 7613 glaciers in the Indian administered part of the Himalaya. Glaciers are commonly regarded as sensitive indicators of climate change and the variation in the position of their snout is the best indicator of glacial retreat over the period of few years or decade. In view of the reports on retreating glaciers in the region, this project in the Dokriani glacier focused on: (i) Collection of data on land use, land cover changes, and factors leading to LUCC in the proposed study area; (ii) Measurement of seasonal and diurnal variations in the levels of atmospheric CO_2 at selected sites; (iii) Assessment of microbial diversity in the soil and in rhizosphere; and (iv) Identification of responses of landscape-ecological features of snowline and timberline and monitoring of successional patterns in microsites caused by glacial recession

Results and Achievements

- Plant biodiversity was assessed
- CO_2 level varied at different locations
- Soil bacteria of varied shapes and size detected

1. Permanent plots for monitoring bio-diversity elements have been marked. Some of the plant species identified were: *Calamagrostis* sp., *Kobressia duthei*, *Juncus bracleatis* (among grass), *Androsace* sp., *Corydalis meifolia*, *Saxifraga* sp., *Sedum* sp., *Swertia augustifolia*.



(BC=Base Camp, UTK=Uttarkashi, BHT=Bhatwari, SGR=Srinagar)

Fig. 4. Carbon dioxide measurement at four different locations in Garhwal Himalaya

2. **Carbon dioxide measurement was taken at four different locations** (Fig. 4) according to the altitude (i.e., Base Camp, Bhatwari, Uttarkashi and Srinagar).

3. In order to know microbial diversity in soil cultures (48 hr, 24°C) were grown on Tryptone yeast. In all the cases the colonies were either slimy or mucoid. The cultures consisted of cocci and rods, gram positive and gram negative cells.

LWRM 8 : Catchment Area Conservation and Management Study *(SWAJAL, UA funded; Period: 2004-05)*

Management strategy for catchment area conservation

The Uttaranchal Himalaya is characterized by ridges and valleys and has wide zone of surface runoff. This region quite often faces water shortages during non-rainy periods. Many natural and human induced reasons in the water recharge zones have been attributed to this phenomenon. A "Source Centred Catchment Area Management" approach has been tested and replicated under this project. The present study focuses on some of prevalent catchment area issues in the Uttaranchal state and development of possible management strategies under the broad objectives of (i) Identification and assessment of the existing catchment area conservation and management issues and causes of depletion of water sources in hilly districts of Uttaranchal for development of a plan for augmentation of spring discharge including its cost requirement; and (ii) Preparation sample TORs for implementing agency, including formats for planning design implementation and operation and maintenance (O&M) of catchment area protection plan.

Results and Achievements

- Survey of all hill districts of UA to augment source discharge
- Estimated the cost for catchment area conservation & management

1. Extensive survey carried out in the selected 14 representative Gram Panchayats (GPs) covering all hill districts of Uttaranchal, pertaining to decline in spring discharge and strong community participation. In these GPs **geohydrological assessment was carried out to explore possibilities of augmenting source discharge by physical and biological treatments** of small source catchment ranging from 5-20 ha.

2. **The cost estimation and O&M for catchment area conservation and management was worked out as Rs. 60-80,000/- per ha** depending upon location and treatment measures. Detail plan for augmentation of various types of spring in different altitude and locations of Uttaranchal is under preparation.

LWRM 9 : Nutrient-Use Optimization by Improving Soil Biological Processes Using Available Resources in a Marginal Upland Jhum Farming System in the North- East India

Improvement in soil fertility and controlling soil erosion

Background and Objectives

Northeast India, particularly the state of Arunachal Pradesh, is well known for its biological and cultural diversity. This State is inhibited by diverse ethnic communities whose livelihood are still closely linked to the surrounding natural resources. The practice of shifting cultivation is still widespread. With Government efforts, agricultural practices among many of these ethnic groups are undergoing rapid transformation. As the shifting agriculture transits to horticulture, cash crop and settled agriculture, the demand for soil fertility enhancement, soil erosion control and water management need to be addressed. Under these circumstances identification and assessment of existing soil fertility enhancement technologies is a must along with the introduction of new technologies. The present project aimed to address this issue is based on studies carried out in Senkhi watershed, Papum Pare district of AP, inhabited by Nishi tribe.

Results and Achievements

- Soil physico-chemical characteristics reflected pattern of soil erosion and crop field
- Higher C, N and K detected in topsoil

1. Soil samples were collected from different land use/cover viz., jhum land, fallow land, forest and wet rice cultivation from the two villages and analyzed for their physico-chemical characteristics. Higher percentage of sand was present in comparison to silt and clay (Table 5). A high percentage of sand and low silt in the soil suggests that the area might be susceptible to landslide and soil erosion and may support poor crop yields.

Table 5. Soil physical properties in different land use system of Senkhi watershed

Parameters	Depth (cm)	Land use							
		Jhum		Fallow		Forest		WRC	
		I	II	I	II	I	II	I	II
Sand (%)	(0-10)	62	70	63	69	70	76	64	70
	(10-20)	63	72	63	69	70	75	64	70
Clay (%)	(0-10)	13	7	9	10	8	8	8	10
	(10-20)	11	10	10	9	9	7	6	10
Silt (%)	(0-10)	25	23	28	21	22	16	28	20
	(10-20)	26	18	27	22	21	18	30	20
Textural class		Sandy silt	Sandy	Sandy silt	Sandy	Sandy	Sandy	Sandy silt	Sandy
Soil Moisture (%)	(0-10)	14.67	8.37	23.23	10.67	17.97	14.43	24.10	11.00
	(10-20)	18.47	13.03	24.20	15.57	17.33	15.57	21.57	13.37

(I = Chimi village, II = Bhatt village, WRC= Wet Rice Cultivation)

2. Soil pH ranges from neutral to acidic and shows variation with depth (Fig. 5 & 6). Soil organic carbon, total nitrogen, and potassium content are higher in topsoil of both the sites. This might be due to the litter decomposition, and potassium percentage may be influenced by bamboo vegetation. **The physico-chemical properties of the forest seem to be better than other land use.**

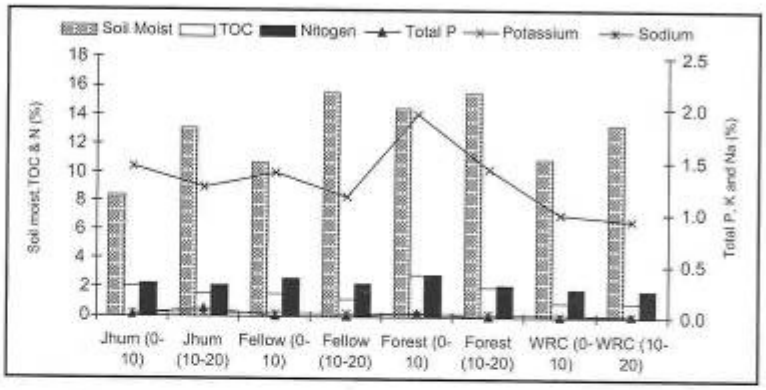


Fig. 5. Soil chemical properties in different land use of Chimi village (Site-I), Senkhi watershed, Distt. Papum Pare (A.P.)

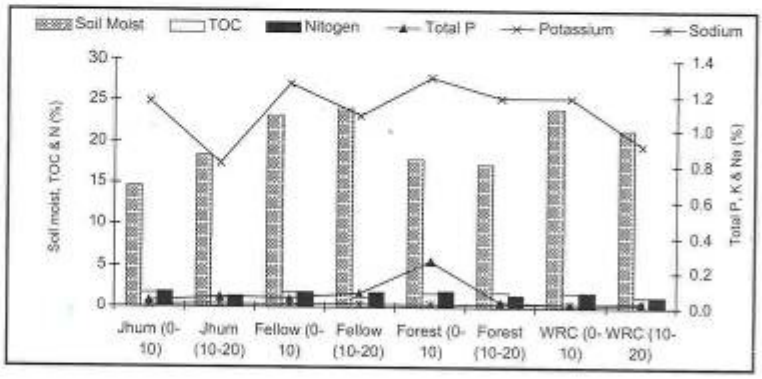


Fig. 6. Soil chemical properties in different land use of Bhatt village (Site-II), Senkhi watershed (TOC- Total organic carbon, WRC= Wet rice cultivation), Distt. Papum Pare (A.P.)

BOX - 1

Summary of the Completed project
(2002-2004)

Global Change Impact Assessment for Himalayan Mountain Region for Environmental Management and Sustainable Development *(APN funded)*

The Himalaya is geologically and ecologically fragile mountain ecosystem. With rapidly growing population and increasing demand for food and water, pressure on the natural resources in the region is very high. Under the changing global climate and globalization the risk of irreparable damage to ecosystem is not ruled out. Alaknanda catchment was selected for the detailed study of climate change in IHR, which represent typical Himalayan climate and socio-economic conditions of the Central Himalaya. The background information on climate variability and socio-economic conditions of the region was compiled and used to develop study program for quantitative assessment of the climate change and associated impacts along three altitudinal transects of the study area.

- In lower transect of Alaknanda valley, rainfall has increased in the last decade. The problem of seasonal drought is occurring due to shifting of rainfall. Most populated middle transects showed largest decline in rainfall and decrease in soil moisture. Upper transect has also shown a decrease in precipitation. During monsoon the intensity of rainfall has increased while the total duration of rainfall is decreased that results in frequent landslide events, cloudburst and other natural calamities.
- The annual temperature in lower and middle transect of Alaknanda valley indicated rising trend in the last decade. Limited data for upper transect was analyzed and increasing trend for temperature was recorded. Increase in temperature and decrease in snow cover in middle transect was recorded.
- An estimate of food grain requirement for two decades has indicated strong dependence on import of food grain from outside the catchment in all the three transects. It is expected that with the growing population, the region will become more vulnerable for food shortage in near future.
- The water demand is expected to grow with growing population and decline in rainfall will put additional stress on the water resources of the region. The total water demand during 1985-86 and 1995-96 was estimated by aggregating demand for irrigation, domestic and livestock purposes. From the estimates, it is important to notice that maximum consumption is accountable for irrigation in all three transects, but water consumed on livestock in lower transect decreases during decade because of decrease in the livestock population. The water deficit increases with time and more shortage is expected in later years all three transects of the catchment.

Core Programe-II
SUSTAINABLE DEVELOPMENT OF RURAL ECOSYSTEMS (SDRE)

The pivotal aim of the programme is to address issues in sustainable development of the rural areas of IHR through identification of development bottlenecks and formulation of strategies for solving location-specific problems. The pre-requisite for this is to identify problems, assess existing strategies and based on these, design corrective approaches which are appropriate to economic, social and environmental needs. The Core, therefore, focussed its activities on resource dependency assessments and management strategies; issues and options for rural livelihood security; appropriate mountain technologies; and strengthening of delivery systems. In the reporting year a few selected tribes in the north-east and central Himalaya were investigated for their dependency on resources with a particular reference to how these communities are adapting to the changes in current environmental scenario. To mitigate the adverse impacts of over exploitation of resources, rehabilitation of degraded lands using scientific means are being promoted at various locations. The agroforestry model in Garhwal and contour-hedgerow-intercropping in Arunachal Pradesh were tested for their validation and efficacy to increase productivity of the land, crop yields, and other benefits to the community. Efforts to strengthen farmers-field-cum-training programme were continued due to its high demand, and accordingly NGOs, farmers, officials, and user groups were trained for different environment-friendly income-generating options.

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

(a) *Natural Resource Management for Sustainable Development*

Demonstration of low cost technologies

Natural resource management through community institutions is effective in Arunachal Pradesh

Background and Objectives

This study aims at to understand people and resource dynamics and document indigenous land uses, knowledge on natural resource management (NRM), local Customary Laws and their efficacy for NRM among selected tribal communities of NE region. This year studies were focused on the cultural landscape, integrated natural resource management and community organization with particular reference to its capacity for local assets building and transformations in the 'Apatani' tribe in Lower Subansiri district of Arunachal Pradesh.

Results and Achievements

1. The Apatani community had a population of 24650 persons that is confined to 1060 km² area. **A total of 14 indigenous land use types have been identified.** The agriculture is limited to just 43 km² area.

- 14 indigenous land use types exist amongst Apatani community
- Customary laws are obeyed and respected

2. To maintain maximum production, early and late growing rice varieties are cultivated with fish in irrigated fields and millet on the field-bunds. Home-gardens are maintained to meet a variety of needs and continually modified over the years to meet cash requirement as well. **Both the systems are ecologically and economically efficient with high degree of self-sufficiency.**

3. The community people show proper institutional arrangements for maintaining forests, water and agricultural resources. Agricultural land is surrounded with a layer of bamboo. The pine plantations were found at mid-slopes and mixed-broad leaved forests on the extreme peripheral part. Bamboo is an important utility item for house construction and various other needs of the community.

(b) Land Use Models for Himalaya

People's participation- a prerequisite for successful land rehabilitation

Background and Objectives

The failure of afforestation and reforestation efforts to develop degraded lands in the Central Himalaya could be attributed largely to the ignorance of people's essential needs and hence their non-cooperation. People's participation is now considered as a pre-requisite for success of any land rehabilitation efforts. A reconciliation of the interests of local communities (immediate tangible benefits) and the global concern for environment of the region (long-term intangible benefits) is utmost importance for sustainable rehabilitation of degraded lands. The development of agroforestry and eco-restoration of degraded lands is one way to achieve land rehabilitation. This study focused on: measurement and comparison

of growth performance and biomass production of some native and naturalized multipurpose tree species (MPTs) in an agroforestry and eco-restoration model developed by the Institute for the last 15 years (1991-2005) on 8 ha degraded land in the Garhwal Himalaya.

Case Study- Garhwal Himalaya

Results and Achievements

- 7 multipurpose trees showed maximum biomass and crown volume

1. Crown volume (m^3/tree) was recorded highest for *Ficus glomerata, Alnus nepalensis, Dalbergia sissoo, Albizia stipulata* and *Sapium sebiferum* at both the sites. However, crown volume was relatively higher at AAL site as compared to the DFL site for almost all the species common to both sites (Table 6).
2. **Among the MPTs planted, *A. nepalensis, F. glomerata, D. sissoo, A. stipulata, S. sebiferum* and *B. rugulosa* showed maximum biomass (kg/tree)** at both the sites (Table 6).

Table 6. Crown volume and above ground biomass of MPTs after 15 years of growth in Garhwal Himalaya (AAL= abandoned agricultural land site; DFL= degraded forest land site, - = not planted).

Species	Crown volume (m^3/tree±SE)		Biomass (kg/tree±SE)	
	AAL	DFL	AAL	DFL
Albizia lebbek	9.9±0.5	15.2±0.7	60.6±2.9	46.3±2.0
Albizia stipulata	-	19.3±0.8	-	65.3±3.1
Alnus nepalensis	42.3±1.9	32.2±1.4	160.6±6.0	110.0±204.5
Bauhinia variegata	15.2±1.7	-	65.0±3.1	-
Boehmeria rugulosa	25.6±1.6	6.0±0.3	79.0±4.0	42.0±1.9
Celtis australis	21.2±1.1	8.0±0.4	68.6±3.9	39.0±1.8
Cedrela toona	-	9.0±0.4	-	35.0±1.6
Dalbergia sissoo	31.3±1.6	19.0±0.9	120.6±4.8	86.0±4.2
Ficus glomerata	48.5± 2.0	15.0±0.8	140.0±5.2	70.0±3.1
Ficus roxburghii	17.5±0.6	-	68.0±3.6	-
Ficus rumphii	14.5±0.5	-	58.0±2.4	-
Grewia optiva	26.5±1.4	6.9±0.3	60.0±3.0	39.0±1.7
Melia azedarach	-	15.0±0.8	-	24.0±0.9
Ougeinia dalbergioides	-	13.0±0.7	-	49.0±2.3
Prunus cerasoides	23.2±0.9	16.0±0.6	76.0±3.9	32.0±1.6
Pyrus pashia	8.9±0.4	6.0±0.2	56.0±2.9	30.0±1.4
Quercus glauca	-	10.0±0.5	-	45.0±1.6
Sapindus mukorossi	-	7.9±0.3	-	41.0±1.5
Sapium sebiferum	29.1±1.3	8.8±0.4	86.0±4.1	59.0±2.3

(ii) Assessment of Agroforestry Models in Different Ecozones of Sikkim

Different agro-forestry models to cater location-specific demands

Background and Objectives

Earlier studies during agroforestry model development have identified various developmental and restoration processes at subtropical Damudara and temperate eco-zone Chhamgaon village in the Mamlay watershed, Sikkim. Agroforestery model and restoration activity has already been developed at Chhamgaon using different developmental packages. Similarly, Damudara agroforestry site is focused for the plantation of fuelwood, fodder, timber and fruit species, and different field technology like rainwater harvesting tank, bio-compost preparation and nursery raising to fulfill the requirement of local farmers. The efficacy of the model is being assessed with reference to its suitability and scope for further extension.

Result and Achievements

- ***Alnus nepalensis*** **and** ***Thysanolaena maxima*** **exhibited 90% survival**
- **Rainwater harvesting preferred by most farmers**

1. The agroforestry model at subtropical zone (Damudara) covering 3.5 acre land has 35 beneficiary households. **A total of 2000 saplings of 9 prioritized species were distributed to the farmers.**
2. The farmer with small land holding (<1 ha) preferred fodder trees (65%), wild edible medicinal plants (18%), timber (10%) and fuel wood trees (7%). Medium land holders (1- 2.5 ha) preferred fodder plants (58%), fruits, wild edible, medicinal plants (24%), timber (12%) and fuel wood trees (6%). Large land holders (>2.5 ha) preferred 32% fodder, 35% timber, 18% other plants like fruits, medicinal, wild edible and 15% fuel wood species.
3. **Survival percentage of planted individuals varied from species to species at Mamlay watershed.** Utis (*Alnus nepalensis*) and Amliso bush (*Thysanolaena maxima*) showed 90% survival and Ranichanp (*Michelia excelsa*) exhibited 45% after 8 months of plantation.

BOX - 2

Summary of the Completed Project

(2001-2004)

Impact of Contour Hedgerow Farming System Technology on Land Capability Restoration in Upland Agriculture System and Capacity Building for Technology Dissemination in north east India *(ICAR - NATP funded)*

The Contour-hedgerow-intercropping is based on growing N_2-fixing hedgerow species on contours along hill slopes at certain intervals and alleys. The desired species are allowed to grow year after year using hedgerow mulch and was found to be an appropriate alternate or modification to degraded or shifting cultivation (jhum) areas of the north-east India. N_2-fixing hedgerows were maintained in double rows, species are cut at 45-50 cm height and the mulch thus produced was applied to the crop fields as green manure. The achievements are summarized as below:

- A total of 175 leguminous species were screened of which five species, viz. *Tephrosia candida, Flemingia macrophylla, Desmodium rensonii, Indigofera anil* and *Leucena leucocephala* performed best. All these species are excellent fodder, soil binder, have high coppicing ability and produce quality mulch for green manure. Incorporation of hedgerow mulch significantly increased maize yield by 2-3 times than the control.
- Application of mulch of N_2-fixing species improved soil fertility with improved status of N, P, K. The enzymatic activity of soil registered a significant increase ($p< 0.01$); the dehydrogenase enzyme activity enhanced by 1.2-1.65 fold and the urease activity increased by 1.5-2.04 fold under different treatments of hedgerow and mulching.
- Performance of hedgerow species in nine major land uses (viz. just burned jhum, 1 year-old jhum, 2 year-old jhum, rainfed agriculture, secondary forest, natural forest, recent landslide, 3 year old landslide, and riverine soil) after 12 months indicated that species performed better in the soils of 2nd year jhum, rain fed agriculture and secondary forest.
- Incorporation of hedgerows on slopes reduced runoff by 40-50% and soil erosion by 50-65% from an annual loss of nearly 19 t/ha soils from traditional jhum fields (control) with mild slope. A significant quantity of organic carbon, N, P, and K was also conserved by employing contour hedgerow technology.
- The above ecological and economic benefits accrued under this experiment have been useful to replicate this approach in the NE region.

BOX – 3

Summary of the Completed Project (2001 - 2004)

Impact of multipurpose contour hedgerows intercropping on crop productivity and soil fertility in shifting agricultural (jhum) fields in the North East India. *(DST funded)*

The Contour-Hedgerow-Farming-System-Technology provides the twin aims of slope stabilization to achieve soil and water conservation and improve soil fertility through biological nitrogen fixation. The objectives of the study were to investigate selected N_2-fixing hedgerow species for their biomass accumulation, and assess impact of mulching on soil moisture, weed proliferation, soil nutrient status, N mineralization and nitrogenage activity. The findings are summarized below:

- The soil temperature was relatively higher in alleys in comparison to between hedgerow species. The soil moisture also varied significantly among different months ($p<0.05$), between control and hedgerow ($p<0.001$) and between alleys and control ($p<0.001$). The weed density reduced by 63% and 52% while weed biomass reduced by 65% and 42% in mulched agriculture plots in comparison to abandoned and agriculture without mulch fields, respectively.
- Decomposition of N_2-fixing species was much faster than the forest-litter. N content of decomposing mulch and litter differed significantly among species ($p<0.001$), indicating that green-mulch of N_2-fixing hedgerow species is important to enrich soil N and labile P pools.
- The soil ammonification and nitrification evaluated for different mulch, varied significantly among different treatments, days, treatment x days; (all $p<0.001$) in both *in situ* and *ex situ* conditions.
- Different hedgerow species vary significantly in number of root nodules ($p<0.05$), and nodule biomass ($p<0.01$).
- The nitrogenase efficiency of the root nodules varied with species and seasons ($p<0.01$; Fig. 7). The nitrogenase activity varied from 200.88-1001.37 µmol/g dry wt. nodule/hr for different species. *Flemingia macrophylla* showed maximum nitrogenase activity, followed by *Indigofera anil*, *Tephroshia candida* and *Desmodium rensonii*.

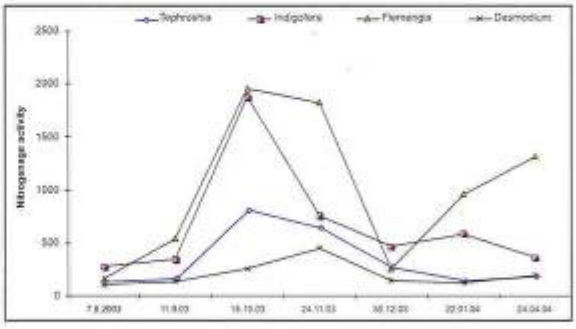


Fig. 7. Seasonal changes in nitrogenase activity (expressed in µ mol/g root nodule dry weight) in various hedgerow species under jhum cultivation in north-east India

SDRE 2 : People-Centered Landuse Development in the Shifting Agriculture Affected Areas in Arunachal Pradesh (*MacArthur- UNESCO funded; Period: 2001-2005*)

Rich biodiversity of Arunachal Pradesh suffered due to anthropogenic pressures Create opportunities for income generation

Background and Objectives

Arunachal Pradesh falls in the eastern Himalayan zone and recognized as a global biodiversity hotspot of the world. About one-thirds of the floral wealth and one-fifth of the faunal wealth of the country is expected to be found in A.P. The forests are rich in biodiversity and contain about 40% endemic flora. This rich biodiversity in the recent past has suffered due to settlements, over exploitation, fires, encroachments and dearth of support. Therefore, there is a need to preserve such an ecologically significant region of paramount importance. Major goal of the project is to look for the issues and linkages of biodiversity conservation in west Kameng district of A.P. by creating opportunities for income generation. The objectives were: (i) To understand dynamics of forest ecosystems and its resource linkages with communities; (ii) Quantify NTFPs harvests and their potential for future use through value-addition; and (iii) To study land use pattern change and role of shifting cultivation in socio-economics of local communities.

- Assessment of income generation per house-hold from NTFPs
- Marked increase in phytomass observed

Results and Achievements

1. In west Kameng district, over 70% population of the major tribal groups (viz. Akas, Mijis and Buguns) rely on shifting agriculture, in which mixed cropping dominates, though mono-cropping of maize, rice and millet are also practised. **The maize crop show highest efficiency with an input: output ratio of 1: 3, and 1:8 in monetary and energy terms, respectively.**
2. People collect large variety of NTFPs, such as *Swertia chirayta* and *Illicium griffithii*. These species provided an annual income of Rs. 2390-8032 per household and nearly 4456% families were involved in their collection.
3. Effect of exclosure and fire on plant phytomass production was studied for different elevations (2500-4100 masl). Plant phythomass increased by 35-117% through simple exclosure and by 1278% after fire treatment over grazed areas at different sites. In the fodder species crude protein content was ranged from 6.11% in *Aconogonum molle* to 14.9% in *Acer pectinata*.

SDRE 3 : An Assessment of Agricultural Production and Strategy for Sustainable Development of Bioresources

Background and Objectives

The ever increasing population of human and livestock in the Himalayan region has made it imperative to assess the production of bioresources

Assessment of bio resources in 40 villages (Hawalbagh block, Almora)

such as agricultural, fuel and fodder in the different geo-environmental conditions. Thus, forty villages in Hawalbagh development block of Almora district (Uttaranchal) were selected for a detailed study. The entire block was divided into three altitudinal zones, i.e., zone I (<1400 m), zone II (1400-1600 m) and zone III (>1600 m).

Result and Achievements

- Livestock size per household was large in the villages of zone III (>1600 m)

1. Primary data on livestock structure (type, distribution, usefulness, etc.) falling in the three zones was analyzed. Livestock size per household was found large in the III zone, as compared to the zones I and II. This is mainly due to more fodder availability in the higher areas. **High yielding livestock was found more in zones I and II, as compared to zone III.**
2. Base map on natural resource management and utilization were prepared for GIS application. Satellite data of 1988 and 2000 are being used for study of land use changes.

SDRE 4 : Promoting Cultivation of Medicinal and Aromatic Plants in the Nanda Devi Biosphere Reserve and Other Areas of Garhwal Himalaya

Background and Objectives

Promotion of MAP cultivation

Medicinal and aromatic plants (MAPs) found in the Himalayan region include species of high economic potential. Domestication and cultivation of the MAPs is one of the viable options to meet the growing demands from the industries and reduce the extraction pressures in their natural habitats. There is an immediate need to improve the existing practices and supplement these with more efficient, innovative, cost-effective and appropriate technologies to improve the yield of MAPs. The objectives proposed during the reporting year were: (i) Evaluation of seedlings production of three species of *Allium* (i.e., *A. stracheyi, A. rubellium* and *A. humile*) under open, shade and polyhouse conditions; and (ii) Work out cost-benefit analysis of 5 *Allium* species that were brought under cultivation.

Results and Achievements

- Shaded environment is more suitable for MP seed germination
- Economics of 5 species of *Allium* cultivation worked out

1. Among the different treatments (i.e. control, shade and polyhouse conditions) the **shade conditions were found more suitable to enhance the number of seedling of *A. humile* and *A. rubillium***, whereas *A. stracheyi* performed better under open conditions than the polyhouse conditions (Fig. 8).
2. Among the five species of *Allium* (*A. stracheyi, A. humile, A. rubellium, A. semenovii* and *A. wallichii*), the net monetary return was obtained maximum for *A. stracheyi* (Rs. 34,663/ha), followed by *A. seminovii*

(Rs. 20702/ha), and minimum for *A. rubellium* (Rs. 12,295/ha). ***A. stracheyi* showed highest monetary output/input ratio** (Table 7).

Table 7. Monetary return (Rs/ha/year) from different species of *Allium* under cultivation

Species	Expenditure (Rs/ha)	Income (Rs/ha)	Profit (Rs/ha	Income/ Expenditure ratio
Allium humile	2800	22450	19650	8.00
Allium stracheyi	2957	37620	34663	13.0
Allium rubellium	1725	14020	12295	8.00
Allium semenovii	2618	23320	20702	9.0
Allium wallichii	7900	20960	13060	11.0

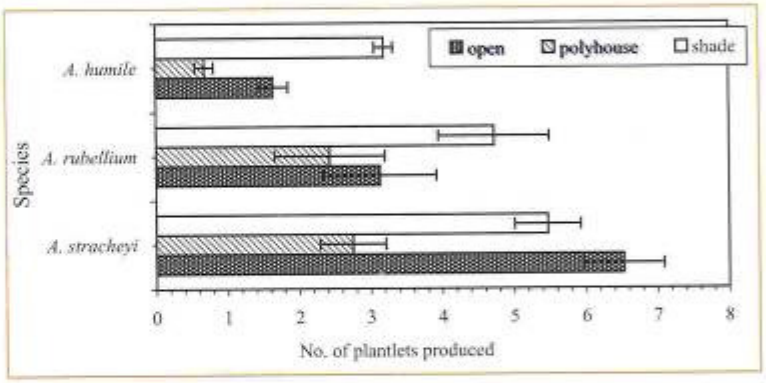


Fig. 8. Multiplication of three species of *Allium* under different microclimatic conditions in Garhwal Himalaya (U.A.)

SDRE 5 : Commercial Utilization for Sustainable Rural Development and Conservation of Some Potential Wild Edible Oil Plants of Garhwal Region of Uttaranchal *(CSIR funded; Period: 2001 – 2005)*.

Utilization and conservation of wild edible oil plants

Background and Objectives

Wild resource of potential economic significance is known to play a crucial role in maintaining the subsistent life styles of traditional mountain societies. The Garhwal region is a repository of such vital resources but still the potential of these resources has not been harnessed properly. There is a considerable scope for bio-prospecting in finding new areas of economic activity, which can minimize unemployment through small village-level cottage industries. Besides, the ignorance and unsustainable harvesting of wild resources has led to the depletion of the

natural population of many valuable species. The multiplication of these species including vegetative propagation and seed germination were covered during this reporting year.

Results and Achievements

- Plant growth regulators improved root formation and seed germination

1. Use of auxins for vegetative propagation revealed that **IAA (Indole Acetic Acid) promoted maximum rooting (67.08%) in *Prinsepia utilis*, while in case of *Neolitsea pallens*, NAA (Naphthalene Acetic Acid) was effective (37.27±%).**
2. **Maximum germination in *Prinsepia utilis* (82%) was observed using 200 ppm GA_3 under light (at 25°C)**, followed by control (76%) and hot water (69%) treatment. Similarly in case of ***N. pallens*** **also 200 ppm GA_3 under light (at 25°C) exhibited maximum germination** (Fig. 9).

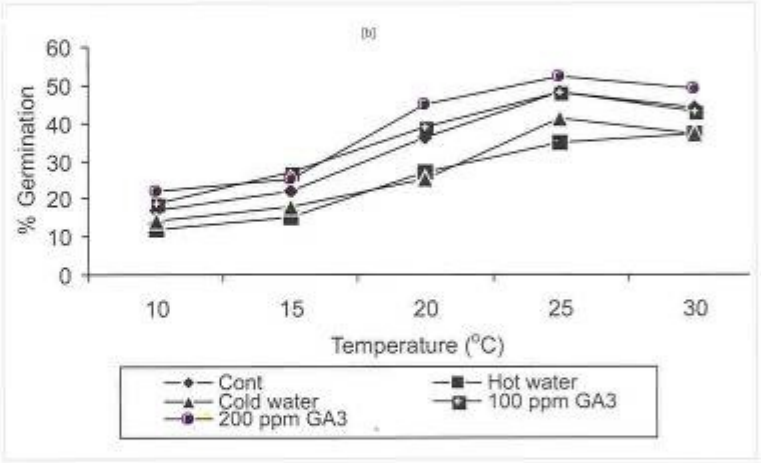


Fig. 9. Seed germination of *P. utilis* (a) and *N. pallens* (b) under light condition and various temperature regimes

SDRE 6 : Conservation and Sustainable Management of Belowground Biodiversity in and Around Nanda Devi Biosphere Reserve *(TSBF/GEF funded, Period: 2003–2005)*

Background and Objectives

Below ground diversity: Survey and identification of earthworms

Soil microorganisms play a prominent role in the sustainability of any terrestrial ecosystem. There is a large number of soil macro, meso and micro fauna which are indispensable and directly responsible for successful completion of soil nutrient cycling. The soil fauna not only maintain the nutrient dynamics but also decompose the waste and other

biomass and regulates nutrient flow in the ecosystem. Therefore, studies undertaken this year were emphasized on: survey, collection and identification of the earthworm diversity in cultural and protected landscape comprising a range of land use/ land cover types in NDBR.

Results and Achievements

- High earthworm counts observed in kitchen garden soils
- Nine earthworm species found in high and low altitude sites

1. Different species of earthworms were collected from different land uses. In kitchen garden soil earthworms were found across all the soil depths, with maximum population at low altitude (mean= 73.6 individuals/m^2), and 67.2 individuals/m^2 at high altitude soil at 0-10 cm depth. **However, increase in soil depths (>10 cm) exhibited low count of earthworms.**
2. Among the 9 different earthworm species collected from high altitude and low altitude sites at different soil depths, *Aporrectodea caliginosa* was represented by large number of individuals followed by *Laenogaster pusillus, Metaphire houlletie, Drawidu nepalensis, Amynthas cortices* and *Dendrodillus rubidus.*

SDRE 7 : Natural Resource Management- Seasonal Migration of Livestock in the Central Himalaya

Background and Objectives

Livestock movement - geospatial & social attributes

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 seasonal dwelling are integral part of the village life and provided opportunities for additional income generation. This study was carried out to investigate: (i) The seasonal livestock movement practices and temporary dwellings in the middle mountain region; and (ii) The geo-spatial, social, and livestock attributes of each temporary settlement in the forests.

Results and Achievements

- Livestock exerts increased pressure on forest resources at higher regions

1. Along an altitudinal gradient (2270–3000 masl) 15 temporary settlements (*Thor*) were surveyed. Among all the migratory livestock about three-fourth of the population (952) was residing above 2600 m altitude and 324 animals were below 2600 m amsl, indicating that **more pressure on forest resources at the higher altitudes.**
2. About 12% of the total animal population of the migratory families has been retained in their respective villages. Among the bovine livestock population adult animals (>3 years) constitute maximum portion, and **buffalos are most preferred animals** (Fig. 10).

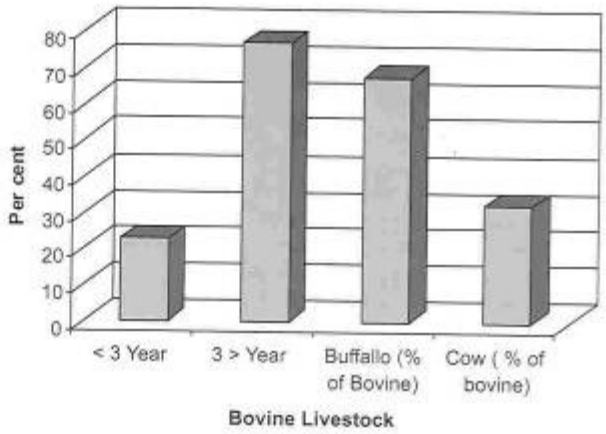


Fig. 10. Bovine population in the *Thors* of Dudhatoli region. (at the border of Almora, Chamoli and Pauri Distt. of U.A.)

SDRE 8 : Global Climate Change Studies in the Higher Altitude Himalayan Ecosystem *(Department of Space, GOI funded; Period: 2003-2006)*

Understanding structure and functioning of high altitude eco-system and its response to global climate change

Background and Objectives

As a consequence of 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, and to understand the relationship between the changing biosphere and the changing climate. Observations and monitoring from space of the changing landuse and landcover from space can be used effectively to collect/update information so as to suggest corrective steps for making landuse more sustainable. The objective of this study is to advance our understanding of the structure and functioning of the high altitude ecosystems of the Himalaya, their major sub-systems, and their response to physical, biological and anthropogenic forces.

Results and Achievements

- Diversity pattern of dominant forest trees in parts of UA analyzed
- Database on diversity and meteorological parameters being developed

1. **Population structures of different dominant forest trees were analyzed with reference to their geo-spatial arrangements of diversity patterns.** Dominance of various oak species differ along altitudinal gradient (Fig. 11), and a successional dominance appear between different species which may be due to control of climatic parameters (mainly temperature).
2. Meteorological data from different stations have been obtained to integrate in geo-spatial modelling (Fig. 12). A digital database has been developed with options of updating the same in the future.

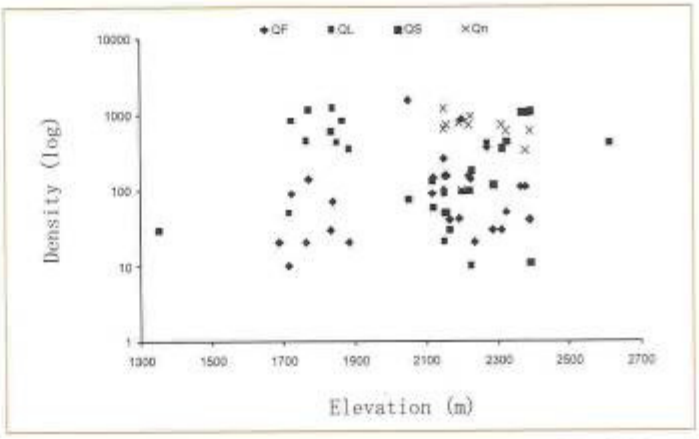


Fig. 11. Successional dominance of different oak species along altitudinal gradient in Kumaun Himalaya (QF- *Quercus floribunda*, QL- *Q leucotrichophora*, QS- *Q semecarpifolia*, QN- *Qlanuginosa*).

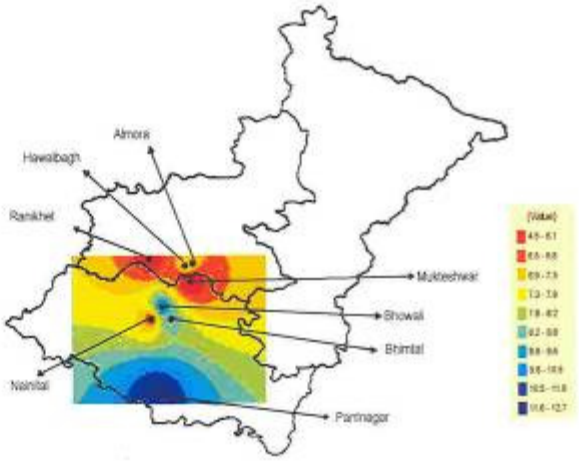


Fig. 12. Meteorological surface for a part of Kumaun (January 1984)

SDRE 9 : Model Demonstration on Raising High Value Crops and Other Potential Hill-Specific Technologies for Household and Small Scale Enterprise Development

Background and Objectives

Integration of MPs cultivation with horticultural plants

Huge environmental and socio-economic diversity in the Central Himalaya warrant designing appropriate cost-effective rural technologies suited to location-specific scenarios. However, all across the region, an integrated natural resource management approach would imply soil, water and

forest conservation such that conservation accompanies improvement in livelihood of the local people on short-and long-term basis. Therefore, the objectives proposed for the reporting year were: (i) To develop cost-effective infrastructure for expansion of nurseries of some valuable medicinal and aromatic plants; and (ii) To demonstrate a model integrating horticulture with medicinal plants.

Results and Achievements

- Field trials have been laid to evaluate economic potential

1. The area under nurseries of three species, namely *Picrorhiza kurrooa, Lavendula angustifolia* and *Saussurea costus* has been increased 28 times as compared to that of last year. A few more simple and cost-effective polyhouses (8 numbers) and four shade-net houses were established at the demonstration site.
2. **An integration of horticulture (apple, hazelnut, etc.) and medicinal plant (*P. kurrooa, S. costus*) was demonstrated on small scale** to evaluate the economic potential of these models.

SDRE 10: 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

Identification and domestication of seabuckthorn, a potential wild edible plant

The central Himalayan region is a store house of wild edible plants. *Hippophae rhamnoides (seabuckthorn)*, locally called 'Ames' is one of the few potential wild plants that have multiple uses / benefits. The plant is a deciduous, thorny and nitrogen-fixing shrub or small tree and grows widely on river-banks, on sun facing steep slopes in the high altitudinal zones ranging between 23008200 m masl in central Himalaya. The fruit berry of Seabuckthorn is rich in vitamins and other bioactive substances. Therefore, the mainobjective during the reporting year was to analyse the nutritional and mineral constituents of different populations of this plant.

Results and Achievements

- Analysis of nutritional and mineral constituents to identify elite genoptype

1. Among the proximate **nutrient composition of Ames, fat and protein was found maximum** (10.3%) and (7.1%), respectively for fruits collected from Dharali population and **minimum was estimated for the fruits from Jumma (8.3%) and Pulna (5.4%) populations.** Quantity of starch (85.1%) and acidity (0.68%) was highest for fruits from Hanumanchatti, and minimum for Dharali (294%) and Jumma (0.63%) populations (Fig. 13).
2. The chemical analysis exhibited maximum N (1.14%) and Mg (1.92 ppm) in the fruits collected from Dharali population, whereas fruits

collected from Pulna population showed least N (0.89%) and Mg (0.62 ppm). Iron was found to be maximum (1.13 ppm) in fruits collected from Yamunotri.

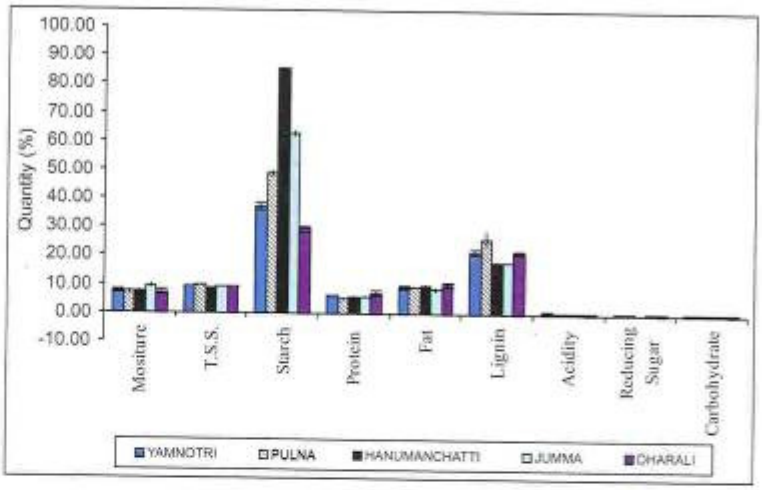


Fig. 13. Nutrient composition of *Hippophae rhamnoides* fruits collected from different populations in Garhwal region, UA.

SDRE 11: Integrated Management of Upper Kosi Watershed– A Preliminary Investigation

Understanding research and action needs for integrated management on watershed basis

Background and Objectives

Kosi is a major river of Kumaun Himalaya that flows through densely populated zone and has been the only source of water supply to a large populace as well as agricultural lands. Off late there has been a major concern for continuous water supply from river Kosi, particularly in upper catchment areas that is constrained by efficient and fair distribution of water resources. Therefore, sustainable management of water sources is needed urgently. Based on secondary data, few points of research and action have been proposed and the need for generation of primary data has also been emphasized.

Result and Achievements

- Analysis of secondary data sets related to natural, serial and developmental aspects

1. **Data on different natural, social and developmental aspects were collected and analyzed.** The Upper Kosi watershed consists of an area of 480.15 km^2 that can be divided into 10 sub-watersheds for planning purpose (Fig.14). Cultivated land in the watershed is under traditional practices and is mostly rainfed (91% of the 14880 ha total cultivated land).

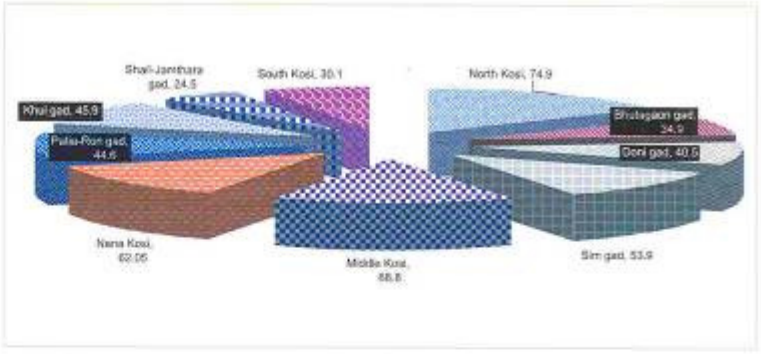


Fig. 14. Total geographical area of the various micro-watersheds in Upper Kosi catchment, Distt. Almora, UA.

2. The forest is poorly represented in the watershed as apparent from the forest cover, which is about 39%. The dominating forest type is chir pine (*Pinus roxburghii*). **Inhabitants are dependent on forest biomass for their daily fuelwood and fodder needs.**

3. Area for future action include: introduction of on - and off-farm activities for reducing natural resources dependence, large-scale treatment for soil and water conservation, capacity building and training of the inhabitants towards management, utilization and development of natural resources.

SDRE 12 : Fallow Management in Shifting Cultivation by Tangkhuls of Ukhrul district, Manipur *(Quick appraisal study)*

Study location specific variant practices of shifting cultivation

Background and Objectives

Shifting Cultivation as practiced by the Tangkhuls of Ukhrul district, Manipur differs from that of their counterparts elsewhere in Manipur and other parts of the Northeast, because of the longer cultivation phase (4 years and beyond). Such prolonged cultivation phase is what sets the practice apart from normal shifting cultivation. The longer cultivation phase implies that the soil fertility levels of shifting cultivation fields must be good enough to support cultivation for more than two years. The better fertility levels suggest that soil recuperation is more effective compared to other areas and hence, suggests that fallow management must be of a higher efficiency than in other parts of Northeast India, as the length of fallow cycles in Ukhrul are similar to fallow cycles elsewhere. This study was carried out with the following objectives: (i) To document the preference of farmers for the species that are consciously retained in the fields during various clearing operations; (ii) To document and assess the values attached to each species and quantify the proportion

of farmers assigning such values to respective species; and (iii) To attempt to categorise the different species in relation to pedological/topographic parameters, yield and fallow length.

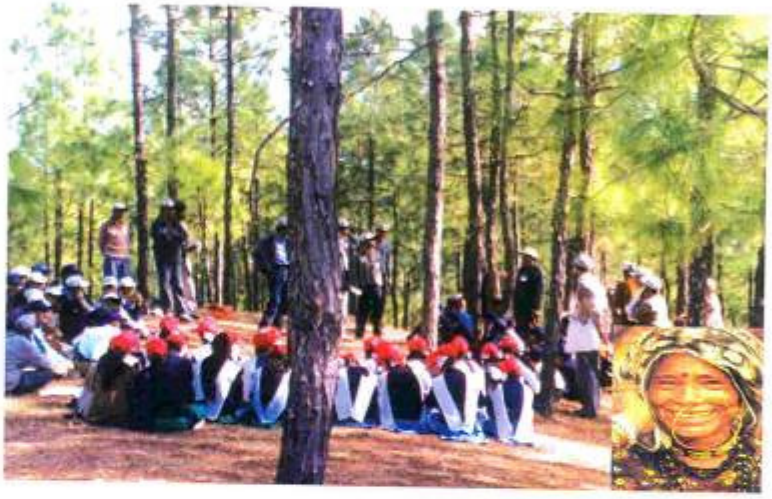
- Package of practices is documented through field surveys to understand specific reasons

Results and Achievements

1. Eight villages have been selected for conducting the study. A total of sixty three farmers, eleven jhum plots and three villages have been covered in the reporting period.
2. A total of 29 species were recorded from the above study sites, of which 5 species are lopped and the trunks of approximately 26 species are retained at a height of about 1.5 metres. The species then coppice from the retained stumps at the initiation of rains. A few species are also introduced for fallow improvement.
3. PRAs and interviews with the farmers (total of 63 farmers) reveal that **farmers are aware of the utility value of the species** and in fact consciously nurture and retain the species because of their perceived utility values.
4. ***Alnus nepalensis* is the most preferred species with all farmers preferring to retain this species in their plots for soil nutrient enrichment.** The species also has the highest utility value assigned by farmers, together with *Trema* sp. and another species, locally known as Ngaraithing.

Core Programe-III

CONSERVATION OF BIOLOGICAL DIVERSITY (CBD)



Realizing the importance of maintaining Himalayan Biodiversity not only for the present but also for posterity, Conservation of Biological Diversity (CBD) core is strengthening its activities through short (location specific) and long (broader spatial scale) term programmes. The activities are responsive to contemporary global thinking on the subject matter and especially follow the guidelines provided by AGENDA 21 in conjunction with the Convention on Biological Diversity. It aims at equitable harnessing of potential bio-resources and also in halting the increasing pressure on biological assets. The umbrella research programmes under progress 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; (iv) *Peoples' Participation in Biodiversity Conservation* to promote participatory mechanisms for Himalayan biodiversity conservation.

CBD 1 : Bioresource Inventory of the Himalaya

Background and Objectives

Inventorying the floral and faunal diversity across IHR

Adequate base line information on biological resources at different levels (i.e. species, population, community habitat and ecosystem, etc.) can help in identification of priorities for conservation and sustainable use. In this context, besides primary surveys, optimal use of secondary datasets available from different published and unpublished sources may help immensely. Realizing this, preparation of inventory of Himalayan bioresources (family and group wise) has been initiated to: (i) develop systematic database of species and their habitats; draw information about various attributes of specific habitats/species; (ii) prioritize species and sites for conservation.

Result and Achievements

(a) Floral Inventories

Family:

- Patterns of altitudinal distribution of species

1. **Database of plant families** Gentianaceae (168 spp.), Asteraceae (895), and Lamiaceae (237) was developed. Gentiana-74 species (Gentianaceae), Taraxacum - 85 (Asteraceae), Nepeta - 37 species (Lamiaceae) are species rich genera. The level of endemism in Gentiana, Swertia (Gentiancae), Aster, Crementhodium, Ligularia, Senesio, Synotis, Saussurea, Taraxacum (Asteraceae) and Salvia and Teucrium (Lamiaceae) was over represented as compared to rest of the flora.
2. **Analysis revealed diverse patterns of altitudinal distribution of endemics in families** (Fig. 15)

Group:

Medicinal Plants of HP

- Proritization of conservation needs especially for MPs of HP

1. **Extensive survey of information on medicinal plants (MPs) of Himachal Pradesh yielded an inventory of 626 species** (trees: 102; shrubs: 119; herbs: 405) belonging to 136 families and 379 genera. Asteraceae (58); Lamiaceae (33); Ranunculaceae (30) and Rosaceae (29 spp.) were species rich families. Maximum (65%) species of MPs were distributed in the altitudinal zone < 1800m.
2. Of the total, 41% MPs were Himalayan native; 27% endemic and 20.3% near endemic; and 68 species fall under different categories of threats.
3. **Based on the analysis, ex situ and in situ conservation priorities for MPs of the State were identified. Also, altitudinal zone wise prioritization of the species for cultivation was suggested.**

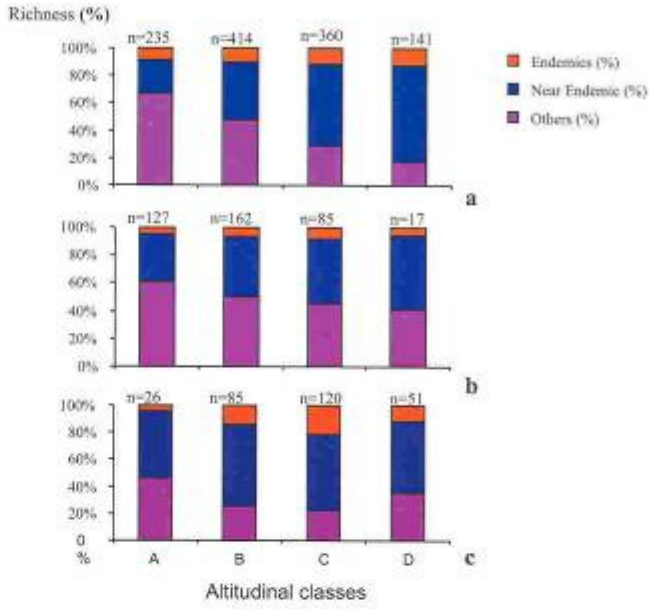


Fig. 15. Altitudinal distribution of endemism in Himalaya (a: Asteraceae, b: Lamiaceae, c: Gentianaceae; A: <1500, B: 1501-3000, C: 3001-4500, D:>4501m asl)

NTFPs of NE States

- Species wise marketing patterns of NTFPs in NE examined

1. Surveys in the states of Arunachal Pradesh (27 items) and Assam (9 items) revealed that a total of 30 species are marketed from these states (Table 8). Decadal revenue records (1993-2003) show that in Arunachal Pradesh, Resin and Cane are important sources of revenue. Apart from these, several medicinal, aromatic and dye yielding plants such as Taxus wallichiana, Swertia chirayta, Illicium griffithii, Rubia cordifolia along with Thatch and Bamboo are also important revenue generating NTFPs.

Area:

1. Information on the Angiosperms of the Trans, North West and West Himalaya was compiled and **inventory prepared for over 4,300 species.** Of these, 70 species are listed in the Red Data Book of Indian Plants. Further compilation and analysis of information continues.

- Reptilian diversity in Himalayan Biosphere Reserves documented
- Initial compilation on diversity, status and management of pollinators

(b) Faunal Inventories

1. **An inventory of 99 species of reptiles belonging to 14 families and 3 orders was prepared across the Himalayan Biosphere Reserves** (HBR). Of the total, 82 species fall under different categories of threat (critically endangered - 3; endangered - 6; vulnerable - 22;

low risk near threatened -24 low risk least concern -14 and data deficient - 13).

Table 8. Marketed NTFPs of Arunachal Pradesh and Assam

Name of the Item	Scientific/Local Name	Part use	State
Bamboo	Bambusa sp	Stem	Ar, As
Cane	Calamus sp.	Stem	Ar, As
Thatch	Imperata cylindrica	Whole Plant	Ar, As
Broom	Thysaenolina maxima	Whole Plant	Ar, As
Wild Cardamom	Ammomum subulatum	Fruit	Ar
Dalchini	Cinnamomum zeylanicum	Bark	Ar, As
Nageswar	Mesua ferrea	Flower	As
Toko	Livistona jenkinsiana	Leaf	Ar
Jeng	Zalacca secunda	Leaf	Ar
Patidoi	-	Bark	Ar, As
Piply	-	Fruit	Ar
Taxus	Taxus wallichiana	Leaf	Ar
Litchi	Illicium griffithii	Fruit	Ar
Loose hay	-	Whole Plant	Ar
Chareang	-	Leaf	Ar
Sungrass	-	Leaf	Ar
Chirota	Swertia chirayta	Stem	Ar
Urticaria leaves	Boehmaria sp.	Leaf	Ar
Fire leaves	-	Leaf	Ar
Ghat leaves	-	Leaf	Ar
K. leaves	-	Leaf	Ar
Decayed chirpine	Pinus roxburghii	Needle	Ar
Boch	Acorus calamus	Leaf	Ar
Acropus	-	Leaf	Ar
Laneru	Rubia cordifolia	Flower/stem	Ar
Chot leaves	-	Leaf	Ar
Chita leaves	-	Leaf	Ar
Satkara	Citrus sp.	Fruit	As
Kawla	Machilus sp.	Bark	As
Resin	Pinus sp./Canarium resiniferum	Resin	Ar

* Ar - Arunachal Pradesh, As - Assam

2. **Across altitudinal range, higher reptilian diversity in HBRs was recorded for 1000-1500 altitudes**; thereafter a sharp decline in species richness is apparent (Fig. 16).

3. Under PDF-B GEF project on "Conservation and management of pollinators for sustainable agriculture, through an ecosystem approach" a document on diversity, status and management of pollinators across IHR has been prepared.

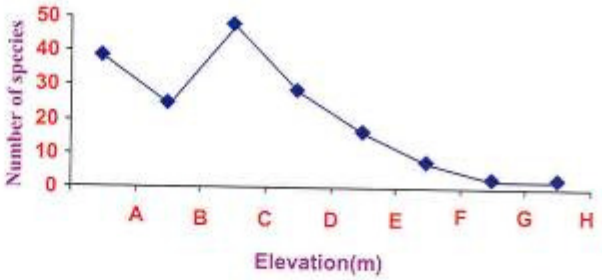


Fig. 16. Species diversity of Reptiles in different altitudes of Himalayan Biosphere Reserves (A= < 500; B=500-1000; C= 1000-1500; D=1500-2000; E=2000-2500; F=2500-3000; G=30008500; H=3500-4000)

CBD 2: Studies on Biodiversity

Background and Objectives

Analyzing diversity patterns in sensitive areas and establishing linkages with disturbances

In recent years, it is being stressed that the proper understanding of ecological consequences of habitat fragmentation is one among most challenging areas of research. In Indian Himalayan Region, habitat degradation due to ever-increasing human pressure is a recognized major cause for loss of biodiversity elements at all organizational levels. However, lack of authentic datasets, which reflect the patterns and intensity of such losses, is a major gap area. Therefore, scientifically planned strategies to address the issues are missing. In view of this, the study focuses on: (i) Investigating distribution of bioresources and their use patterns in biodiversity rich areas, including the Protected Areas (PAs); (ii) Studying dynamics of structural and functional features of biodiversity in response to disturbance; and (iii) Assessment of diversity of important (ecologically and economically) species across altitude and disturbance gradient.

Result and Achievements

(a) Biodiversity Rich Areas

Kanawar Wildlife Sanctuary- KWLS (H.P.)

- Distribution patterns of floral diversity in three biodiversity rich areas (wildlife sanctuaries) of Himachal

1. Study in 16 populations, covering 14 microhabitats, of Polygonatum cirrhifolium along 1450 to 2700 m altitude in KWLS revealed density range between 1.5 to 6.0 ind./m2.
2. Amongst most common microhabitats, 'below tree canopy' (87.5% sites), and 'above boulders' and 'forest gaps' (75% sites each) offered the high availability of the taxa.
3. **The plant height positively correlated with altitude ($p<0.01$). Very strong correlation was obtained between plant height and belowground biomass ($p<0.01$).**

1. Forty-six sites, representing 4 habitats, between 1640-2380 m asl were sampled for the assessment of forest vegetation. Twenty-three forest communities were identified. Attributes of major forest types are included (Table 9). Patterns of natural regeneration in *Abies pindrow* community are presented (Fig. 17).

Table 9. Features of major community types in Khokhan Wildlife Sanctuary, HP

Community types	Altitude	SR	Density (Ind. ha-1)	TBA (m2 ha-1)	Habi-tats	Slope (0)	Aspect
Rhododendron *arboreum-Quercus* glauca mixed	1640	1	540	182.24	2	40	E
Quercus glauca-Alnus nitida mixed	1660	1	420	94.01	1	35	W
Persea odoratissima-Aesculus indica mixed	1700	1	440	164.09	1	35	W
Pinus wallichiana	1740-2380	4	443	300.98	4	65	E, W, NW
Abies pindrow	1860-2380	4	488	554.20	1	25-40	NW
Abies pindrow-*Quercus floribunda* mixed	2240	1	370	144.3	1	15	W
Quercus semecarpifolia-Ilex dipyrena-Abies pindrow mixed	2320	1	82.56	430	1	45	NE
Cedrus deodara	2140-2400	9	676	364.14	1	20-60	NW, NE
Quercus leucotrichophora	1870-2100	5	414	222.03	1,3	25-45	SW
Quercus floribunda	2020	1	789.17	840	1	25	W
Aesculus indica	2280	1	320	221.96	1	15	N
Quercus semecarpifolia	2260	1	320	235.21	1	40	NW

Abbreviations: SR=Site representation; TBA=Total Basal Area; IVI=Importance Value Index; 1=Shady Moist; 2=Riverine; 3=Dry; 4=Exposed

Kais (KaWLS) and Manali (MWLS) Wildlife Sanctuary

- **Species wise resource utilization pattern by local inhabitants**

1. **An inventory of 320 species of the vascular plants** (*i.e.* Angiosperms, Gymnosperms and Pteridophytes) **was prepared** for KaWLs. Quantitative sampling (24 sites) in sanctuary revealed availability of 13 forest communities.

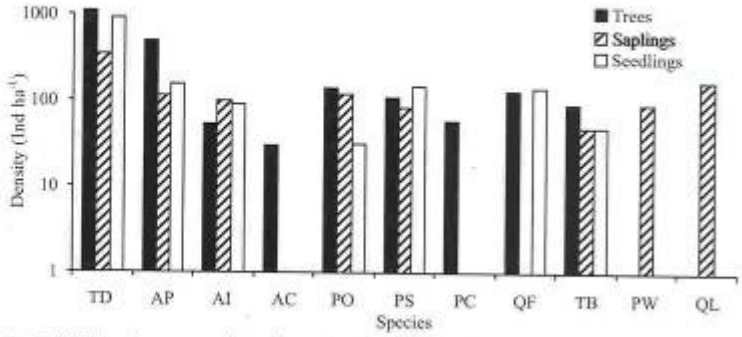


Fig. 17 Natural regeneration of species in Abies pindrow community of Khokhan Wildlife Sanctuary (H.P.) (AP=*Abies pindrow*; AI=*Aesculus indica*; AC=*Acer cappadocicum*; PO=*Persea odoratissima*; PS=*Picea smithiana*; PC=*Populus ciliata*; QF=*Quercus floribunda*; TB=*Taxus baccata* subsp. *wallichiana*; PW=*Pinus wallichiana*; and QL=*Quercus leucotrichophora*)

2. **Resource utilization pattern of the 5 villages indicated that over 130 plant species** (*i.e.*, grain crops, vegetables, fruits, medicinal plants, wild edibles, fuel, fodder, house building, agricultural tools, religious, fibers, etc.) **were used by the inhabitants**. Species wise quantification of the fuel resource of five villages indicated that inhabitants collect thirty-two species for fuel. **Resource Use Index (RUI) for different villages is depicted** (Fig. 18).

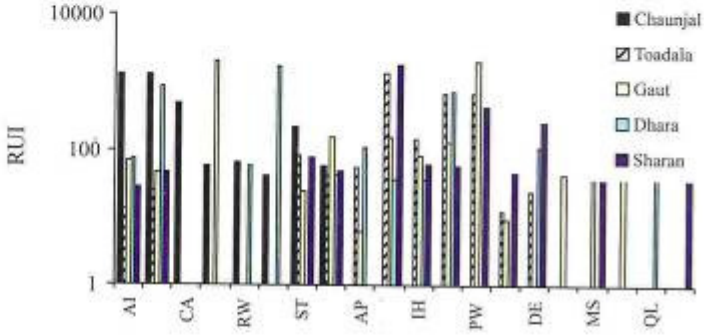


Fig. 18. Preferred fuel species of Kais Wildlife Sanctuary in Himachal Pradesh (RUI=Resource Use Index; AI= *Aesculus indica*; AN= *Alnus nitida*; CA= *Celtis australis*; PC=*Populus ciliata*; RW= *Rhus wallichii*; RJ=*Rhus javanica*; ST= *Sorbaria tomentosa*; UV=*Ulmus villosa*; AP=*Abies pindrow*; IH=*Indigofera heteranthe*; PS=*Picea smithiana*; PW=*Pinus wallichiana*; BL=*Berberis lyceum*; DE= *Desmodium elegans*; PC=*Prunus cornuta*; MS=*Morus serrata*; BC=*Buddleja crispa*; QL=*Quercus leucotrichophora*; and JR=*Juglans regia*)

3. The quantification of fuel resources in old Manali, Dhungri, and Nasogi villages of MWLS was conducted. In village old Manali (32 species), and Dhungri and Nasogi (31 species, each) of fuel were collected

- Studies initiated on distribution and use patterns of floral diversity in CDBR

Cold Desert Biosphere Reserve

1. Assessment of vegetation and resource utilization pattern in Cold Desert Biosphere Reserve (CDBR) was initiated. **Inventory of 150 species of Angiosperms and Gymnosperms representing trees, shrubs and herbs was prepared.**
2. Intensive survey for Juniperus polycarpos population in 45 sites (between 2760-3570m) was conducted. Out of 45 sites, 41 sites were represented by Juniperus polycarpos only, in remaining 4 sites, Picea smithiana, Pinus wallichiana, and Cedrus deodara were the major tree associates. The resource utilization pattern of the inhabitants of four villages i.e., Sitingri, Yurnath, Kishore and Kamring were investigated. Analysis is in progress.

(b) Biodiversity Studies Along Disturbance Gradient

Sensitive Habitat – Timberline Zone *(in-house, completed sub activity)*

BOX-4

Summary of the Completed Project

(1999- 2005)

Lead/ Coordinating Institution for Nanda Devi, Manas, Dibru-Saikhowa, Dehang-Debang and Kangchendzonga Biosphere Reserves *(MoEF funded: Phase-I)*

The Phase I of the project envisaged: (i) Collection, synthesis and dissemination of research based information in respect to Himalayan Biosphere Reserves from all sources; (ii) Interaction with regional Research Organizations for development of suitable research projects; (iii) Interaction with Biosphere Reserve managers to assess research needs and crucial issues requiring research efforts; (iv) Publication of compendium of up to date information and bringing bi-annual publications aimed at educating stakeholders. The major out-come of the project includes:

- Document on Guidelines for Protection, Maintenance, Research and Development in the BRs of India (Published for MoEF).
- Through interaction / Coordination with the various State and Central Government organizations and NGOs, made by correspondence, facilitated development of various project proposals to address specific issues pertaining to respective BRs.
- Formats developed for data collection and gaps identified in R & D in identified Biosphere Reserves.
- Publication and wide disseminated the Biannual Bulletin 'Himalayan Biosphere Reserves' Vol. 1-6.
- Document on Nanda Devi Biosphere Reserve (Nomination Form for UNESCO MAB net) has been incorporated in the world Biosphere Network of UNESCO-MAB.

- Database on: (i) floral, and (ii) faunal (reptilian, avian and mammalian) diversity of the Himalayan BRs (Flora/Fauna: Nandadevi- 602/518; Manas- 622/491; Dibru-Saikhowa-625/474; Dehang-Debang- 1831/426; Kangchendzonga- 1225/300 species).
- Bibliography on Himalayan Biosphere Reserves (Total561 references: flora- 82, fauna-125, biodiversity-19, ecology-92, management84, ethnobotany-65, conservation-20, miscellaneous-121; NDBR-160, MBR-28, DSBR36, DDBR-14, KBR-6, general- 317).

Dynamics of Structural and Functional Features of Biodiversity in Relation to Disturbance Gradient in Forests of Kumaun Himalaya (DST funded)

- Relationship between disturbance and demography of tree species investigated

1. Compositional features of Quercus semecarpifolia forest at different disturbance intensities were compared. **Total tree density declined from low to high disturbance intensities (Low disturbance - 563, High disturbance- 407 ind. ha-1) and decline was significant ($p<0.05$).** Total basal area was highest (69.75 m2 ha-1) in moderately disturbed site. Along increasing disturbance intensity, while seedling and herb density exhibit decline in density, shrub and sapling showed increasing patterns.

2. Demographic profiles across disturbance intensities for dominant tree species are depicted (Fig. 19). **Characteristically, the dominant taxa (*Q. semecarpifolia*) was absent in sapling layer in all levels of disturbance, on the contrary, seedlings were missing from the high disturbance site.**

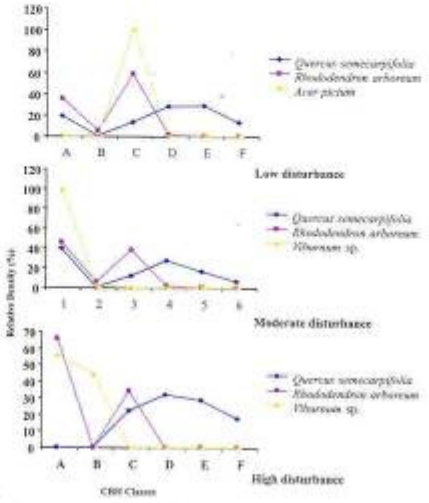


Fig. 19. Population structure of dominant tree species in Q. semecarpifolia forest across disturbance intensities in Kumaun Himalaya (U.A.) (A- *seedling*, B- *sapling*, C 31-90, D- 91-150, E- 151-210, F- >210 cm cbh).

BOX - 5

Summary of the Completed Activity
(2001-2005)

Studies on Responses of Functional Features of Communities to Habitat Alterations in Timberline Zone of West Himalaya
(in-house, sub activity)

The activity focused on assessment of responses, against increasing level of disturbance, of functional features in 3 identified forests. The study attempted to: (i) analyze patterns of litter fall, nutrient composition and nutrient return; (ii) assess patterns of mass loss and nutrient change during decomposition; (iii) identify relationship in nutrient release patterns. The major findings of study include:

- With change in disturbance intensity the timberline forests exhibited variation in litter fall (t ha-1year-1). The results clearly establish that with increasing intensity of disturbance the total annual litter fall declined in broad leaf B. utilis and Acer mixed forests. However, A. pindrow, a needle leaf forest, did not experience such impacts of disturbance on total annual litter fall.

Forest types		Litter components				Total
		Leaf	Wood	Misce-llaneous	Reprod-uctive Parts	
B. utilis	PA	1.28 (36.23)	1.35 (37.92)	0.42 (11.79)	0.50 (14.04)	3.56
	SD	0.72 (26.66)	1.11 (41.11)	0.43 (15.92)	0.44 (16.29)	2.70
	DG	0.74 (30.32)	0.95 (38.93)	0.44 (18.03)	0.31 (12.70)	2.44
A. pindrow	PA	0.60 (23.43)	0.83 (32.42)	0.45 (17.57)	0.68 (26.56)	2.56
	SD	0.57 (22.00)	0.98 (37.83)	0.41 (15.83)	0.63 (24.32)	2.59
	DG	0.43 (16.66)	0.91 (35.27)	0.37 (14.34)	0.87) (33.72	2.58
Acer mixed	PA	1.05 (36.71)	0.94 (32.86)	0.53 (18.53)	0.34 (11.88)	2.86
	SD	0.67 (27.01)	1.04 (41.93)	0.52 (20.97)	0.25 (10.08)	2.48
	DG	0.62 (29.80)	0.75 (36.05)	0.46 (22.15)	0.25 (12.01)	2.08

PA- *pristine*, SD- *semi-degraded*, DG- *Degraded* (Values in parenthesis are percentage of total)

- Nutrient concentration (N, P & K) in litter components of studied forests varied significantly across disturbance intensities. N concentration in litter of B. utilis forest was invariably higher in pristine stands, whereas N concentration in leaf litter increased with intensity of disturbance in A. pindrow and Acer mixed broad leaf forests. In leaf litter, P concentration decreased with increasing disturbance intensity in B. utilis and Acer mixed forests. However, concentration increased with increasing disturbance intensity in A. pindrow forest.
- The nutrient return patterns were highly sensitive to disturbance intensities. The return of N through total tree litter fall decreased continuously (0.05 t ha-1yr-1- pristine to 0.023 t ha-1yr-1- degraded under B. utilis forest. P and K followed the similar trends.
- The rate of leaf litter decomposition decreases marginally for B. utilis and Acer mixed broad leaf forests, and significantly ($p<0.05$) in case of A. pindrow forest. However, miscellaneous litter did not show such clear trends.

CBD 3: Establishment of Gene Banks Across the Himalaya

Strengthening of gene bank for plant species found across the IHR

Background and Objectives

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 (Kosi-Katarmal, Kumaun and Pangthang -Sikkim), herbal gardens (Kosi-Katarmal-Kumaun, Pangthang-Sikkim, and Mohal-Kullu) and demonstration sites (Lata, Chamoli) are being developed. The activity focuses on: (i) Establishment of gene bank (s) of Himalayan species including economically important ones; (ii) Development of propagation protocols for locally acceptable plants; (iii) Large scale multiplication of important species and making the saplings available to local people.

Results and Achievements

(a) Enriching Gene Banks

- Enrichment of gene banks and upgradation of one site as eco-observation site
- Large scale multiplication of identified MPTs for plantation

Arboretum at Kosi-Katarmal -UA and Pangthang -Sikkim

1. The arboretum at Pangthang was enriched with the germplasm of the species of *Bridelia retusa* (Rhenock, 800 m), *Magnolia globosa* (Gangtok, 1500 m), *Semecarpus anacardium* (Jorthang, 700 m), *Tetrameles nudiflora* (Geilkhola, 600 m), *Taxus baccata* (Rimbik, 1900 m), *Rhododendron anthopogon* (Pangolakha, 2400 m). Survival of the propagules was found to be 50%.
2. **Fifteen new species of angiosperms and pteridophytes were added to the arboretum** at the Kosi-Katarmal. The arboretum site was further developed as an eco-observation site.

3. The arboretum nursery at Kosi-Katarmal remained a major source of seedlings for plantation in various eco-restoration sites of the Institute. Over 4000 seedlings were made available for internal use in the Institute and over 2500 seedlings of multipurpose trees (MPTs) were distributed among the schools and other stakeholders in the region. Likewise the nursery for MPTs is being maintained at Pangthang-Sikkim (Table 10).

Table 10. MPTs raised in the Pangthang Arboretum nursery

Name of MPTs	Seedlings raised (nos.)	Surviving stock(nos.)	Remarks
Acer pectinatum	1200	1134	Timber, Fuel
Alnus nepalensis	500	500	Fuel, Timber, N2-fixing
Castanopsis tribuloides	250	235	Timber, Fuel, Fruits
Celtis tetrandra	500	225	Fodder (twice a year), Fuel
Edgeworthia gardeneri	400	400	Fuel, paper-making
Ficus roxburghiana	800	713	Fodder, Fuel, Plates
Machilus edulis	800	754	Timber, Fuel, Fruits
Michelia excelsa	1700	1623	Timber, Ornamental
Pyrus pashia	300	276	Fuel, Fruits
Saurauia napaulensis	1300	1284	Fodder, Fuel
Spondias axillaris	300	270	Timber, Fuel, Fruits
Symingtonia populnea	250	230	Timber, Fuel, Fodder
Bielschmeidia roxburghiana	250	230	Timber, Fuel
Total	8550	7874	

Herbal Gardens and Medicinal Plant Nurseries (DASD, Ministry of Agriculture funded 13; NMPB funded -4)

- Herbal gardens and Nurseries were strengthened at different locations of IHR
- Awareness among stakeholders for promoting cultivation of MPs

1. **Medicinal Plant Nursery (0.5 ha) at Mohal-Kullu (Fig. 20) and Kosi-Katarmal (1 ha) were developed.** Eleven species namely *Acorus calamus, Hedychium spicatum, Thymus linearis, Viola canescens, Bergenia ligulata, Podophyllum hexandrum, Phytolacca acinosa, Dioscorea deltoidea, Adhatoda vesica, Roylea cinerea, Boerhaavia diffusa*, were introduced in Mohal nursery. At Kosi-Katarmal nursery large scale sowing of *Terminalia chebula, Embelica officinalis, Solanum indicum, Berberis asiatica, Heracleum candicans* and *Bergenia ligulata* was performed.

2. Over 25 MAPs were introduced in the Doharanala herbal garden (1 ha), HP. The notable species include: *Angelica glauca, Dioscorea deltoidea, Phytolacca acinosa, Taxus baccata subsp. wallichiana, Thymus linearis, Ajuga parviflora, Salvia lanata, Adhatoda vasica, Skimmia laureola, Valeriana jatamansi, Acorus calamus, Hedychium spicatum, Bergenia ligulata*, etc. **Over 70 species of medicinal and**

Fig. 20. Development of medicinal plant nursery at Mohal, Kullu (H.P.)

aromatic plants were maintained in the herbal garden (2 ha) at HQs and 12 species (*Ainslea cordifolia, Bergenia ciliata, Clematis buchananiana, Costus speciosus, Fraxinus floribunda, Panax pseudo-ginseng, Phytolacca acinosa, Rhus semialata, Schizandra grandiflora, Spirea himalayensis, Swertia chirata*, and *Tupistra nutans*) at Pangthang-Sikkim (0.5 ha).

3. Herbal garden in farmer's land was established (1 ha) at Lata (Chamoli-Garhwal) for representation of high altitude medicinal plants. Germplasm of following important Himalayan medicinal plants are being maintained - *Picrorhiza kurrooa, Aconitum balfourii, Saussurea obvallata, S. costus, Swertia sp, Artimesia sp, Arnebia benthamii, Berginia stracheyi, Dactylorrhiza hatagirea.*

(b) Propagation Protocols and Cultivation Packages

- Standardization of propagation protocols/ cultivation practices of MPs at different locations

Medicinal Plants (HQs)

1. Experiments to improve the **percentage germination of *Picrorhiza kurrooa* and *Aconitum balfourii*** conducted at Kosi-Katarmal Almora, revealed: (i) **GA_3 (200µM) improved germination in both the cases;** and (ii) responses in agro-peat were the best (Fig. 21).
2. Different provenances of *Heracleum candicans* and *Selinum tenuifolium* were tried using various pre-sowing treatments. **Best seed germination response was found less than 14 days chilling for both the species *H. candicans* (89%) and *S. tenuifolium* (87%).**
3. One thousand seedlings each of *H. candicans* and *S. tenuifolium* (Fig. 22) were transplanted at different sites- Katarmal and Dwarsoon (Kumaun) and Lata (Garhwal).

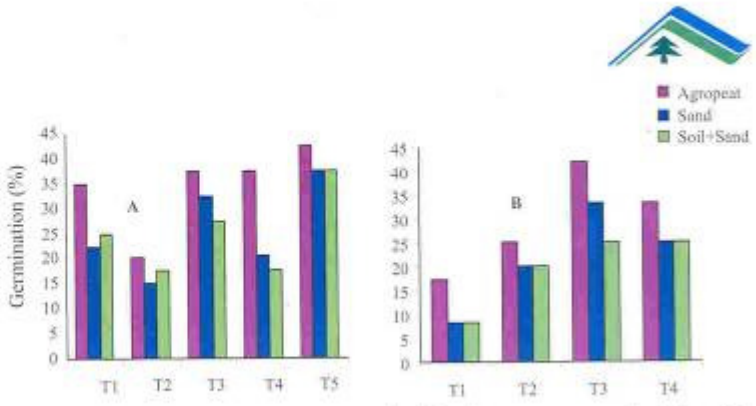


Fig. 21. Effect of different treatments and soil substratum on germination of **A-** *Picrorhiza kurrooa* (T1 - Control; T2- water soaking 18h; T3 - water soaking 24h; T4- GA_3 100µM; T5- GA_3 200 µM), **B-** *Aconitum balfourii*. (T1- Control, T2- water soaking, T3- GA_3 200µM , T4-GA_3 400µM)

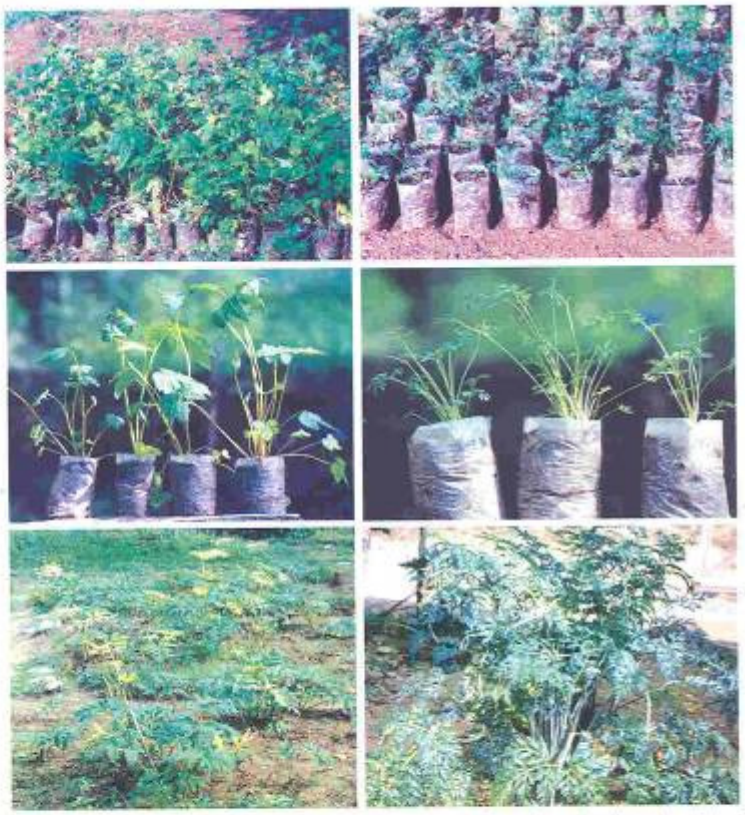


Fig. 22. Stages of seed germination and seedling transplantation of selected medicinal plants (A- *H. candicans*; B- *S. tenuifolium*) at Kosi-Katarmal (1240 m asl), Almora (UA)

Medicinal Plants (HP Unit)

1. Of the 9 substrates used for improving **seed germination in *Hedychium spicatum* Sand:FYM:FH and Sls:FYM:FH combination significantly (p< 0.05) improved germination and reduced MGT** (Fig. 23). One-year growth for *H. spicatum* seedlings revealed the following: (i) average root length varied between 45.5 mm (soil) and 173.8 mm (Sls:FYM:S dust); (ii) aboveground and belowground fresh weight correlated strongly (0.944; p<0.01).

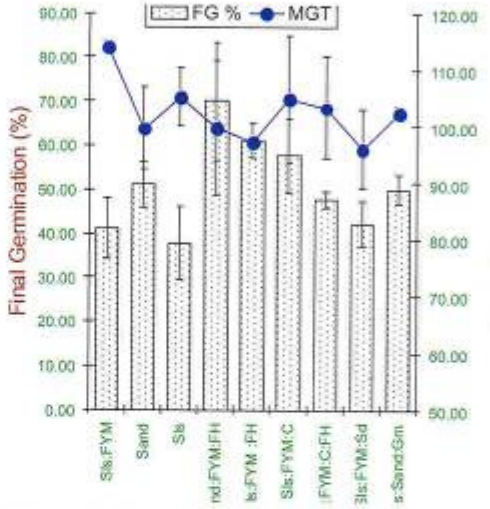


Fig. 23. Effect of different substrates on germination of *H. spicatum*

2. **Seeds of *Angelica glauca* from 12 sources showed significant differences in germination (12-76%; P<0.05).** One season seedling growth of *A. glauca* revealed: (i) plant height strongly correlates with root diameter (r=0.869; p<0.001), root length (r=0.717; p<0.001) and belowground dry weight (r=0.717; p<0.001).

3. Seedlings of *A. glauca* developed under poly-tunnel, using Soil+FH+Compost, were strong for their collar diameter (6.248±0.720 mm) over plants grown in open (4.467±0.7 mm) and net shade (4.213 ±0.292 mm). Below ground biomass followed the similar patterns; growing conditions influenced plant growth.

High value trees

Propagation and Improvement of Apple Root Stock *(DBT funded)*

- Development of propagation protocol for apple

1. Survival and growth performance of three elite varieties of apple (Chaubattia Green Sweet, Chaubattia Red Delicious, Chaubattia Princes) was monitored at different localities.

2. **Tissue culture experiments conducted on Chaubattia princes have resulted in shoot elongation and multiplication** (Average shoot no=27 shoots/explant and average shoot length=8.0 cm/ explant) (Fig. 24).

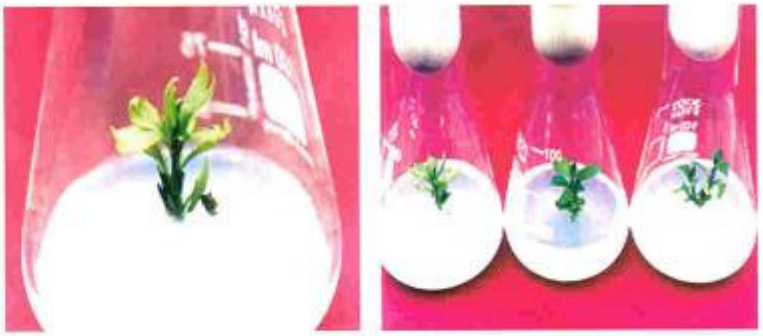


Fig. 24. Effect of different growth regulators on shoot multiplication and elongation

• Work on seed germination of *Hippophae rhamnoides*

Seed Germination of Hippophae rhamnoides

1. **Seed germination experiments of *Hippophae rhamnoides* (family Elaeagnaceae), revealed variation in viability (86.11- 91.66%) in seed sets from different sources.**
2. Pre-chilling (30d) improved the percent germination as compared to control set (25.33 - 27.34%) in all seed sources. The treatment also reduced significantly the mean germination time (MGT) (Table 11).

Table 11. Effect of pre-sowing treatments on percentage germination of *Hippophae* seeds from different provenances

Provenance	Percentage germination					Population mean (%)
	T1	T2	T3	T4	T5	
Helang	25.3	83.3	64.6	40.6	53.3	53.4
Badrinath	25.3	80.0	64.6	33.3	49.3	49.5
Lata	27.3	63.34	66.0	38.66	54.0	51.4
Treatment mean	26.0	75.7	65.1	37.7	52.22	

Core Programe-IV

ECOLOGICAL ECONOMICS AND ENVIRONMENTAL IMPACT ANALYSIS (EE & EIA)

Developmental activities in the Indian Himalayan region involve conflict between man and nature. The development, so far, has mainly focused on economic growth with gross disregard to fragile ecosystem and socio cultural matrix of the Himalayan communities. This leads to depletion and marginalization of natural and human/ cultural resources through rapid loss of forest cover, indigenous plant and animal species, and gene pool and also depletion in the quality and quantity of soil and water resources. Social losses include, degradation of community culture, deterioration in traditional knowledge and practices on sustainable use of resources. Environmental costs in the Himalaya, therefore, need to be integrated with traditionally practiced cost benefit analysis. Identification of strategies for ameliorating environmental damage and looking at alternate pathways for development are important aspects of environmental cost benefit analysis. Keeping this in view, all developmental activities in the Himalaya need to be evaluated and monitored in terms of comprehensive Ecological Economics framework and scientific system of natural resource accounting, making Ecological Economics a basic tool for decision making at various levels, i.e., local, regional and national. With this background, the R&D activities were focused on two themes: 'Ecosystem Services and Ecological Economics' and 'Environmental Impact Analysis of Development Initiatives'.

EE & EIA 1 : Ecosystem Services and Ecological Economics of Forestry Sector

Quantification of eco-system services offered by dominant forests types of central Himalaya

Background and Objectives

Forests are the most precious resource and form the lifeline of the Himalaya. In addition, the forests are source of fuel, fodder, and sustainable means of livelihood for the rural populace of the Himalaya. The hill agriculture depends heavily on forests for its energy subsidies. The environmental services of the forests are enormous and they have an important role in the regulation of the regional climate. The hill people have lived symbiotically with the forests and their cultural roots are entwined with them. Off late, the alterations in forest regimes through promotion of monocultures, new silvicultural practices, creation of protected area networks, and government policies with regard to tapping of NTFP have begun impinging on the symbiotic relationship between man and the forests. The implications involved are- loss of biodiversity, environmental services and values, indigenous knowledge associated with the forests, and poor regeneration. The analysis of these issues in Ecological Economics framework is important in the wider context of environmental conservation and human development. The present study deals with the ecological economics and environmental services offered by Oak (*Quercus* spp.) and Pine (*Pinus roxburghii*), the two major forest types in the middle montane belt of the central Himalayan region.

Results and Achievements

- In case of Pine forests direct benefits from resin sale are more than timber sale
- Pine forest provides more revenue benefits as compared to Oak

1. Data collected from Forest Department, Pithoragarh Division (UA) revealed that the revenue **earned from Pine forests from the sale of resin is several times greater than through sale of timber** (Table 12).

Table 12. Annual values for different products obtained and revenue earned from Pine forests in Pithoragarh forest division (Source: Forest Office, Pithoragarh).

Year	Timber production (m^3)	Revenue earned (Rs.)	Resin production from Pine forest (Q)	Revenue earned (Rs.)
1999-2000	739.309	517516.3	2433	49300000.00
2000-2001	679.902	448941.00	2513	4352000.00
2001-2002	4503.884	6314101.00	4474	8700000.00
2002-2003	3530.510	2541779.00	5449	10000000.00
2003-2004	2240.950	1179674.00	4835	12087500.00
2004-2005	-	-	6633	13500000.00

- Data not available

2. The production of timber from the forests of Kumaun (between 1977-78 and 1981-82) was recorded maximum for Pine (622.82 x 10^3 m^3) as compared to Oak forests (5.82 x 10^3 m^3). The revenue generated from the sale of Pine resin between 1978-79 and 1981-82 was about Rs. 211 million. The revenue earned from the sale of ringal bamboo (a product of Oak forests) was only Rs. 1 million during the same period. This indicates the high commercial value of Pine forests in Kumaun.

EE & EIA 2 : Tourism: Impacts on Ecosystem and its Ecological Economics

Understanding ecosystem impacts associated with tourism development

Background and Objectives

Tourism is the most potent but untapped sector of the IHR. The Himalaya exhibits three types of tourism viz., religious tourism, adventure tourism, and leisure tourism. The development of tourism has been spontaneous, the government interventions started very late. For most tourist destinations, lack of proper infrastructure is the major block in its further growth. Management problems associated with carrying capacity are another subject of concern. Solid wastes, pollution, cultural disruptions, provision of basic facilities, sharing of benefits and costs, encroachment in commons, are the implications of poor planning and management. Therefore, stock taking for this sector seems to be an immediate need within the framework of Ecological Economics. This would help in correcting the managerial shortcomings and devising eco-friendly tourism. During the reporting year, in continuation to earlier efforts on tourism in Kullu-Manali tourist complex on solid waste management, tourist influx and infrastructure, investigations continued on air quality monitoring in the Kullu valley. In Uttaranchal, studies in selected tourist destinations were aimed at: (i) Nature and process of tourism; (ii) Impacts of tourism and its ecological economics; and (iii) Analysis of modalities for sustenance and better management of tourism.

Results and Achievements

(a) ***Ambient Air Quality in Kullu Valley*** *(With partial support from DST)*

- **Recorded data suggests correlation between tourism and air quality parameters**

1. The concentration of PM_{10} (particulate matter below 10 µ) at Mohal ranged from 9.5 - 97.2 µg m^{-3} and at Kothi from 2.4-85.0 µg m^{-3}. Sample wise total suspended particles (TSP) concentration at Mohal varied from 11.8 - 247.5 µg m^{-3} and at Kothi from 6.8-166.1 µg m^{-3}.

2. **The average total dissolved solids (TDS) of rainwater at Mohal and Kothi were 20.4 and 16.9 mg l^{-1}, respectively.** The highest TDS value at Mohal was 46.8 mg l^{-1} in April and at Kothi 51.1 mg l^{-1} in May. In April the lowest TDS values were recorded at Mohal and Kothi, i.e., 4.8 and 3.5 mg l^{-1}, respectively.

3. **SO_2 concentration in air at Mohal varied from 0.07-16.5 µg m^{-3} and at Kothi from 0.08-24.2 µg m^{-3}.** NO_2 concentration at Mohal varied from 0.6-21.3 µg m^{-3} and at Kothi from 0.03-11.4 µg m^{-3} (Fig. 25). **Concentration of surface ozone (O_3) was found ranging from 1.8-26.3 ppb.** The highest surface O_3 was recorded 984 ppb (Fig. 26).

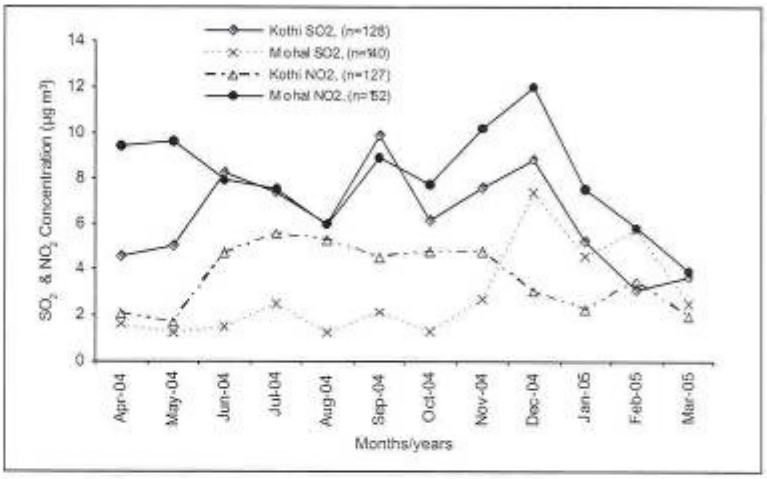


Fig. 25. SO_2 and NO_2 concentrations at Mohal and Kothi, Kullu (H.P.)

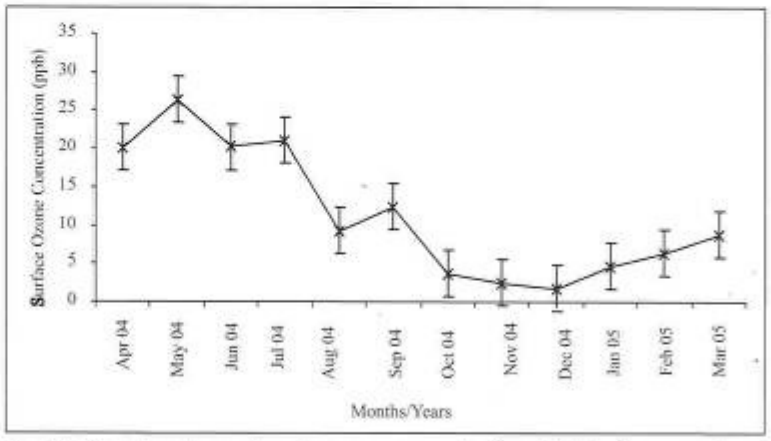


Fig. 26. Monthly values of surface ozone concentration at Mohal (n = number of samples, 3 on May 2004 & 31 for most months), Kullu (H.P.)

(b) *Ecological Economics of Tourism in Central Himalaya*

- Religious tourism appears to be dominant in Uttaranchal

1. Secondary information on tourist influx and infrastructure was collected and updated for tourist destinations of Uttaranchal. The perceived negative impacts of tourism are over-crowded settlements, pollution of water bodies, problem of waste disposal and solid wastes,

upcoming slums, traffic problems, deforestation, encroachment on commons, increase of general cost of living, drying of springs, etc.

2. Tourist influx trends for some tourist destination reveals that **the tourist influx to religious tourism destinations is far better compared to other tourism sites/ destinations** (Fig. 27).

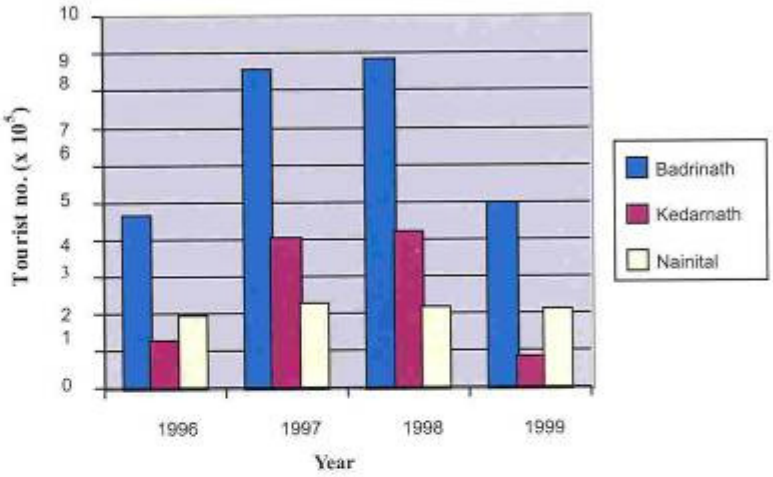


Fig. 27. Tourist influx pattern in three townships of Central Himalaya (U.A.)

EE & EIA 3 : Environmental Impact Analysis of Hydropower Projects

Understanding environmental impacts of hydropower projects through case studies

Background and Objectives

All the major rivers of the Indian subcontinent originate from Himalaya. Thus Himalaya offers 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, has enough potential to revolutionize the economy of the Himalayan states. But the Himalaya is very fragile and also a good repository of bio-diversity. While the development of mini and micro hydel projects is always eco-friendly, the large or small river valley projects have certain implications, such as, loss of agricultural land and bio-diversity, displacement of people, structure failure and risk of flash floods etc. Besides the choice between large and small dams that shrouds in controversy, the rehabilitation and inter-boundary disputes are the other debatable issues. The major objectives of this study were to undertake case studies on EIA/EMPs of selected projects and impact assessment of already upcoming projects, and suggest suitable remedial measures.

Results and Achievements

(a) *Impact Assessment of Hydropower projects in Beas Valley*

- Affected people perceive both the positive and negative environmental impacts

1. Of the 99 families surveyed in a hydroelectric project area in H.P. (Table 13), 21% families perceive that they will be benefited from the project. About 14% families rated road construction as a major positive impact. About 80% people opined that the overall environmental status would be deteriorated in their surroundings. The negative impacts listed were noise pollution, wildlife disturbance, and damage to land due to blasting, tree felling, litter problem, and water crises.

Table 13. Characteristic features of the villages under study in Allian Duhangan hydropower project in the Upper Beas Valley, HP

Details	Prini	Chalet	Hamatah	Sethan
Total existing families	111	5	3	25
Number of surveyed families	76	4	3	16
Village altitude (m)	1910	2510	2580	2720
Total population in surveyed families	444	17	18	83
(i) Above 12 years	346	17	17	76
(ii) Below 12 years	98	0	1	7
Literacy (%)	73.9	64.7	83.3	77.1
Available land in different forms of land use (in bigha)*	7812	340	760	702
Agricultural land	3076	-	-	680
Fodder trees	68	-	-	-
Grassland	321			
Barren land	8	-	-	-
Orchard	4146	335	751	
Residence	193	5	9	22
Total persons (who are already in service):	26			4
Private12			2	
Government	14			2

2. A total of six sites covering 60 quadrates (10x10m size) were sampled for the quantitative analysis of vegetation between the proposed reservoir and the powerhouse. The mean density, mean total basal area (TBA) and mean importance value index (IVI) of the sites have been presented in Table 14. Two forest communities, i.e., *Quercus*

semecarpifolia (at five sites) and *Quercus semecarpifolia- Acer acuminatum* mixed (at one site) were identified.

3. Silt load data (1990-2004) for River Beas showed an average yearly value of silt deposition 0.371 g/l. The maximum silt deposition was 0.647 g/l in 1995 and minimum 0.022 g/l in 2004 (Fig. 28).

Table 14. Mean values of density, TBA and IVI in and around the Allian Duhangan Hydropower Project in the Upper Beas Valley, H.P.

Sampling sites	Density (Ind. ha^{-1})	TBA (m^2 ha^{-1})	IVI
Site-1	148.03	338.51	75
Site-2	66.06	528.01	50
Site- 3	13.47	956.30	60
Site-4	14.38	1036.20	75
Site- 5	28.89	991.57	75
Site-6	10.11	1311.40	100

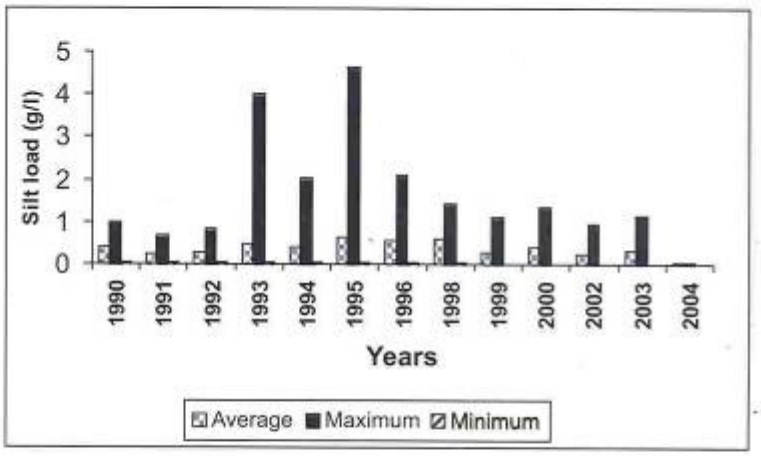


Fig. 28. Silt load (1990-2004) data of River Beas observed at dam site of Larji Hydroelectric Project, H.P. (*Source: Larji Hydroelectric Project, 2005*)

BOX-6

Summary of Completed Project

(2004–2005)

Rapid EIA and Formulation of EMP for Lakhwar Vyasi HE Project in Yamuna river *(NHPC funded)*

LakhwarVyasi is a multipurpose project proposed to be constructed on river Yamuna in Garhwal Himalayan region. The Lakhwar dam is proposed to be a 200 m high concrete gravity structure to generate 300 MW and the Vyasi dam is planned to have a 80 m high about 5 km downstream of Lakhwar dam and will generate 120 MW power. In addition to this, a water balancing reservoir is proposed in the downstream of Vyasi dam to provide drinking water to the capital city of India and irrigation water to state of U.P. to about 25000 ha agricultural land. An estimated 162 million cubic drinking water will be regulated through these dams. The LakhwarVyasi dam will generate about 1000 million units of electricity on annual basis. In order to execute the project the mandatory clearances from MoEF were sought and were accorded by the MoEF in the year 1987 However, in November 2004, Uttaranchal signed an agreement in the form of a MOU with National Hydro-power Corporation (NHPC) for execution of the project. As per the MOU, revised DPR of the project is to be prepared at the first instance for obtaining the approval of Govt. of India to take up the remaining project works for execution. In view of the above, the earlier Environmental clearance granted by MoEF for execution of the project is now required to be transferred in the name of NHPC. It is apt to state that due to time lag between 1992 and 2004 many of the considerations and concerns pertaining to implementation of suggested stipulations have changed, and therefore, a new environmental management plan based on present day requirement is required to be formulated.

- After generating baseline data related to land, water, air, biological, social environment, rapid EIA was completed.
- An erosion intensity map (Fig. 29) for the catchment of the proposed project was prepared.
- Based on the baseline data, prediction of likely impacts on the land, water, air, biological and social environment due to construction of the project was attempted. Prediction of impacts included prediction with the development of different environmental management plans (EMPs), and also without any EMPs adopting graded matrix approach, which suggested that the project is marginally viable without EMPs. However, with the incorporation of suggested EMPs the project is a viable preposition.
- For the mitigation of the likely impacts, different management plans including R&R plan, catchment area treatment plan, reservoir rim plan, landscaping plan, biodiversity management plan, green belt plan, fishery management plan, health management plan, fuel management plan, solid waste management plan, disaster management plan, water and air quality management plan were prepared with total estimated cost of Rs. 98,96,64,785.00.

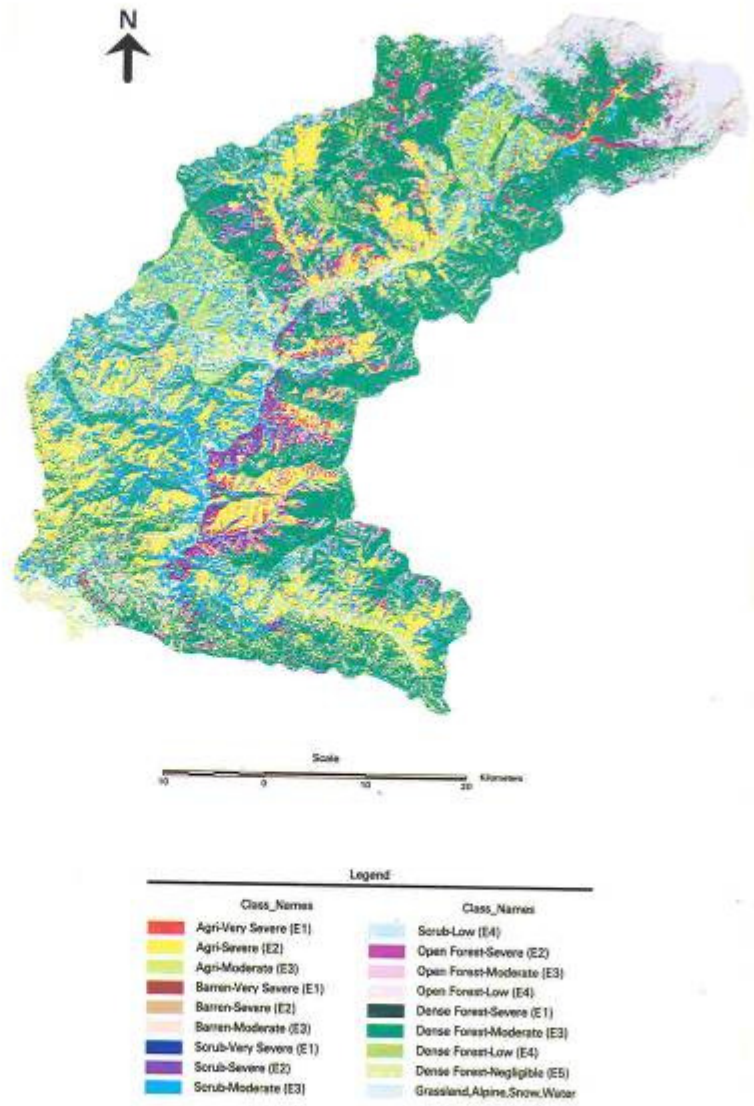


Fig. 29. Erosion intensity map for the catchment of proposed LakhwarVyasi HE project, Yamuna valley (U.A.)

BOX - 7

Summary of the Completed Project (2004-2005)

Landscaping and Restoration Plan for Dhauliganga HE Project-I in Uttaranchal *(NHPC funded)*

The National Hydro-electric Power Corporation has undertaken the task of harnessing hydro-power potential of Dhauliganga River by setting up a series of run-off the river hydro-electric projects along its course. A dam is constructed on this river, around 4 km upstream before river Dhauli confluences with river Kali at Tawaghat, Pithoragarh Distt., Uttaranchal. Considering the need for environment conservation in the project area, a number of efforts under catchment area treatment plan, reservoir rim treatment plan, etc. are being made. There are few spots in the project area where mass movement/landslides are taking place. In order to stabilize all such sites, a plan is prepared for landscaping and restoration of identified sites. The salient features of the report are:

- Under this short-term consultancy assignment a total of 11 landslide sites were identified and evaluated in terms of causes of hill slope failure and natural setting so as to suggest appropriate remedial measures using bio-engineering practices. The project site is situated in inner Himalayan region that has highly rugged topography. Fig. 30 presents a view of one of the sites requiring landscaping.
- Based on extensive field work in the project area in Dharchula (Distt. Pithoragarh), a number of engineering and bio-engineering techniques were suggested for each of the landslide / restoration sites.
- Plants useful for fast revegetation and soil erosion control were also suggested based on primary survey.
- The landscaping and restoration plan was completed and submitted in the form of final report. The report includes landscaping and restoration plan for eleven major landslides with estimated total cost of treatment as Rs. 2,61,56,788.

Fig. 30. View of the slope instabilities in the Dhauliganga project area, Distt. Pithoragarh (U.A.)

EE & EIA 4: Impact Assessment of Alternative Land Uses

Assessing consequences of induced changes in land use

Background and Objectives

The development of hill agriculture is constrained by the barriers of topography and the scarcity of water. In the wake of sprawling demands of increasing population, the hill agriculture is witnessing a surge for change. Such changes are spontaneous as well as intervention-based. These include: monoculture plantations like tea, floriculture, off-season vegetables, introduction of high yielding crop varieties, diversified agriculture, and cultivation of medicinal plants. Their implications are many, which range from nutrition and health, to loss of traditional varieties; pollution, land use and land cover change, and socio-economic changes including gender- specific ones. Women, which constitute the main workforce of hill agriculture, are the worst affected group. As many of these changes in the sector are capital intensive or labour intensive and need a good supportive infrastructure, their sustainability therefore, is always mootable in Himalayan context. In this direction the current efforts were focused on case studies of tea cultivation and off-season vegetable cultivation in Uttaranchal apart from impact assessment of land conservation measures and demonstrations on agriculture potential in Sikkim Himalaya and silvi-pasture development in wastelands of Central Himalaya.

Results and Achievements

(a) *Impact Assessment Studies on Tea Cultivation in Uttaranchal Hills*

- Lack of infrastructure and availability of other livelihood options caused earlier failure
- Tea cultivation exhausts soil nutrients

1. **Altogether the eight reasons of failure of British tea gardens in Uttaranchal were found out** through the survey of old tea gardens (Table 15).

Table 15. Reasons of failure of British gardens in Uttaranchal

Reasons of failure	Responses (%) (n=50)
Availability of employment in townships, migration to urban centers for employment and increase in labour cost	82
Lack of market, availability of outside tea on competitive rates	58
More emphasis on agriculture	56
Lack of tea factories locally	52
Lack of technical knowledge on tea cultivation with the local people	44
Political changes after independence	44
Lack of means of transport	36
Carelessness and mismanagement of tea garden owners	20

2. **Primary survey of the recent tea cultivation vis-a-vis traditional agriculture revealed that the latter was more remunerative compared to the former till 4th year of tea plantation** (Table 16). It is only in the 5th year that the tea cultivation compares well with the traditional rain fed farming (output: input ratio, 1.86 vs. 1.82).

3. In the water samples draining from tea gardens during rainy season, the concentration of nitrate was found significantly high compared to control (1.80 vs. 077 ppm; $P < 0.05$). Concentration of both organic carbon (1.16 vs. 1.38%; $P<0.01$) and organic matter (2.01 vs. 2.38%; $P<0.01$) was found significantly low in tea garden soil as compared to control, indicating that **tea farming exhausts soil nutrients considerably.**

Table 16. A comparative account of output: input ratio of tea cultivation with other traditional land use practices (n= number of people surveyed)

Cultivationpractice	Expenditure (Rs./ha.)	Income (Rs./ha.)	Income/ Expenditure
Tea cultivation (Yrs.)*			
0	148613.00	0.00	0.00
1	53564.00	4500.00	0.08
2	50036.00	22500.00	0.45
3	61211.00	58500.00	0.96
4	60644.00	112500.00	1.86
5	61805.00	180000.00	2.91
Agriculture (n=79)	8440.00	15399.00	1.82
Orchard (n=31)	0.00	2753.76	-
Grassland (n=111)	0.00	13435.32	-

* Data source: Uttaranchal Tea Development Board

(b) *Vegetable Cultivation in Khairna Valley and its Impact on the Environment*

- Easy cash and maximized land use are promoting reasons

1. **Responses of 150 key respondents on perceived impacts, reasons for spurt in vegetable cultivation, and marketing were compiled.** Ranked comparison of reasons for spurt in vegetable cultivation is shown in Table 17. Easy cash and easy and maximized use of land were rated as the major reasons by most of the respondents.

2. In general, out of 150 respondents, around 80% of the respondents accept a spurt in vegetable cultivation/ production in the recent past. 75% respondents admit that this increase has been accompanied by

the increase in the cultivation area, and 70% accept increase in income as a result.

Table 17 Comparison of spurt in cultivation (Rank score: 4-Max, 0-Min; n=150)

Attributes	Reasons for spurt			
	Easy cash	Easy and maximized use of land	Better food security	Availability of market
Rank/ Rank Score	I 3.51(0.85)	II 2.66(1.54)	III 0.12 (0.65)	IV 0.11(0.61)
Percentage Response	54.76	41.64	1.87	1.76

(c) ***Impact Assessment of Land Conservation Measures***

- Initial stages of experiment on soil loss/ run off from erosion plots having land conservation treatments

1. **An experiment was set-up involving three potential fodder grasses** (Barseem, Napier and *Digitaria* spp.) **sown in three different geometry** (across, diagonal and herringbone) in 9 runoff plots (size 100 m^2). Each of the treatment was replicated thrice.

2. A total of 17 rainfall-runoff events occurred from August 2004 to March 2005 with a total rainfall of 358 mm. The runoff was found ranging from 1178 liter in across sowing of Barseem grass to 2372 liter in Barseem sown in herringbone pattern. **The soil loss was found ranging from 1.92–13.28 kg/plot in Barseem sown in diagonal pattern and Barseem sown in herringbone pattern.** In general, the soil loss was found corresponding to runoff.

(d) ***Demonstration of Silvi-Pasture Model for Wasteland Restoration in Western Himalaya*** *(DoLR funded; Period: 2002 - 2006)*

- Wasteland restoration by silvi-pasture model yielding direct benefits to the community

1. At the Dobh-Srikot site **mean survival of fodder plants was recorded 45% after two years of plantation** (Table 18). Mean height of the fodder plants was recorded to be 654 cm after 20 months and 128.3 cm after 25 months of plantation. At the Katarmal site the mean height of plants was recorded 378 cm after one year of plantation.

2. **At the Dobh-Srikot site (treatment area 10 ha) 520 Q, and at the Katarmal site (treatment area 5 ha) 153 Q fodder grass (green wt.) has been harvested so far by the stakeholder communities from the silvi-pasture demonstration sites.** Earlier these sites did not produce any fodder to be harvested by the village people.

Table 18. Survival and mean height of main fodder trees planted at Dobh-Srikot village (Pauri-Garhwal)

Species	Number planted	Survival (%) after 23 months	Mean height (cm) after 20 months	Mean height after 25 months
Dalbergia sissoo	509	88	63.0 ± 1.28	188.8± 11.9
Bauhinia retusa	408	85	59.4 ± 3.08	120.3±10.0
Morus alba	123	64	96.1± 10.7	135.6±16.2
Albizzia lebbek	112	63	185.9 ± 8.65	498.9± 37.4
Melia azedarach	168	52	63.7 ± 5.28	62.9±4.1
Celtis australis	218	32	78.5± 15.5	86.0±2.0
Ougeinia dalbergioides	64	23	27.2 ± 2.16	47.5±16.7
Grewia optiva	145	18	12.5 ± 2.5	53.0 ±4.6
Acacia catechu	43	17	15.2 ± 1.65	41.7±3.8
Toona ciliata	190	6	52.5 ± 16.0	47.9±3.2
Average	2281	45	65.4 ± 15.9	128.3±43.9

(e) ***Impact of Geology and Land Use / Land Cover on Spring Discharge in Western Himalaya*** *(MoWR funded; Period: 2003 - 2006)*

- Relationship between geology, land use/land cover and spring discharge being investigated

1. **A total of 29 springs those presented almost all possible geological set-up / rock types, altitude, aspect, slope, vegetation** (broadleaf and conifer forests), biotic interference, land use (forests, grasslands / grazing lands, wasteland, agricultural land, settlements and urban set-up) in the recharge zones **were identified involving intensive surveys in the western Himalaya.** Detailed geohydrological mapping of the springs is continuing.

2. **Peak discharge of these springs ranged from 7855-86400 liter/ day.** The minimum discharge was recorded for Joint/fracture related spring having Pine forest in the recharge zone and maximum was recorded for the fracture / joint / colluvial type springs having mixed land use (grassland, agriculture, forests) in the recharge zone.

BOX - 8

Summary of Completed Project

(2003-2004)

Technology Vision 2020 Mission Projects on Agriculture Potential- Sikkim Project *(TIFAC, DST funded)*

This project was aimed at to demonstrate the agricultural production potential in farmer's field in Sikkim with better management and improvised collateral practices. Interventions in the farmer's field were done to increase productivity potential of the existing upland on-farm practices and hands-on trainings to the farmers / rural youth for motivating them towards improved agricultural technologies. Interventions such as, poly ponds for water harvesting, bio-composting for soil fertility improvement and poly tunnels for raising seedlings were made. The major achievements were:

- The user group could generate additional income in the ratio of 1:3 (investment: returns) through capturing better market demand of improved quality seed / seedlings / vegetables at the sites of intervention (Fig. 31).
- Demonstration done under this project triggered the neighboring farmers to adopt similar technologies.

Fig. 31. Sale of produce by local farmers in Sikkim

BOX - 9

Summary of Completed Project

(2002 - 2005)

Geometry, Kinematics and Deformation Mechanisms in Darjeeling-Sikkim Himalaya Using GPS Geodesy

(Collaborative project with C - MMACS, Bangalore; DST funded)

This project was aimed at to investigate the geometry and kinematics of deformation in the Darjeeling-Sikkim Himalaya in the light of modern concepts in fold-and-thrust belt geology. In this study network of GPS stations established in Darjeeling and Sikkim Himalaya were used to work out the shortening related to compression from the convergence of the Indian and Tibetan plates across the Darjeeling-SikkimTibet wedge. To supplement the data such GPS stations were also installed in western Himalayan region (Fig. 32).

- A permanent GPS station was installed in Pangthang (Sikkim).
- Following image processing of digital data of IRS 1C LISSIII satellite the major orientation was found to be NE-SW in the Sikkim and adjacent West Bengal Himalaya.
- This approach may lead to better interpretation of seismic hazard in general using an integrated methodology by gaining insights into the kinematics of deformation and earthquake distribution in compressive wedges.

Fig. 32. Nambhidhang- GPS station (background: Om Parvat) in western Himalaya (U.A.)

Core Programe-V

ENVIRONMENTAL PHYSIOLOGY AND BIOTECHNOLOGY (EPB)

In view of the harsh climatic conditions prevailing in the Himalaya, an understanding of the factors that govern the productivity and functioning of plants is extremely important. The application of conventional techniques coupled with biotechnology will greatly help in increasing productivity as well as environmental health. Besides other factors, microorganisms play a significant role in influencing plant growth. A number of bacteria, isolated from soil, have been developed as inoculants, which exhibit improvement in plant growth and also enhance seed germination. Quality plant propagules are often needed, and continuous efforts are underway to develop propagation protocols using both conventional as well as *in vitro* techniques for economically important species. Successful protocols are subsequently used for large-scale multiplication programmes. Plants are subjected to various types of stresses affecting the overall growth. Thus an understanding of the physiological and biochemical basis of adaptation in relation to water stress would help in screening of plants for plantation in this region. Increased biotic pressure has threatened the survival of several important medicinal plants of the region. Based on the content of active biomolecules of medicinal importance, attempts are being made to conserve and cultivate such plants. The relevance of establishing demonstration and training centers in the hilly region has been realized and successful programmes of various hill-specific technologies are being demonstrated on a regular basis for economic upliftment of the rural people.

EPB 1 : Rhizosphere Microbiology of Himalayan Plants

Isolation & characterization of micro organismsMicrobial diversity in Himalayan soils

Background and Objectives

With a view to study the microflora of Himalayan soils several studies have been initiated based on the isolation and characterization of three groups of microorganisms, i.e., bacteria, actinomycetes and fungi (including mycorrhizae). 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 and characterization of extremophiles from higher altitudes
- Isolation and application of rhizobacteria for improving plant growth

1. Soil samples for studying thermophiles and psychrophiles were collected from various locations of Garhwal Himalaya. Various groups of microorganisms were isolated on culture media along a temperature range. The morphological, physiological, biochemical and molecular characterization of the pure cultures are in progress.
2. *Pseudomonas corrugata*, an isolate of colder regions that has been screened and selected as a potential inoculant under the category-plant growth promoting rhizobacteria, was tested for its pathogenecity through bioassay under greenhouse conditions. **The seeds of tomato and chilli inoculated using broth culture of *P. corrugata* resulted in improvement in plant growth without any pathogenic symptoms** (Fig. 33).
3. **Diversity of arbuscular mycorrhizal fungi associated with Himalayan trees, such as five species of rhododendrons and *Taxus baccata* has been completed.**

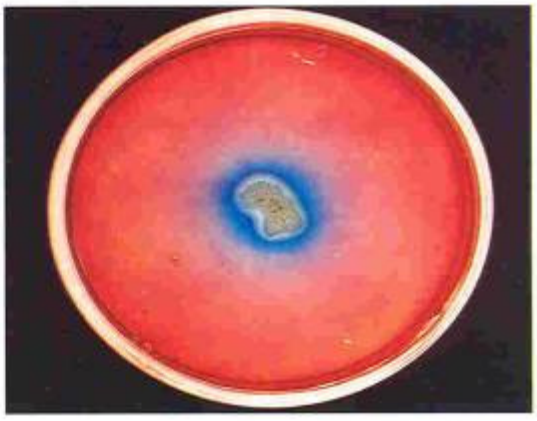


Fig. 33. A siderophore producing isolate of *Pseudomonas* sp.

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

Development and application of propagation protocols for large scale multiplication

Background and Objectives

Large quantities of quality planting material are required in order to initiate plantation 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 for field transfer of *in vitro* raised plants.

- *In vitro* propagation and field transfer of selected species
- Maintenance of *in vitro* cultures of important species

Results and Achievements

1. **Plants of *Dendrocalamus hamiltonii* and *Picrorhiza kurrooa* are being multiplied by *in vitro* methods for large-scale production.** Micropropagation studies on *Arundinaria*, another important bamboo species has been initiated. Efforts continued for improving shoot multiplication rate in *Rhododendron maddeni*.
2. *In vitro* cultures of *Rosa damascena*, *Thamnocalamus spathiflorus*, *Camellia sinensis*, *Gladiolus* sp., *Sinningia speciosa* and orchids are being maintained in the laboratory

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

Water relation in plants: screening based on gas exchange capacity

Background and Objectives

A variety of environmental factors influence plant growth, survival and productivity. Water is one of the most important environmental variables that influence not only growth and productivity of plants but also their geographical distribution. Plants growing in the rain fed areas of the Central Himalaya are generally exposed to natural cycles of water deficit and water sufficiency depending upon the highly variable and unpredictable rains. Trees make a significant contribution to support sustained agriculture production and to meet the fuel wood, fodder and small timber requirement of the local people. Therefore, there is need for evaluation, screening and identification of tree species that could be successfully used for the revegetation of rain fed degraded lands. Studies are therefore, required to understand (i) Effect of water stress on growth and morphology; (ii) Effect on biochemical processes; and (iii) Effect on relative water status and relative water content.

Results and Achievements

1. Seasonal changes in dry matter content, relative water content, proline and total soluble carbohydrate contents were related to drought stress were observed in *Bauhinia retusa*, *Ficus glomerata* and *F. roxburghii* growing in rain fed agricultural field during May (Table 19).

- Variation in dry matter, RWC & biochemical parameters in plant leaves
- High proline associated with certain species

2. When averaged across the season, ***F. roxburghii*** **maintained a greater leaf dry matter content followed by** ***F. glomerata*** **and** ***B. retusa.*** On the other hand, relative water content was higher in *F. glomerata* followed by *F. roxburghii* and *B. retusa*, when averaged across the seasons.

3. Maximum accumulation of proline content was observed in *B. retusa* followed by *F. roxburghii* and *F. glomerata*. **Total soluble carbohydrate was maximum in** ***F. roxburghii,*** **followed by** ***B. retusa*** **and** ***F. glomerata.***

Table 19. Physiological and biochemical parameters related to drought stress

Plant species	Proline (mg/g fresh wt.)	Total soluble carbohydrates (mg/g fresh wt.)	Percent dry matter	Relative water content (%)
F. glomerata	35.65±3.99	28.01±3.56	38.54±4.43	80.23±9.76
F. roxburghii	76.17±7.24	52.44±5.84	36.17±3.11	78.43±9.44

BOX - 10

Summary of the Completed Project (2001 - 2005)

Selection of plant growth promoting microbes for their potential use in mountains *(Funded by CSIR)*

In this project, plant growth promoting microorganisms with special reference to mycorrhizal associations (vesicular arbuscular mycorrhizae, VAM) in important tree species of Himalayan region were examined.

- Root samples of five species of Rhododendrons, *Taxus baccata, Abies pindrow, Betula utilis, Ginkgo biloba* were processed for mycorrhizal associations and trap cultures were developed.
- Root colonization by the VAM fungi and the corresponding spore population(s) in soil samples were recorded.
- Diversity of VAM fungi associated with the rhizosphere of these species was observed. Inoculation trials using *Glomus* species for better growth of tree species at nursery level under net house conditions were conducted.
- Experiments conducted to select suitable host species for maintenance and mass propagation of VAM fungi.
- A number of annual plants like maize, wheat and finger millet, *Thysanolaena maxima* (a perennial grass), in view of its adaptability to the higher altitudes were selected as host species for maintenance and mass propagation of the VAM fungi.

EPB 4: Genetic Profiling and Pilot Production of the Identified Elite Species and Quantification of Active Biomolecules

(Funded by DBT; Period 2003-2006)

Quantification of active biomolecules from alpine medicinal plants

Background and Objectives

This activity is the second phase of a project entitled, "Bioprospecting of biological wealth using biotechnological tools", and mainly focuses on selection of elite populations of identified medicinal plants based on their active biomolecules. These identified plant populations would be subsequently genetically characterized. It was also thought relevant to conserve and set up demonstration plots of these identified species. The research work related to genetic profiling is being taken up by Delhi University and assisted by several centers including this institute. The various objectives taken up during this year included: (i) Quantification of biomolecules from *Podophyllum hexandrum*; and (ii) Setting up of demonstration plots for *Podophyllum hexandrum*, *Picrorhiza kurrooa*, *Aconitum heterophyllum* and *A. balfourii* in a high altitude field station.

Results and Achievements

- Wide variation in podophyllotoxin detected in populations
- Satisfactory growth of plants observed at demonstration plots

1. In order to select elite clones for germplasm collection and multiplication, *P. hexandrum* was collected from various populations of Sikkim and Himachal Pradesh. **A wide variation in the podophyllotoxin content in rhizome samples of 22 populations was recorded** (range= 0.0045-4.133% on dry wt. basis).

Fig. 34. *P. kurrooa* growing in the field at Khaljhuni village, Distt. Bageshwar (U.A.)

2. **Plants of *A balfourii, P. kurrooa* and *P. hexandrum* collected from various Himalayan locations are being grown and maintained** at the Khaljhuni village (2450m amsl) demonstration site (area– 0.8 ha) Growth performance of plants was monitored and found normal (Fig. 34).

EPB 5: Network Programme for the Establishment of Demonstrations of Bamboo Plantations in Uttaranchal

(DBT funded; Period 2004-2007)

Mass multiplication & field demonstration of bamboo

Background and Objectives

Development of propagation protocols is necessary for obtaining quality plant propagules and also for conservation and cultivation of economically important plants. Bamboo constitutes a group of highly sought after industrial raw material for use in pulp, paper, mat, board industries, beside a source of green fodder and numerous traditional uses. Keeping the usefulness of this species this activity focussed on: (i) Large scale multiplication using both conventional as well as *in vitro* methods; and (ii) Setting up of demonstration plots for field testing the performance of plants.

Results and Achievements

- Mass multiplication of bamboo
- Establishment of nursery at Kosi

1. Plants of *Dendrocalmus hamiltonii* were multiplied by *in vitro* methods for large-scale production (Fig. 35). **About 2000 plants of *D. hamiltonii* were rooted and being hardened for field-transfer.** Improvement in rooting has been achieved through chemical treatments in the cutting raised plants as well as in the seedlings.

Fig. 35. In vitro mass multiplication of *D. hamiltonii* using nodal cuttings in lab. conditions at Kosi-Katarmal, Almora

2. **About 1000 seedlings and 500 cutting raised plants are being hardened in a demonstration plot / nursery** that has been developed near the Institute HQs at Kosi.

EPB 6 : Capacity Building and Economic Upliftment of Rural Women Through Livestock- Fish- Crop Farming *(DST funded; Period: 2004-2006)*

Capacity building by integrated livestock fish crop farming

Management of fish health

Background and Objectives

The study focuses on addressing the complex problems, such as sustainable development, rural employment generation, poverty alleviation and to improve quality of life of rural folk, primarily women and children through intensive utilization of wastewater and underused land resources. These resources may be used for a low-cost integrated livestock-fish-crop farming, which has been identified as an excellent means to provide food security, employment generation and providing additional income to the farmers. The objectives were: (i) Capacity building of local people, particularly women, through training and demonstration on bi- or tri-commodity based integrated approach of livestock-fish or livestock-fish-crop farming for income generation; and (ii) Monitoring of physico-chemical and biological parameters of water for identifying suitable condition for management of fish health.

Results and Achievements

- Adoption of integrated livestock fish crop farming
- Identification of different fish pathogens

1. **Two farmers at village Basoli and Manan in Almora District (UA) adopted the tri-commodity approach of fish polyculture, poultry/duck farming and vegetable cultivation coupled with assured supply of safe drinking water.**
2. Temperature (12.0-27.5°C), pH (6.9-7.8), dissolved oxygen (5.2-8.5 ppm), conductivity (78.2-116.3 mohs) of the pond water was well within the range for normal growth of fish. However, presence of several species of potential fish pathogens, viz., *Achlya*, *Aphanomyces* and *Saprolegnia* spp. has been observed (Fig. 36 A).
3. **Substantially low number of coliforms (Nil-7, MPN/100 ml) in filtered water indicated effectiveness of slow sand filtration system.** Growth of fish, poultry/duckery, and yield of vegetable grown by using overflow of storage tank and pond was satisfactory (Fig. 36 B).

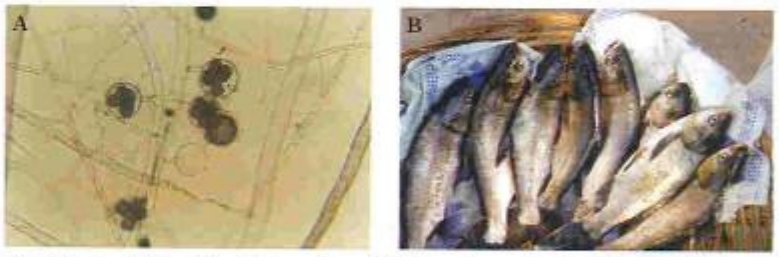


Fig. 36 A. *Achlya flagellata*, a fungal fish pathogen isolated from a fishpond **B.** Eight months old Silver carps from a fishpond at village Basoli, Distt. Almora (U.A.)

BOX – 11

Summary of the Completed Project (2000-2004)

Establishment of Biotechnology Complex for Capacity Building and Economic Upliftment with Particular Reference to Women of the Indian Himalayan Region *(DBT funded)*

The Rural Biotechnology Complex has been set up in a way that it aims at to bring changes, over a period of time, leading to improvement in the economic status of the inhabitants, generation of employment possibilities, and reduction of environmental degradation and sustainable use of the resources. It was felt that a generalized uniform sustainable development model could only be of very limited use because of the complexity in natural aspects (i.e., topography, climate, elevation, soil, etc.), social, economic and cultural practices. Therefore, location or area-specific technology packages, which are based on ecological, social, economic and cultural considerations, have been demonstrated and implemented through participatory approach in different geo-environmental conditions in the Uttaranchal State. While the external funding has stopped and the project has been completed, the Institute is supporting some of the activities; this will lead to reaping further benefits of the efforts done through this Rural Biotechnology Complex.

- Level of awareness enhanced considerably among the rural folk through trainings, capacity buildings, interaction and demonstration of different hill-specific technologies on the farmers' fields.
- Total impact and the resulting outcome of the project will become fully evident after some more time, as most of the benefits from the adopted technologies will come gradually year after year.
- These technologies can be easily, cheaply and practically applied, with local variations in other rural remote locations (states) of the IHR.
- Gained tremendous popularity among the various user groups, as evident from the continued demand for conducting trainings, capacity building and setting up of various demonstrations.
- Currently various persons / organizations are bearing expenses for undertaking trainings.

EPB 7 : *In vitro* Approaches Towards Commercial Cultivation of *Podophyllum* spp. *(DST Funded; period: 2004-2007)*

Refinement of existing in vitro propagation protocol Initiation of callus and suspension cultures

Background and Objectives

Podophyllum spp. is an important source of podophyllotoxin. used in the treatment of different cancers. *P. hexandrum* species has become threatened due to indiscriminate extraction from the natural habitat. To augment this and conserve the plant, alternative methods of propagation is the need of time. Therefore, conventional and biotechnological approaches have been applied to propagate the plant and produce podopyllotoxin. This activity focused on: (i) Modification and standardization of existing

in vitro protocol for *P. hexandrum* (selected elite plants) and *P. peltatum* for large-scale multiplication; and (ii) Biological hardening of *in vitro* raised plants by microbial inoculations and evaluation of field performance of tissue culture raised plants.

- **Improvement in seed germination by gibberellic acid**
- **Enhanced shoot multiplication by benzyladenine**

Results and Achievements

1. **Seeds treated with 250 mM GA_3 resulted in almost 60% germination under controlled green house conditions.** Shoot initiation was observed after four months of germination.
2. **When excised embryos were placed on medium supplemented with 2.0 mM BA, multiple shoots were formed.** Highest shoot multiplication (3.5 shoots/embryo) was observed on medium containing both 2.0 mM BA. The base of cotyledonary leaf in the embryos swelled to give rise to multiple shoots in about 45 weeks; maximum number of multiple shoots were formed in the above medium.

BOX - 12

Summary of the Completed Project

(2001 - 2004)

Characterization and Improvement of Tea Through Biotechnological Tools – Phase I (DBT funded)

Realizing the need to develop high yielding clones with superior quality and stress tolerance, and also to understand some of the physiological and biochemical parameters, which may help in improving yield of existing plantations, studies under this project were focused on: (a) Complete characterization of existing clones using physiological, biochemical and molecular tools; (b) Standardization of technology for *in vitro* propagation and field establishment of superior clones; and (c) Development and testing of complete package of microbial inoculants including VAM.

- A simple method of physiological assessment for early selection of ten clones using CO_2 uptake and chlorophyll fluorescence has been developed.
- Analysis of some biochemical constituents of green tea leaves like caffeine, amino acids, and polyphenol along with isozymes and protein profiles were carried out. A significant variation was observed in total soluble sugar (both reducing and non reducing), caffeine, protein and polyphenol contents and in isozyme pattern amongst the different clones (T - 78, RR - 17, AV - 2, B/6/61, BSS - 379 & BSS - 449).
- A complete *in vitro* propagation protocol was developed earlier using explants taken from local chinery bushes for large-scale multiplication. Following transfer to field (under shaded condition) in the Institute nursery about 90% survival was observed following 10 months of acclimatization.
- The isolation, identification and mass propagation of VAM fungi associated with tea rhizosphere has been initiated. The root samples collected from young and established tea bushes have been processed and mycorrhizal colonization has been worked out. Trap cultures for identification of VAM fungi up to species level have been developed.

Development of bacterial and VAM formation as fertilizer

EPB 8 : Characterization and Improvement of Tea Through Biotechnological Tools- Phase II *(DBT funded; Period: 2004-2006)*

Background and Objectives

Based on the leads achieved in the first phase (please see Box 12) this project has been extended for two years with a focus on development / standardization of bacterial and VAM formulation as fertilizer for tea clones.

Results and Achievements

- Bacterial inoculants tested for tea
- Chemical fertilizers affected diversity of VAM fungi

1. Bacterial inoculants in liquid formation have been tested for their root colonization ability using antibiotic markers under greenhouse conditions. The inoculation experiments have been set-up under field conditions at Kausani tea gardens.
2. **Diversity of VAM associated with rhizosphere of tea has been worked out. It was found that the diversity of VAM fungi was adversely affected due to application of chemical fertilizers.**

BOX - 13

Summary of the Completed Project

(2000 - 2004)

Genepool Preservation and Mass Propagation of Sikkim Himalayan Rhododendrons Using Biotechnological Tools

(DBT funded)

Sikkim Himalayan rhododendrons are represented by a group of 36 species out of the total 42 Indian species. At present, owing to the immense direct and indirect anthropogenic pressure, these plants are gradually getting scarce. With a view to conserve the group in general, a representative species- *R. maddeni*, was selected to find out the means of propagation (both biotechnological and conventional methods), conservation and restoration of rhododendron population in the wild. The findings were:

- Sterilized seeds of *R. maddeni* were germinated under aseptic conditions and seedlings were used for shoot multiplication. Apical dominance played a significant role as removal of tips of seedlings necessitates shoot multiplication *in vitro*.
- A complete regeneration protocol has been developed for *R. maddeni*. *In vivo* transplants grew best on peat moss with 80% survival.
- Two hundred plants have been rooted, hardened under mist polyhouse and successfully transferred to polybags under green house conditions (Fig. 37). The present protocol facilitates cost-effective production of plantlets within eight months starting from a single cotyledonary nodal explant using single medium.

- Callus cultures were initiated from leaf and stem explant on B5 medium supplemented with BA and 2, 4-D. All possible permutations and combinations of medium salts, growth regulators and reciprocal transfers failed to induce proper somatic embryogenesis.

Fig. 37. Hardened micropropagated plant of *R. maddeni* at Pangthang, Sikkim

Box - 14

Summary of the Completed Project (2000-2004)

Demonstration and Capacity Building of Mountain Farmers and Rural Women on Farm Based Simple Technologies in Sikkim *(DST funded)*

This project focused on better use of available physical and biological resources for sustainable development of rural ecosystems in Mamlay watershed of Sikkim. Community participatory methods integrating the resource generation and build-up and use constituted the common methodology. Low-cost biotechnological packages were employed for generating economic incentives. The project was aimed mainly for the participation of women folk with major emphasis on: (i) Demonstration of various technologies developed and adopted by the Institute; (ii) Field implementation of different technologies; and (iii) Capacity building of local people.

- Project implemented six technological packages through extension-oriented activities in a cluster of households in two different ecological zones (subtropical and temperate) of the Mamlay watershed near Namchi in South Sikkim. The project activities were designed to cover cluster of upland farm families, i.e., at least 15 families at each site.
- Two improvised cardamom curing kiln were constructed at temperate region (Jaubari village and Darakharka) of the watershed. The user groups appreciated the technology as it reduces the time as well as fuel-wood consumption (Table 20).

- Twenty-two polytunnels using UV resistant plastic films were constructed in the farmers' field for off-season vegetable production. Mushroom cultivation was introduced through practical demonstrations.
- Following training and extension, considerable number of women folk/ user groups adopted these technologies. Each user group could generate additional income in the ratio 1:3 (investment: earning) through better market demand of improved quality seed/seedlings/vegetables at the sites of intervention.

Table 20. Performance of GBPHIED improvised large cardamom curing kiln

Sample House-hold	Raw cardamom (kg)	Raw fuel wood consumption (kg)	Dry cardamom (kg)	Moisture content of cardamom (%)	Drying time (hr)	Raw fuel wood consumption/kg of dry capsule
I	190	75	52	73	12	1.44
II	92	29	32	66	8	0.91
III	235	130	54	77	9	2.40
IV	480	190	90	81	11	2.11
V	211	84	35	83	12	2.40
VI	199	85	47	76	9	1.81
VII	127	90	29	77	8	3.10
VIII	103	80	24	77	8	3.33
Mean	205±40.7	95.38±15.6	45.38±7.0	76.25±1.7	9.63±0.6	2.19±0.3

Core Programe - VI

INSTITUTIONAL NETWORKING AND HUMAN INVESTMENT (INHI)

With the passing of time, the Integrated Eco-development Research Programme (IERP) has matured to a robust and very successful programme of the Institute by meaningfully complimenting to the R&D needs of the IHR and effectively developing expertise, scientific manpower and infrastructure all across the region. This programme is strongly complimenting to the mandate of the Institute by helping it in achieving/fulfilling its broad objectives, such as networking of the existing expertise and promoting institutional infrastructure in the IHR, which are critical for optimal use of the available scientific talent. A major contribution of the IERP is its reach to all the nooks and corners of the IHR, i.e., IERP projects have been implemented all across the IHR in its 12 States. Since 1992-93, when this programme was transferred to the Institute, as many as 236 projects have been handled successfully by this Institute. During the year 2004-2005, this programme funded 34 new projects in the States of Himachal Pradesh, Uttaranchal, Assam, Nagaland, Tripura, Mizoram and Arunachal Pradesh. While creation of environmental awareness among various identified target groups continued to remain an important priority, R&D projects of the Core have been focused on developing/replicating a model for sound environmental management by rehabilitating degraded lands and conserving biodiversity by the blend of science and religion and also developing a strategy for socio-economic development and capacity building of the local communities by alleviating the poverty.

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

Application and blending of science and religion

Background and Objectives

In the IHR continued degradation of land and biological diversity is 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 Institute executed 'Badrivan Restoration Programme' at Badrinath that clearly demonstrated the value of adopting 'cultural approach' for reforesting degraded lands. This approach also illustrates the importance of blending science and religion for the protection of environment and biodiversity conservation. The present project, 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 in Kumaon Himalaya.

Results and Achievements

- Declaration of sacred hill and eco-restoration of a site
- Use of multipurpose tree model

1. Based on extensive surveys, two degraded sites (namely, Daikhura Kattarkandi and Kail Bakriya hills; total area– 6 ha) were identified in the Kolidhaik village of Champawat district of Uttaranchal (Fig. 38). One of the sites has been declared 'Daikhura Kattarkandi Sacred Hill' in which a sacred forest 'Kalika Van' developed with people participation. At the other site called 'Kali Bakriya', a multipurpose tree model is being developed.

Fig. 38. The Daikhura Kattarkandi and Kail Bakriya project sites in Distt. Champawat (U.A.)

2. Physico-chemical analyses of the soil, collected from both the project sites, revealed that the soil is poor in nitrogen and organic carbon.

3. At these sites, four water-harvesting tanks were constructed and pits have been dug for plantation in the coming monsoon season. To cater to the need of elite planting stock, a plant nursery has been established at the Institute headquarters.

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 (Capacity Building Programme)

Understanding poverty from different perspectives

Background and Objectives

In the central Himalayan region research and empirically based strategic recommendations to policy planning are desired on: (i) Situation of poverty and its ramifications and poverty alleviating measures; and (ii) Relevance, adequacy and performance of existing infrastructures, 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 in the mountains. Therefore, this activity envisages to investigate: (a) Current situation of poverty, policy and implementation issues associated with poverty and poverty alleviation measures, rural infrastructure including credit, and their further development, (b) Poverty vis-a-vis social infrastructure, cultural institutions, value systems, and social exclusion, and (c) Relationship between poverty and gender focusing on role of women to optimise the management options for effective reduction in poverty. At present two hill districts of Uttaranchal, Uttarakashi and Pauri with 68.71% and 26.74% of their population below poverty line, respectively, are being studied.

Results and Achievements

- **Population growth and livelihood patterns**
- **Analyses of secondary data to understand poverty**

1. Analysis of secondary data on socio-economic and developmental issues reflected some contrasting development indicators for the two districts (Table 21). The decadal growth rate (1991-2001) for Uttarakashi was 22.72% against 3.87% that for Pauri (Fig. 39). Total literacy rate in Uttarakashi (66.58%) was lower than that of Pauri (77.99%), and female literacy in Uttarakashi (47.48%) was noticeably lower than that of Pauri (66.14%). The lower sex ratio of Uttarkashi against that of Pauri is another indicator that also necessitates investigating the links between gender and poverty.

2. The perpetuation of poverty in Uttarakashi, as appears, is further accentuated by non-availability of agricultural land as only 3.78% of total land in Uttrakashi is net cultivated against 13.12% that for Pauri and per capita net cultivated land is comparatively lower in Uttarakashi (0.10 ha) in comparison to Pauri (0.14 ha).

Table 21. Livelihood patterns in Uttarakashi and Pauri (2001)

Livelihood patterns	(in percentage)	
Uttarakashi	Pauri	
Main workers	47.97	31.60
Cultivators to total population	37.81	20.10
Cultivators to total workers	81.77	61.80
Livestock	2.20	2.51
Trade	2.61	4.41
Service sector	11.79	22.20
Others	1.63	9.08

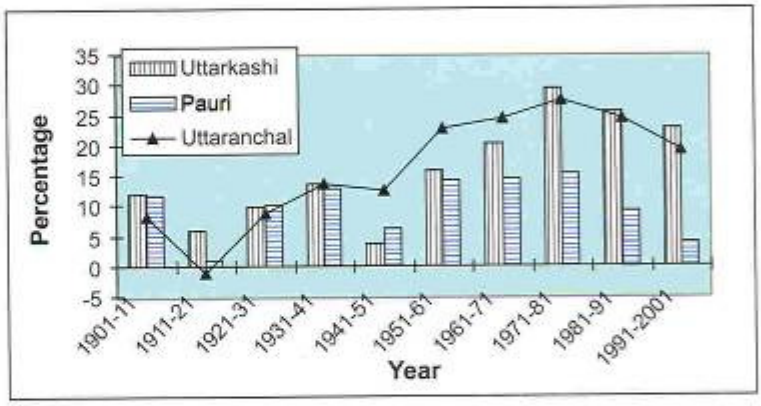


Fig. 39. Decadal variation in population growth rate in two districts of UA.

3. Investigation on distribution, adequacy and access of social and rural-credit infrastructure indicated that in Pauri district people has better access to social infrastructure, while Uttarkashi has a better adequacy of credit infrastructure.

INHI 3 : Integrated Eco-development Research Programme (IERP) in the Indian Himalayan Region

Background and Objectives

The Ministry of Environment and Forests, Government of India entrusted the responsibility of Integrated Action Oriented Research, Development and Extension Programme (termed as Integrated Ecodevelopment Research Programme- IERP) in the IHR to the Institute in 1992. Subsequently the Institute identified two broad thrust areas, namely Technology

Testing two thrust areas, namely Technology Development and Research (TDR) and Technology Demonstration and Extension (TDE) through extra-mural funds

Development and Research (TDR) for Integrated Ecodevelopment, and Technology Demonstration and Extension (TDE), under IERP. The main objectives of the programme are: (i) To provide extra mural funds to different Universities / Institutions / NGOs / Voluntary agencies for the support of location-specific R&D activities in the IHR; (ii) To develop scientific capabilities in the IHR and strengthen infrastructure for environmental research; and (iii) To develop and execute coordinated programmes on the recommendations of the completed projects/special theme(s)/R&D need(s) in the IHR with the help of identified network partners.

Results and Achievements

- Thirty four projects were funded (13 to Universities, 9 to NGOs and 12 to Govt. Institutions)

1. Based on the recommendations of the Project Evaluation Committees (PECs), the **following thirty-four projects** (13 to Universities, 9 to NGOs and 12 to Govt. Institutions) **were sanctioned and funded during the financial year 2004-2005. (Annexure I)**
2. The coordinated programme on *"Sacred values, eco-restoration and conservation initiatives in the IHR"* was strengthened by funding three more new projects in the states of Himachal Pradesh and Uttaranchal.
3. Annual Progress Reports (APRs) of 46 on-going projects were processed and sent to the subject experts for evaluation. Subsequently, the comments on the APRs were communicated to the concerned PIs for follow-up.
4. Fourteenth meeting of the Project Evaluation Committee (PEC) was convened at the Sikkim Unit of the Institute (Pangthang) in which 120 project proposals were examined by the PEC. Also two IERP Workshops entitled, *"Creation of awareness among the prospective*

Fig. 40. The participants of the fourth IERP workshop at Palampur (H.P.)

PIs/Groups/ NGOs, etc., of the Himachal / Uttaranchal region for execution of location-specific action-oriented R&D activities under the IERP of GBPIHED: Project presentation cum evaluation" were organised. In the Himachal Pradesh workshop held at Palampur and Srinagar-Garhwal. A total 325 participants (Fig. 40) attended these workshops and 68 project proposals were evaluated.

INHI 4 : Strengthening and Maintenance of the Central Library at the Headquarters

Background and Objectives

Total books - 12918 Subscription of periodicals 124 (foreign 77 Indian 47)

The Library started in the year 1989 with the initial grant of Rs. 1,53,99700. About 553 books were purchased during the year 1989. Subscription of 18 journals was started from the year 1990. At the end of financial year 2004-2005, total number of books in the Institute library was 12,918. At present, the library is subscribing 124 periodicals (77 Foreign and 47 Indian). The objective is to cater to the need of researchers of the Institute as well as outsiders working on IHR and other mountain areas.

Achievements/Services

- Providing library and information service to researchers
- Dissemination of R&D outcome of the Institute

1. Using Software Package PALMS that was developed earlier by the Institute, services such as Article Alert, Current Awareness Services, Selective Dissemination of Information, Reprographic, Referencing and Indexing, Abstracting and Bibliographic, etc., for the development of the human resource are being provided.
2. **During the reporting year, as many as 928 new books/volumes were added to the library.** The web site of the library (http://gbpihed.nic.in/library.htm) was being kept continually upgraded.
3. The Institute Library has been disseminating R&D outcome of the Institute through its regular in-house publications, namely *Hima-Paryavaran*- a biannual newsletter and Institute *Annual Report*, Folders / Manuals and other Institute publications to various users.

INHI 4: Strengthening and Management of ENVIS Centre in the Institute

Background and Objectives

ENIVS Centre on Himalayan Ecology set up by MoEF

Collection / collation /Publication of information on various aspects of Himalayan ecology

The Environmental Information System (ENVIS) Centre on Himalayan Ecology was set up in the Institute in 1992 as a part of ENVIS network in India by the Ministry of Environment and Forests, Govt. of India; the nodal agency in the country to collate all the information from these centres to provide national scenarios to the international set up INFOTERRA Programme of the UNEP. The ENVIS Centre of the Institute has the responsibility of collecting, collating, compiling and building qualitative and quantitative databases of information related to various

aspects of Himalayan ecology. Through print/electronic media, the Centre is regularly disseminating all available information, free of cost, to various stakeholders/users that include all District Information Centres (operating in the Himalayan states of the country), ENVIS Centres/Nodes elsewhere in the country and other user groups.

- Average ENVIS website hit rate - 15,000 per month
- Volume 12 of ENVIS Bulletin (2 in numbers) published
- Volume 1 of ENVIS Newsletter published

Results and Achievements

1. Volume 12 of the **ENVIS Bulletin (2 in numbers)** and Volume 1 of the **ENVIS Newsletter were published** during the reporting year and also made available on-line through internet.

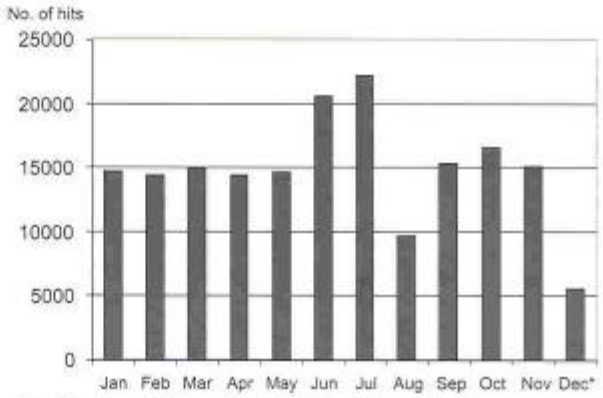


Fig. 41. Number of hits to the ENVIS website of the Institute (year 2004).

2. **Development, up-gradation and maintenance of ENVIS Website and Institute Website** were continued. Management Information System, current topics, seminars/conferences were also compiled and uploaded in the ENVIS website. The ENVIS website had a phenomenal average hit of about 15,000 per month (figures up to December 2004) during this year (Fig. 41).

Core Programe-VII

INDIGENOUS KNOWLEDGE SYSTEMS (IKS)

Mountain cultural heritage and traditional knowledge systems play significant role in sustainable use, management and conservation of resources. Restrengthening of culture and indigenous knowledge base should lead to enhanced conservation practices. Integration of indigenous knowledge with modern techniques is possible. 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 analysis of indigenous knowledge and management practices of upland societies, and analysis of indigenous agricultural practices in the light of its efficiency and sustainability.

IKS 1 : Documentation and Analysis of Indigenous Knowledge and Management Practices of High Altitude Societies

(a) Indigenous Practice of Vegetable Drying

Adaptation to environmental conditions is the IKS

Background and Objectives

The upland Himalayan region is characterized by diverse ethnic groups, which have developed their own diverse cultures based on available natural resources. They are also known to use a number of dry food items quite extensively without losing its taste and vitality. The practice of using dry food made them secured from regular supply of such edibles, particularly during the harsh winter months when virtually no vegetable grows in the region. This is also a period when their entire region is cut-off due to heavy snowfall, and movement of men and animal becomes quite difficult. This study was focused on: (i) Documentation of indigenous methods of drying different wild cultivated vegetables used by the Bhotiya tribe; and (ii) Identification of possible options for value addition to their product.

Results and Achievements

- Availability of vegetable during lean period
- Evolution of different methods of drying

1. Drying and storage method of vegetables by Bhutyas was documented. They ae diverse drying (sun, sun and shade) methods depending upon the nature of vegetables. For instance potato, chilly are sun dried. Tomato, cabbage, cucurbit, bean cucumber, spinach are dried both under sun and shade, brinjal and karela are dried under shade only. However, radish, gaderi and ginger are kept as such in pits.
2. Drying of potato is slightly different, where the tubers are first pealed and then sliced into thin pieces (potato chips); then they are soaked in warm water (80^0 C) for some time before they are exposed to sun light for drying.

(b) Indigenous Knowledge of Pastoralism and Transhumance

Utilization of available grazing resources and distribution of production risk

Background and Objectives

For the majority of upland communities of Kumaon and Garhwal in Uttaranchal, agriculture and pastoralism is the main livelihood activity. Amongst the high altitude transhumant pastoral communities of this region, women have been traditionally playing a major role in decision making relating to various livestock management practices and subsistence agricultural activities. Over the last few decades, the pressure on women has increased, due to large number of male out migration to the urban areas in search of employment. In addition, now market forces have penetrated to the far flung and remote high altitude areas of the region, and have begun the process of purchase of local resources, which started to disrupt the traditional practices, and has thus marginalized the pastoral and transhumant communities. This study

was aimed at: (i) To identify the traditional institutions and indigenous knowledge relating to the resource use pattern; and (ii) To understand the process of gradual disruption of traditional knowledge systems in relation to changes in the social system.

Results and Achievements

- Continuance of earliest of production method
- Marginal and peripheral mode of existence

1. **Social survey among the four pastoral groups,** which migrated from Munsyari and Dharchula (high hills of Kumaon Himalaya) to their winter settlement in the forests near Tanakpur (plains of Kumaon) **was conducted to document the division of labour, social interaction and barter system of the shepherds** with the settled neighbouring communities.
2. Analysis of the information / data generated is continuing.

IKS 2 : Documentation of Perceptions Regarding Indigenous Uses of Selected Plant Species of Uttaranchal Himalaya

Background and Objectives

Evolution and perfection of indigenous uses of selected plant species

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. Quantification and documentation of traditional uses of such plant species and knowledge can provide valuable information on important aspects. It is hypothesized that each indigenous social group may have its own ideas about which plant species and plant parts that can best serve as food and medicine. The present study was conducted with a focus on: (i) Peoples perception on importance of plant species; and (ii) How ethnobotanical knowledge is distributed among the population with respect to age, gender and village.

Results and Achievements

- Preference of available food crops
- Availability of fodder during winter is the mark of preference

1. **Of the 14 agricultural species, *Triticum aestivum* was the most preferred species** by local people, followed by *Elusine coracana*, and *Oryza sativa* (Table 25).
2. Of the total 13 important fodder species, *Quercus leucotrichophora* was the most preferred species by local people, followed by *Grewia optiva* and *Celtis australis*.

IKS 3 : Traditional Knowledge of Understanding Indicators of Weather

Background and Objectives

The people in the rural areas of the Himalayan region have good understanding of their natural systems and accordingly have learnt to

Understanding nature was more due to living in harmony with nature

utilize a wide range of biological resources in diverse ways. They had sound understanding of ecological knowledge pertaining to indicators of weather, agriculture and pastoralism. Historically, the natural environment, particularly physiographic and climatic constraints, has strongly influenced their settlement pattern and their resource-use pattern. This study is an endeavor in this direction to understand and document the traditional knowledge of indicators of weather among various groups of the societies involving surveys in 36 villages of Bageshwar and Pithoragarh district of Kumaon Himalaya.

- Understanding indicators of nature
- An imperceptible observation

Results and Achievements

1. Primary survey suggested that **flowering/fruiting of mango in sufficient quantity is an indicator of dry weather/less rainfall** and less productivity of mango fruits.
2. Sighting of wild bear on lower elevation around agricultural fields is an indicator of good crops in the valley. Chirping of birds during noon and mid-day is an indicator of good crop and time for harvest.

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

- Extensive inventory of medicinal plants of Himachal Pradesh; analysis of nativity, endemism, and identification of conservation priorities for the medicinal plants.
- Forest vegetation assessment and regeneration status in biodiversity rich areas (i.e., Khokhan Wildlife Sanctuary, Kais and Manali Wildlife Sanctuary and Cold Desert Biosphere Reserve) in H.P.
- Improvement of seed germination of *Hedychium spicatum* (a medicinal plant) using different substrates. Seedling growth studies were carried out for *Angelica glauca*.
- Continuous monitoring of ambient air quality (particulate matter, total dissolved solids, SO_2, No_2 and O_3) at two locations in Kullu valley.
- Impact assessment of hydropower projects in Beas valley in H.P. using household surveys and vegetation analysis in project affected areas.
- Maintenance of a medicinal plants nursery at Mohal-Kullu and herbal garden at Dhoranala herbal garden.

Organised exposure visits to school children and teacher and BSF trainee officers

State level workshop on development of medicinal plant sector (2 day)

Training workshop (2 day) on medicinal plant identification and utilization

- Organization of a state-level seminar, "Mainstreaming medicinal plants for development of the region - Himachal Pradesh a case in point ".
- Organization of an exposure workshop and two participatory training lectures under the programme on "peoples participation for biodiversity conservation".

GARHWAL UNIT

Organiszed 2 (5 day) science motivation training programme for students

Training programme (2 day) for promotion of eco-tourism in NDBR

Training (2 day) on cost-effective rural technologies

- Performance studies for seedling production of three important species of Allium (*A. humile, A. rubillium* and *A.stracheyi*) under different environmental conditions. Also cost-benefit analysis of cultivation of these species was worked out.
- Investigations on effect of growth hormones on rooting and seed germination of selected potential wild edible oil plants (*Prinsepia utilis* and *Neolitsea pallens*) of Garhwal region. Improvement of germination up to 82% in case of *P. utilis* and > 50% for *N. pallens* recorded under 200ppm GA_3 (at 25 °C) treatment.
- Studies on earthworm diversity in and around Nanda Devi Biosphere Reserve. Population density in different soil depths was investigated for nine species of earthworms.
- Nutrient analysis of 5 different populations of sea buckthorn was conducted. Dharali (Garhwal Himalaya) population exhibited elite characteristics with respect to the nutrient and mineral composition.
- Established a Rural Technology Park at Maletha village and demonstrated environment -friendly low-cost technologies. A total of 140 persons were trained.

- Two trainings, each of five days on natural resources management were organized for 80 students from 30 students of Garhwal region.

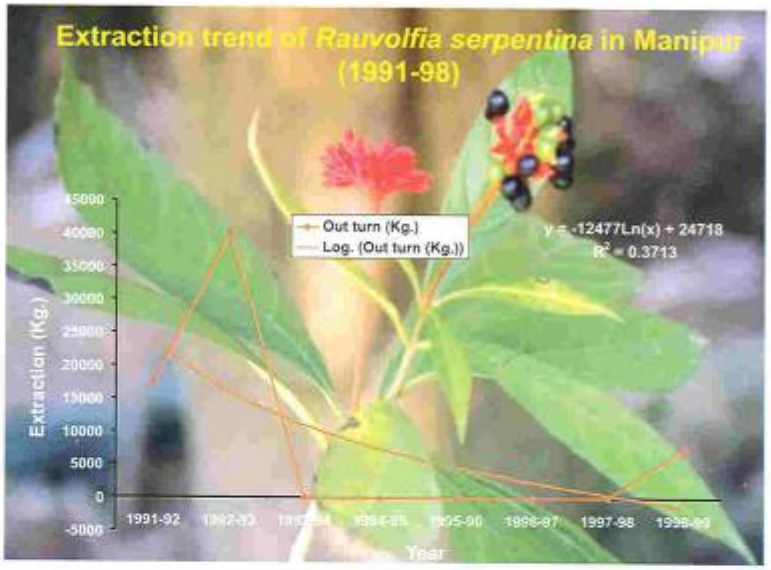
SIKKIM UNIT

Five (2 day) training programme on disaster management

Expert group meeting on national global positioning system

- Strengthened Rhododendron arboretum with germplasm of some rare, endangered, endemic and economically important species at Pangthang (Sikkim).
- Organized an interactive programme with school children under the programme on "Peoples participation for biodiversity conservation".
- Under the Technology vision 2020 Mission Mode Project on Agriculture Potential of TIFAC participatory R&D work was completed out with the farmers of Sikkim and low-cost technological interventions were provided to farmers (Please see page 72 for details).
- Collaborative project on "Geometry, Kinematics and Deformation mechanisms in Darjeeling - Sikkim Himalaya using GPS geodesy was completed (Please see page 73 for details).
- A project on Sikkim Himalayan Rhododendrons was completed with development of a complete regeneration protocol for a rare threatened species, Rhododendron maddeni (Please see page 83 for details).
- The project on capacity building of mountain farmers of Sikkim was successfully accomplished and low-cost biotechnological packages were employed for generating economic incentives (Please see page 84 for details).

NORTH-EAST UNIT



Workshop on Technology Backstopping in NE India

Training (3 day) on Contour Hedgerow and Low input farming

- An ICAR-NATP funded project aimed at land capability restoration and capacity building for technology dissemination was successfully completed (Please see page 29 for details).
- Investigations on land use/cover, soil physico-chemical properties on indigenous land use practices in Senkhi watershed in Arunachal Pradesh were carried out.
- Studies were undertaken on local customary laws and their efficacy for natural resource management among selected tribal communities of N.E. region (Apatani tribe in lower Subansiri district of A.P.).
- Collection and analysis of secondary data on income generated through collection of NTFPs by the major tribal groups (viz. Akas, Mijis and Burgurs) in west Kameng district, Arunachal Pradesh.
- Studies on maize crop in shifting cultivation found output: input ratio of 1:3 and 1:8 in monetary and energy terms, respectively.
- A DST funded project on impact of contour hedgerow intercropping on crop productivity and soil fertility in shifting cultivation was completed (Please see page 30 for details).
- Market survey of important revenue generating non-timber species was conducted in Assam and Arunachal Pradesh.

Application of R&D Outputs in Demonstration & Dissemination

Capacity Building

(a) *Livelihood Options*

The Institute has established Rural Technology Centers (RTCs) at its HQs (Kosi-Katarmal, Almora) and Gartrwal Unit (at Maletha Village). Imparting training on sustainable livelihood practices through participatory technology transfer method is a major goal of these RTCs. Training of trainers (ToTs) and progressive farmers from the region, who have potential of training others and understanding the intricate details of scientific interventions, was attempted. Apart from this, dissemination and demonstration is an integral part under most of the R&D activities. The major activities carried out under these efforts are as follows:

Technical support on integrated water harvesting and pisciculture

Improving income generating options

1. Under a regional collaborative programme "People and Resource Dynamics in Mountain Watersheds of Hindu-Kush Himalaya" technical support on integrated water harvesting coupled with pisciculture helped over 45 farmers of 24 villages, which enabled them to earn an additional income of Rs. 1,39,200 (Table 22). The same activity linked with off-season vegetables and cash crop cultivation, high yielding agricultural crops, and nursery development etc., adopted by over 110 farmers of 34 villages, earned a net profit of Rs.1860 to 37,672 during the year.

Table 22. Progression of fish farming activity (2000 to 2004) in Bhetagad-Garur Ganga watershed, Uttaranchal

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

2. Based on Institutes inputs on fish-livestock-crop farming (tri commodity approach), two farmers at village Bascti and Manan (Amora District, UA) adopted the fish polyculture, poultry/duck farming and vegetable cultivation coupled with supply of safe drinking water.

3. During the reporting period, 21 training courses (3 day each) were organized under the title "Krishak Vikas Evam Aarthik Uttathan" for

Trainings on Krishak Vikas Evam Aarthik Uttathan

On-site trainings on organic cultivationand post-harvest technology

officials of various Govt. organizations, farmer groups, and other stakeholders of Uttaranchal. A total of 727 persons (433 males and 294 females) were trained. Similarly, 19 training courses (1-3 days) were organized for different NGOs representatives (662) farmers and students (301 males and 361 females). Also, an amount of Rs. 5.6 lakhs was generated through this activity.

4. Under the broad objectives of Technology Vision 2020 Mission Mode Project on Agriculture of Technology Information, Forecasting and Assessment Council (TIPAC) in Sikkim on-site training camps for organic cultivation and post-harvest technology for vegetables and ginger were organized at 3 villages. Also, the technique of solar treatment of ginger (pre-sowing) and storage methods were demonstrated.

On-site trainigs on nursery and plantation techniques

5. On-site training programme on nursery development, tree plantation techniques, and natural resource conservation and management was organized at village Saim Dev in Almora district in collaboration with NIDHI (NGO of Uttaranchal). A total of 150 persons from 17 villages including farmers, rural women, ex-army personnel, students and teachers, and representatives of various NGOs attended (Fig. 42).

Fig. 42. On-site training programme at Saim Dev village, Distt. Almora (U.A.)

Trainings on cost effective rural technologies

6. Three training programmes (3 days each) focusing on cost-effeciive and appropriate rural technologies were organized at ihe Maletha (Tehri-Garhwal) demonstration site and a total of 140 persons (75 local farmers, 5 NGOs and 60 University students) were trained.

Capacity building of mountain farmers and rural women on farm based simple technologies

7 Under the completed project on "Capacity building of mountain fanners and rural women on farm based simple technologies" following was achieved; (i) demonstration of six technological packages through extension-oriented activities in a cluster of households in two different ecological zones (subtropical and temperate) of the Mamlay watershed (Sikkim); (ii) construction of two improvised cardamom curing kiln at temperate region (Jaubari village and Darakharka) of the watershed; (in) devlopment of twenty-two polytunnels in the farmers' field for off-season vegetable production, and (iv) introduction of mushroom cultivation. Each user group could generate additional income in the ratio 1:3 (investment: earning) through better market demand of improved quality seed/seedlings/ vegetabies at the sites of intervention.

(b) *Natural Resource Conservation and Management*

Trainings on NRM and eco-tourism

Establishment of conservation models in identified schools

1. Two trainings (5 days each) on natural resource management were organized for 80 students from 30 schools of Garhwal. Similarly a programme on eco-tourism promotion in Nanda Devi Biosphere Reserve (NDBR) was organized (over 70 people participated).

Fig. 43. Demostration and trainings on low cost environment friendly technologies at Rural Technology Centre, Kosi- Almora

2. Seeking the participation of students and teachers' establishment of six biodiversity conservation models was initiated in the identified schools of Kumaun (GIC Majkhali, 3 ha and GIC Binta 1.5 ha- Almora; GIC Wajula 1.5 ha- Bageshwar; GIC Gangolihat 2 ha and GGIC Gangolihat 1 ha - Pithoragarh; GIC Pati 2 ha -Champawat).

Demonstrations on protected cultivation

3. Demonstrations on protected cultivation- polyhouse, bio-composting, vermi-composting, green manuring, agroforestry, horticulture, multi-purpose tree plantations, cash crop cultivation, water harvesting technology, fish farming, soil conservation measures, etc. were demonstrated in different parts of IHR (Fig. 43).

Awareness Generation and Interactions

The growing realization that conservation efforts need to be promoted and implemented by bringing local people into the conservation movement and considering them as potential allies has prompted various organizations to take initiatives in this direction. However, the initiatives in the Himalayan region are not adequate. Considering this gap, an initiative was made to bring the various target groups into the conservation movement.

(a) Conservation Education

Orientation course on conservation education

Facilitating participatory weather data recording in schools

1. An orientation course on Conservation Education was organized at GIC Ramgarh (20th Nov. - 26th Nov. 2004) in Nainital district for 23 identified teachers of different educational institution of four districts of Kumaun (Almora, Bageshwar, Pithoragarh and Champawat). This event was followed by a three-day (24 - 26 November 2004) training workshop, which was attended by 70 participants (18 teachers and 52 students) representing 18 schools of district Nainital.

2. As a technical resource center under "U-PROBE" (Participation of youth in real time/field observations of various meteorological parameters to benefit the environmental education in Uttaranchal was facilitated in nine identified schools of Kumaun region. Also, the activities for participatory and interactive learning for the students was initiated in different schools (GIC, Almora, GIC, Pithoragarh and GIC, Kausani) wherein following were focused: (i) introduction of weather and their measuring elements; (ii) application of weather instruments and its uses; (iii) demonstration of order and accuracy of readings (Fig. 44).

3. The HP Unit organized an exposure workshop targeting 21 teachers belonging to different schools/institutions (Kullu and Solan district). Also, two participatory training lectures were delivered among 60 teachers (eco-club in charges).

Fig. 44. Demonstration of meteorological observatory at GIC, Pithoragarh (U.A.)

4. At the, Sikkim unit of the Institute a programme on "People's Participation in Biodiversity Conservation" was organized for students from High school and Senior Secondary school in and around Gangtok (from East District). The course work and training was conceptualized and structured for enabling the participating students to better understand and recognize awareness activities through discourse and disscussions.

Dissemination through Interactive Forums

Forum/Event	Place & Dates	Target Groups
Patent awareness workshop	HQs, May 21, 2004	Academics, Researchers, NGOs
IERP workshop on Creation of awareness among the prospective PIs of the Himachal region	IHBT, Palampur, June 28-29, 2004	Academics, Researchers NGOs
State-level workshop on Disaster management	Pangthang (Sikkim), June 30, 2004	Govt. Officials, Academics, Researchers
Training programme on Science motivation and curiosity interest in high school standard (science) students of Garhwal region	Garhwal Unit, August 17-21 & Sept. 21-24, 2004	Students
Brain storming on Receding glaciers in Indian Himalayan region-Environmental and social implications	HQs, Almora, Sept. 11, 2004	Govt. Officials, Academics, Researchers, NGOs
National Stakeholders consultation workshop on conservation &	Hqs, Almora, Oct. 8-9, 2004	Govt. Officials, Academics, Researchers

management of pollinators for sustainable agriculture, through an ecosystem approach		
IERP workshop on Creation of awareness among the prospective PIs of the uttaranchal region	HNB Garhwal University, Srinagar, Oct. 18-19, 2004	Academics, Researchers, NGOs
Training programme on Promoting ecotourism in Nanda Devi Biosphere Reserve	Joshimath, Nov. 18-19, 2004	Govt. Officials, Academics, Researchers
Orientation course on Himalaya ki jaiv vividhata sanrakshan mai janta ki bhagidari	GIC Ramgarh, Nainital, Nov. 20-23, 2004	Teachers
Training workshop on Himalaya ki jaiv vividhata sanrakshan mai janta ki bhagidari	Ramgarh, Nainital, Nov. 24-26, 2004	Teachers, Students,
National partners consultation workshop on Conservation & management of pollinators for sustainable agriculture, through an ecosystem approach	INSA, New Delhi, Nov. 29-Dec. 1, 2004	Govt. Officials, Academics, Researchers, NGOs
Workshop on Analysis of contemporary issues related to carrying capacity of pastoralism in higher Himalaya	HQs, Almora, Dec. 7-8, 2004	Academics, Researchers, Pastoralists, NGOs
Training programme on Monitoring impacts of watershed management programmes in Himalayan mountains	HQs, Almora, Jan. 11-12, 2004	Leading NGOs of Kumaun
State- level workshop on Mainstreaming of medicinal plants for development of the region sector - Uttaranchal	INHERE, Masi- Almora, Jan. 28-29, 2005	NGOs, Farmers, Women Academics, Researchers
Training programme on simple cost-effective rural technologies	Maletha, Teri-Garhwal, Feb 2-3; Feb. 18 & Mar. 11-12, 2005	Farmers, Women, NGOs, Govt. Officials
District- Level workshop on Mainstreaming of medicinal plants	Lohaghat, Mar. 17-18, 2005	Govt. Officials, Academics, Researchers, Farmers
Training programme on Nurery development, tree plantation techniques, and natural resource conservation and management	Saim Dev village, Almora, Mar 17-19, 2005	Farmers, Women, NGOs
Meeting of the project evaluation committee under IERP programme	Pangthang, Sikkim, Mar. 19-20, 2005	Academics, Researchers
Regional workshop on Natural resource based sustainable rural development in Central Himalaya	Garhwal Unit, Srinagar, Mar. 21-23, 2005	Govt. Officials, Academics, Researchers
Training courses (40) on Krishak vikas evem arthik uttathan	HQs, Almora	Govt. Officials, NGOs, Women, Farmers

MISCELLANEOUS ITEMS

1. Membership of Professional Societies / Committees

Life Member:

National Institute of Ecology (D.K.Agrawal)

Indian Society of Tree Scientists, Solan, H.P. (G.C.S. Negi)

Indian Sociological Society, New Delhi (P.K. Samal)

Indian Water Resources Society, Roorkee (P.P. Dhyani)

Indian Association of Soil and Water Conservationists, Dehradun (P.P. Dhyani & S.C. Joshi)

Indian Society of Life Sciences (S.S. Samant & J.C. Kuniyal)

National Institute of Ecology, Jaipur and New Delhi (S.C.R. Vishvakarma)

Member:

Biotechnology Society of India (Anita Pandey)

National Geographic Society; USA (D.S. Rawat)

Himalayan Phytochemical & Grower's Association, Mandi, (H.K. Badola)

Society for Environmental Communications, New Delhi (H.K. Badola)

National Associations of Geographers of India, New Delhi (J.C. Kuniyal)

Indian Society of Life Sciences on Bioresources, Environment and Society, Kanpur (J.C. Kuniyal)

Indian Society of Glaciological Sciences, Lucknow (K.Kumar)

American Rhododendrons Society, U.S.A. (K.K. Singh)

Computer Society of India, Mumbai (S.N. Nandy)

Operational Research Society of India, Kolkata (S.N. Nandy)

Indian Society for Remote Sensing, Dehradun (S. Sharma)

Indian Society of Plant Physiology, New Delhi (S. Sharma)

International Association for Landscape Ecology, USA (S. Sharma)

Sikkim Science Society, Gangtok (S. Sharma)

World Cultural Council, Mexico (S. Sharma)

International Society for Tropical Ecology (S.C.R. Vishvakarma)

2. Awards and Honours

Prof. P. N. Mehra Memorial Young Scientist Award for the meritorious contributions in Plant Sciences (Plant Taxonomy and Plant Diversity Evaluation) for the year 2001 (S.S. Samant)

3. Scientific Publications

(I). Scientific Journals

Agnihotri, R.K., S. Sharma, M. Joshi & L.M.S. Plani (2004). Crop diversity in the home gardens of Kumaun region of Central Himalaya, India. *Plant Genetic Resources* 138: 23-28.

Airi, S., R.S. Rawal & U. Dhar (2005). Presowing treatment effects on germination of *Cornus capitata* seeds. *Seed Science & Technology* (33): 77-86.

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Butola, J.S. & H.K. Badola (2004). Effect of pre-sowing treatment on seed germination and seedling vigour in *Angelica glauca*, a threatened medicinal herb. *Current Science* 87: 796-799.

Butola, J.S. & H.K. Badola (2004). Seed germination improvement using chemicals in *Heracleum candicans* Wall. a threatened medicinal herb of Himalaya. *Indian Forester* 130 (5): 565-572.

Chandra, B., L.M.S. Palni, & S.K. Nandi (2004). Micropropagation of *Picrorhiza kurrooa* Royle, an endangered alpine herb, using cotyledonary node and shoot tip explants. *Phytomorphology* 54 (3/4): 303-316.

Chaurasia, B., Anita Pandey & L.M.S. Palni (2005). Distribution, colonization and diversity of arbuscular mycorrhizal fungi in Rhododendrons of central Himalayan region of India. *Forest Ecology & Management* 207 (3): 315-324.

Chaurasia, B., Pandey, A., Palni, L.M.S., Trivedi, P., Kumar, B. & N. Colvin (2005). Structural deformities in pathogenic fungi caused by diffusible and volatile compounds produced by an antagonist (*Bacillus subtilis*): *in vitro* studies. *Microbiological Research* 160(1): 75-81.

Dhyani, P.P. & C.P. Kala (2005). Current research on medicinal plants: Five lesser known but valuable aspects. *Current Science* 88(3): 335.

Farooquee, N.A., B.S. Majila & C.P. Kala (2004). Indigenous knowledge systems and sustainable management of natural resources in a high

altitude society in Kumaun Himalaya, India. *Journal of Human Ecology* 16 (1): 33 - 42.

Ghosh, P. & P.P. Dhyani (2004). Baranaaja: The traditional mixed cropping system of the central Himalaya. *Outlook on Agriculture* 33 (4): 261-266.

Ghosh, P. & P.P. Dhyani (2004). Temporal changes in soil microbial biomass and N-mineralization in sole verses intercropped paddy and foxtail millet. *International Journal of Ecology and Environmental Sciences* 30(3): 229-239.

Joshi, H.C. & S.S. Samant (2004). Assessment of forest vegetation and prioritization of communities for conservation in a part of Nanda Devi Biosphere Reserve, West Himalaya, India. *International Journal of Sustainable Development and World Ecology* 11: 326-336.

Joshi, B.K., P.K. Verma & B.P. Kothyari (2004). Erosional behavior of different land use soil of Bhetagad watershed: A case study from Indian Central Himalayas. *Journal of soil conservation* 32(2): 139-142.

Joshi, S.C., M.C.Nautiyal and M.P. Khali. (2005). Chlorophyll fluorescene characteristics of short- and long- growth cycle alpine species during their vegetative and reproductive stages. *Physiol. Mol. Biol. Plants* 11: 87-92.

Kala, C.P., N.A. Farooquee & U. Dhar (2004). Prioritization of medicinal plants on the basis of available knowledge, existing practices and use value status in Uttaranchal, India. *Biodiversity and Conservation* 13(2): 453-469.

Kala, C.P. (2004). Pastoralism, plant conservation, and conflicts on proliferation of Himalayan Knotweed in high altitude protected areas of the Western Himalaya, India. *Biodiversity and Conservation* **13**(5): 985-995.

Kala, C.P. & R.J. Shrivastava (2004). Successional changes in Himalayan alpine vegetation: two decades after removal of livestock grazing. *Weed Technology* 18: 1210-1212.

Kala, C.P. (2004). Indigenous uses and structure of chir pine forest in Uttaranchal Himalaya, India. *International Journal of Sustainable Development and World Ecology* 11(2): 205-210.

Kala, C.P. (2004). Community composition, species diversity and secondary succession in grazed and ungrazed alpine meadows of the west Himalaya, India. *International Journal of Fieldwork Studies* 2(1): 1-11.

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Kala, C.P. (2005). A multifaceted review on the biodiversity conservation of the Valley of Flowers National Park, India. *International Journal of Biodiversity Science and Management* 1(1): 25-32.

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Kumar, B., P. Trivedi, A.K. Mishra, **Anita Pandey & L.M.S. Palni** (2004). Microbial diversity of soil from two hot springs in Uttaranchal Himalaya. *Microbiological Research* 159 (2): 141-146.

Kumar, S., K.K. Singh & L.K. Rai (2004). *In vitro* propagation of a endangered Sikkim Himalayan rhododendron (*R. maddeni*) from cotyledonary nodal segments. *Journal of American Rhododendrons Society* 58 (2): 101-105.

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Negi, G.C.S. & V. Joshi (2004). Rainfall and spring discharge patterns in two small drainage catchments in the western Himalayan mountains, India. *The Environmentalist* 24 : 19-28.

Pant, S. & R.C. Gupta (2004). Diversity of macrofungi of Binsar wildlife sanctuary in Kumaun, west Himalaya. *Indian Journal of Forestry* 27 (4): 334-334.

Pandey A. & L.M.S. Palni (2004). Tea rhizosphere: microbial diversity and characteristic features and comments on microbial communication in rhizosphere. *International Journal of Tea Science* 3 (3&4): 285 - 290.

Purohit, V.K., S.K. Nandi, L.M.S. Palni, N. Bag & **D.S. Rawat** (2004). Successful air layering in *Myrica esculenta* a simple and clonal method of propagation. *Science Letters* 27 (5&6): 205 - 208.

Rawat, Y.S., S.S. Oinam, S.C.R. Vishvakarma & J.C. Kuniyal (2004). *Saussurea costus* (Falc.) Lips.: A promising medicinal crop under cold desert agroecosystem in North Western Himalaya. *Indian Journal of Forestry* 27(3): 297 - 303.

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Chaurasia B, A. Pandey & L.M.S. Palni (2004). Occurrence of arbuscular mycorrhizae in the rhizosphere of Himalayan Yew (*Taxus baccata* L. subsp. *wallichiana* (Zucc.) Pilger) - A case study. In: G.K. Podila & AK Varma (eds.), *Basic Research and Applications of Mycorrhizae*. IK International Pvt. Ltd., New Delhi, pp. 26 - 35.

D.S. Rawat (2004). Chara Parvandhan ke Vibhin Aayam. In: *Samarika*, pp. 1- 3.

D.S. Rawat & D.S. Bisht (2004). Uttaranchal me bhoomi sanrachhan ke parampargat vidhiya. In: P.C. Pande (ed.), *Madya Himalaya ke Paramparei Evam Paramparik Gyan*, pp. 147 - 158.

Dhar, U. & R.S. Rawal (2004) Environmental education- Focus on promoting conservation education. In: S.K. Dash (ed.), Master Training Workshop on PROBE Project in Uttaranchal. Centre for Atmospheric Sciences IIT, New Delhi, 1: 316 - 321.

Dhyani, P.P. (2004). The Badrivan model for reforestation of degraded lands and biodiversity conservation. In: D. Harmon & G. Worboys (eds.), *Managing Mountain Protected Areas: Challenges and Responses for the 21st Century*. Andromeda Editrice Press Publication, Colledara, Italy, pp. 192 - 195.

Dhyani, P.P. (2004). Role of religion in ecological restoration and biodiversity conservation. In: L.M. Khubchandani (ed.), Gandhi, Ganga, Giriraj, Navajivan Trust & NWO Publication, pp. 147 - 152.

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Kimothi, M.M., J.K. Garg, Ajai, J.S. Rawat, R.K. Maikhuri & V. Joshi (2004). Potential of IRS-P6 LISS IV data for discrimination of underutilized wild trees/shrubs in Uttaranchal. IRS-P6 Early Evaluation Studies, SAC/ RESIPA/SR-02.

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Kuniyal, J.C. & S. Bhowmick (2005). Ambient air quality in the hill spots of Kullu-Manali tourist complex, northwestern Himalaya, India. In: J. Singh (ed.), *Environment Development Challenges & Opportunities*. I.K. International Pvt. Ltd., New Delhi, pp. 483 - 495.

Maikhuri, R.K., K.S. Rao & S. Nautiyal (2004). Land use land cover change impacts on strategies for rehabilitation of degraded land: A case study from the Central (lesser) Himalaya (Uttaranchal). In: M.S.S. Rawat (ed.), *Central Himalaya: Potentials, Actions and Challenges*. Printmedia Publication, Srinagar Garhwal, pp. 230 - 240.

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Pandey A., P. Trivedi, B. Kumar, B. Chaurasia, S. Singh & L.M.S. Palni (2004). Development of microbial inoculants for enhancing plant performance in mountains. In: M.S. Reddy & S. Khanna (eds.), *Biotechnological Approaches for Sustainable Development*. Allied Publishers Pvt. Ltd, New Delhi.

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Ramakrishnan, P.S., K.G. Saxena, M.J. Swift, K.S. Rao & R.K. Maikhuri (2005). *Soil Biodiversity: Ecological Processes and Landscape Management* (eds.). Oxford & IBH, New Delhi, pp. 466.

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of the National Conference on Resource Conserving Technologies for Social Upliftment (Extended Abstracts). Indian Association of Soil and Water Conservationists, CSWCRTI, Dehradun, pp. 427 - 429

Saxena, K.G., R.K. Maikhuri & K.S. Rao (2004). Changes in agriculture biodiversity: Implications for sustainable livelihood in the Himalaya. In: Saxena, K.G., L. Liang, Y. Kono & S. Miyata (eds.), *Small-scale Livelihoods and Natural Resources Management in Marginal Areas: Case Studies in Monsoon Asia.* UNU Press, Tokyo, pp. 49 - 65.

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Sundriyal, R.C. & S.C. Jamir (2005). Contour hedgerow intercropping for improving crop yields and ecosystem function. *In:* Ramakrishnan, P.S., Saxena, K.G., Swift, M.J., Rao, K.S. & Maikhuri, R.K. (eds.), *Soil Biodiversity Ecological Processes and Landscape Management,* Oxford & IBH, New Delhi, p. 211 - 217.

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

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Kuniyal, J. C., S.C.R. Vishvakarma, H.K. Badola & A.P. Jain (2004) *Tourism in Kullu Valley: An Environmental Assessment.* Bishen Singh Mahendra Pal Singh, Dehradun, pp. 210.

Rao, K.S., R.K. Maikhuri, K.K. Sen, A.K. Das, R.L. Semwal, K. Singh & K.G. Saxena (2005). Soil fertility management in settled farming systems of Himalaya. In: Ramakrishnan, P.S., K.G. Saxena, M.J. Swift, K.S. Rao & R.K. Maikhuri (eds.), *Soil Biodiversity: Ecological Processes and Landscaope Management.* Oxford & IBH, New Delhi, pp. 243-276.

4. Popular Articles

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Dhyani, P.P. & C. P. Kala (2005). Current research on medicinal plants: Five lesser known but valuable aspects. *Current Science* 88 (3): 335.

Gaira, K.S., A. Andola & A. Bhatt (2004). U- Probe - Yuvaoo main vaigyanin chetna ka karyakram. In: Dhar, U., R.S. Rawal & S. Airi (eds.), *Himalaya ki Jaib Vividhata Sangrakshan me Janta ki Bhagidhari* (in hindi), GBPIHED, Kosi- Katarmal, Almora. 11: 52 - 59.

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(II). Participation of Institute Faculty/ Project staff in different events

Events	HQs	Units				Total
		NE	Sikkim	Garhwal	HP	
National						
• Symposia / Conference / Training Courses / Workshops	23	01	01	09	10	44
• Training Courses	15	00	01	01	01	18
• Meetings	26	03	03	10	08	50
• Partipation as a Resource Person	05	00	00	02	16	23
International	02	01	00	00	01	04

Singh K.V. Gupta & Co.
Chartered Accountants
7/38, Ansari Road Darya Ganj,
New Delhi-110 002
Tel: 011-23275713,23260728
Branch Office: Mall Road, Almora 263 601
Tel: 05962-233170, 233270

To
The 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 Govind Ballabh Pant Himalayan Paryavaran Evam Vikas Samiti)** as at 31stMarch, 2005, 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 Kosi-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

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

b) Non provision of sales tax liability for wrong issue of "D" form against purchases.

c) Non provision of liability towards income tax, if any.

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

e) Non provision of retirement benefits payable to employees.

f) Non provision of liability for not getting registration with Provident Fund Department.

g) We have not checked the working of depreciation on fixed assets since 1988-89 but have relied only on calculation provided by the management.

h) Subscription for various magazines for library Rs.10,43,363/- charged to revenue instead of capitalizing the same under Fixed Assets.

i) In the case of balance sheet, of the state of affairs of the Institute as at 31st March2005.

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 receipts & payments of the Institute on that date.

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

Sd/-
RAKESH K. AGGARWAL
(PARTNER)
M.NO.85908

DATED: 17-08-2005
PLACE: ALMORA

SEAL

Singh K.V. Gupta & Co.
Chartered Accountants
7/38, 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

BALANCE SHEET AS ON 31ST MARCH 2005

PARTICULARS	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
CORPUS / CAPITAL FUND	1	15619133.80	13742521.64
RESERVE AND SURPLUS	2	329316478.11	375147059.84
EARMARKED / ENDOWMENT FUNDS	3	32219962.64	28285346.28
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	31528095.70	29424859.05
TOTAL		408683670.25	446599786.81
ASSETS			
FIXED ASSETS	8	296954862.11	313542595.84
INVEST. FROM EARMARKED/ENDOWMENT FUND	9	26837587.00	6464718.00
INVEST. OTHERS	10	0.00	0.00
CURRENT ASSETS, LOANS, ADVANCES ETC.	11	84891221.14	126592472.97
MISCELLANEOUS EXPENDITURE			
TOTAL		408683670.25	446599786.81

SIGNIFICANT ACCOUNTING POLICIES 24

CONTINGENT LIABILITIES & NOTES ON ACCOUNTS 25

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

Sd/-
(RAKESH K. AGGARWAL)
(PARTNER)
M.NO.85908

DATED : 17/08/2005
PLACE : ALMORA

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

Sd/-
(DR. P.K. SAMAL)
(D.D.O)

Sd/-
(NEENA KAPOOR)
(FINANCE OFFICER)

SEAL

Singh K.V. Gupta & Co.
Chartered Accountants
7/38, Ansari Road Darya Ganj, New Delhi-110 002
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G.B.PANT INSTITUTE OF HIMALIYAN ENVIRONMENT & DEVELOPMENT KATARMAL, KOSI (ALMORA) UTTARANCHAL

INCOME & EXPENDITURE A/C FOR THE YEAR ENDED 31ST MARCH 2005.

PARTICULARS	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
INCOME			
Income from Sales/Services	12	132488.00	151935.00
Grants/Subsidies(net off exp)	13	72141906.63	80897489.00
Fees/Subscriptions	14	0.00	0.00
Income tfr from Fixed Assets fund (to the extent of depreciation)		73872984.73	
Income from Royalty,Income from Inv. Publication etc.	16	345.00	320.00
Interest Earned	17	746233.16	690186.97
Other Income	18	997546.00	1804202.70
Increase (decrease) in stock of Finished goods and work in progress)	19	0.00	0.00
T O T A L (A)		**147891503.52**	**83544133.67**
EXPENDITURE			
Establishment Expenses: a) Institute	20	14508935.00	13609150.00
b) Projects		6597174.00	6754234.00
c) F.C (Projects)		2465325.00	2060481.00
Administrative Expenses : a) Institute	21	27014913.13	36592929.00
b) Projects (As per Annexure)		8083983.00	11419023.00
c) F.C (Projects)(As per Annexure)		2849300.50	1252574.00
Expenditure on Grants, Subsidies etc.	22	10622276.00	9209098.00
Interest		0.00	0.00
Depreciation (Net Total at the year-end as per Sch. 8)		73872984.73	0.00
T O T A L (B)		**146014891.36**	**80897489.00**
Balance being excess of Income over Expenditure (A - B)		1876612.16	2646644.67
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		**1876612.16**	**2646644.67**
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/-
(RAKESH K. AGGARWAL)
(PARTNER)
M.NO.85908

DATED : 17/08/2005
PLACE : ALMORA

SEAL

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

Sd/-
(DR. P.K. SAMAL)
(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 2005

Singh K.V. Gupta & Co.
Chartered Accountants
7/38, Ansari Road Darya Ganj,
New Delhi-110 002
Tel: 011-23275713, 23260728
Br. Off: 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	30308.05	339.05	**a) Establishment Expenses**	13512417.00	13542112.00
b) Bank Balances			**b) Administrative expenses**		
i) In current accounts	1744153.85	3964241.53	a) Institute	15312390.13	26445884.00
ii) In deposit accounts	0.00	0.00	b) R&D (Rev) expenses	10334216.00	
iii) Savings accounts	17200659.70	11871981.74	c) Payments for current liabilities	19272381.05	35974.70
c) Advances & Others	39710693.03	32634818.42	**c). Capital expenditure**		
(As per annexure Attached)			a) Purchase of Fixed Assets	17155264.00	9819561.00
F.C. ACCOUNT			b) Expenditure on Capital Work in Progress	9000000.00	8000000.00
A) Cash in hand	406.00		**II. Payments made against funds for various proj.**	0.00	27382355.00
b) Cash at bank	1051207.84		**Expenditure State govt. projects**		
II. Grants Received			a) Capital	5959878.00	0.00
a) From Government of India			b) Revenue;		0.00
i) Institute	63000000.00	63500000.00	Establishment exp	6597174.00	
ii) IERP Projects	7000000.00	28466786.00	Administration exp	8083983.00	
b) From State Government	14531024.00	0.00	**Expenditure FC projects**		
c) From other sources [from FC]	5498970.06		a) Capital	100714.00	
III. Income on Investments from			b) Revenue:		
a) Earmarked/ Endow.Funds	427825.43	389459.75	Establishment exp	2465325.00	
b) Loans, Advances etc.	0.00	0.00	Administration exp	2849300.50	0.00
IV. Interest Received			**IERP grant released**	10694383.00	0.00
a) On Bank deposits savings a/c	371184.98	598835.97	**III Investments and deposits made**		
b) On term deposits a/c	108473.18		a) Out of Earmarked/ Endowment funds	0.00	0.00
c) Loans, Advances etc.	261995.00	91351.00	b) Out of own funds (Investments Others)	0.00	0.00
			c) General Fund	0.00	3100000.00
V. Other Income			**IV Refund of Surplus money/Loans**		
(As per annexure Attached)	1130231.00	1956457.70	a) To the Government of India	5856.00	49161.00
VI. Amount Borrowed	0.00	0.00	b) To Others/ security / caution money	0.00	10580.00
VII. Any other receipts.			**V Other payments**		
a] (As per annexure Attached)	4303742.93	4007151.17	PF withdrawl/ transfer	796814.00	409980.00
b) Advance FC a/c	190073.00	0.00	PF Bank Charges	138.00	0.00
c) receipts current liabilities	18308914.63		**VI Closing balances**		
d) IERP grants refunded by grantee Org.	72107.00		**a) Cash in hand**	11984.05	30308.05
e) Suspense a/c FC	68848.00		**b) Bank Balance**		
			i) In Current account	5749910.88	1744153.85
			ii) In deposit accounts		
			iii) In savings accounts	1342917.78	17200659.70
			C) Advances and others	44370855.89	39710693.03
			FC Project		
			a) Cash in hand	125.00	
			b) Bank Balance	1394790.40	
TOTAL	175010817.68	147481422.33	TOTAL	175010817.68	147481422.33

AUDITOR'S REPORT
As per our separate report of even date annexed.
FOR: SINGH K V GUPTA & CO.
CHARTERED ACCOUNTANT
Sd/-
(Rakesh K Aggarwal)
PARTNER
M No. 85908

SEAL

DATED : 17.8.2005
PLACE : ALMORA

Sd/-
DR. UPPEANDRA DHAR
(DIRECTOR)

Sd/-
DR.P.K.SAMAL
(D.D.O)

Sd/-
NEENA KAPOOR
(FINANCE OFFICER)

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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 31 MARCH 2005
STATEMENT OF OPENING & CLOSING BALANCES

PARTICULARS AMOUNT	OPENING AMOUNT	CLOSING
Cash & Bank Balances		
Cash In Hand :		
Srinagar	0.09	5.85
Sikkim	0.00	0.00
Kullu	7.36	1236.36
Itanagar	12540.27	19924.27
Cash at Bank Balances		
SBI Almora A/c No.01170003256 (Endo)	35548.47	36920.98
SBI Tadong A/c No 01000050044	37489.92	590315.92
SBI Kullu A/c NO.01100076038	12800.82	122195.82
SBI Itanagar A/c No 01100050337	284396.39	66392.10
SBI Srinagar A/c No 01100030433	1333399.21	914568.80
SBI Almora PF A/c 01100003255 (P.F.)	1317476.81	1275819.74
Advances		
House Building Advance	2932967.00	3167235.00
Motor cycle/Car Advance	158127.00	509017.00
Festival Advance	18450.00	21750.00
PF Advance	677678.00	814098.00
G.S.L.I	398.50	0.00
C.P.F	36.00	36.00
Revenue Stamp Recovery	(3.00)	0.00
Units of Institute:		
Sikkim Unit	42957.10	331907.10
HP Unit	0.00	32527.00
Garhwal Unit	(306774.24)	(226665.59)
NE Unit	(34232.67)	48972.62
Fixed Deposit		
With SBI Endowment Fund	6464718.00	6464718.00
Interest Accrued on FDR(General Fund)	303161.00	729613.92
SBI PF	11042365.00	10268469.00
CBI PF	5696185.00	6104400.00
Interest Accrued on FDR(PF)	2748214.00	2525923.00
Post office savings	0.00	4000000.00
FDR (Margin Money/LC A/C)		
Biotech-XIII	2424000.00	0.00
Institute	2828256.00	4283412.00
BIOTECH -XI	67732.00	577.00
BIOTECH -XII	758.00	0.00
DST MN	0.00	184000.00

SEAL

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

Due Staff/ other IC A/c		
Dr.Mukesh Joshi (Bitech-XII)	(1000.00)	(1000.00)
Allen Press Inc (SDRE)	7711.00	0.00
M/s Amersham Bio Sciences(EPB)	147759.00	0.00
A.S.Parihar	0.00	0.00
Post Master G.P.O Almora	10052.00	2.00
M/s Bio-rad Laboratories, Australia	81344.00	81344.00
Employment News	13287.00	48287.00
Sigma Aldrich Chemicals	10590.00	10590.00
Siltap Chemicals Ltd (Biotech -III)	408.00	408.00
NRSA Hyderabad	8400.00	158400.00
R.K.Nanda & Sons	28517.00	28517.00
Elsvier Science (CSIR-AP)	9500.00	0.00
S.K.Gurani (IERP)	(75.00)	0.00
NRSA Hyderabad (MOE & F-KSR)	138000.00	11500.00
M/s Environmental Data Pvt. Ltd.	153503.00	0.00
M/s TKA Wasse Stockland Germany	351000.00	0.00
NIC New Delhi	495000.00	67147.00
Sh. Chander Lal (LTC)	838.00	838.00
Sh. Suraj Lal LTC	1296.00	0.00
Dr. Varun Joshi (DST- KK-II)	9000.00	0.00
M/s Bio-Rad Scientific (Biotech-XIII)	68148.00	0.00
Garden Supdt.,Ranikhet (Apple-UD)	8250.00	0.00
NRSA Hydrabad (ISRO-GBP-SS)	40000.00	0.00
NRSA Hydrabad (DST-KK-I)	22200.00	7400.00
Allen Press Inc (KANSAS)	5813.00	0.00
M/s Backman Coultr. Intl. Switezerland	0.00	0.00
F.C.Inter A/C	2500.00	2500.00
DST U-PROBE :Principal GIC Danya	0.00	6000.00
Principal,GIC Kheti	0.00	6000.00
Principal GIC Lamgara	0.00	6000.00
Principal , GIC Barechina	0.00	6000.00
Principal GIC Hawalbagh	.00	6000.00
DST NB Pantnagar Univ.grant tfr	0.00	221298.00
M/s TERI New Delhi	0.00	150000.00
M/s CCU New Delhi	0.00	790000.00
Mr P S Bhakuni	0.00	1440.00
M/s Spectronics Corpn.	0.00	48000.00
M/s Hind Motors Dehradun	0.00	368815.00
M/s Atto Corporation	0.00	58000.00
TOTAL	**39710693.03**	**44370855.89**

SEAL

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G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT
KATARMAL, KOSI (ALMORA) UTTARANCHAL
DETAILS OF FIXED ASSETS AS ON 31st MARCH 2005
(corresponding to schedule 8)

Particulars	Cost as on 1/4/2004	Addition during the Year	Cost at the end of the Year	Depreciation Upto 31.03.2004	Depreciation for 2004-05	Total Depreciation	Cost of Sales/ Tfd. During The Year	Closing Bal as on 31.03.05
Land	75639.23	0.00	75639.23	0.00	0.00	0.00	0.00	75639.23
Building	152108848.00	38242848.00	190351696.00	5579239.76	3102732.65	8681972.41	0.00	181669723.59
Furniture & Fixture	**14795280.40**	**796449.00**	**15591729.40**	**5947582.64**	**951159.86**	**6898742.50**	**0.00**	**8692986.90**
(Details)								
Institute	14777673.40	796449.00	15574122.40	5936437.41	950045.34	6886482.75	0.00	8687639.65
ICIMOD SALT	11000.00	0.00	11000.00	6963.00	696.30	7659.30	0.00	3340.70
ICIMOD ISSMA	6607.00	0.00	6607.00	4182.23	418.22	4600.45	0.00	2006.55
Scientific Equipments	**92802238.11**	**15430582.00**	**108232820.11**	**29339938.97**	**5141058.95**	**34480997.92**	**0.00**	**73751822.19**
(Details)								
Institute	69858922.19	9369990.00	79228912.19	22407626.85	3763373.33	26171000.18	0.00	53057912.01
DST (RSR)	7415.00	0.00	7415.00	3874.34	352.23	4226.57	0.00	3188.43
BIOTECH-I	1840346.00	0.00	1840346.00	898503.91	87416.50	985920.41	0.00	854425.59
BIOTECH-II	4029751.00	0.00	4029751.00	1863357.08	191413.50	2054770.58	0.00	1974980.42
BIOTECH-III	2129381.00	0.00	2129381.00	720380.76	101145.61	821526.37	0.00	1307854.63
UNDP (HAIGAD)	70960.00	0.00	70960.00	29617.20	3370.60	32987.80	0.00	37972.20
CSIR (RCS)	137948.00	0.00	137948.00	54064.22	6552.53	60616.75	0.00	77331.25
DST (SKB)	808564.00	0.00	808564.00	345661.11	38407.00	384068.11	0.00	424495.89
Fao-Bio-Diversity	132792.00	0.00	132792.00	33456.72	6307.62	39764.34	0.00	93027.66
ICAR (ES)	174507.00	0.00	174507.00	41176.33	8289.10	49465.43	0.00	125041.57
ENVIS	242380.00	0.00	242380.00	102671.81	11513.05	114184.86	0.00	128195.14
NWDPRA	64858.00	0.00	64858.00	24646.04	3080.71	27726.75	0.00	37131.25
IEG PROJECT	52465.00	0.00	52465.00	16744.70	2492.09	19236.79	0.00	33228.21
DST (SKN)	323172.00	0.00	323172.00	122805.36	15350.67	138156.03	0.00	185015.97
BIOTECH (V)	112159.00	0.00	112159.00	22554.62	5327.60	27882.22	0.00	84276.78
WWF (CBD)	7700.00	0.00	7700.00	2560.25	365.75	2926.00	0.00	4774.00

Contd...

Particulars	Cost as on 1/4/2004	Addition during the Year	Cost at the end of the Year	Depreciation Upto 31.03.2004	Depreciation for 2004-05	Total Depreciation	Cost of Sales/ Tfd. During The Year	Closing Bal as on 31.03.05
HAIGAD II	115438.00	0.00	115438.00	38383.14	5483.31	43866.45	0.00	71571.55
NORAD	1921158.00	0.00	1921158.00	996031.34	91255.03	1087286.37	0.00	833871.63
ICIMOD (SALT)	216447.92	0.00	216447.92	72267.55	10281.30	82548.85	0.00	133899.07
INDO CANADIAN	180076.00	0.00	180076.00	83065.53	8553.65	91619.18	0.00	88456.82
ICIMOD ISSMA	67161.00	0.00	67161.00	31901.47	3190.15	35091.62	0.00	32069.38
ECO-TOURISM	75738.00	0.00	75738.00	28409.80	3597.56	32007.36	0.00	43730.64
MACARTHER UNESCO	63450.00	0.00	63450.00	20455.88	3013.90	23469.78	0.00	39980.22
ICIMOD (PARDYP)	349590.00	24600.00	374190.00	66609.25	17774.05	84383.30	0.00	289806.70
ICIMOD (CBD)	52801.00	0.00	52801.00	15048.29	2508.10	17556.39	0.00	35244.61
ICIMOD (FIBRE)	216882.00	0.00	216882.00	60969.57	10301.90	71271.47	0.00	145610.53
MRE	2450.00	0.00	2450.00	698.25	116.40	814.65	0.00	1635.35
Icimod-GIS Equipment	148800.00	0.00	148800.00	42408.00	7068.00	49476.00	0.00	99324.00
BIOTECH (IV)	244811.00	0.00	244811.00	58142.61	11628.60	69771.21	0.00	175039.79
BIOTECH (VI)	701137.00	8841.00	709978.00	107012.75	33724.00	140736.75	0.00	569241.25
BIOTECH (IX)	1470488.00	44923.00	1515411.00	157838.80	71982.02	229820.82	0.00	1285590.18
BIOTECH (XI)	495039.00	0.00	495039.00	65965.48	23514.40	89479.88	0.00	405559.12
BIOTECH (XII)	1293703.00	0.00	1293703.00	174116.52	61450.90	235567.42	0.00	1058135.58
BIOTECH (XIII)	135763.00	3399643.00	3535406.00	6448.74	167931.80	174380.54	0.00	3361025.46
CSIR (AP)	105004.00	0.00	105004.00	14963.07	4987.70	19950.77	0.00	85053.23
DST (HCR)	106144.00	10655.00	116799.00	10613.02	5548.00	16161.02	0.00	100637.98
DST (KK)	508702.00	0.00	508702.00	103492.91	24163.40	127656.31	0.00	381045.69
CSIR(SCR)	507339.00	0.00	507339.00	119924.53	24098.60	144023.13	0.00	363315.87
MOE&F (RSR)	13541.00	0.00	13541.00	1929.59	643.20	2572.79	0.00	10968.21
MED.ARO. PLANT	76320.00	43513.00	119833.00	10875.60	5692.10	16567.70	0.00	103265.30
ISRO (APK)	135667.00	0.00	135667.00	26561.62	6444.20	33005.82	0.00	102661.18
ISRO-GBP	212190.00	397800.00	609990.00	10079.03	28974.55	39053.58	0.00	570936.42
MOE&F (NDMD)	148900.00	0.00	148900.00	35363.75	7072.80	42436.55	0.00	106463.45
DST (GCSN)	52281.00	0.00	52281.00	12005.86	2483.40	14489.26	0.00	37791.74
BIOTECH VIII	145850.00	0.00	145850.00	18311.63	6927.90	25239.53	0.00	120610.47
MOE&F (US)	11076.00	0.00	11076.00	2104.44	526.11	2630.55	0.00	8445.45
DST(MANJU SUND.)	29877.00	0.00	29877.00	4257.47	1419.20	5676.67	0.00	24200.33
ICAR-NATP (RCS)	967575.00	0.00	967575.00	122309.65	45959.81	168269.46	0.00	799305.54
CSIR(RKM)	149400.00	0.00	149400.00	21289.50	7096.50	28386.00	0.00	121014.00
DST (SCR)	57242.00	0.00	57242.00	8156.99	2719.00	10875.99	0.00	46366.01
DST KK II	89790.00	97300.00	187090.00	5832.53	8886.85	14719.38	0.00	172370.62
DST KK GPS SURVEY	0.00	4454.00	4454.00	0.00	211.55	211.55	0.00	4242.45
ICAR [NATP] KSR	120931.00	0.00	120931.00	10531.08	5744.22	16275.30	0.00	104655.70
ENVIS II	119200.00	14990.00	134190.00	11324.00	6374.05	17698.05	0.00	116491.95
MED PLANT B. [UD]	62900.00	30760.00	93660.00	5457.75	4448.90	9906.65	0.00	83753.35
DST [KKS/SCR]	58012.00	0.00	58012.00	3528.59	2755.60	6284.19	0.00	51727.81
DST-UD	136323.00	42415.00	178738.00	6475.34	8490.10	14965.44	0.00	163772.56

Contd...

Particulars	Cost as on 1/4/2004	Addition during the Year	Cost at the end of the Year	Depreciation Upto 31.03.2004	Depreciation for 2004-05	Total Depreciation	Cost of Sales/ Tfd. During The Year	Closing Bal as on 31.03.05
DST-JCK	826184.00	135000.00	961184.00	39243.74	45654.25	84897.99	0.00	876286.01
DST-VJ	100470.00	969088.00	1069558.00	4772.33	50804.00	55576.33	0.00	1013981.67
DST-RKM	177115.00	109039.00	286154.00	8412.96	13592.32	22005.28	0.00	264148.72
DST-APPLE(UD)	83624.00	0.00	83624.00	3972.14	3972.14	7944.28	0.00	75679.72
DST-DEEPA BISHT	14000.00	34500.00	48500.00	665.00	2304.00	2969.00	0.00	45531.00
BIOTECH-XIV	42328.00	52198.00	94526.00	2010.58	4490.00	6500.58	0.00	88025.42
DST-MN PROJECT	0.00	2085.00	2085.00	0.00	99.04	99.04	0.00	1985.96
DST-Mitali Joshi	0.00	25594.00	25594.00	0.00	1215.75	1215.75	0.00	24378.25
DST-U PROBE PRO.	0.00	284800.00	284800.00	0.00	13528.00	13528.00	0.00	271272.00
DISASTER MANG. FAC.	0.00	45200.00	45200.00	0.00	2147.00	2147.00	0.00	43053.00
MOWR-GCSN PRO	0.00	98500.00	98500.00	0.00	4678.75	4678.75	0.00	93821.25
NHPC- LAKHWAR PRO.	0.00	70000.00	70000.00	0.00	3325.00	3325.00	0.00	66675.00
SWAJAL-II PROJECT	0.00	38580.00	38580.00	0.00	1832.55	1832.55	0.00	36747.45
TSBF-GEF-RKM PRO	0.00	76114.00	76114.00	0.00	3615.45	3615.45	0.00	72498.55
Office Equipments	**6231998.35**	**575310.00**	**6807308.35**	**3637411.53**	**534350.72**	**4171762.25**	**0.00**	**2635546.10**
Institute	5966654.35	575310.00	6541964.35	3593200.81	523298.04	4116498.85	0.00	2425465.50
I.E.R.P	265344.00	0.00	265344.00	44210.72	11052.68	55263.40	0.00	210080.60
Fire Fighting Equipments	**60962.00**	**0.00**	**60962.00**	**23165.56**	**2895.70**	**26061.26**	**0.00**	**34900.74**
Library	**38633448.50**	**2240062.00**	**40873510.50**	**12056036.81**	**1941491.75**	**13997528.56**	**0.00**	**26875981.94**
Vehicles (Details)	**4922632.25**	**0.00**	**4922632.25**	**3689622.45**	**318090.59**	**4007713.04**	**0.00**	**914919.21**
Institute	3393403.30	0.00	3393403.30	2639264.59	236116.95	2875381.54	0.00	518021.76
ICIMOD SALT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TSBF-RKM	280475.00	0.00	280475.00	280474.00	0.00	280474.00	0.00	1.00
MACARTHER								
UNESCO	290375.00	0.00	290375.00	290374.00	0.00	290374.00	0.00	1.00
ICIMOD	233589.95	0.00	233589.95	233588.95	0.00	233588.95	0.00	1.00
Biotech XII	724789.00	0.00	724789.00	245920.91	81973.64	327894.55	0.00	396894.45
Glass/Net House (Details)	**3911549.00**	**0.00**	**3911549.00**	**1422408.21**	**185798.58**	**1608206.79**	**0.00**	**2303342.21**
Institute	1517793.00	0.00	1517793.00	821642.65	72095.17	893737.82	0.00	624055.18
BIOTECH (III)	2050788.00	0.00	2050788.00	584474.58	97412.43	681887.01	0.00	1368900.99
DST-TIFEC(SIKKIM)	342968.00	0.00	342968.00	16290.98	16290.98	32581.96		310386.04
TOTAL Rs..	**313542595.84**	**57285251.00**	**370827846.84**	**61695405.93**	**12177578.80**	**73872984.73**	**0.00**	**296954862.11**

Projects funded by the Institute under IERP during 2004-05

1. Anthelmintic activity of some traditional medicinal plants in Mizoram by Dr. Bishnupada Roy, Department of Zoology, Pachhunga University College, Aizawl, Mizoram [Total outlay: Rs. 4,99,675/-].

2. Prodhyogiki pradarshan evam prasar yojana by Mr. Gaur Singh Kunwar, Himalayan Paryavaran, Krishi evam Grmodyog, Shiksha Nagrik "HAVEN" Samiti, Premnagar (Parsari), Joshimath, Uttaranchal. [Total outlay: Rs. 5,52,000/-].

3. *Geranium* farming: A new perspective in boosting economy of Uttaranchal by Ms. Ritu Nautiyal, Himalayan Institute for Environment Ecology and Development, Ranichauri, Tehri Garhwal, Uttaranchal. [Total outlay: Rs. 4,31,000/-].

4. Strengthening occupations in vermicomposting for enhancing agriculture production and generating rural employment in block - Narendra Nagar, District- Tehri Garhwal (Uttaranchal) by Mr. Narendra Singh Chauhan, Society for Entirety, Efficacious Development and Awareness, Rishikesh, Dehradun, Uttaranchal. [Total outlay: Rs. 4,76,000/-].

5. Use of natural carotenoids as food colorant by Dr. Bhabesh C. Goswami, Department of Chemistry, Gauhati University, Guwahati, Assam. [Total outlay: Rs. 4,01,500/-].

6. Biodiversity of spider fauna in rice agro-ecosystems of Assam by Dr. Prabal Saikia, Regional Agricultural Research Station, Assam Agricultural University, North Lakhimpur, Assam. [Total outlay: Rs. 4,99,900/-].

7. Documentation of ethnic invertebrate food resources and evaluation of nutritional content and their role in primary health care of selected tribes of Arunachal Pradesh, India by Dr. Jharna Chakravorty, Department of Zoology, Arunachal University, Rono Hills, Itanagar, Arunachal Pradesh. [Total outlay: Rs. 3,99,970/-].

8. Cultivation and propagation of high value MAPs for sustainable development and germplasm conservation in subtropical and temperate agro-climatic zones in Apatani valley by Mr. Rubu Buker, Nature Care and Disaster Management Society, Ziro, Village Lempia, Lower Subansiri, Arunachal Pradesh. [Total outlay: Rs. 5,20,000/-].

9. Changing landuse/landcover and soil loss in the Indian eastern Himalaya, a drainage basin input-output analysis, Arunachal Pradesh by Dr. R.C. Joshi, Department of Geography, Arunachal University, Doimukh, Arunachal Pradesh. [Total outlay: Rs. 5,99,725/-].

10. Action and extension of appropriate technology for jhum lands in the Papum Pare district of Arunachal Pradesh by Mr. Vishal Nath Rai, Arunachal Pradesh Sewa Sangh, Doimukh, Papum Pare, Arunachal Pradesh. [Total outlay: Rs. 5,99,500/-].

11. Attitudinal parameters of human resource and development: A study of indigenous people of Arunachal by Dr. S.K. Sharma, Department of Commerce, Dera Natung Govt. College, Itanagar, Arunachal Pradesh. [Total outlay: Rs. 3,99,900/-].

12. Survey and studies on wild mushrooms of Arunachal Pradesh by Dr. Rishikesh Mishra, Department of Botany, Dera Natung Govt. College, Itanagar, Arunachal Pradesh. [Total outlay: Rs. 2,99,250/-].

13. Qualitative analysis of the faunal biodiversity of the Kane Wildlife Sanctuary, West Siang, Arunachal Pradesh by Mr. B.B. Bhatt, North East India Biodiversity Research Foundation, State Forest Research Institute, Van Vihar, Itanagar, Arunachal Pradesh. [Total outlay: Rs. 3,99,625/-].

14. Studies on wild and semi-wild plants of Tripura with special reference to their diversity and socio-economic values by Dr. R.K. Sinha, Department of Life Science, Tripura University, Suryamaninagar, Tripura (West), Tripura. [Total outlay: Rs. 5,52,000/-].

15. Documentation and evaluation on rice bean [*Vigna umbellata* (Thumb) Ohwi and Ohashi] diversity of Nagaland by Dr. Sapu Changkija, Department of Genetics and Plant Breeding, Nagaland University, Medziphema, Nagaland. [Total outlay: Rs. 5,50,000/-].

16. Ecology and management of bamboos in home gardens of Barak valley, North- East India by Dr. Ashesh Kumar Das, Department of Ecology and Environmental Science, Assam University, Silchar, Assam. [Total outlay: Rs. 5,50,000/-].

17. Evaluation of different variant of Muskbala (*Valeriana jatamansi*) for enhanced productivity and quality under mid hill conditions of Himachal Pradesh by Dr. Virendra Singh, Natural Plant Product Division, Institute of Himalayan Bioresource Technology, Palampur, H.P. [Total outlay: Rs. 5,98,000/-].

18. Eco-restoration through involvement of religious institutions in Himachal Pradesh by Dr. R.D. Singh, Institute of Himalayan Bioresource Technology, Palampur, H.P. [Total outlay: Rs. 5,99,955/-].

19. Forest based community livelihood through sustainable protection and exploitation in Shiwalik and Shiwalik foothills of Himachal Pradesh by Mr. Pushpendra Rana, DFO - Paonta, Paonta, District - Sirmaur, H.P. [Total outlay : Rs. 5,67,000/-].

20. Evaluation of indigenous wild types of Himalayan roses for rose rootstocks by Mr. D. Dhyani, Institute of Himalayan Bioresource Technology, Palampur, H.P. [Total outlay: Rs. 4,49,995/-].

21. Farm women training in value addition of indigenous products with emphasis on post harvest management by Dr. Sangita Sood, Department of Food Science and Nutrition, Himachal Pradesh Agricultural University, Palampur, Kangra, H.P. [Total outlay: Rs. 4,79,000/-].

22. Survey, collection and maintenance of promising large Cardamom germplasm in Himachal Pradesh by Dr. R. K. Sud, Institute of Himalayan Bioresource Technology, Palampur, H.P. [Total outlay: Rs. 4,99,675/-].

23. Inventory of biomass resources and livelihood strategies by the rural populace of Mizoram by Dr. H. Lalramnghinglova, Department of Forest Ecology, Mizoram University, Aizawl, Mizoram. [Total outlay: Rs. 5,99,250/-].

24. Documentation of indigenous knowledge on traditional resources in Chakrata region, Dehradun, Uttaranchal by Dr. V.P. Sharma, Himalayan Environment and Agriculture Development Society, Maikoti, Rudraprayag, Uttaranchal. [Total outlay: Rs. 5,83,000/-].

25. Unveiling the sacred: Documenting the conservational practices of the Dev Vans of Kumaun by Dr. Girija Pande, Himalaya Sansakriti Evam Vikas Sansthan (HSVS), Nainital, Uttaranchal. [Total outlay: Rs. 5,35,500/-].

26. Dhara vikas pariyojana by Mrs. Pushpa Sharma, Neera, Pithoragarh, Uttaranchal. [Total outlay: Rs. 2,57,000/-].

27. Studies on plant diversity in Rakchham-Chitkul Wildlife Sanctuary of District Kinnaur, Himachal Pradesh by Dr. R. K. Verma, Department of Ecology and Biodiversity Conservation, Himalaya Forest Research Institute, Shimla, Himachal Pradesh. [Total outlay: Rs. 5,47,500/-].

28. Inventorization, documentation of plant diversity and to evolve site-specific management strategies for conservation of various sacred groves in Kullu Valley of Himachal Pradesh by Dr. A. Rajasekaran, Department of Non Wood Forest Products, Himalaya Forest Research Institute, Shimla, Himachal Pradesh. [Total outlay: Rs. 5,61,200/-].

29. Environment, tribal culture and resource management in the kiliki watershed of Zunheboto hills, Nagaland by Dr. M.S. Rawat, Department of Geography and Resource Management, Nagaland University (Lumami), Mokokchung, Nagaland. [Total outlay: Rs. 5,79,600/-].

30. Efficient use of mid-hill grasslands of Himachal Pradesh through participatory silage making by Dr. Sudesh Radotra, Regional Research Centre, Indian Grassland Fodder Research Institute, CSKHPKV Campus, Palampur, Himachal Pradesh. [Total outlay: Rs. 5,46,700/-].

31. Mass multiplication and short to medium-term conservation of two rare and threatened orchids of Nagaland: An in-vitro approach by Dr. C.R. Deb, Department of Botany, Nagaland University, Lumami, Mokokchung, Nagaland. [Total outlay: Rs. 6,50,000/-].

32. Arbuscular mycorrhizal diversity in disturbed, conserved and cultivated system in Kumaun region in Uttaranchal by Dr. A.K. Sharma, Department of Biological Sciences, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttaranchal. [Total outlay: Rs. 6,49,000/-].

33. Development, demonstration and dissemination of agro-technology for Rosemary *(Rosemarinus offcinalis)* in Uttaranchal by Dr. Laiq Ur Rahman, CIMAP Resource Centre, Purara, Bageshwar, Uttaranchal. [Total outlay: Rs. 6,80,000/-].

34. Development of ecologically viable and socio-economically acceptable integrated models of arresting willow (*Salix* spp.) mortality in Lahaul valley of Himachal Pradesh by Dr. K.S. Kapoor, Himalayan Forest Research Institute, Shimla, Himachal Pradesh. [Total outlay: Rs. 7,10,000/].

Appendix - II

Response to observations on Audit Report and Statement of Accounts for the year ending 31st March, 2005

S.No	Observation	Response
1.	Grants/Subsidies shown in "Income and Expenditure A/c" are after net of expenditure. However, details of expenditure are not given.	Grants/Subsidies shown in "Income and Expenditure A/c"are net of expenditure. As per Accounting Standards of ICAI on Accounting for Govt. Grants, Grants received for specified purpose only is shown as Income (after net of expenditure) to the extent of expenditures (the details are given in schedule-13). Balance of grants unutilized is shown under Current Liabilities in Balance Sheet. The details of expenditures incurred are already shown under Expenditure head of the "Income and Expenditure A/c".
2.	Details of income from fixed assets are not shown in the schedules.	As per Accounting Standards specific grant for Fixed Assets is shown as Reserve Fund (Fixed Assets) in Balance Sheet and the amount charged as depreciation on that particular fixed assets is shown as withdrawn from fund a Income to the extent of depreciation charged. There is no income from fixed assets in the financial year 2004-2005.
3.	An amount of Rs. 7.39 crore has been provided to the Head "Depreciation Account" during the year. The Auditors have not checked Calculations/ Method of Depreciation.	The amount of Rs. 7.39 Crore has been provided to the Head "Depreciation Account" for last 15 years. Special efforts have been made in the current year to work out depreciation on fixed assets on Straight Line Method basis. This being the first year in which depreciation is provided on Fixed Assets. Since there is no sufficient time for auditors to check the calculations of depreciation for the last 15 years, they have relied on the calculations made by the accounts staff of the Institute.
4.	Huge amount of Rs. 3.83 crore has been spent out of the grants for addition in the Assets named "Building."	The amount of Rs. 3.83 Crore shown as additions in the "Building-Asset" is the amount transferred from Capital work-in-progress account of the Institute after the completion of Construction Work and report submitted by the CCU, New Delhi in current financial year.
5.	An amount of Rs. 68,848.00 has been shown under the "Suspense A/C". This must be accounted for.	An amount of Rs. 68848.00 has been shown under the "Suspense A/c" which is credited by bank in our foreign currency account. In the absence of required information the amount is shown as suspense a/c (for the purpose of FCRA return). The same has already been accounted for after receipt of required information from bank.
6.	Bank reconciliation statements are not enclosed to verify the correctness of Bank Balances shown in the Balance Sheet. without this, the audited Accounts are incomplete.	The bank reconciliation statements are enclosed.

ABBREVIATIONS

CHFST	Contour Hedgerow Farming System Technology
CSIR	Council of Scientific and Industrial Research
DBT	Department of BioTechnology
DST	Department of Science and Technology
ENVIS	Environmental Information System
GEF	Global Environmental Facility
ICAR	Indian Council of Agricultural Research
ICIMOD	International Centre for Integrated Mountain Research and Development
IHR	Indian Himalayan Region
ISRO	Indian Space Research Organisation
NATP	National Agricultural Technology Project
NDBR	Nanda Devi Biosphere Reserve
NHPC	National Hydropower Corporation
PARDYP	People and Resource Dynamics in Mountain Watershed of Hindukush Himalaya
SDC	Swiss Agency for Development and Cooperation
SWC	Soil and Water Conservation
SWEET	Sloping Watershed Environmental
TIFAC	Technology Information Forecasting and Assessment Centre
TSBF	Tropical Soil Biology and Fertility
UNESCO	United National Educational Scientific and Cultural Organisation
VEAP	Village Environmental Action Plan

INSTITUTE SUPPORTING STAFF

Head Quarters

Neena Kapoor	Finance Officer
K.K.Pande	A.O. (I/C)/Ac. O
Suryakant Langyan	O.S. (A)
Sanjeev Hingis	Estate Manager
Mritunjay Anand	Library Assistant
L.M.S. Negi	U.D.C.
Sarita Bagdwal	Steno Gd III
Jagdish Kumar	Steno
Mamta Hingis	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 FA.
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
R.C. Nainwal	Field Astt.
R.P. Sati	Peon

Himachal Unit

S.P. Maikhuri	O.S.
J.M.S. Rawat	Driver
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
Anita Pandey	Scientist-D	Microbiology
D.K. Agrawal	Scientist-D	Soil & Water Conservation Eng; Impact Assessment
K. Kumar	Scientist-D	Environmental Engineering; Hydrology
K.S. Rao**	Scientist-D	Plant Ecology; Rural Ecosystems
R.C. Sundriyal	Scientist-D	Plant Ecology; Rural Ecosystems
S.K. Nandi**	Scientist-D	Plant Physiology; Biochemistry
B.P. Kothyari	Scientist-C	Plant Pathology; Restoration Ecology
D.S. Rawat	Scientist-C	Settlement Geography; Rural Ecosystems
P.K. Samal	Scientist-C	Social Science; Anthropology
R.C. Prasad	Scientist-C	Information Systems
R.S. Rawal	Scientist-C	High Altitude Ecology; Conservation Biology
G.C.S. Negi	Scientist-B	Forest Ecology; Watershed Management
N.A. Farooquee	Scientist-B	Social Science; Indigenous Knowledge Systems
B.S. Majila	Tech-B	Forest Ecology; Restoration Ecology
Ranjan Joshi	Tech-B	Natural Resource Management; Econometrics
R.G. Singh	Tech-B	Applied Arts; Social Science
S. Sharma	Tech-B	Agroecology, Remote Sensing / GIS

North East Unit

D. Choudhury	Scientist-D	Animal Biology; Entomology
S.C. Rai	Scientist-C	Rural Geography; Hydrology

Sikkim Unit

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

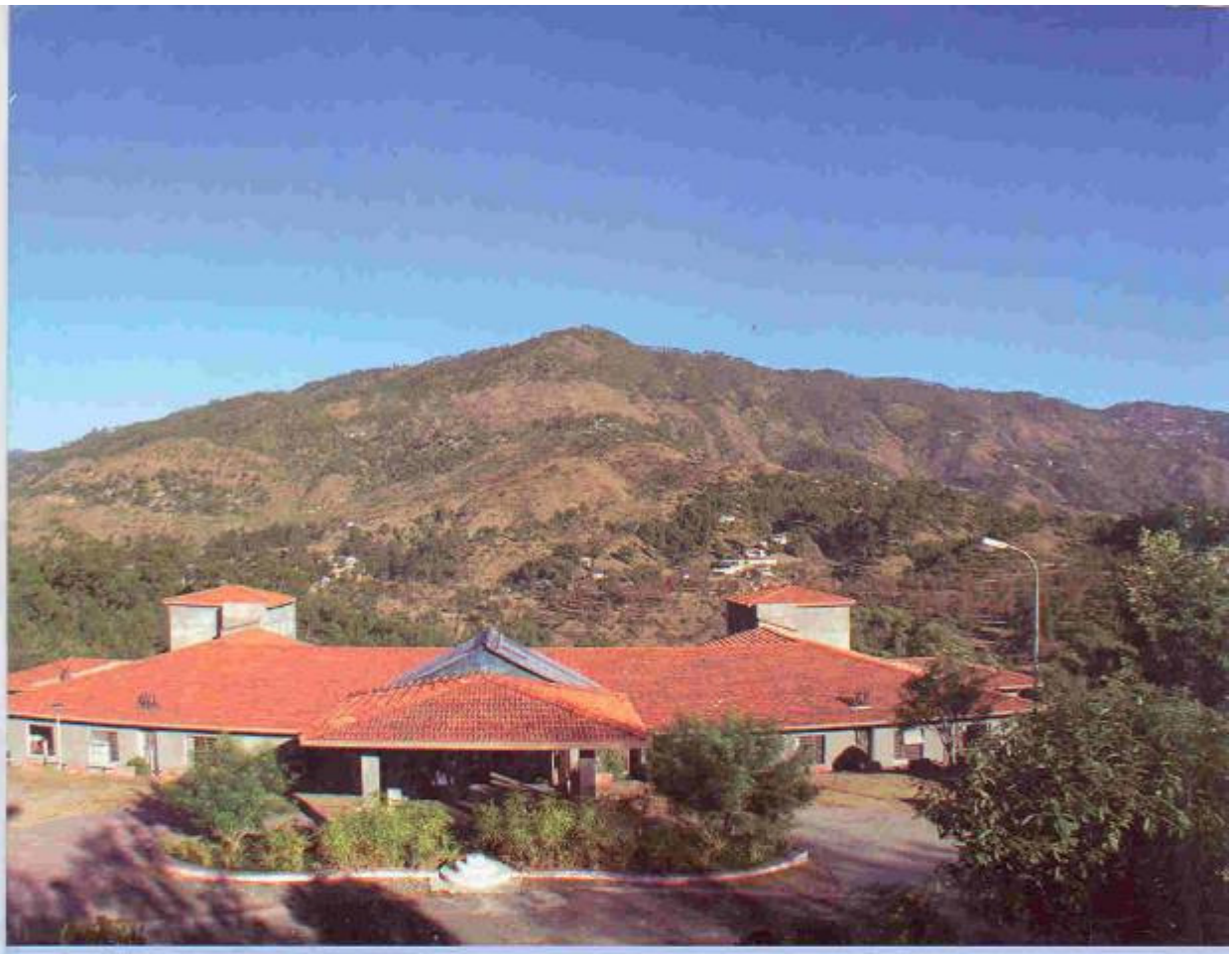
Garhwal Unit

R.K. Maikhuri	Scientist-D	Plant Ecology; Rural Ecosystems
S.C. Joshi	Scientist-C	Plant Physiology; Stress Physiology
Varun Joshi	Tech-B	Environmental Geology

Himachal Unit

S.C.R. Vishvakarma	Scientist-D	Plant Ecology; Rural Ecosystems
S.S. Samant	Scientist-D	Plant Taxonomy; Conservation Biology
J.C. Kuniyal	Scientist-B	Development Geography; Waste Management

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



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