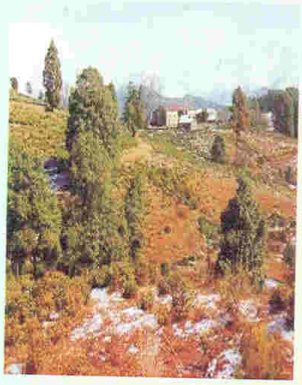
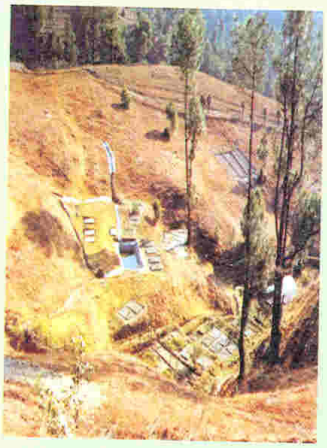
ANNUAL REPORT
2003-2004





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

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IERP & INHI GBPIHED

Annual Report
2003 - 2004

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

CONTENTS

DIRECTOR'S FOREWORD

The mandate of the Institute presents challenges as well as opportunities for the faculty and the partners to pursue R&D initiatives that suits local and regional developmental needs without compromising the overall goal of environmental conservation in the Indian Himalayan Region (IHR). Scientists at the Headquarters and four regional Units along with the support and project based staff are making all efforts to address diverse issues of paramount importance, be it related to rehabilitation of wastelands, conservation of biological diversity, monitoring of active landslides, development of medicinal plants sector, strengthening of capacity building mechanisms, enhancement of productivity using biotechnological tools or strengthening integrated eco-development research programme through networking with identified partners.

Over the years, technology development and demonstration related activities have strengthened our outreach with diversity of stakeholders, which include, among others, NGOs, farmers, government line agencies, research institutions, students and teachers. The institute recognizes the potential of strengthening interactive and collaborative mechanisms with these stakeholders so as to reach closer to fulfilling mandated objectives of the Institute.

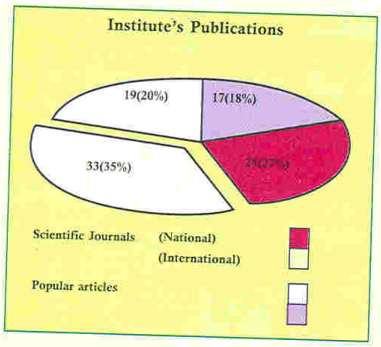
During the reporting period R&D programmes focused on mountain landslide hazard monitoring, rehabilitation of wastelands, medicinal plant conservation and cultivation, microbes as modifier of plant performance, climate change and impact analysis of farming interventions. Special efforts were made to strengthen R&D of Northeast region under Integrated Ecodevelopment Research Programme (IERP) of the Institute. The Institute successfully established linkages with the state governments by (i) developing environmental and social management guidelines for watershed management programme for Uttaranchal and (ii) disaster management of Sikkim state. Besides, a series of over 27 events across the IHR were organized, notable among these are: Regional Workshop on watershed management and peoples' participation; Orientation programme on conservation education; trainings for rural people on wasteland restoration and IERP Workshops in Northeast and Himachal Pradesh for execution of location specific action oriented R&D activities. Trainings on farmer friendly, cost effective income generating activities were imparted to over 2000 inhabitants including women, weaker section, students, NGO's and Government officials of the region during the year.

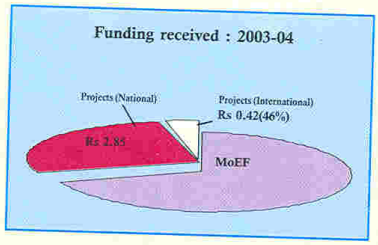
The results of R&D were published by the Institute scientists in National (25) and International (19) journals of repute during the reporting period. Besides, the Institute scientists received several honours and awards. Notable among them include, Indian Council of Forestry Research and Education Award of Excellence in Forest Conservation and National Young Woman Scientists Award from Department of Biotechnology, New Delhi. The Institute scientist also represented the country as a member of ad-hoc Technical Expert Group on Mountain Biodiversity organized by CBD Secretariat.

Despite of the challenges posed by vast area of operation and complexities of issues in mountain systems, the above achievements were possible only through the untiring efforts of scientists and researchers, and all the partners involved with our R&D programmes throughout the IHR and they deserve due compliments. I also thank my colleagues, documentation team, in particular for their involvement in preparing this document.

(Uppeandra Dhar)

Major Achievements





- Initiation of special efforts under Integrated Ecodevelopment Research Programme for region specific R&D in NE, corroborated by award of 16 projects with a total cost of approx. Rs 89 lakhs
- First ever monitoring of active landslides in the region using GPS geodesy and successful establishment of permanent GPS station at Pangthang (Sikkim)
- Induction of Sikkim Unit of the Institute as a disaster management faculty by the State Govt. Sikkim
- Demonstration of SWEET model for rehabilitation of wasteland and silvi-pasture demonstration in community land of Uttaranchal, and dissemination of soil conservation and fertility enhancement technologies in NE region
- Strengthening of activities in Medicinal Plant Sector through: (i) *research*– preparation of grid maps, population dynamics study and propagation (conventional/*in vitro*); (ii) *demonstration*- establishment of herbal garden (HQs- 1 ha, 40 spp.) and promotion of cultivation in selected villages; and (iii) *dissemination*- training workshops for farmers (3 No.) and state level seminar (HQs)
- Completion of investigations on occurrence of vesicular arbuscular mycorrhizal associations of Rhododendrons of Uttaranchal
- Identification of three species of bacterial isolates, namely *Bacillus subtilis, B. megaterium* and *Pseudomonas corrugata* as potential inoculants for plant growth in mountains
- Analysis and interpretation of climate data in Garhwal region, which indicated shift in rainfall and snowfall periods under influence of global climate change
- Development of Environmental and Social Management Framework, Environmental and Social Guidelines, and Environmental and Social Implementation and Monitoring Manual for Uttaranchal Decentralized Watershed Development Project, Govt. of Uttaranchal
- Promotion of capacity building programmes with the help of on-site training on rural technologies at Institute HQs and Units (253 farmers; 18 NGOs, 698 rural people); and strengthening of conservation education among school teachers and students through orientation course and training workshops
- Ecological and economic impact analysis of Diversified Agriculture Support Programme executed in selected villages of the Uttaranchal

Executive Summary

Research and Development Activities

Following a multidisciplinary and holistic approach in Research and Development 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 has been placed on the preservation of fragile mountain ecosystems, indigenous knowledge systems and sustainable use of natural resources. A conscious effort is being made to ensure participation of local inhabitants for long-term acceptance and success of various programmes. A brief summary of R & D activities of the Institute during reporting year 2003-04 is as follows:

Land and Water Resource Management (LWRM)

- Studies on glaciers
- SWEET implementation
- Kinematics GPS for landslide monitoring

The efforts of LWRM Core were focused on research, demonstration and dissemination activities related to study of community irrigation systems, documentation of traditional land and water management practices, demonstration of sloping watershed environmental engineering technology (SWEET) model for rehabilitation of community and private wasteland, quantification of tectonic deformation rate using GPS geodesy, hydrometry and sediment study of Gangotri glacier, global change study for environment management and sustainable development, and people and resource dynamics in mountain watersheds (PARDYP), etc. Based on the village environment action plan (VEAP), a development plan for village Barwa was prepared for the Uttaranchal Government. For the first time in the IHR, the core initiated monitoring of an active landslide in Nainital area using kinematics GPS surveys. Also, quantitative assessment of traditional irrigation systems of cold desert area in HP was initiated.

Sustainable Development of Rural Ecosystems (SDRE)

- Appraisal of livelihood and income-generating options
- Farmers training on agro-forestry and medicinal plants
- Low-cost technology interventions

During the reporting period, activities of SDRE Core continued focusing on resource dependency and use patterns among various tribes in Arunachal Pradesh in the Eastern Himalaya. Similar assessment has also been initiated in Uttaranchal (West Himalaya), focusing on livestock-based livelihood activities. Assessment of the dynamics of demographic changes on resource use, management strategies and livelihood options remained a focused activity in the Hawalbagh Block in Almora District (Uttaranchal). Efforts are also on to assess the impact of restoration models on productivity, particularly soil physico-chemical characteristics, to test the suitability of selected species for agro forestry systems in Arunachal Pradesh and Uttaranchal. Further, attempts to find suitable income-generating options have also been carried out based on promising medicinal plants, particularly in Garhwal. Capacity building of the rural populace has been another important activity of the Core and several trainings were conducted on rural technologies and propagation techniques, catering to different stakeholder groups in continuation of the Institute's mandate of strengthening delivery systems.

Conservation of Biological Diversity (CBD)

- Grid maps for occurrence of medicinal plants
- Studies along disturbance gradient in forests
- Orientation course on conservation education

The Core, during the reporting period, attempted to keep a balance of research, demonstration and dissemination activities. While detailed floral and faunal inventories for selected groups/families strengthened the database on Himalayan Bioresources, the Grid Map developed for medicinal plant diversity and distribution in Uttaranchal is first of its kind in the region. Data sets generated for biodiversity rich areas, especially the representative Protected Areas (i.e., Kanawar- HP, Nandadevi- UA, Namdapha- AP), provided first hand information, which can be incorporated in the management plans of respective areas. The studies along disturbance gradient, completed for selected mid-altitude forests, revealed characteristic changes in compositional features. *Ex situ* gene bank efforts were further strengthened through R & D interventions in arboretum (HQs & Sikkim Unit) and herbal gardens (HQs & HP Unit). These sites were used extensively for teaching, training and demonstration for different target groups. The experiments on seed germination (*Swertia chirayita, Heracleum candicans* and *Selinum tenuifolium*) and *in vitro* organogenesis (*Saussurea obvallata*) of high value endemic medicinal plants complemented the initiatives of gene bank establishment. Under Lead Coordination, the database on Himalayan Biosphere Reserves (BRs) was further improved through interactive mechanisms. Promotion of Conservation Education in school/college students and teachers continued to be the most effective dissemination activity. Successful organization of seven-day orientation course for teachers and three-day training workshop for students/teachers provided further strength to the programme.

Ecological Economics and Environmental Impact Analysis (EE & EIA)

- Studies related to socio-economics, developmental projects, climate change and landslide hazards
- Quick appraisal studies

The core activities in the reporting period continued to focus on various aspects of EE &EIA related to socio-economic, natural resources, developmental projects, climate change and environmental hazards. Notable among these include: geographic and other factors leading to adoption of vegetable cultivation in Kumaun hills, ecological economics of tourism in Central Himalaya with particular emphasis on some prime townships of Kumaun region, carrying capacity and impact assessment studies on tea cultivation in Uttaranchal and environmental services and ecological economics of oak and pine forests. In the Himalayan region efforts to harness the potential of hydropower are undergoing in a big way. To understand the environmental impacts of these projects studies were carried out in Himachal Pradesh. Growing vehicular traffic in tourist destinations is another problem that warrants investigations on air quality. In this context, air quality monitoring was conducted in the Kullu-Manali area. Realizing the serious concerns of recurring landslides in the fragile Himalaya, studies were initiated in the Darjeeling-Sikkim Himalaya using GPS geodesy. The core also achieved soil and water conservation and biomass production in wastelands through vegetative measures. In addition, some quick appraisal studies were also carried out for the developmental programmes executed by the State Governments in the IHR.

Environmental Physiology and Biotechnology (EPB)

- Isolation of useful bacteria for plant growth
- *In vitro* protocols of medicinal plants
- Training on hill specific technologies

Research and Development activities of EPB core, during 2003-04, concentrated on understanding the factors that govern the productivity and functioning of plants through conventional and modern techniques. Efforts were made to develop propagation protocols for economically important species. Successful protocols were subsequently used for large-scale multiplication programmes. Studies were initiated to examine the physiological and biochemical basis of adaptation in relation to water stress for screening suitable plants. While considering the plant growth, role of microorganisms remained a focus of investigations. Numbers of bacteria, isolated from soil, were developed as inoculants, which exhibited improvement in plant growth and also enhanced seed germination. The microorganisms isolated from various sources are being maintained under laboratory conditions for further investigations. Realizing the importance of the content of active compounds for elite stock selection, studies on genetic profiling and quantification of active biomolecules of medicinal importance received attention. A wide variation in podophyllotoxin content in rhizome sample of *P. hexandrum* collected from various populations of Kumaun and Garhwal was observed. Attempts were strengthened to maintain variations and cultivate elite stocks. Further, recognizing the relevance of establishing demonstration and training centers in the hilly region various hill-specific technologies were demonstrated on a regular basis for economic upliftment of the rural people.

Institutional Networking and Human Investment (INHI)

- Thrust on NE specific R&D under IERP
- Execution of coordinated programme in sacred mountains
- Guidelines for decentralized watershed development (UA)

During the reporting period, under IERP 28 new projects were funded to various Universities/ Institutions/NGOs for the execution of location-specific R&D activities in the IHR. This raises the list of on going projects in eight states of IHR to eighty. Eighty projects reached to the logical end during the year 2003-04. Execution of a coordinated programme on "*Sacred values, eco-restoration and conservation initiatives in the IHR*" in the states of H.P., U.A., Assam, Meghalaya and Arunachal Pradesh with the help of the identified network partners deserves a special mention. Further, an IERP workshop "*Creation of awareness among the prospective PIs/Groups/ NGOs, etc. of the North East region for execution of location-specific action-oriented R&D activities under the IERP: Project presentation cum evaluation*" at Itanagar in Arunachal Pradesh provided a special forum for over 175 prospective Principal Investigators of NE region. Thirteenth meeting of the Project Evaluation Committee (PEC) was convened at the Institute HQs, wherein 83 project proposals were examined critically. A three-day on-site training programme on nursery development, tree plantation techniques, and natural resource conservation and management was organized at village Digoli in Almora (Uttaranchal). Towards strengthening the Central Library, 618 new books were added and 117 periodicals (77 international and 47 national) subscribed. While Vol. 11 of ENVIS Bulletin (in 2 numbers) was published, six volumes of the Bulletin (Vol. 6 to 11; each in two numbers) made available on-line through ENVIS-EMCB Node. Ph.D. theses on Himalayan ecosystem were compiled and uploaded as new modules to the ENVIS Website of the Institute. In collaboration with other cores of the Institute, Environmental and Social Guidelines, Environmental and Social

Implementation and Monitoring Manual and Environmental and Social Management Framework for Watershed Management Directorate, Govt. of Uttaranchal, were developed.

Indigenous Knowledge Systems (IKS)

- **Uses of medicinal plants by *Vaidiyas***
- **Indicators of weather**
- **Drying of vegetables**

The R&D activities of the Core, during 2003-04, focused on understanding and documenting indigenous practices relating to the natural resource management. While detailed practices relating to traditional indicators of weather have been documented, the verification of such knowledge through PRA exercises in selected villages has confirmed the authenticity of the information collected. The studies on indigenous knowledge and uses of medicinal plants by the *Vaidyas* has generated database on different types of formulations, types of ailments treated, frequency of use of some medicinal plants. The studies on drying of vegetables was further expanded in the high altitudes of Kumaun, the database was enriched and improved through interactive mechanisms. Two farmer interactive workshops were conducted during the reporting period, which provided valuable information on the ongoing activities of the Core.

Activities completed

- Biodiversity studies along disturbance gradient
  - Mid altitude forests *(In house)*
  - Timberline zone *(MoEF funded)*
- Inventory of tree diversity in Namdapha National Park *(MoEF funded)*
- Socio-economic upliftment of rural communities of Himachal Himalaya *(DBT funded)*
- Augmenting food and economic security of tribal communities, particularly women in Arunachal Pardesh *(DBT funded)*
- Ecological and economic impact analyses of diversified agriculture programme in selected villages of Uttaranchal *(DASP, Govt of UA funded)*
- Community forestry management in Sikkim as part of environmental law capacity building project *(WB Natn. Univ., Kolkata)*
- Microbes in Himalayan soil : biodiversity & potential applications *(DBT funded)*
- Development of Environmental and Social management framework for watershed development in Uttaranchal *(Govt of UA funded)*
- Indigenous knowledge and uses of medicinal plants by Vaidyas in Uttaranchal *(In house)*

Promotion of capacity building programmes

Exposure Visits on ex/situ *Conservation, MPs culti.etc*	(2 No : 260 students, 27 teachers)
Interaction/Awareness	(3 No: state level officers, 9 State)
Trainings on Rural Technology	(26 No: 49 NGOs from 6 States; 120 farmers, officials of 12 dept)
Training on Land Restoration	(4 No; 115 students, 17 teachers, 68 farmers)
Conservation Education	
- Orientation Course	(22 teachers, 20 Schools)
- Training Workshop	(18 teacher, 51 students)

1. INTRODUCTION

The year 2003-04 is fifteenth 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 problems. The Institute implements its activities through the programmes supported through the core funds provided to the Institute by the Ministry of Environment and Forests, 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 activities of the Institute are centered on seven designated core programmes. Various activities/projects reached to their logical conclusion during the 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 2003-2004 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 Ministry of Environment and Forests, Govt. of India.

2. MILESTONE EVENTS

- 11th SAC Meeting

The 11th meeting of Science Advisory Committee (SAC) of the Institute was held (July 7-8, 2003) under the Chairmanship of Prof. K.P. Singh, BHU. Committee reviewed the progress under R&D activities of the Institute and provided guidance for future programmes. While SAC members showed keen interest and appreciated the R&D efforts, they made following suggestions: (i) make efforts for strengthening cores/units with scientific/technical manpower in view of wider mandate and area of operation across the IHR; (ii) focus on some of the priority issues for effective out put and wider recognition; (iii) disseminate the outcome of the Institute's R&D work through print as well as electronic media; (iv) networking with other Institutes/ University should be strengthened in terms of joint projects and publications on area of mutual interest; (v) under the IERP, make provisions of awarding fellowships for young talented researchers to strengthen in-depth research under Institute's mandate.

- 26th GB Meeting

The 26th meeting of the Governing Body (GB) of the Institute was held at Paryavaran Bhavan, New Delhi (November 25, 2003). Dr. Pradipto Ghosh,

Secretary, MoE&F and the Chairman GB of the Institute welcomed the members. Dr. Uppeandra Dhar, Director of the Institute, made a brief presentation on the progress of the Institute and vision for the future. A detailed discussion was made on the presentation. Members offered suggestions for further improvement of Institute's R&D efforts. GB expressed satisfaction on the overall progress of the Institute.

• 10th G.B. Pant Society Meeting

The 10th meeting of Govind Ballabh Pant Society of Himalayan Environment & Development was held on March 9th, 2004 at Paryavaran Bhavan, New Delhi, under the Chairmanship of Mr. Ramesh Bais, the Hon'ble Union Minister of State (Independent Charge), Ministry of Environment & Forests, GOI. Among other dignitaries, the meeting was attended by Sri Kailash Sharma, MLA, Uttaranchal; Mr. M. K. Bhan, Secretary DBT; Sri N. K. Joshi, DG (F); Mrs Veena Chhotray, Additional Secretary, MoE&F; Mrs Shushma Singh, Additional Secretary, Ministry of Water Resources; Mrs Veena Upadhayaya, Joint Secretary, MoE&F; Dr. B. D. Acharya, Adviser DST; Dr. S.C. Deorani, Principal Secretary Nagaland Ministry of Water Resources; Dr. R. C. Pant, Vice Chancellor, Kumaun University, Nainital; and 6 other officers. Sri Sunil Pant and Captain M.S. Kohli attended the meeting as non-official members. Mrs Veena Chhotray, Additional Secretary, welcomed the Hon'ble President of the Society, members, the nominees and special invitees and she briefly introduced the mandate of the Institute. The meeting commenced with a presentation about the R&D activities of the Institute by Dr. U. Dhar, Director GBPIHED. The presentation was followed by discussions. During his Presidential observations, the Chairman urged the Institute to identify the areas for priority actions. He underlined the need for taking up studies on receding glaciers and emphasized the need for stepping up the training of students, teachers and farmers.

During reporting period, towards promotion of capacity building programmes, the Institute made significant contribution through organization of (i) exposure visits (2 No. – 260 students and 27 teachers); (ii) interaction/awareness raising meetings (3 No; state level officers of 9 states); (iii) trainings on- rural technology (26 no; 49 NGOs from 6 states of NE and Uttaranchal, 120 farmers, and officials from over 12 line departments), land restoration (4 No; 115 students, 17 teachers, 68 farmers), medicinal plant cultivation (5 No; farmers, NGOs and women from different parts of IHR); (iv) orientation course and training workshops on Conservation Education (2 No; 40 teachers and 51 students); and (v) seminar/ workshops (3 No; 23 farmers, 56 NGOs, 41 researchers/ scientists and 26 officials from line departments). Institute also made a special effort through organization of an IERP workshop (January 29-30, 2004) at Itanagar to focus on NE region. About 175 prospective PIs/Groups/NGOs, etc., attended the workshop and 63 project proposals were presented and evaluated.

3. RESEARCH AND DEVELOPMENT PROGRAMMES

- **Interdisciplinary R&D programmes – linking natural and social sciences**
- **Activities – need based, target oriented and time bound**

The R&D activities of the Institute are essentially multi-disciplinary in nature, and based on conscious efforts to inter-link natural and social sciences to promote sustainable development in the region. Institute's activities are centered on seven core programmes, viz., Land and Water Resource Management, Sustainable Development of Rural Ecosystem, Conservation of Biological Diversity, Ecological Economics and Environmental Impact Analysis, Environmental Physiology and Biotechnology, Institutional Networking and Human Investment and Indigenous Knowledge Systems.

The achievement of goals and the progress made under various projects during the year have been placed under appropriate core programmes in the text. The project 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 prescription. To meet the targets and to accomplish the objectives, 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, including technology packages of the Institute, are underlying elements of all project activities. 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 2003-2004, along with a brief, conceptual background, specific objectives and major achievements are summarized for individual projects.

3.1. LAND AND WATER RESOURCE MANAGEMENT

The survival of living organisms is dependent on land and water resources. Throughout human history the availability, distribution, use and access to these basic resources have been major drivers of civilizations and human development. As a consequence, management of land and water resources is becoming more important each day as human populations increase and natural resources and habitats become limited. Management of these resources aims to help balance the needs of people with the ability of ecosystems to support soil, water, forests and wildlife resources. Like many other ecosystems of the earth the fragile ecosystems of the Himalaya are also facing ecological degradation vitiated by the dynamic geological and geomorphological processes, ever growing human population and global climate changes. As a consequence, serious problems related to sustenance of ecosystem services provided by land and water resources have arisen. Therefore, the need is felt to conduct long-and-medium term R&D studies focused on quantification of the resource use pattern and critical linkages it has with other ecosystem components. These attempts will help in developing strategies for sustainable use of land and water resources.

Performance analysis of community managed canal systems (Kumaun)

Performance appraisal of spring sanctuary development (Garhwal)

3.1.1. Management of Irrigation Systems and Rural Water Supply in Central Himalaya

Background and Objectives

Community attempts have been there in the past to build and operate small canal systems to fulfill their irrigation needs with or without government support. It has been seen in the past that government schemes do not perform well due to poor maintenance and improper operational arrangements. In the hills, topography does not support any large irrigation works and small canal systems provide an answer to this challenge. These community irrigation systems generally lack proper scientific planning, which is overcome by strict institutional arrangements for water sharing and canal maintenance. Under this study performance of two canal systems made by government and managed by community was studied in Almora district with the objectives: (i) Performance study of selected canals under different cropping systems in Kumaun Himalaya; (ii) Study of physico-chemical properties of irrigated soil under selected canal systems; and (iii) Study of springs with particular reference to water availability, growing water demand and people's perception about rural water management.

Results and Achievements

- **Application and conveyance efficiency varies from one canal to another**
- **Soil quality attributes of cropfields at two locations**

1. The application efficiency of Tana canal (88.6±3.2%) was found higher than Vetnayaljoola canal (85.3±0.81%). Mean conveyance loses in Tana (5.97±0.02 m/day) was marginally higher than Vetnayaljoola canal (5.77±0.03 m/day). Higher conveyance efficiency was recorded for Vetnayaljoola (65.6±0.31%) due to low conveyance loss as compared to Tana canal (61.2±0.23%). The efficiency was better in both the systems in kharif crop (Tana=97.6±0.1%; Vetnayaljoola=90.2±0.23%) season due to reduced seepage and evaporation losses.
2. Water holding capacity at Tana crop-fields (51.8±0.27%) was higher than Vetnayaljoola (45.2±1.6%) crop-field soil (Table 1). Organic carbon content of Tana (1.28±0.04%) was found lower than Vetnayaljoola crop field soil (2.31±0.02%).

Table 1. Physico-chemical properties of soil

Parameters	Tana canal	Vetnayaljoola canal
Soil moisture (%)	23.32±0.60	19.32±1.26
Water holding capacity (%)	51.78±0.27	45.17±1.60
pH	5.56±0.03	4.91±0.02
Electrical conductivity (ms)	0.022±0.0007	0.015±0.0002
Particle composition (%)	8.0	87.5
Sand	8.67	11.11
Silt	2.97	1.21
Clay		
Organic carbon (%)	1.28±0.04	2.31±0.02

- Interventions in spring recharge zone increased water discharge of spring during summer

3. In the spring sanctuary developed in Garhwal, increase in discharge of spring during summer (April to June) was recorded after applying engineering and bioengineering measures (Fig. 1).

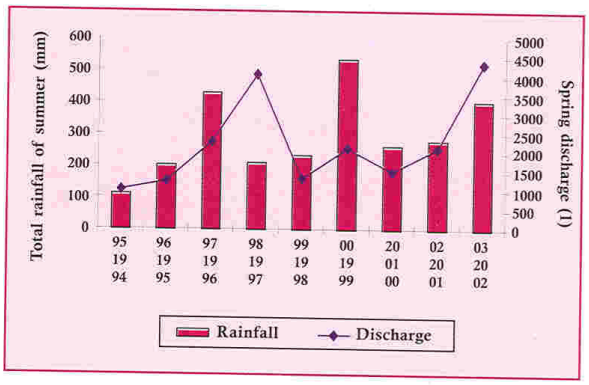


Fig. 1. Spring discharge of summer

3.1.2. Study of Traditional Land and Water Management Practices in Himalaya

Documentation of region specific traditional irrigation practices

Background and Objectives

Himalayan region is well known for its traditional land and water management practices. These traditional practices of land and water management are time tested and cost effective. Use of Khals, the natural depressions on hill topes, for harvesting of surface runoff water is an age-old practice. The water, so collected, is used for the cattle during grazing and also has recharging effects for these springs and streams downhill. These *Khals* are now disappearing due to lack of maintenance, affecting the cattle water availability and recharging of water regimes. In addition, scores of moisture conserving and irrigation management practices are also used in agriculture. These practices are region specific and owe critical eco-system bearings. The studies envisage: (i) identification and documentation of traditional and modified land and water management practices in Himalayas; and (ii) Analyses of associated institutional and operational arrangements.

Results and Achievements

- *Khals* of UA - natural depressions used for harvesting of runoff water- are on decline
- *Huburs* of AP- tiered network of water channels permits wise use of water

1. Water harvesting practice in unlined ponds (*khals*) is on decline. In Almora istrict more than 45% of *khals* have dried up in last fifty years. Majority of respondents (63%) suggested that less rainfall and low water availability was responsible for this, and some (37%) suggested that it is due to decline in livestock population.
2. In northeast Himalaya (Arunanchal Pradesh) stream water is diverted through a network of primary, secondary and tertiary channels to paddy fields. At a short distance above the terraces, some water is allowed to flow

in the first feeder channel through a diversion, while the stream continues on its course. The angled feeder channel branches lead water to any terraced paddy field, which can be flooded or drained as per need by blocking or opening of connecting ducts known as "*Huburs*" (Fig. 2).

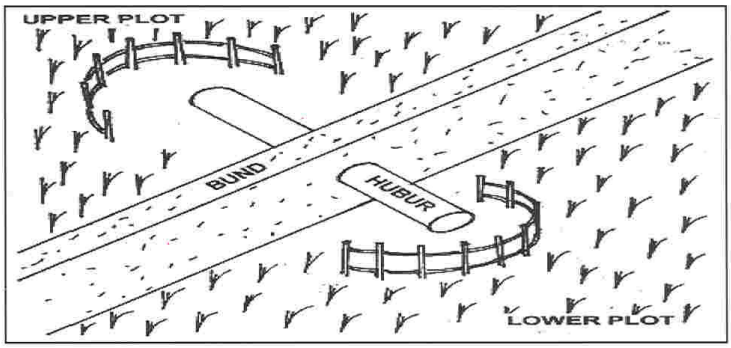


Fig. 1. Spring discharge of summer

- ***Kuhls* of Lahul, HP- irrigation systems utilize snowmelt off-takes**

3. In Lahaul valley 99.6% of agriculture land is irrigated through traditional snow melt off-take *kuhl* systems. Some of these *kuhls* were about 900 years old. Study of four villages revealed slope angle for 100 m *kuhls* length ranged from 5° to 6°. Canal ratio of community owned *kuhls* ranges from 0.3 km/ha to 0.06 km/ha (Table 2) with mean value of 0.12±0.046 (n = 9). Canal ratio of Government owned *kuhls* was 0.11±0.017 km/ha (n = 23).

Table 2. Number of dependent families, canal ratio and area irrigated in Lahaul valley (n = No. of *kuhls*)

Attributes	Khoksar (3200m) n =5	Jahlma (3000m) n = 2	Hinsa (2700m) n = 1	Kuthar (2600m) n= 1
No. of dependent family	11	28	70	22
No. of major branches	4	9	4	3
Length of *Kuhl* (km)				
Main canal	0.38	0.37	0.26	150.00
Branches	0.50	1.47	1.80	645.00
Total	0.88	1.84	2.06	0.80
Area under irrigation (ha)				
Agriculture	1.66	17.81	20.66	6.28
Forestry	0.26	3.44	1.91	0.01
Grassland	0.91	6.58	9.64	3.91
Kitchen garden	0.07	0.30	0.31	0.12
Total	2.90	28.13	32.53	10.31
Canal ratio (km/ha)	0.30	0.07	0.06	0.08

3.1.3. People and Resource Dynamics in Mountain Watersheds of the Hindu-Kush Himalaya *(SDC, IDRC, and ICIMOD funded; Period: 1997-2005)*

Improvement in livelihood conditions using low-cost technologies

Generation of database on resource dynamics

Background and Objectives

People and resource dynamics project (PARDYP), a regional collaborative programme, is presently in its third phase (since January 2003) of operation at Garurganga watershed in Uttaranchal. 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. Synthesis of results modeling, dissemination of the results / information and strengthening of long-term database on resource dynamics, including hydrometeorology and erosion aspects, are the major objectives of the present phase.

- **Beneficiaries – 90 families of 30 villages in Bageshwar (UA)**
- **Fodder production in rehabilitated wasteland reduced pressure on surrounding forests**

Results and Achievements

1. Interventions related to conservation of water resources linked with integrated fish farming, soil fertility improvement and cultivation of off season vegetables, cash and high yielding variety crops etc. have helped over 90 families from 30 villages through an additional annual income of Rs. 615.00 to 26,900.00 (Table 3).
2. Rehabilitation of degraded community lands has significantly contributed to fodder availability at Khaderiya, Lawbanj, Puniamaphi and Arah villages to the tune of over 50 tonnes, which translates for a cost of Rs. 50,000 during this year.
3. Rainfall observation at 5 meteorological stations of Bhetagad watershed showed that there is no clear-cut pattern of rainfall distribution over the last 6 years. The watershed received an average annual rainfall of 1315 mm during last 6 years.

Table 3. Additional annual income (household basis) from different activities during the year 2003

Activities	Villages covered	Household Covered	Income Rs. /household
Off-season vegetable production	26	67	8900- 22800
Integrated fish farming	22	40	1040 - 26900
High yielding variety crops	30	86	615 - 1870
Cash crop cultivation	5	27	1460 - 4250
Fodder from rehabilitation sites	4	106	530 - 1640
Knitting/weaving training	6	112 (women)	270 - 680

3.1.4. Hydrometry and Estimation of Sediment Load of Gangotri Glacier in Garhwal Himalaya *(DST funded; Period: 1999-2004)*

Assessment of sediment load, source, and erosion rate

Modeling of discharge, SS load, and meteorological parameters

Background and Objectives

Snow and glacier covered mountains in the Himalaya are the perennial sources of most of the north Indian rivers and streams. In every ablation season (June to September) large quantities of melt water along with suspended sediment (SS) is driven away from the glaciers. The seasonal variation in the amount of runoff derived from snowmelt, is however affected by meteorological variables. Gangotri glacier is one of the largest glacier systems in Garhwal Himalaya. This project is focused on discharge and SS transport in the proglacial stream draining the Gangotri glacier with a view to identify relationship between hydrological characteristics and the SS delivery. The objectives of this project are: (i) Collection of hydrometeorological data of Gangotri glacier to study the relationship between discharge variations and meteorological parameters; (ii) Quantification of SS load of the glacier and their relationship during the melt water season; (iii) Assessment of erosion rate of the glacier and identification of the sediments source area, production mechanism, and transport pathways of the suspended and dissolved load of the glacier.

Results and Achievements

- **Average discharge- 56.16 Cums and average SS load - 2.54 g/l**
- **Rainfall over ablation zone increased SS load transport in melt water**

1. The mean discharge and SS recorded in the five consecutive years of Gangotri glacier catchment was 56.17 cums and 2.54 g/l (Fig. 3). The mean temperature recorded was 10.85 ^{0}C with an average rainfall of 232.31 mm.

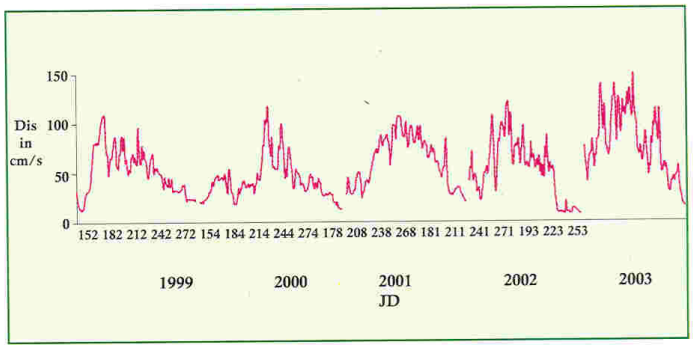


Fig. 3. Discharge 1999-2003 (June to sept.)

2. Maximum melting and SS transport from Gangotri glacier was observed in the month of June (70 %) and July (77%) in the entire monitoring period. This may be due to high melting rate under the influence of strong radiation over the ablation zone (Fig. 4). After mid-August, a decrease in temperature was noticed. However, September shows marked recession in runoff and SS concentration due to decreasing temperature.

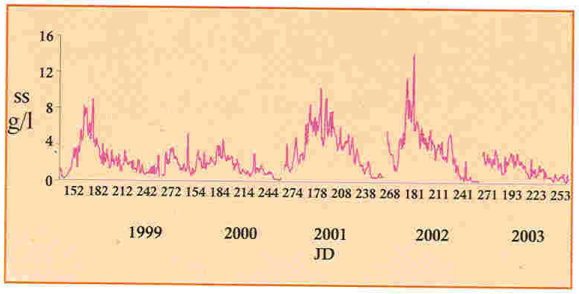


Fig. 4. Suspended sediment from 1999-2003 (June to sept.)

3. This decreased temperature has affected both discharge and SS load. Precipitation over the ablation zone pushing surface cover of moraine debris through valley walls, medial moraine and extensive longitudinal and transverse crevasses (Fig. 5) into englacial and subglacial tunnels and causing transport in melt-waters.

Fig. 5. Debris deposit near the crevasses on Gangotri glacier

3.1.5. Quantification of Tectonic Deformation Field in Kumaun Himalaya -A Basic Framework for Landslide Hazard Modeling Using Sub-cm Precision GPS Surveys *(DST funded; Period: 2002-2005)*

Monitoring of N-S strain gradient and temporal evolution of landslides using GPS geodesy

Background and Objectives

In Himalayas topographical hazards are built-in, landslides take a heavy toll of life and property every year. The occurrence of landslides is the result of gravity sliding, which is a universal planetary process constantly at work to moderate the topographical relief produced by tectonic activity. The use of GPS geodesy in determining the rate and patterns of the temporal deformation of potentially unstable slopes presumes that slow creep precedes most catastrophic landslips. This project envisages study of tectonic deformation fields using GPS geodesy in Kumaun Himalaya and monitoring of landslides with the following objectives: (i) Study of N-S strain gradient using high-precision GPS survey, to determine the annual strain rate field in Kumaun Himalaya from Dung (north of Milam)

- Establishment of GPS reference station at Sikkim
- Monitoring of Balia nala landslide (Nainital)

to Almora and Malpa to Pithoragarh, Dharchula, Askot and Chapawat; and (ii) Monitoring of temporal evolution of some potentially damaging landslides using kinematics GPS survey.

Results and Achievements

1. A permanent GPS reference station was established at Sikkim Unit of the Institute (Fig. 6). With respect to fieldwork 14 sites has been taken up for GPS data collection and the data has been changed in RINEX format.
2. Ninety three grid points have been taken for GPS survey along the landslide area at Balia Nala, the biggest threat to Nainital. Data has been collected for rapid static mode and collection of data in static campaign mode is under progress.
3. Coordinates of local reference stations at Nainital and GBPK points and some observation sites are estimated with respect to IGS stations, IISC Bangalore and KIT3 Kitab-Uzbekistan. Baseline results have been estimated for different sites in Kumaun Himalaya (Table 4).

Table 4. GPS Processing results of different stations

Station	Coordinates (lat, long and height from msl)	Baseline length with IISC (m) ility(m)	North repeatab- ility(m)	East repeatab- ility(m)	Vertical repeatab- ility(m)
IISC	N13°01'16. 18972" E77°34'13. 33486" 842.9796 m	-	-	-	-
GBPK	N29°38'16. 65351" E79°37'13. 11630" 1257.849 m	1845790.14082	0.00474	0.00784	0.01126
NTLP	N 29°:22': 58.13592" E 79°:27': 51.25317" 2059.5487 m	1816060.29030	0.00442	0.00733	0.01074
BALA	N29°51'26. 24467" E80°09'10. 71108" 1581.34778 m	1894657.97518	0.00721	0.00824	0.05123
CHOK	N29°40'19. 76851" E80°02'25. 95288" 1899.23328 m	1872978.56538	0.00425	0.00421	0.06124

IISC- IISC Banglore, GBPK- Institute site, Katarmal (Almora), NTLP- Nainital, Bala –Bala (Pithoragarh), CHOK – Chaukori (Pithoragarh)

Fig. 6. GPS Campaingn site Laspa (Central Himalaya)

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

SWEET, a package for reclamation and rehabilitation of degraded land, with provision of usufruct benefits for the target groups

Background and Objectives

Degradation of land is a quite common phenomenon in Indian Himalayan region. Various reasons can be assigned to this degradation. Such cases in the study sites of Kumaun Himalaya are mainly related to sloping topography, abandonment and out-migration, acute water shortage, and uncontrolled and heavy grazing of the community lands. This project contemplates rehabilitation of village common lands through SWEET package for some direct benefits such as fodder, fuel wood, SWC etc other than the associated non-tangible restoration gains. Objectives of the study include: (i) Performance and adaptability analyses of SWEET for wastelands; (ii) Awareness building and skill improvement of extension workers and villagers for reclamation of wastelands; and (iii) Technology modification for future applications in wasteland development and for SWC in Himalaya.

Results and Achievements

- **Implementation of SWEET in 5 villages (72 ha farm land, 36.4 ha community land) in Almora district**
- **Plantations of promising fodder tree species**

1. So far 72 ha village community land and 36.4 ha farmers land has been treated under SWEET model for wasteland development in five different villages of Almora district.
2. The survival rate of plant species planted in different sites (20180) was highest for *Alnus nepalensis* (85%), *Cassia nilotica* (85%) and *Prunus cerasoides* (85%), among all the other species (Fig. 7). *Grevillea robusta* (80%) and *Grewia optiva* (70%) also showed a good survival (Table 5).

Fig. 7. Two-year-old plantation of *Prunus cerasoides* on degraded community wasteland

Table 5. Progress of plantation in different project sites (as on March 2004)

Village	Year of plantation	Number of species	Number 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	64.71 ± 1.02	103.0 ± 1.30
Bansgaon	2003	13	3565	60.00 ± 0.57	73.84 ± 1.38

3.1.7. Global Change Impact Assessment for Himalayan Mountain Region for Environmental Management and Sustainable Development *(APN funded; Period: 2002-2004)*

Importance of global change impacts on Himalayan mountains

Vulnerability assessment of mountain people to climate change

Background and Objectives

The climate of Indian Himalaya is governed by the extra–tropical weather systems of Asia. The Himalayan mountain belts are considered to be the youngest mountains on the earth, and also are tectonically very active, and hence inherently (geologically) vulnerable to hazards triggered by extreme climatic events. In higher, inner Himalayan mountain heavy snowfall, melt water and glacial lakes out bursts can cause hazards in downstream, which may lead to heavy toll of human/animal lives, depletion in natural resources, disturbance in communication, and damage to infrastructure. Alaknanda catchment was selected for climate change study in Indian Himalayan region, as this catchment represents typical Himalayan climate and socio-economic conditions of the region. Objectives of the study are: (i) Determination of the relative importance of global change impacts on the Himalayan mountain environments for prioritization of monitoring efforts and anticipation of consequences with respect to food security and water resources; and (ii) Vulnerability analyses of mountain people to global change and identification of the factors that promote resilience of these groups in the face of multiple and interacting environmental stresses.

Results and Achievements

- **Impacts in Alaknanda valley in central Himalaya**
  - **Increase in rainfall intensity**
  - **Increase in forest cover**
  - **Snowfall restricted to higher altitudes**

1. Yearly mean rainfall for overall IHR is not similar. In Alaknanda catchment a decreasing trend for rainfall and increasing trend for temperature was found (Fig. 8 & 9). During monsoon the intensity of rainfall has increased; while the total duration of rainfall has decreased resulting in heavy landslide events, cloudburst and other natural calamities.
2. The total available area decreased by 3% during 1985-95 all over the catchment while the area under forest shows a 25% increase in the same decade. The area put to non-agricultural use, barren and uncultivated area was also found increasing. The dependence for food grain import from outside is increasing in the catchment.
3. Participatory Rural Appraisal (PRA) in Alaknanda valley villages indicates that the trend of rainfall has changed. During monsoon the intensity of rainfall has increased, while the total duration of rainfall has decreased, drought frequency and extreme events have increased and snowfall has restricted to higher altitude during last 10-15 years.

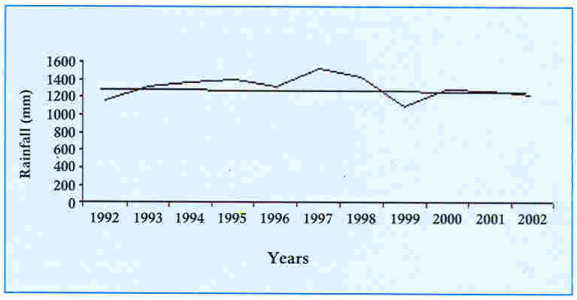


Fig. 8. Total annual rainfall in Alaknanda catchment

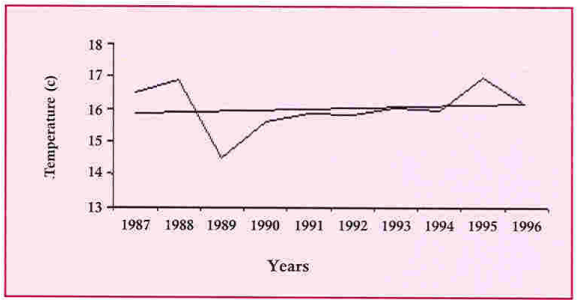


Fig. 9. Average annual temperature in Alaknanda catchment

3.1.8. Environmental Impact of Recession of Himalayan Glaciers: A Case Study of Dokriani Bamak *(DST funded; Period: 2002-2005)*

Estimation of landuse and land cover change

Seasonal and diurnal variations in Co_2 levels

Background and Objectives

Himalayan glaciers are receding faster than glaciers in any other part of the world. The higher receding rate of Himalayan glaciers is posing a threat to their existence. If the glaciers continue to recede, incidents of landslides, change in river regimes and flood will be increased till the water stock in the glaciers lasts. The present project attempts to explore possible impacts of a receding glacier in the Garhwal Himalaya. The objectives are: (i) Collection of data on land use land cover changes (LUCC), and factors (natural/human-induced) leading to LUCC in the proposed study area; and (ii) Measurement of seasonal and diurnal variations in the levels of atmospheric CO_2 at selected sites.

Results and Achievements

- **Preparation of Basic maps and Landuse demarcation in a glaciated catchment**

1. Based on Survey of India toposheet land use, drainage and altitudinal zone maps, stream slope profile of Din Gad (the stream origin from Dokriani bamak glacier) have been prepared.
2. The different land uses identified in Din Gad were: forest area, degraded land and glaciated area, and the area covered by these land uses were 41.4 Km^2, 33.0 Km^2 and 11.6 Km^2, respectively.

3.2. SUSTAINABLE DEVELOPMENT OF RURAL ECOSYSTEMS

The programmes under this Core Group are designed to provide an understanding of location specific problems of natural resource management and to formulate suitable solutions. The focus is to assess the dependency, consumption patterns and prospects of managing currently available resources more judiciously so as to reduce the pressure on these resources while ensuring livelihood security. Studies, therefore, have focused on resource dependency and use patterns among various tribes in Arunachal Pradesh in the Eastern Himalaya while a similar assessment has been initiated in Uttaranchal focusing on livestock-based livelihood activities. Assessment of the dynamics of demographic changes on resource use, management strategies and livelihood options continue to form a focused activity in the Hawalbagh Block in Almora District. Continued efforts are also on to assess the impact of restoration models on productivity, particularly soil physico-chemical characteristics to test the suitability of selected species for agro forestry systems. Such efforts are being carried out in Arunachal Pradesh as well as Uttaranchal. Efforts to find suitable income-generating options have also been carried out based on promising medicinal plants, particularly in Garhwal. Capacity building of the rural populace has been another important activity of the Core, and several trainings have been conducted on rural technologies and propagation techniques, catering to different stakeholder groups in continuation of the Institute's mandate of strengthening delivery systems.

3.2.1. Sustainable Resource Management Strategies for Rural Development in the Himalaya

1. Natural Resource Management for Sustainable Development

Study of resource use and institutional arrangements amongst various tribes of AP for understanding resource conservation and management

Background and Objectives

This study aims to understand people and resource dynamics and document indigenous land uses, knowledge on natural resource management, local Customary Laws and their efficacy for NRM among selected tribal communities in West Kameng and Lower Subansiri districts of Arunachal Pradesh where both shifting cultivation and settled agriculture are the major economic activities. While West Kameng district has 5 major tribes, the Monpas, Akas, Sherdukpens, Khowas and Mijis, the Ziro plateau of Lower Subansiri district is inhabited by the Apatani community only. The Apatanis and Monpas, unlike the other tribes, do not practice shifting cultivation. These areas have been focus of the development in recent times and deserve suitable strategies for sound and sustainable management of the natural resources.

Results and Achievements

- All tribes owe heavily to forests for their demands of natural resources
- Agricultural area shows increase over last quarter of 20th century
- Forests and natural resource management is governed by tribal institutions using local customary laws

1. Natural resource dependency among the studied communities is substantial, with every household collecting huge quantity of firewood (120 q/family), wild vegetables (60 kg/family), and wild fruit (10 kg/family), Bamboos (50 no./household) and cane (10/household) annually for diverse household needs.
2. In Rupa and Dirang circles forest cover during 1974-1999 reduced by 11% and 21% respectively. Both settled and shifting agriculture increased significantly during this period. For settled agriculture the increase was 57% in Rupa and 73% in Dirang circles. Under shifting agriculture this increase was 48%. The ecological energetic analysis of Monpas showed that wet rice cultivation is most efficient system (1 unit energy input = 10 units energy output). Maize production yielded an output of 8 units on every 1 unit of energy input.
3. The Apatanis of Ziro plateau has 14 traditional land uses that comprises from individual holdings to clan and community lands used for different purposes. The community plays an important role in forest preservation using local customary laws. The Apatani community practice 4 major ceremonies and 12 ritual practices, of which 8 are linked with agriculture, and conservation of water and forest resources.

2. Land Use Models for Himalaya

Soil enrichment efficacy of selected agroforestry species for rehabilitation of degraded lands

Background and Objectives

Land degradation is a major problem throughout the Himalayan ranges predominantly due to increased land use pressures. In Northeast India, an added dimension in land degradation is the increasing marginalisation of shifting cultivation. An important activity of the Core over the years has been to develop appropriate restoration practices based on biological interventions.

In this context, different agro-forestry species are being tested for their efficacy in increasing soil fertility and moisture retention, in the Central Himalaya as well as Eastern Himalaya, the latter in the context of reversing the negative effects of shifting cultivation. In the Central Himalayas, selected multi-purpose tree species (MPTs) are being studied for litter fall, litter decomposition, nutrient return and nutrient release patterns in a mixed agroforestry plantation done basically for rehabilitation of degraded agricultural land. In the Eastern Himalayas, the impact of contour hedgerows, using nitrogen-fixing species are being tested for their overall impact on fertility improvement, soil erosion control and crop productivity.

i) Case Study - Central Himalaya

a) Agroforestry Model for Garhwal Himalaya

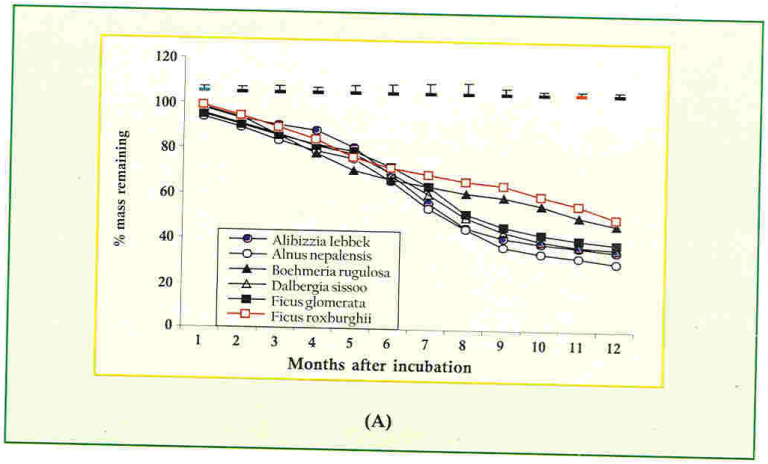
Results and Achievements

- **Plant species differ in rate of leaf mass loss and release of N, P, K on litter decomposition**

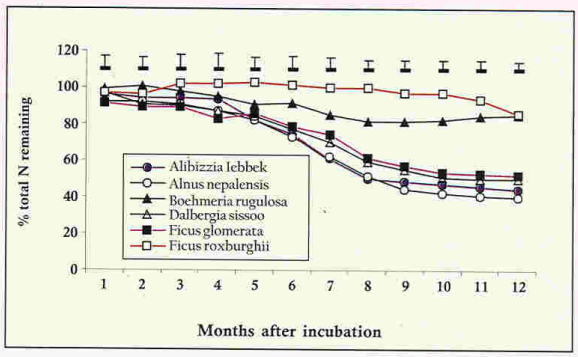
1. Leaf mass loss and nutrient release patterns of six prominent multipurpose tree species i.e., *Albizzia lebbek, Alnus nepalensis, Boehmeria rugulosa, Dalbergia sissoo, Ficus glomerata* and *Ficus roxburghii* revealed significant ($P < 0.01$) differences in decomposition rates due to species, incubation time and species ´ incubation time interaction.

2. *A. nepalensis, A. lebbek, D. sissoo* and *F. glomerata* showed three phases in mass loss and N and P release (Fig. 10 A-C). *F. roxburghii* showed a prolonged immobilization and started mineralizing N after 10 months of incubation. All species showed fast release of K (Fig. 10 D) soon after incubation.

3. Differences between species were more marked after 7 months onwards in mass, N and P remaining and during initial 6 months in K remaining. Percentage mass, N, P and K remaining after one year of incubation varied. *F. roxburghii* and *B. rugulosa* showed significantly ($P<0.05$) higher mass, N and P remaining than other species after 8 months of incubation.



(A)



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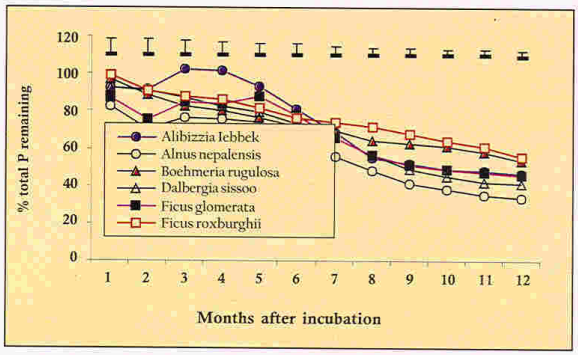

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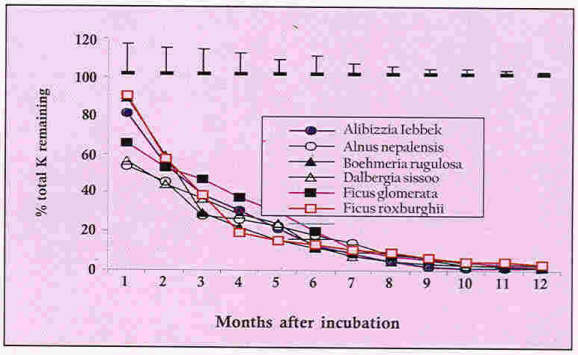


(D)

Fig 10 (A-D). Percent litter mass and nutrients (N,P,K) mass remaining in six multipurpose trees (vertical lines represent LSD P = 0.05)

ii) Case Study – NE Himalaya

a) Impact of Multipurpose Contour Hedgerows Intercropping on Productivity and Soil fertility in Shifting Agricultural (Jhum) Fields in the North East India *(DST-OYS funded; Period: 2001-2004)*

- Contour hedgerow plantation and mulch applications in *jhum* has improved the yield of vegetables
- Contour hedgerow cropping has positive SWC impacts for horticultural and agricultural trial plots

Results and Achievements

1. Impact of mulching of hedgerow biomass on crop yield of cabbage, tomato, ladies finger and capsicum was studied under randomized block design. The crops were grown at the plant-to-plant distance of 45 cm and row-to-row distance of 60 cm. The plots were given different kinds of mulch treatments. Crop yields are presented in Table 6.
2. Soil loss and run-off under contour hedgerow and control was measured, establishing 3x5 m sample plots. The total run off for control plot was recorded 1019.14 and 1067.394 m^3/ha/yr in 2002 and 2003, respectively, and it decreased to 876.35 and 530 m^3/ha/yr in horticultural plots, and to 988.41 and 82.5 m^3/ha/yr in agriculture plots in respective year after incorporation of hedgerows. Total soil loss from control plot was estimated 24.42 and 32 t/ha/yr in 2002 and 2003, respectively, and it reduced by 40-60% after incorporation of hedgerows.

Table 6. Impact of different quality mulching on yield of different vegetable crops (t/ha)

Treatments	Mulch application	Cabbage	Tomato	Ladies finger	Capsicum
Control	-	19.9	4.3	19.1	2.3
H/R + No mulch	-	19.9	5.0	33. 6	5.3
H/R + Light mulch	Green mulch of N_2 - fixing spp. @ 20 kg N/ha	26.9	NR	NR	NR
High quality mulch	Green mulch of N_2 – fixing spp. @ 40 kg N/ha	NR	8.7	41.6	17.0
Low quality mulch	Rice husk @ 40 kg N/ha	NR	4.7	38.3	9.2
High + Low quality mulch	Rice husk + green mulch @ 20 kg N/ha	29.8	7.0	46. 0	15.3

H/R= Hedgerow, NR- Data not recorded

- CHFST technology involves planting of double rows of N_2 fixing species along contours for yield improvement and nutrient enrichment
- Corn yield improved 2-3 times than control using this technology

b) 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; Period: 2001-2004)*

Results and Achievements

1. The Contour-Hedgerow-Farming-System-Technology (CHFST), which is based on growing N_2-fixing hedgerow species on contours along hill slopes

at certain intervals and alleys are allowed to grow desired crops year after year using hedgerow mulch is an appropriate modification to shifting cultivation areas of the northeast India. N_2-fixing hedgerows are maintained in double rows, species are cut at 45-50 cm height and the mulch thus produced is applied to the crop fields as green manure.

2. Incorporation of hedgerow mulch increased corn yield by 2-3 times than control. Application of N_2-fixing species mulch also improves soil nutrient status and enzymatic activities.

3. The selected N_2-fixing species perform better growth in nutrient deficient soils thus make them appropriate choice for shifting cultivation areas and degraded agricultural soils. Decomposing mulch of *T. candida* maintained higher microbial population thus recorded fastest decomposition rate.

3.2.2. People-Centered Landuse Development in the Shifting Agriculture Affected Areas in Arunachal Pradesh *(MacArthur-UNESCO funded; Period: 2001-2004)*

Devising sustainable livelihood strategies with care for environment

Focus on forest and animal resources

Background and Objectives

This project focuses on designing strategies for sustainable livelihoods of traditional hill societies, and linking environmental concerns with sustainable development in selected locations in Arunachal Pardesh. It is a multi-institutional project, and GBPIHED is working in the West Kameng district. Shifting cultivation, fire, grazing, timber collection, poaching, and NTFPs harvesting are perceived as major threats to rich flora and fauna of the area. The project aims to design and develop site-specific *in situ* strategies, explore *ex situ* conservation possibilities by bringing together scientists, manager, planners and local communities to achieve community development. In the reporting year, efforts were made to assess the people-resource dynamics with a focus on forest and animal resources.

Results and Achievements

- **ARFs are worst affected and need special conservation efforts to restore plant regeneration**
- **10 of 16 largely traded NTFPs comprise threatened taxa in west Kameng district of AP**
- **Livestock is major income support sector**

1. The West Kameng district has 76.31% land under forest, and 5.6% under agricultural land use. Three legal forest categories, viz. Reserve Forest (RF), Unclassed State Forest (USF) and Anchal Reserve Forest (ARF), were investigated. The tree diversity was recorded highest in USF (122 spp.), followed by RF (83 spp.) and ARF-1 (6 spp.) (Table 7). Species regeneration was recorded highest in RF (58400 individuals/ha), followed by USF-1 (34600 individuals/ha) and minimum in ARF. This shows the greater need to conserve ARF areas.

2. Of the 257 NTFPs recorded from the area, 16 species are traded in large quantities that also included 4 endangered, 5 vulnerable, and 1 near threatened species. Some important plants, like *Altingia excelsa, Corylopsis himalaya, Illicium griffithii* (all primitive species), *Ficus* spp. (a keystone species), *Dipteris wallichii, Panax bipinatifibus, Wightia* spp. (rare and endangered species) were also recorded.

Table 7. Diversity, index of dominance of different forest stands

Category	RF*	USF-1*	USF-2*	ARF-1*	ARF-2*
Diversity					
Tree	1.5186	1.6362	1.3587	0.6285	0.1452
Sapling and shrub	1.2694	1.6954	1.2759	0.6958	0.7097
Seedling	1.0801	0.7463	0.9963	-	-
Dominance index					
Tree	0.0448	0.0434	0.8710	0.2710	0.8475
Sapling and shrub	0.03913	0.0330	0.7811	0.2664	0.2331
Seedling	0.1223	0.2526	0.8097	-	-

* RF: Reserve Forest, ARF-1: Namshu Anchal Reserve Forest, ARF-2: Thembang Anchal Reserve Forest USF-1: Unclassed State Forest, Jamiri; USF-2: Unclassed State Forest, Yewang

3. Livestock based economy is the main support of the people and dependency on animal's increases with increase in elevation from 1400 m to 3600 m. The major animals products, that generate revenue to the community are milk and wool and by selling poultry animals (Fig. 11).

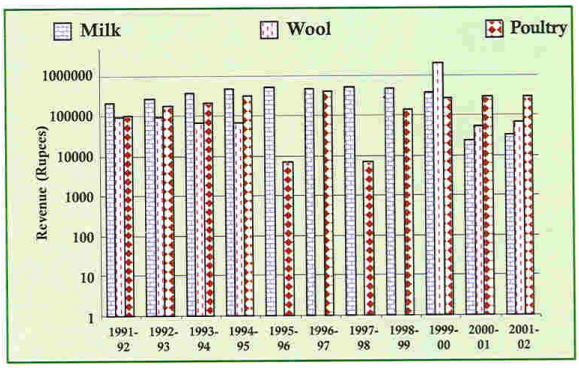


Fig. 11. Revenue from different livestock products in West Kameng district, Arunachal Pradesh

3.2.3. An Assessment of Agriculture Production and Strategy for Sustainable Development of Bioresources

Assessment of demand and supply gaps of bio-resources

Linkages between resource use and demographic and occupational patterns in 40 villages of Almora district

Background and Objectives

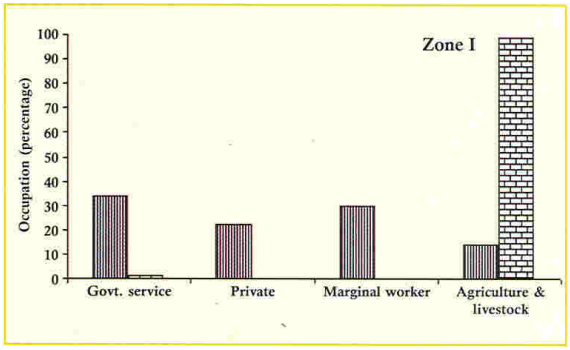
The Himalaya constitutes a unique geographical and geological entity comprising a diverse social, cultural, agro-economic and environmental setup. The ever increasing demands for human population and livestock in the region makes it imperative that different geo-environmental condition wise assessment of bioresources such as agricultural production, fuel, fodder etc be made. With this in view, 40 Villages in Hawalbagh development block of Almora district, representing three altitudinal zones (i.e., Zone-I: less then 1400m, Zone-II: 1400-1600m and Zone-III: more than 1600m) were selected. For identification of gaps in demand and supply and formulation of suitable strategies, primary

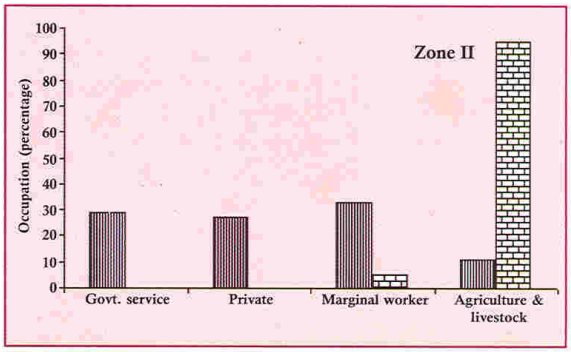
information on demography and occupational categories were collected and analyzed for zone wise comparisons.

- **Nearly 54% of population in working age group of 15-60 yrs**
- **90% of female workforce in agriculture and livestock sector**

Results and Achievements

1. Nearly 53% of the male and 54% of the female population in the study villages fall under the working age group of 15-60 yrs. This suggests a good strength of available workforce for various occupations.
2. he occupational profiles for different zones (Fig. 12) suggest ample work opportunities in the secondary and tertiary sectors, yet a significant gender imbalance in occupational structures in all the zones exists. While occupational pattern for males suggests fairly even representation in all categories, more than 90% of the female workforce is engaged in agriculture and livestock sector only.
3. The women's representation in secondary and tertiary sectors fares negligible presence, this may partly be attributed to their poor educational status. The educational opportunities in the villages still remain at primary level.





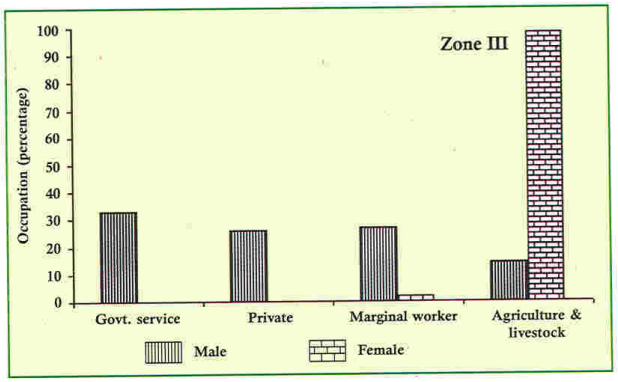


Fig. 12. Occupational structure in Hawalbagh block (Almora)

3.2.4. Farmers Field-School-Cum-Training Programme

Participatory technology transfer among rural people for income generation

Background and Objectives

A critical constraint in rural development is access to technology, particularly in regard to simple technologies for production enhancement and income generation. Capacity building of different stakeholders in simple, low cost, appropriate technologies is a critical imperative towards establishment of an effective delivery system for development. Providing sustainable livelihood technology training through participatory technology transfer method is a major activity of the programme. The core under this programme attempted training trainers from the local inhabitants who have potentials of training others and understanding of the intricate details of scientific interventions.

i) Farmers Field School-Cum-Training Programme in Rural Technologies

Results and Achievements

- **Trainings imparted (27)**
- **Beneficiaries (698 persons)**
- **Revenue generated (Rs. 1.94 lakhs) through sponsored trainings**

1. Ten, three-day training courses were organized on *"Krishak Vikas Avem Aarthik Utthan"* at the Farmers' Training Centre, Kosi, for officials of different Government organizations, NGOs, farmer groups and women. A total of 276 persons (195 males and 81females) were trained. In addition, five three-day and twelve one-day training courses were also organized for students and different NGOs and other organizations working in Uttaranchal. A total of 422 NGOs, farmers and students (203 males and 219 females) were trained (Fig. 13).
2. To improve the status of land resource and also to boost the economic condition of the inhabitants trainings were imparted on protected cultivation (polyhouse), bio-composting, vermicompost, green manuring, agroforestry, horticulture, multipurpose tree plantations, cash crop cultivation, water harvesting technology, fish cultivation, soil conservation measures, medicinal plant cultivation, etc.

3. Based on the participatory discussions, a number of training manuals were prepared, and distributed to the farmers and user groups. During this year an amount of Rs. 1, 94, 000.00 was generated through this programme.

Fig. 13. Farmers fild school-cum-training programme at various places in Kumaun Himalaya

i) Skill Development and Training on Multidisciplinary and Sustainable Environmental Technologies for North East

Results and Achievements

- **Trainings in collaboration with APSS and WWF-India (NE) to 68 persons on various low-cost environment-friendly technologies**

1. Training on sustainable environmental technologies was jointly organized, with APSS at Midphu, Arunachal Pradesh. A total of 45 persons comprising 18 NGOs from six states of north-east region participated in the training. The major themes covered in training were: contour-hedgerow-intercropping, water harvesting, organic farming, bamboo propagation, fish farming, poly film technology, and nursery and green house techniques.
2. Another training on "Improvement in traditional methods of replenishing soil fertility vis-à-vis organic farming for food security and biodiversity conservation for Arunachal Pradesh" was organized at Midphu, along with WWF-India, Itanagar. A total of 13 selected persons participated in the training.

iii) Farmers Training Programme in Medicinal Plant Propagation

Results and Achievements

Trainings on medicinal plants cultivation at Garhwal to over 240 persons

1. Three training programmes (each of two days) focused on medicinal plant cultivation and conservation was organized in remote villages of Garhwal region. A total of 240 persons (local farmers, representative of NGOs and GOs) were trained (Fig. 14) on large-scale cultivation of some economically important species i.e., *Saussurea costus, Picrorhiza kurrooa, Rheum australe, Arnebia benthamii, Allium spp., Aconitum heterophyllum* and *Pleurospermum anglecoides.*
2. Eight day study-cum-observation visit of participants in the field of medicinal plant cultivation and conservation was organized for UNESCO nominated participants of Nepal, Bhutan and India.

Fig. 14. Training programme on cultivation and conservation of medicinal plant

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

Background and Objectives

Focus on cultivation and uses of Allium spp., a traditionally grown MP in Garhwal region

Lack of appropriate initiatives to enhance capacity to gain economic benefits from the new market opportunities deprives local communities from getting monetary benefits on one hand and gives way to unsustainable exploitation of precious resources base on the other. Central Himalayan region is known to be storehouse for a variety of valuable medicinal and aromatic plants (MAPs) and *Allium* species is one of them. Bhotiya communities of the higher Himalayan region are utilizing it since long for food, spices and condiments, and medicine. Therefore, the reporting year was to study ecological, socio-economic and other attributes of *Allium* spp. as well as extension and promotion of some other MAPs.

- Seed germination of *A. stracheyi* was recorded 100% under GA_3 at 25 °C
- Cultivation of some MPs at Ginothi village for demonstration

Results and Achievements

1. There are about six species of wild *Allium* (*A. stracheyi, A. humile, A. rubillium, A. semenovii, A. walichii* and *A. tuberosum*), which are used in a variety of purposes viz., medicine, spice and condiments, as a food and also act as fly and moth repellent by the local inhabitants (Fig. 15).

Fig. 15. Larg-scale cultivation of *Allium stracheyi* at Suraithota

3. Seed germination for two *Allium* species (*A. stracheyi* and *A. humile*) was studied. *A. stracheyi* exhibited 100% germination under GA_3 (50 ppm) in light condition at 25 °C, followed by cold (97%) and hot (60%) water treatments. In case of *A. humile* cold water treatment at 20°C (light condition) exhibited 90% germination. Two-piece cuttings of *A. stracheyi* and *A. humile* treated with IAA (500 ppm) showed 96 and 92% emergence.
4. Seeds and cuttings of *P. kurooa, S. costus, Carum carvi*, etc. brought from demonstration sites maintained in NDBR buffer zone areas were planted in Ginothi village of Uttarkashi district (Fig. 16). Besides, 200 plants of sweet chestnut and hazelnut have been planted in this village.

Fig. 16. Medicinal plant cultivation/demonstration at Ginothi, Uttarkashi

3.2.6. Augmenting Food and Economic Security of Tribal Communities, particularly Women in Arunachal Pradesh through Simple and Low Cost Technological Intervention *(DBT funded; Completed project)*

Traditional knowledge of food resources of Nyishi community

Economic and food security interventions

Tribal communities in Northeast India are intimately dependent on natural resources for their survival. In recent times there has been tremendous pressure on natural habitats and many useful plants have come under the threat category. There is an urgent need to study useful plants, document indigenous knowledge about their utilization and management and taking necessary step for their *in situ* conservation, and *ex situ* cultivation within or around the homestead using

poly-pits, polyhouses in their jhum fields and fallows using shrub and tree species as hedgerows. The project was focused on evaluating the traditional knowledge for use of food resources that play a vital role in proper nourishment of all including the nursing and expectant mothers of the Nyishi community in the Papumpare district of Arunachal Pradesh. The major activities were attentive around developmental trails on some simple low-cost technological innovations for upgrading tribal farmers' income for better socio-economic security. Summary of the project presented in Box –1.

Box - 1

Summary of the Completed Project

(2001-2003)

Augmenting Food and Economic Security of Tribal Communities, Particularly Women in Arunachal Pradesh through Simple and Low Cost Technological Intervention *(DBT funded)*

The project focused on evaluation of the traditional knowledge for use of food resources of the Nyishi community in the Papumpare district of Arunachal Pradesh. The findings include:

- Nyishi tribe uses about 163 (48 herbs, 32 shrubs, 21 climbers, 61 trees) wild edible species, out of these 24 are extensively used. Of the total screened species 43% species are edible for their leaves, 7% for roots, 3% for pith, 15% for flowers, 20% for fruits and 11% for their seeds.
- To improve the economic status of the farmers, a few selected crops and technologies have been adopted that include 'multi-tier cropping' using fruit tree, cash crops, food plants and root-crop, bamboo propagation, liquid manuring, weed composting, water harvesting and poly-film technologies.
- *Piper longum* (Pipli) and pine apple were introduced as cash crops and recorded good returns. Experiments were conducted on the yield improvement measures of some important root/tuber crops, such as sweet potato (*Ipomea batatus*), cassava (*Manihot esculenta*), aroid (*Colocassia* spp.) and yam (*Dioscorea* spp.). The yield of all crops increased significantly when raised in 5 m long trenches, filled with quality mulch and compost (Table 8).
- Improved method of bamboo propagation (clumps were cut to sizes of about 2 m or culms containing at least 3-4 nodes, square holes of about 3-4 cm size made on each internodes; the culms after filling the holes with water were buried underneath the soil up to 10 cm depth) increased number of clumps 4-6 times than the traditional system of propagation through split rhizomes.

Table 8. Yield of root/tuber crops (fresh weight) as affected by managed cropping and mulching after 1.5 years of experiment

Scientific name	Common name	Yield (t ha^{-1})	
		In treated plots	Traditional practice
D. bulbifera	Yam	74 ± 5.7	53.2±3.1
Colocassia spp.	Kuchhu	62 ± 4.5	48.25±6.6
M. esculenta	Cassava	50 ± 5.3	38.13±5.6
I. batatus	Sweet potato	32 ± 8.5	25.26±7.1

3.2.7. Conservation and Sustainable Management of Belowground Biodiversity (BGBD) in and Around Nanda Devi Biosphere Reserve *(TSBF/GEF funded; Period: 2003-2004)*

Below ground diversity of soil fauna is important for sustenance of terrestrial ecosystems

Focus on awareness, and demonstration of conservation methods

Background and Objectives

Traditional and conventional agriculturists have largely ignored the diversity and role of soil fauna. Soil invertebrates are major determinants of soil processes in any terrestrial ecosystem, key group such as earthworms, termites, ants and litter feeding arthropods have been shown to affect the physical structure of the soil and influence the nutrient dynamics through their effects on immobilization and humification. However, recent research in this area demonstrates the practices, which eliminate soil faunal communities, are not going to be sustainable in long-run especially the traditional agriculture that is based on organic inputs. Therefore, the present study have been initiated in and around the buffer zone area of Nanda Devi Biosphere Reserve (NDBR) with the objectives to enhance awareness, knowledge and understanding of BGBD important to sustainable agricultural production through demonstration of methods for conservation and sustainable management.

- **Selection of benchmark sites for isolation of key soil fauna groups in Nanda Devi Biosphere Reserve**

Results and Achievements

1. The benchmark sites for inventory and evaluation of soil faunal key groups such as earthworms, termites, ants etc in NDBR and its adjoining areas have been selected which include: Traditional rainfed agriculture, Vegetable cultivation, Cultivation of MAPs, Pure potato, Pure pea, Mature oak forest, Pine forest, *Cedrus deodara* forest and alpine pasture.
2. Soil samples from different land use types at different time intervals (monthly or bimonthly) were collected and brought to lab for isolation of the key groups of soil fauna.

3.2.8. Commercial Utilization for Sustainable Rural Development and Conservation of Some Potential Wild Edible Oil Plants of Garhwal Region of Uttaranchal *(CSIR funded; Period: 2002-2005)*

Sustainable harvest and management of wild edible plant resources for (i) optimal yield point, and (ii) oil extraction

Background and Objectives

Under- exploited wild resources of the potential economic significance are known to play a crucial role in maintaining the subsistence life styles of the traditional mountain societies. The present development policy ignores this vital resources base with regard to its scientific management and sustainable harvesting, which is resulting in decline in population of many of these species affecting the livelihood of the dependent populations. Therefore, finding new areas of economic activity, which can minimize unemployment through small village level cottage industry based development, is important especially if under-utilized resources are utilized. The objective (s) envisaged for the reporting year include: (i) estimation of optimal fruit yield, and (ii) comparison of oil extraction employing traditional and modern methods.

- Positive correlation between fruit yield and bush size (*P. utilis*)
- Modern oil extraction methods are more (1.5 to 1.8 times) efficient

Results and Achievements

1. Fruit yield in *Prinsepia utilis* varied with the size of bushes and it exhibited positive correlation (r=0.988) between bush size and fruit yield (Table 9). In *Prunus persica* small size trees (about 15-20 years old) provide higher yield (131.0±1.2 kg/ha) as compared to large size (about 40-50 years) trees (115.0±3.7 kg/ha).
2. Oil extracted from the seed kernels of *P. utilis, P. persica* and *Neolitsea pallens* using modern methods (oil mills run by electricity or diesel) provide 1.5-1.8 time higher oil yield as compared to traditional system i.e., oil extracted using *Kohlu* and *Silbat*.

Table 9. Fruit yield from different size of bushes of *P. utilis*

Size	Average no. of branches/ bush	Density/ha	Fruit yield /bush (g fresh wt.)	Yield kg /ha (fresh wt.)
Small	6	79	744±1.7	58.77±0.04
Medium	12	63	1884±2.6	118.69±0.08
Large	18	51	3006±3.8	153.30±0.92

3.2.9. Natural Resource Management – Seasonal Migration of Livestock in the Central Himalaya

Analysis of seasonal migration pattern of livestock in Dudhatoli region in Central Himalaya

Background and Objectives

Seasonal movement of villagers with livestock, in search of fodder and livelihood, is an age-old phenomenon in the Central Himalaya. Livestock activities and various products of their seasonal dwellings were integral part of the village life and have provided opportunities for additional income generation. Studies on this livestock-based livelihood practice and functioning of temporary dwellings, have not been conducted in the Central Himalayan region. The objectives for the target period were to identify and record the seasonal livestock movement practices towards temporary dwellings in the middle mountain region and to characterize the geo-spatial, social, and livestock attributes of each temporary settlement in the forests.

- Migration pattern of livestock in Dudhatoli region
- Livestock size and composition of temporary settlements *(Thors)*

Results and Achievements

1. In Dudhatoli region villagers from several villages of Almora, Chamoli, and Pauri districts migrate with their livestock (cow, buffalo, bullock, goat, and sheep), and about 100 temporary settlements (*Thors*) were observed in the forests in which livestock from 29 villages migrated (Table 10). Total human population in the studied *Thors* was 101 persons of 58 families.
2. Total livestock strength in the studied *Thors* was 1006. Livestock units per *Thor:* average 83.8, max- 266, min- 9 were recorded. Amongst the different *Thors* the migratory livestock population varied between 60% and 97% of the total animal population of these villages. Of the total livestock population Caprine constituted maximum (62%) followed by Bovine 29% and Ovine (8%).

Table 10. Various attributes of different *Thors* in Dudhatoli region

Name of the Thor	Elevation (m)	Human Population		Livestock	
		Migratory from the villages (nos.)	Resident population (nos.)	Migrated to Thor (nos.)	At villages (nos.)
Amgreekhat	2020	2	5	31	11
Dankhali	2120	2	3	9	6
Beechram thor	2200	2	3	47	7
Bharam Bhatena	2480	1	8	140	4
Bherrapani	2320	3	7	42	3
Talla Kotha	2210	2	2	11	4
Malla Kotha	2220	3	20	257	41
Phulwari	2480	4	9	128	6
Mallikhori	2230	1	19	99	4
Aaglaga	2310	2	9	94	19
Raajgudhan	2220	1	7	49	6
Panyali Malli	2020	3	9	96	13

3.2.10. Global Climate Change Studies in the High Altitude Himalayan Ecosystems *(DOS funded; Period: 2003-2006)*

Monitoring the changes in LUCC of high altitude ecosystems in the Himalaya

Background and Objectives

As a consequence of the green house effect and global climate change, vegetation cover is expected to respond to changes in temperature and precipitation. There are continuing efforts worldwide to build a strong interagency focus on global change impacts on managed and natural ecosystems, and to understand the relationship between a changing biosphere and a changing climate, however, there is a large gap between the Indian studies and the knowledge that exists in other parts of the world. Observations and monitoring from space of the changing land use and land cover can be used effectively to collect/update information so as to take corrective steps and to make land use more sustainable. The objective of study is to advance our understanding of the structure and functioning of the high altitude ecosystems of the Himalaya, its major sub-systems, and its response to physical, biological and anthropological forces.

Results and Achievements

- **Compilation of population structure of dominant trees**
- **Collection of meteorological data for modeling**

1. Preliminary surveys have been done to identify the field sites in different parts of the Kumaun Himalayan region. Population structures of different dominant forest trees have been compiled.
2. Meteorological data from different stations at various locations have been obtained to integrate in geo-spatial modeling.

3.3. CONSERVATION OF BIOLOGICAL DIVERSITY

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 research programmes under progress include: Documentation and prioritization of important components of biological diversity; identification and monitoring the processes and activities responsible for depletion of biodiversity; identification of priorities for maintenance of existing biodiversity in the Himalaya and assessing threats to biodiversity in selected protected areas. Efforts are also on to complement in situ conservation with the help of ex situ methods and participatory mechanisms of biodiversity conservation.

3.3.1. Bioresource Inventory of the Himalaya

Background and Objectives

Development of a systematic database

Identification of conservation priorities and potential resource base, for any biogeographic region, is dependent on availability of adequate base line data on biological resources. Considering this, it was felt imperative to develop a systematic database of existing bioresources in the Himalaya. In this context, preparation of inventory of bioresources (family and group wise) has been initiated with the objectives to: (i) develop a systematic database of species and their habitats; (ii) draw information about various attributes of specific habitats/ species; (iii) prioritize species and sites for conservation.

Results and Achievements

(i) Floral Inventories

- **Database for 70 vascular families of IHR was developed**

Family:

1. Database prepared for 70 families of vascular plants of Himalaya and 30 families analyzed for pattern of endemism (Table 11). Analysis revealed most of the species rich (>100 spp.) families represent higher (>1) index of endemicity than the expected normal distribution.

Table 11. Species richness and extent of endemism in identified families of IHR

Family	Taxa (genera/spp.)	Endemic (%)	Near endemic (%)	Index of endemicity (Ie)
Pittosporaceae	1/3	33.3	0.0	3.2
Polygalaceae	2/23	13.0	17.4	1.2
Capparaceae	4/28	7.14	35.7	0.7
Flacourtiaceae	5/16	18.8	43.8	1.8
Nymphaceae	3/7	14.3	0.0	1.4
Portulacaceae	1/5	0.0	20.0	0.0
Tamaracaceae	5/12	8.3	0.0	0.8
Caryophyllaceae	24/163	22.1	42.3	2.1
Saxifragaceae	5/109	14.7	85.3	1.4
Umbelliferae	59/199	32.1	9.6	3.1
Gentianaceae	23/168	29.7	45.8	2.8
Hypericaceae	1/19	36.8	57.9	3.5
Ternstromaceae	4/7	14.2	42.9	1.4
Theaceae	1/2	0.0	5.0	0.0
Actinidaceae	1/2	0.0	0.0	0.0
Saurauiaceae	1/5	20.0	20.0	1.9
Rosaceae	40/448	25.7	47.1	2.4
Malvaceae	16/61	1.6	29.5	0.2
Stachyuraceae	1/1	0.0	0.0	0.0
Dipterocarpaceae	1/1	0.0	0.0	0.0
Boraginaceae	39/135	15.6	47.4	1.5
Campanulaceae	10/39	23.1	51.3	2.2
Lamiaceae	55/225	11.1	53.8	1.1
Polymoniaceae	2/4	0.0	0.0	0.0
Chenopodiaceae	13/32	12.5	34.4	1.2
Polygonaceae	13/130	15.4	47.7	1.5
Chochlorospermaceae	1/1	0	0.0	0.0
Asteraceae	143/838	27.2	40.1	2.6
Primulaceae	8/103	19.4	69.0	1.8
Onagraceae	6/49	18.4	36.7	1.8

2. Orchids (886 species; 152 genera) of IHR listed and analyzed for species diversity and distribution pattern. The species rich genera include *Bulbophyllum* (80), *Dendrobium* (76), *Eria* (45), *Liparis* (34), *Oberonia* (33), *Cymbidium* (25), *Habenaria* (23), *Peristylus* (22) and *Calanthe* (21 spp.). Maximum orchids (92.78%) are distributed in the zone <1800m asl. and minimum (2.6%) in the alpine zone. Nearly 50% species are Himalayan natives. Forty one species are recorded in the Red Data Book of Indian Plants.

Group:

- **Grid maps were prepared for MPs (UA) – first of its kind**
- **Inventory of plants in sacred groves (246) of Kumaun**
- **Survey of NTFPs (NE India)**

1. Continuing with the studies of previous year on the database for Uttaranchal Medicinal Plants the grid map (5' interval) for MPs distribution was prepared (Fig. 17). Also, distribution Maps for high value MPs and threatened MPs were developed.

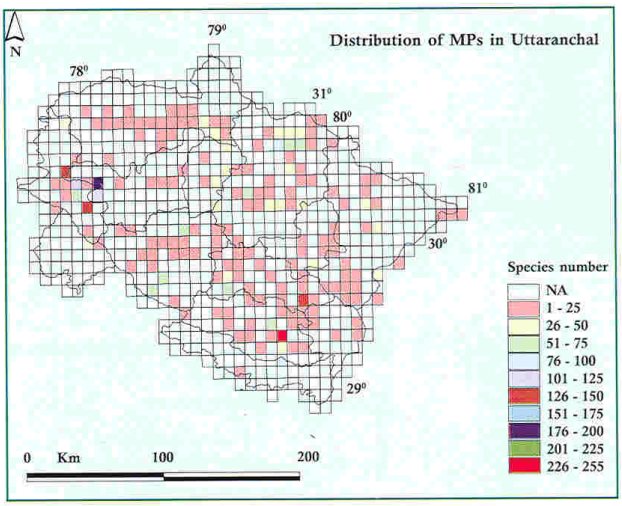


Fig. 17. Grid wise species richness of MPs in Uttaranchal

2. Information from 246 Sacred Groves of Kumaun Himalaya compiled and 214 plant species (Trees: 133 and Shrubs: 81 spp.) belonging to 79 families and 154 genera recorded. The families, Rosaceae (18), Moraceae (13), Fabaceae (11), Euphorbiaceae (10) and Rutaceae (7) are most represented. Nearly 36% species were native to Himalayan region.
3. Surveys of NTFPs in the 5 states of NE India, viz. Manipur, Meghalaya, Mizoram, Nagaland and Tripura, revealed that a total of 33 species are being marketed from these states, of which Manipur has the highest 32 species, followed by Nagaland (5 species), Meghalaya and Tripura (3 species each) and Mizoram (2 species). Bamboos are harvested in large quantities from all states (Tripura - 8, 32,034, Mizoram - 6,58,436, Nagaland -39,338, Manipur -15,230 and Meghalaya -2640 Truckload).

(ii) Faunal Inventories

Avi -fauna in Himalayan Biosphere Reserves

• **Bird inventory of Himalayan Biosphere Reserves (485 spp.)**

1. Across the identified BRs, 485 species of birds (20 orders, 61 families and 224 genera) have been listed. Of these, Nanda Devi Biosphere Reserve represents 208, Manas 137, Dibru Saikhowa 225, and Kanchendzonga 176 species. Families, such as, Muscicapidae (107 spp.), Phasianidae (32 spp.), Anatidae (24 spp.), Fringillidae (20 spp.), Columbidae (16 spp.), Paridae (15 spp.), Charadriidae (14 spp.) and Ardeidae, Picidae and Corvidae (12 spp., each) were species rich.
2. Four species (i.e., *Gyps bengalensis, G. indicus, G. tenuirostris* and *Rodonessa caryophyllacea)* were Critically Endangered, 10 - Endangered, 23 - Vulnerable, and 19 - Low Risk Near Threatened. Of the total, 29 species have been listed in the Schedule I of Wildlife Protection Act.

3.3.2. Studies on Biodiversity

Background and Objectives

Detailed studies of biodiversity components for addressing the issues of conservation and sustainable use

In-depth investigation of biodiversity components, especially those representing sensitive elements (i.e. ecosystems, habitats, taxa, etc.) are of paramount importance for addressing the issues of conservation and sustainable use. In this context, attempts were made to: (i) investigate the distribution of bioresources and their use patterns in biodiversity rich areas, including the Protected Areas (PAs); (ii) identify the impacts of disruptions on natural forest ecosystems across the varying intensities of pressures; (iii) assess diversity of important (ecologically and economically) species.

Results and Achievements

(i) Biodiversity Rich Areas

(a) Biodiversity studies of sub-tropical and temperate forests

1. Continuing with the previous attempts, in the upper Siraunt Gad Catchment of Kumaun, 741 species of vascular plants were recorded (Table 12). Further analysis of data for endemism, human dependence including extraction trends of fodder and fuel resources and rarity is continuing.

Table 12. Plant diversity of the upper Siraunt Gad Catchment (Reserve Forest) in Ranikhet

Taxonomic Groups	Families	Genera	Species	Life Forms			
				H	Sh	T	Pt
Angiosperms	130	452	633	419	116	98	-
Gymnosperms	2	4	4		1	3	-
Pteridophytes	39	51	104	-	-	-	104
Total	171	507	741	419	117	101	104

Abbreviations used: H= Herb; Sh= Shrub; T=Tree; and Pt=Pteridophytes

(b) Biodiversity Studies in Protected Areas

I. Kanawar Wildlife Sanctuary, H.P. -Population assessment of threatened species

- Population assessment (9 sites) of *A. glauca* in Kanwar Wildlife Sanctuary (HP)

1. Assessment of populations of *Angelica glauca*, a high value threatened medicinal plant, was conducted. Across 9 sites (between 2100-3200 m asl) density varied significantly ($p<0.05$; Fig. 18), recording 1.0 to 1.97 individuals/m^2.

2. Nineteen microhabitats were identified, exhibiting 0.37 (minimum; tree stump base) to 17.8 % (maximum; shrubberies) plant-frequency. Dripping-rock (open) provided highest plant-density (2.71) but low frequency (2.6%). Study revealed altitude was poorly correlated (negatively) with plant-height ($r= -0.149$), but significantly (negatively) with aboveground dry weight ($r= -0.370$).

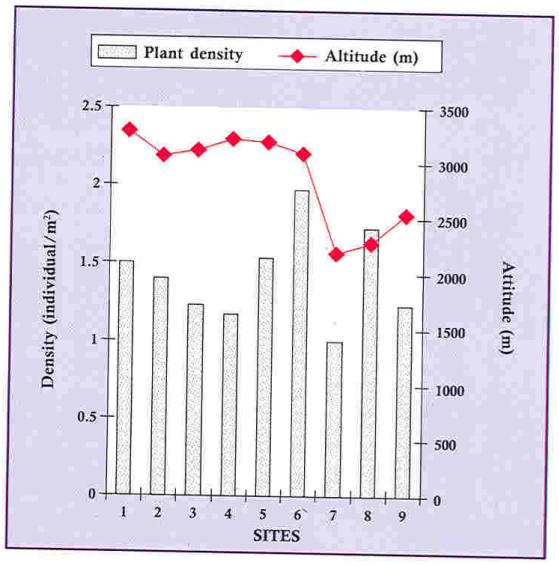


Fig. 18. Average desity of Angelica glance at different Sites along Various attitudes in Kanawar Wildlife Sunctuary, kullu (H.P.)

II. Nanda Devi National Park - Uttaranchal

- Report of the revisit to the Nanda Devi NP after 10 yrs.
- Identification of 57 communities and biodiversity rich areas

1. During Biodiversity Monitoring Expedition (organized by Uttaranchal Forest Department - 2003) in the park 568 species (Trees: 30, shrubs: 103; and herbs: 435 spp.) belonging to 314 genera and 110 families of the Angiosperms, Gymnosperms and Pteridophytes were recorded. Of the total, 73.1% species were Himalayan native, 34.2% near endemic and 2.1% endemic. Presence of 7 RDB species [i.e., *Cypripedium himalaicum*, *C. elegans* (Rare), *Saussurea costus* (Endangered) and *Acer caesium*, *Allium stracheyi*, *Nardostachys grandiflora*, *Picrorhiza kurrooa* (Vulnerable)] was observed.

2. Based on the phytosociological parameters, 57 plant communities (forests: 02; scrub: 06; and alpine herbaceous communities: 49) were delineated.

Among forests the density of trees in *Abies spectabilis* community varied from-700– 1460 plants ha^{-1} and for *Betula utilis* community from-350 – 1210 plant ha^{-1}. Regeneration pattern of the *A. spectabilis* and *B. utilis* communities in the park are presented (Fig. 19-20).

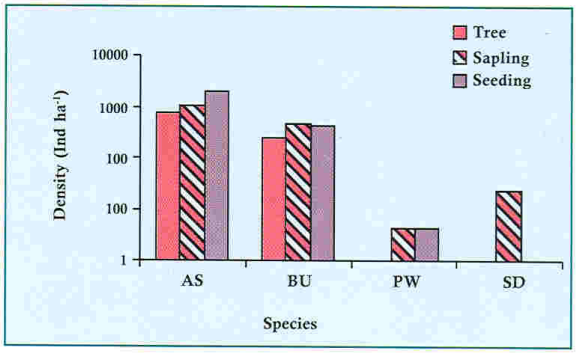


Fig. 19. Regeneration pattern of tree in *Abies spectabilis community* (AS= *A. spectabilis*; BU= *B. utilis*; PW= *P. wallichiana*; SD= *S. disperma*)

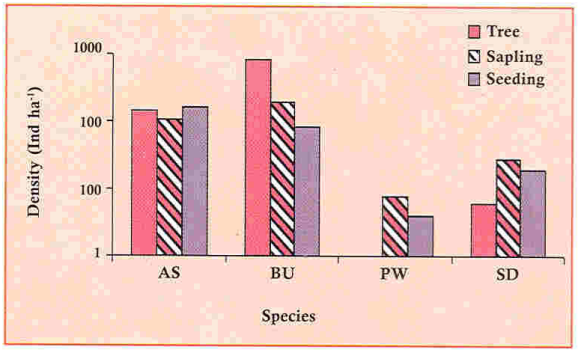


Fig. 19. Regeneration pattern of tree in *Betula utilis community* (AS= *A. spectabilis*; BU= *B. utilis*; PW= *P. wallichiana*; SD= *S. disperma*)

3. Based on the community patterns, species richness and availability of sensitive species, following areas within the park were identified as biodiversity rich areas: Satkhola, Dharansi slopes, Dibrughetta meadow, Barapani, Bethartoli and Sarsopatal.

III. Namdapha National Park- Arunachal Pradesh (MoEF funded, completed project)

Box - 2

Summary of the Completed Project

(October 2000- September 2003)

Inventory of tree diversity and collection and propagation of high value taxa in Namdapha proposed biosphere reserve , Arunachal Pradesh (MoEF funded)

The study was conducted in Namdapha National Park area. The project focused on documenting the tree diversity of the Park. Major outcome of the study include:

- Three representative lowland tropical forest stands, viz., *Altingia* mixed stand, *Shorea-Dipterocarpus* stand and *Albizia* riverine stand were sampled. The tree species richness and density ranged from 68 species and 412 tree ha^{-1}, 39 species and 390 tree ha^{-1}, and 21 species and 246 trees ha^{-1} in respective stands.
- All the forests exhibited good regeneration except for *Albizia* stand which showed poor regeneration. *Beilschmiedia assamica*, and *Dysoxylum procerum* in *Altingia* mixed stand, and *Knema angustifolia*, *Saprosma ternatum* and *Shorea assamica* in *Shorea-Dipterocarp* stand showed fairly good regeneration.
- Seed germination studies, conducted for some selected tree species, revealed that: (i) the light seeded pioneer species, *Altingia excelsa,* showed less germination (40%), whereas the heavy seeded *Beilschmedia assamica* (52%) and *Dipterocarpus macrocarpus* (65%) showed fair germination. The most dominating *Ostodes paniculata* showed 68% germination.
- Study of resource use exhibited, with the increase of population size, the carrying capacity of the Unclassed State Forest areas is going down and inhabitants are deriving the forest resources from the National Park. Also, growing settlements inside the park is an emerging concern that needs to be tackled immediately for better management of the park.
- Dearth of manpower and trained wildlife personnel in the park is a major handicap for proper vigilance and to ward off the illegal activities especially from the southeastern side, which is totally unmanned. Also, there is a need to start more scientific researches to understand this pristine ecosystem, which will pave the way for its better management.

(ii) Biodiversity studies along disturbance gradient

(a) Structural and compositional patterns - mid altitude forests ***(In- house funded, completed project)***

Box - 3

Summary of the Completed Project

(2001- 2003)

Diversity Studies along Disturbance Gradient – Mid Altitude Forests of Kumaun

Three representative forest types (Banj-oak, Chir-pine and Mixed broad leaf forest) of mid altitude (1000-2500 m) zone were investigated across three levels of disturbance (i.e. pristine, semi degraded and degraded), in Kumaun Himalaya. The study concludes the following:

- Increasing disturbance intensity shows significant decrease in total forest density and total basal area (TBA) in all three forests; shrub density increases significantly in chir-pine and banj-oak, while herb density in creased in mixed broad leaf forest.
- The herb layer revealed that relative frequency of non-natives increases significantly with increasing level of disturbance. Representativeness (native species) along disturbance gradient varies considerably among the forest types (Table 13). While significant variations were observed in presence of native and non-native species in banj-oak ($\chi^2 = 8.4626$ *df - 1,* $p<0.05$) and mixed broad leaf forest ($\chi^2 = 3.725$, df-1 $p<0.05$), proportionately the significant difference between native and non-native contribution was was apparent in banj-oak ($\chi^2 = 4.3091$*df - 1,* $p<0.05$) and chir-pine ($\chi^2 = 4.292$, *df - 1,* $p<0.05$) forests.

Table 13: Representativeness of herbaceous species along disturbance gradient in different forest types of Kumaun Himalaya

Forest Condition	RF %		RD %	
	Native	Non - native	Native	Non – Native
Oak Forest				
Degraded	12.54	87.46	1.64	98.36
Semi degraded	19.77	80.23	14.88	85.12
Pristine	28.93	71.07	28.04	71.96
Mixed Forest				
Degraded	13.71	86.29	2.02	97.98
Semi degraded	28.34	71.66	2.15	97.85
Pristine	37.43	62.57	4.95	95.05
Pine Forest				
Degraded	17.27	84.73	12.61	87.39
Semi degraded	22.45	77.55	21.79	78.21
Pristine	22.02	77.98	12.44	87.56

- **Developed 27 cell matrix for identification of disturbance intensities across different forest sites**

(b) Dynamics of structural & functional features of biodiversity in relation to disturbance gradient in forests of Kumaun Himalayas *(DST funded)*

1. Disturbance history of the identified forest sites was obtained through a survey among the neighboring villages. Preliminary data analysis on compositional features completed, which reveals considerable variation

across different disturbance categories. Detailed synthesis of information and analysis of soil and litter samples is in progress.

2. Considering various attributes of disturbance, a matrix was developed for possible combinations. A total of 27 combinations of disturbance were possible. However, based on the field situation following five combinations of sites were available - LL-LG-PR/ 5 yrs (Oak and Oak- mixed broad leaved forests); LL-LG-PR/ 25yrs (Oak and Oak- mixed broad leaved forests); ML-MG-00 (Oak- mixed broad leaved forest); LL-HG-UP (Oak forest); HL-HG-UP (Oak and Oak- mixed broad leaved forests) and identified for detailed investigation.

(ii) Studies in sensitive habitats - timberline

"Studies on species and community response to habitat alterations in timberline zone of proposed Uttarakhand Biosphere Reserve: management implications" *(MoEF funded, completed Project).*

Box - 4

Summary of the Completed Project

(January 2000- March 2004)

Studies on species and community responses to habitat alterations in timberline zone of proposed Uttarakhand Biosphere Reserve: management implications (MoEF funded)

Project focused on assessment of plant diversity patterns across various intensities of human interventions at timberline zone (TLZ) of west Himalaya. The study specifically attempted to address the issues of: (i) identification and characterization of TLZ habitat relationship with biodiversity elements; (ii) assessing consequent effects of habitat alterations on native elements; (iii) identifying and prioritizing sensitive TLZ habitats and species. The study concluded the following:

- Across increasing disturbance intensities, *Betula utilis* ($F=12.02$, $p<0.01$) and *Acer* mixed broad-leaved forest ($F=4.88$, $p<0.05$) showed significant decline in tree density. Whereas, for *Abies pindrow* maximum density was recorded in degraded condition. Patterns of diversity in different life form classes varied across the disturbance intensities (Table 14).
- Besides affecting composition, increased level of disturbance in all the forests caused a sharp decline in: (i) total leaf litter fall from Pristine (P) to Degraded (D) conditions (*B. utilis* P- 204.4, D - 104.2; *A. pindrow* P - 85.2, D - 49.3; *Acer* mixed P- 177.8, D -93.8 g m^{-1} yr^{-1}), (ii) annual decay rates (*B. utilis* P- 0.892, D - 0.734; *A. pindrow* P - 0.755, D - 0.431; *Acer* mixed P- 0.942, D -0.741). Both these factors have implications for nutrient cycling patterns of system.
- Patterns of regeneration in different communities and important species showed variations among forest types and dominant species across disturbance intensities suggesting need for different management strategies.

Table 14: Pattern of species richness (r), diversity index (H') and Beta diversity (b) across disturbance conditions of three forest types at TLZ.

Forest types		Pristine		Semi-degraded		Degraded		β
		r	H'	r	H'	r	H'	
Betula	T	6	0.35	6	0.59	6	1.01	1.83
utilis	S	13	2.10	10	1.93	9	1.69	1.87
	H	48	3.46	36	3.17	16	3.07	1.95
Abies	T	7	0.80	6	0.99	9	1.35	1.90
pindrow	S	16	2.29	10	1.92	14	1.23	2.10
	H	38	2.85	34	2.97	19	3.04	1.78
Acer	T	8	1.36	7	1.22	11	1.67	1.61
mixed	S	8	1.84	13	2.4	6	1.34	2.0
broad leaf	H	35	2.47	36	2.73	15	2.56	1.95

(T- trees, S- shrubs, H- herbs)

3.3.3. Establishment of Gene Banks Across the Himalaya

Establishment of germplasm bank of Himalayan plants

Background and Objectives

In order to develop a germplasm bank of Himalayan plant species and ensure *ex-situ* conservation, enrichment of germplasm in arboreta (Kosi-Katarmal, Kumaun and Pangthang - Sikkim), herbal gardens (Kosi-Katarmal, Kumaun and Mohal -Kullu) and demonstration sites (Lata, Chamoli) has been envisaged. The project attempts to cover maximum representative species in the region. Special focus is on: (i) establishing gene bank(s) of Himalayan species including economically important ones; (ii) developing propagation protocols for locally acceptable species; (iii) large scale multiplication of important species and making the saplings available to local people.

Results and Achievements

- ***Ex situ* maintenance of 20 rare and endangered species**
- **Distribution of >2500 saplings of MPTs**

(i) Enriching gene banks

I. Arboretum at Kosi-Katarmal, Almora

1. Propagules (seeds) of 20 species, including thirteen rare endangered species namely *Aconitum heterophyllum, A. balfourii*, *Arnebia benthamii*, *Pleurospermum sp., Allium* sp., *Bergenia* sp., *Rheum austral*, *Heracleum candicans*, *Dactylorhiza hatagirea*, *Picrorhiza kurrooa, Cyperus rotundus, Bergenia ligulata* and *Salvia lanata* were collected from different populations and maintained in the arboretum. Data collection on germination, growth and survival of plant species was continued.
2. Based on the requirement of species, over 5000 saplings of various species (namely *Quercus leucotrichophora, Q. glauca, Grewia oppositifolia, Celtis australis, Melia azedarach, Alnus nepalensis, Fraxinus micrantha, Bauhinia variegata, Terminalia chebula, Thuja orientalis, Heynea trijuga, Phoenix humilis,* etc.) maintained in the nursery. Over 2500 saplings of these species made available to different user groups.

II. Arboretum at Pangthang, Sikkim

- **Performance study of 18 species**

1. Collection and performance of germplasm at Pangthang arboretum is given (Table 15). Over 600 saplings / seedlings (elite stock) of MPTS were distributed to the local farmers.
2. Strengthened bamboo germpool and attempts being made to establish the target species *Cephalostachyum latifolium*, *C. fuchsianum*, *Neohouzeana dullooa*, and *Thamnocalamus spathiflorus* in the nursery.

Table 15. Collection and performance of germplasm at Pangthang, Sikkim

Species collected	Origin	Profile	Status
Acer osmastoni	Darjeeling	Branches	Surviving
Aesculus punduana	Melli	Branches	Surviving
Albizia marginata	Ranipool	Seeds	Failed
Ficus hirsuta	Pakyong	Branches	Surviving
Hovenia dulcis	Tadong	Seeds	Failed
Litsaea salicifolia	Rataychhu	Seeds	Failed
Machilus gammieana	Rataychhu	Fruit	Failed
Machilus odoratissima	Yuksam	Fruit	Failed
Morus laevigata	Tadong	Branches	Surviving
Orchis latifolia	Yumthang	Plant	Failed
Panax pseudo-ginseng,	Yumthang	Plant	Failed
Podophyllum hexandrum	Dzongri	Seeds	Surviving
Rhododendron edgeworthii	Darjeeling	Seeds	Failed
Cephalostachyum latifolium	Aho	Culms	Failed
Dendrocalamus hamiltonii	Setipool	Culms	Surviving
Neohouzeana dullooa	Setipool	Culms	Surviving
Thamnocalamus spathiflorus	Dzongri	Culms	Failed
A reed bamboo (unidentified)	Setipool	Plant	Failed

III. Herbal Garden and Medicinal Plant Nurseries

Kullu- H.P.

- **Improvement of seed germination of *A. glauca* (HP)**

1. Infrastructure strengthened (poly-ponds, beds, net-house, vermi-composting) in Herbal Garden/Kasol nurseries. Propagules of A. glauca and H. candicans were sown for mass multiplication; monitoring continued. Phenology recorded for *Acorus calamus, Angelica glauca, Arctium lappa, Dioscorea deltoidea, Hedychium spicatum, Heracleum candicans, Polygonum amplexicaule, Saussurea costus, Valeriana jatamansi,* etc.
2. Seed germination studies revealed, under different storage time/ conditions it declined from 40 to 14.4, 32.2 and 35.4%, after 11-months' storage, respectively, at room-temperature, 4°C and -10°C for *Angelica glauca*. Germination did not decline (freeze) in *Aconitum heterophyllum*. *Heracleum candicans* retained 41% germinability at 4 °C storage over 73% (initial).

Kumaun- Uttaranchal *(DASD, Ministry of Agriculture funded)*

- Maintenance of herbal garden (1 ha, 40 spp.) at Almora
- Organized a State level seminar on -Developing MPs Sector in UA

1. Strengthened Herbal Garden (1 ha) at Kosi-Katarmal. Over 40 species of Medicinal and Aromatic Plants (MAPs) maintained and demonstrated in the garden. Developed a field nursery-cum-demonstration site (0.5 ha) for medicinal plants in the farmer's field at Dwarson (Almora). Over 10 species (namely *Malaxis acuminata, Acorus calamus, Bergenia ligulata, Valeriana wallichii, Hedychium spicatum, Potentilla fulgens, Ajuga parviflora, Solanum indicum, Tinospora cordifolia, Zanthoxylum armatum, Emblica officinalis* and *Taxus baccata* subsp. *wallichiana*) were introduced. To strengthen the component of transfer of technology an exposure visit of farmers' (18) was made to this site.

2. A state level seminar "Developing Medicinal Plant Sector in Uttaranchal - Prospects and Constraints of Cultivation and Marketing" was organized. Total of 32 participants from different organizations (18 NGOs, 6 GOs and 3 farmers) participated in the seminar. Recommendations of the seminar made available to participants and State Govt. officials for implementation.

(ii) Propagation protocols

I. Medicinal Plants

- Improved seed germination protocol for *S. chirayita*
- *In vitro* organogenesis of *S. obvallata* was achieved

1. At Kullu- HP, seed germination (*Heracleum candicans* and *Selinum tenuifolium*) was nursery tested using different substrate combinations. Sls:F:FH (89%; Fig. 21) and S:F:FH (76%), respectively, proved best ($p<0.05$) for seed germination. S:F:FH and Sls:F:C:FH grown 6-months' old seedlings of *S. tenuifolium* showed significantly ($p<0.05$) higher plant-height (42.6 and 45.8 cm). Maximum dry-weight for *S. tenuifolium* was

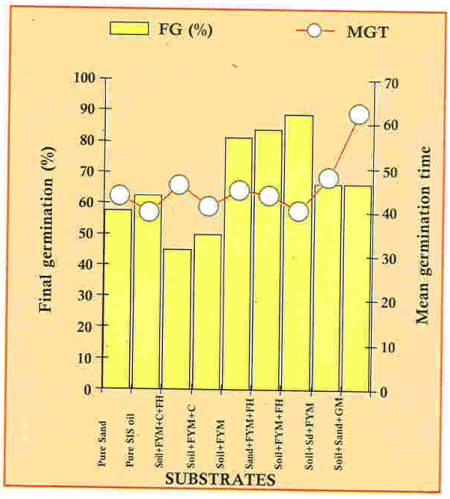


Fig. 21. Influence of Various substrate combinations on seed germination and MGT in *H.candicans* under polyhouse condition

achieved using Sls:FYM:Comp:FH (841 mg) and Sand:FYM:FH (713 mg), which was significantly more (F= 3.071; p<005) than Sls:FYM (38 mg; minimum). Whereas maximum dry-weight in *H. candicans* was achieved using Sand:FYM:FH (116 mg) and Sls:FYM:FH (113.7 mg).

2. Experiments on seed germination of *S. chirayita,* conducted at Kosi-Katarmal Almora, revealed: (i) low (<33%) germination in control condition. However, the variations across populations were non significant ($p > 0.05$); (ii) GA_3 improved the germination in all four populations, but improvements were significant under GA_3 (100 ppm.). Germination was improved up to 79% in two populations and was significantly better ($p< 0.05$) than the control and other two populations. This treatment significantly reduced mean germination time (MGT) in all the populations as compared to control (Fig. 22); (iii) KNO_3 treatments also improved the germination percentage significantly ($P< 0.05$) in almost all the populations. The maximum improvement (up to 76.0%) was achieved under 1.98mM KNO_3 treatment.

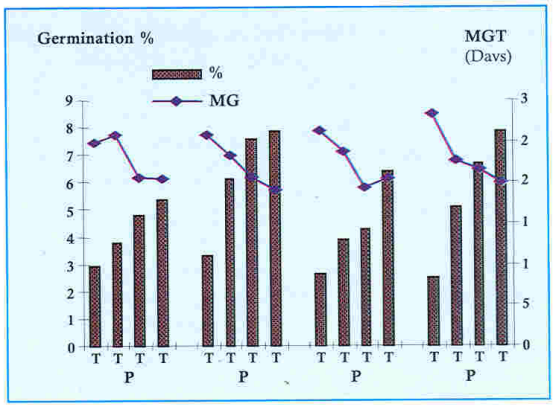


Fig. 22. Effect of various pretreatments to improve germination % and reduce mean

3. Under a CSIR sponsored scheme, *in vitro* organogenesis protocol developed for *Saussurea obvallata* (state flower of Uttaranchal). Experiments conducted on *in vitro* rooting and *ex vitro* performance of plantlets revealed considerable effect of: (i) shoot length, (ii) concentration of gelling agent, and (iii) concentration of carbohydrate.

II. *High value trees*

Propagation and improvement of apple root stock (*DBT funded*)

- **Plantation of three varieties of apple at different locations in Kumaun hills**

1. Apple plants of three varieties (Chaubattia Green Sweet, Chaubattia Red Delicious, Chaubattia Princess) were collected from Government Hill Fruit Research Station, Chaubattia and maintained at three different localities of Kumaon (i.e., Kosi-Katarmal- 1200, Majkhali 1750 and Gangolihat - 1500 m asl).

2. Experiments conducted to develop *in- vitro* propagation protocols of Apple *(Malus domestica)*: (a) nucellar embryogenesis attempted on Chaubattia Green Sweet variety, (b) tissue culture experiments conducted for Chaubattia princess variety. Using mature leaves highest embryogenic callus frequency was obtained in 2,4D along with BAP. Further experiments are continuing.

3.3.4. Peoples' Participation in Biodiversity Conservation

Conservation promotion through awareness and action

Background and Objectives

Across the globe, it is well recognized that the conservation efforts need to be promoted and implemented by bringing local people into the conservation movement and considering them as potential allies. However, such initiatives in the Himalaya are not adequate. Realizing this gap, an initiative was made to bring the target groups into the conservation movement. The study envisages to: (i) promote conservation science especially among School/College students, (ii) impart on-site training on collection, storage and propagation methods of target species focusing on teachers and students, (iii) obtain and analyze response of different target groups with respect to location - specific conservation option/ priorities.

Results and Achievements

I. Initiatives in Kumaun Region

- **Orientation course (7 days) and training workshop (3 days) on conservation education to 91 participants**
- **Strengthening of school conservation models (7.5 ha)**

1. A seven day (Nov. 27th-Dec.3rd, 2003) orientation course was organised at GIC, Wajulla in Bageshwar district of Kumaun. 22 teachers, representing 20 selected educational institution, of four districts (Almora, Bageshwar, Pithoragarh and Champawat) participated. Training was imparted in view of developing their skills as resource persons for future activities. Subsequently, a three days (1st Dec.-3rd Dec., 2003) training workshop was also organized that was attended by over 69 participants (18 teachers and 51 students) representing 18 schools (Fig. 23).

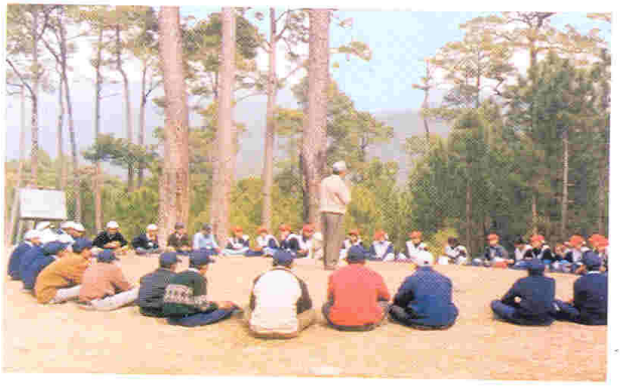


Fig. 23. Imparting conservation education among students

2. Activities were strengthened, through the active involvement of teachers and students, to establish conservation models in identified four educational institutions (G.I.C. Gangolihat - approx 2 ha; G.I.C. Binta - 1.5 ha; G.I.C. Majkhali - 3 ha and G.G.I.C. Gangolihat- 1 ha).

3. With the funding support from DST, under U-PROBE initiative for Uttaranchal, core group started functioning as Technical Resource Center. Preliminary survey of identified schools (9) was conducted for establishment and monitoring of weather recording station. A review meeting was organized wherein 59 participants (6 teachers and 53 students) along with the representatives from IMD Dehradun, U-PROBE Technical Resource Center Kosi, and Department of Science & Technology New Delhi, attended the meeting.

II. Initiatives in Sikkim and Himachal

- **Organization of trainings on MPs cultivation and conservation**

1. A training was organized in Sikkim for high school students and teachers (n=20). Also, course materials for a 3-month biodiversity conservation programme and group-wise study kits to the participants were developed.

2. In HP, exposure was provided to over 144 visitors (66-students, 12-teachers, 35-Government and NGO officials, and 31-farmers) on MP diversity and conservation at Herbal-Garden (Mohal-Kullu). Six formal trainings/ exposures were organized (Fig. 24). In HP Unit DBT funded project on participatory biodiversity conservation was concluded during this year (Box- 5).

Fig. 24. On site training on medicinal plant cultivation demonstration plot in a village in Parvati vally, Kullu (H.P.)

Box – 5

Summary of the Completed Project

(2000- 2003)

Socio-Economic Upliftment of Rural Community of Himachal Himalaya, Particularly Women, and Biodiversity Conservation through Cultivation of Medicinal Plants using Low Cost and Simple Techniques (DBT funded)

The specific objectives of the project included, providing means of socio-economic upliftment to the rural populace particularly women through introduction and encouragement of medicinal plants cultivation as an income generating approach and strengthening biodiversity conservation and its sustainable use. The project concluded with the following achievements:

- Activities were implemented at Silha (2200 m) and Shat (1800 m) villages, Kullu district (H.P.). Cultivation demonstrations were developed and mobilization resulted in voluntary lands' offerings for demonstration by villagers, and subsequent cultivation adoption by several. The project successfully sensitized farmers in the valley and adjacent areas, and realized as a precursor of awareness education on biodiversity conservation.
- Laboratory/nursery research strengthened *ex-situ* cultivation, targeting *Aconitum heterophyllum, Angelica glauca, Dioscorea deltoidea, Dactylorhiza hatagirea, Hedychium spicatum, Heracleum candicans, Picrorhiza kurrooa, Podophyllum hexandrum, Saussurea costus* and *Valeriana jatamansi*.
- Propagation technology for selected MPs was standardized. *S. costus* showed high below-ground productivity using compost over FYM and humus at 1800 m. *A. glauca* and *A. heterophyllum* showed economically viable productivity by using both seeds and vegetative propagule, after two years. *P. kurrooa* and *V. jatamansi* were other highly profitable taxa.
- Demonstrations on low-cost technical interventions (poly-tunnels, poly ponds, vermicomposting, etc.) were highly appreciated. Over 220 beneficiaries were trained for MP cultivation by conducting over 6 formal training (Fig. 25), and numerous interactions/meetings. Propagule distribution benefited over 30 families; *A. hetero-phyllum, A. glauca, P. kurrooa* and *S. costus* covered highest number of households. Over 70 households adopted MP cultivation.

Fig. 25. Village level training workshop on cultivation of medicinal plants in Parvati valley, Kullu (H.P.)

3.3.5. Lead/ Coordinating Institution for Nanda Devi, Manas, Dibru – Saikhowa and Dehang- Biosphere Reserves (*MoEF funded*)

Collection, synthesis and dissemination of research based information in Himalayan BRs

Publication and distribution of Bulletin on the above database

Background and Objectives

The Ministry of Environment & Forests, New Delhi, has identified G. B. Pant Institute of Himalayan Environment & Development as a Lead/Coordinating Institution for Nanda Devi, Manas, Dibru-Saikhowa, Dehang-Debang, and Kanchendzonga. The objectives include: (i) collection, synthesis and dissemination of research based information in respect of BRs from all sources; (ii) interaction with regional research organizations for development of suitable research projects; (iii) interaction with BR Managers to assess the research needs and crucial issues requiring research efforts; (iv) publications of compendium of up to date information and bringing biannual publication aimed at educating stakeholders

- **Himalayan BRs Bulletin published and distributed**
- **Preparation of database on Manas BR for UNESCO-MAB net format**

Results and Achievements

1. The Himalayan Biosphere Reserves (Biannual Bulletin) Vol. 5 (1&2) was published to strengthen the database of the Biosphere Reserves. The Bulletin includes information on the Diversity and distribution of flowering Plants in identified BRs; Database on Avifauna of the Nanda Devi, Manas, Dibru-Saikhowa, Dehang- Debang and Kangchendzonga Biosphere Reserves, India; Altitudinal distribution pattern of Amphibian fauna of Arunachal Pradesh with special reference to Dehang- Debang Biosphere Reserve; a preliminary survey of Mammals and Birds in Dehang-Debang Biosphere Reserve; checklist of Reptilian fauna of Dehang Debang Biosphere Reserve in North East India; and periphytonic diversity of Dhauliganga in Nanda Devi Biosphere Reserve, Uttaranchal; Ph.D. summaries; project summaries; news items, bibliography etc.
2. Interaction/Coordination with the various State and Central Government organizations and N.G.O's were made through correspondence, and project proposals on various gap areas of the respective BRs were invited from these organizations.
3. The document on "Nanda Devi Biosphere Reserve (Nomination for UNESCO MAB net) was revised.
4. Development of data- base on Manas Biosphere Reserve for UNESCO MAB net format was carried out. Database on vascular plants (> 300.); birds (> 150), arthropods (>150); mammals (60); amphibians (7.); fishes (22) reptiles (33) and useful plants (60 spp.) was developed. Further updating of the data- base is continuing.

3.4. ECOLOGICAL ECONOMICS AND ENVIRONMENTAL IMPACT ANALYSIS

Development in the IHR involves conflict between man and nature. The focus on economic growth, at times, disregards the fragile ecosystem and socio cultural matrices and leads to depletion and marginalization of natural and human/ cultural resources. Reflected as loss of - vegetal cover, indigenous species, soil and its fertility, and water quantity and quality. Social losses include degradation of community culture and deterioration in knowledge base regarding sustainable use of resources. Environmental costs in the Himalayan region, 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 development and intervention in the region need to be evaluated and monitored under a comprehensive Ecological Economics and Environmental Impact Assessment framework. During the reporting year studies focused on aspects of air pollution monitoring in and around tourist destinations of Kullu, impact of hydropower project on socio-economic condition of people, evaluation of hill slope instabilities in Sikkim region, monitoring of commercial cultivation of vegetables and tea, impact of tourism in selected townships of Kumaun region, land restoration activities, and ecological and economic efficiency of crop system.

3.4.1. Vegetable Cultivation in Khairna Valley and its Impact on the Environment

Analyses of driving forces for adoption of vegetable cultivation

Impact based on people's perception

Background and Objectives

Khairna valley, in Kumaon Himalaya, is predominantly a rural regime, which comprises of 190 settlements spread over an altitudinal range of 900m to 2000m

msl. Agriculture is the mainstay in the valley. Of late, the agriculture in the valley has been gradually replaced, through intensive cultivation of season and off-season vegetables. Several underlying factors have been identified as the driving forces that have been precocious in precipitating this change. An analysis of these factors would help understanding the critical factors affecting farmers' decision psychology, life style, land use, cropping patterns, socio-economy and in making policy suggestions. The specific objectives pertained to assessment of the scale and extent of vegetable cultivation, identification and analyses of the driving factors responsible for successful vegetable cultivation in the valley and impact identification and study of land use changes.

Results and Achievements

- **Maximum adoption in mid-adtitudinal zone and near road-head (distance < 2 km)**
- **Compilation of people's perceptions on impacts**

1. Maps depicting the altitudinal zone and road-head distance wise demarcation of the villages in study area were prepared. Across altitude zones adoption to vegetable cultivation is maximum in the middle zone (90.2%), and minimum in the lowest zone (70.5%). The road-head distance wise maximum (86.6%) adoption is in the area (>5 km) and minimum (72.9%) in the middle distance range (Table 16).

Table 16. Geographical area vis-à-vis adoption of vegetable cultivation

Altitudinal zone (m)	Number of villages	Geographical area (sq.km.)	Adoption of vegetable cultivation (%)
<1200	52	63.3	70.5
1200-1500	67	84.8	90.2
>1500	51	106.5	83.5
Road head distance (km)			
<2	96	121.5	88.8
2-5	66	92.5	72.9
>5	8	40.6	86.6
Total	170	254.6	

2. Field survey for impacts of vegetable cultivation as perceived by the people (150 key respondents from amongst thirty villages of the valley), associated problems, and for understanding of reasons for adoption/ spurt, and marketing rationales was carried out and the data compiled for analyses.

3.4.2. Ecological Economics of Tourism in Central Himalaya

Background and Objectives

Study of nature and process of tourism

Analyses of tourist trends and typology

Himalaya is endowed with natural bounties that provide a natural realm for the growth of tourism. Tourism, in some established tourist destinations is proving a lucrative enterprise and also making in-roads to many unexplored areas. But, this growth of tourism also has its diseconomies. Increased cost of living, encroachment on commons, pollution of water bodies, overcrowded settlements, defilement of aesthetics, deforestation, erosion, etc., are some of the perceived negative impacts of tourism development in the region. A study of tourist

destinations would help understanding the process and nature of tourism in the region. The findings will also help in formulating policy guidelines for tourism management and in devising alternative pathways for its sustenance and optimization of benefits. The objectives of the study are: (i) study of the nature and process of tourism; (ii) assessment of impacts and ecological economics of tourism; (iii) appraisal of management options for sustenance and better management of tourism.

- **Hill stations of Kumaun emerge as big markets of domestic tourism**
- **Annual tourist traffic at Nainital hints a changing pattern**

Results and Achievements

1. The yearly data on tourist traffic for four tourist destinations of Kumaun – Nainital, Almora, Ranikhet, and Kausani, was compared for the period 1994-1999. The number of tourist visiting Nainital (mean= 218319; sd= 28849) is almost four times higher than those visiting other tourist towns i.e., Almora, Ranikhet and Kausani (mean= 52668; sd= 11144). The significantly higher traffic at Nainital is probably because of the more diverse and veried kind of tourism there. Fluctuations in the annual tourist trend for Nainital were also observed suggesting its sensitivity to extraneous factors. Static trend and low level of tourist traffic at Almora (mean=58896; sd= 4674), Ranikhet (mean= 60033; sd= 7236), and Kausani (mean= 39074; sd= 3829) indicates a limited type of clientele for these places.
2. Tourism in all these places is mainly of domestic type, less than 2% of the tourists are foreigners. Tourist statistics for Nainital for year 2002, suggests an average influx of 34732 ± 7027 (Mean, SE) tourists per month. The profile in Fig. 26, indicates May-June as the months of maximum tourist activity, and proliferation of tourism beyond summer and autumn seasons, hence a changing nature of tourism in Nainital.

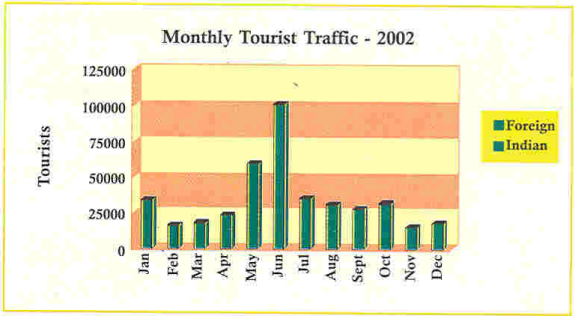


Fig. 26. Annual profile of tourist influx - Nainital

Impact of tea cultivation on socio-economic and environmental setting in UA

Impact of fertilizer treatments on tea growth and soil and water

3.4.3. Carrying Capacity and Impact Assessment Studies on Tea Cultivation in Uttaranchal Hills

Background and Objectives

Tea cultivation in Uttaranchal hills, promoted by the State Government, has come up as an important land management activity for income and employment

generation. This activity also addresses the problem of restoration of the growing wasteland, which otherwise provides poor quality fuel wood, and foraging grounds for cattle. However, fact remains that many of the well-established tea gardens during the British period are now abandoned. The reasons behind this have to be understood. Further, the environmental impacts of this activity on soil and water quality, biodiversity, socio-economic changes and gender issues have to be taken care of to expand this activity in an environment-friendly way. The objectives of this study are: (i) ecological, economic and social impacts of tea cultivation in Uttaranchal; and (ii) impact of FYM, organic fertilizer and fertilizer (NPK) application on tea growth, soil fertility and SWC.

Results and Achievements

- **Soil and water quality attributes indicate a slight increase of concentration of different elements over control**
- **Initial survival of tea plants was recorded better under fertilizer treated plots**

1. Chemistry of soil collected from selected tea gardens (during rains and winter 2003-04) of Kausani (Distt. Bageshwar) varied from one site to another (Table 17). Also, the chemistry of water from different sources was analysed for same period (Table 18).

Table 17: Some chemical characteristics of soil collected from tea gardens in Kausani

Parameter	SOIL					
	Site-1		Site-2		Site-3	
	Control	Cultivated	Control	Cultivated	Control	Cultivated
PH	5.25±0.39	4.74±0.58	5.23±0.19	3.67±0.24	5.78±0.03	5.31±0.08
Phosphorus (%)	0.12±0.01	0.07±0.03	0.048±0.012	0.065±0.02	0.12±0.01	0.06±0.03
Organic carbon (%)	1.77±0.33	0.86±0.12	1.03±0.21	1.44±0.23	1.35±0.24	1.26±0.13
Organic matter (%)	3.36±0.65	1.47±0.21	1.77±0.36	2.47±0.40	2.32±0.42	2.16±0.22

Table 18: Some chemical characteristics of water collected from upper and lower sources from tea gardens in Kausani

Parameters (ppm)	WATER					
	Site-1		Site-2		Site-3	
	Upper source	Lower source	Upper* source	Lower source	Upper source	Lower source
PH	7.65±0.14	7.6±0.10	7.87	6.98±0.08	7.55±0.18	7.51±0.23
Phosphate (ppm)	0.23±0.03	0.28±0.09	0.2	0.2±0.1	0.17±0.03	0.20±0.05
Chloride (ppm)	3.21±0.85	3.44±0.68	2.9	5.15±2.65	6.38±2.96	6.4±0.33
Sulphate (ppm)	49.3±13.2	58.6±18.7	57	45±8.0	40.5±4.79	38.7±4.67
Nitrate (ppm)	0.53±0.15	0.7±0.1	0.8	0.3	1.2±0.7	0.45±0.05
Nitrite (ppm)	0.009±0.002	0.011±0.001	0.02	0.014	0.014±0.012	0.03±0.025
Total Hardness	70.3±6.14	81.7±3.67	78	55	55±19	76±13.2

*Replication for season could not be available due to the drying up of water source in winter

2. Survival of tea plants (UPASI- 9) at Suryakunj (Almora) was found highest for fertilizer treated plots (95.1%) and lowest (86.4%) for organic fertilizer.
3. Treated plots after six months of plantation showed both soil organic carbon (0.81%) and organic matter (1.39%) was more in FYM treated plots. Soil moisture was almost equal in fertilized (12.5%) and FYM treated plots (12.8%), but slightly higher in organic manure treated plots (14.4%).

3.4.4. Environmental Services and Ecological Economics of Oak and Pine Forests in the Central Himalayan Region

Comparison of Oak and Pine forests for their environmental services and for suitable management

Background and Objectives

Oak (*Quercus* spp.) and Pine (*Pinus roxburghii*) are the two major forest types in the middle mountain belt of the Central Himalaya. Oak forests are mostly preferred for quality fuel wood, availability of year-round green fodder, manuring leaves and other minor forest products and face high biotic pressure. Pine leaves are unpalatable, the wood quality is inferior but the Pine forests produce better ground forage. However, economic benefits from Pine forests, such as resin and timber are considerable. Among the indirect services, Oak forests are considered best for high biodiversity, soil and water conservation (SWC) and soil fertility enhancement. Pine forests are accused for promotion of forest fire, depletion of soil moisture, and degradation of soil quality. Pine is a stress-tolerant, fast growing conifer and survives in soils poor in moisture and fertility, where Oak fails to survive. Therefore, there are certain advantages and disadvantages associated with these two types of forests. This study aims to highlight the relative importance of these two dominant forest types with regard to environmental services for their future conservation and management in this region.

Results and Achievements

- **Direct monetary benefits of Pine forests are several times more compared to Oak forests**
- **Preparation on values and services of Oak, Pine, and Oak-Pine forests put Oak forests on high counts**

1. Data collected from Forest Department, Almora Division revealed that the reserve forest area under Pine forests (42732.6 ha) is about 4.5 times more than the area under Oak forests (8793.3 ha). However, the revenue earned annually from the sale of various forest products (Table 19) was about 27 times more for Pine forests (Rs. 169.58 lakh) than the Oak forests (Rs. 6.32 lakh).

Table 19. Annual mean values for different products obtained and revenue earned (Rs. in lakh) from Oak and Pine forests in Almora forest division (Source: Forest Office, Almora)

Forest type	Area (ha)	Firewood (m^3)(1993 -2000)	Timber (m^3)(1993 -2002)	Resin (q) (1995 -2002)	Bark (q) (1999 -2002)	Torch wood (q) (1999-2002)	Lichen (q)(1999 -2002)
Oak forest	8793.3	23.6	-	-	-	-	379.0
Revenue earned		0.01	-	-	-	-	6.31
Pine forest	42732.6	-	4468.1	10046	20	1700	-
Revenue earned		-	4.51	158	0.14	6.93	-

2. Results of a preliminary survey (n= 12; representative teachers of Kumaun region associated with biodiversity conservation education programme of the Institute) for ranking of the three forest types with regards to various direct and indirect benefits depicted superiority of Oak forests among others with respect to indirect benefits (Fig. 27).

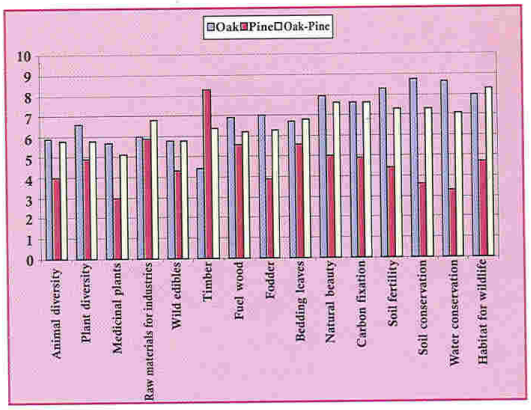


Fig. 27. A comparative account of relative benefits from Oak, Pine and mixed oak-Pine forests

3.4.5. Environmental Assessment of Hydropower Projects in the Beas Valley of Himachal Pradesh

Analyses of hydropower project impacts on environment and human concerns

- **Employment and road development perceived as positive impacts**
- **Concerns for compensation for land, employment, and subsidized / free electricity**

Background and Objectives

Himachal Pradesh is currently experiencing a spurt in hydroelectric power projects. A number of hydropower projects are being planned and implemented in the region. To examine the social and environmental impacts of these projects, and for the understanding of pre and post construction phase human concerns, 24 villages were surveyed within the influence area of three hydropower projects (14 in Parbati II, 6 in Parbati III and 4 in Larji hydropower projects). Nearly 76% of the families were interviewed and responses recorded.

Results and Achievements

1. Employment and road development are the major positive impacts perceived by the local communities. Over 15% villagers obtained jobs in these projects (Table 20). Still the major demands of the villagers from hydropower projects are employment, reasonable compensation in return for their land, and free or subsidized electricity when the concerned projects are functional.
2. More than 89% of the respondents agreed that the overall environmental conditions have deteriorated since the introduction of the hydropower projects. As remedial measures they suggest - plantations in barren areas, water sprinkling to minimize dust around construction areas, upgrading of unpaved roads and shifting stone crushers from inhabited locations.

Table 20. Characteristics of the study villages in and around different hydropower projects in the Beas valley

Details	Parbati II	Parbati III	Larji
Number of study villages	14	6	4
Total families	372	105	72
Families surveyed	277	87	53
Altitude range of villages (in metres)	1330-2317	1045-1420	1055-1330
Total population in surveyed families	1854	506	428
Literacy (%)	63.5	64.8	68.0
Available land (in ha)	173.6	38.5	33.7
Agriculture land (%)	77.2	60.07	66.1
Orchard (%)	15.7	21.8	7.8
Employment through hydroelectric projects	31	17	15

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

Monitoring of ambient air quality and establishment of background values

Identification of pollution source

Linking pollution episodes with weather change

- **Monthly average values max *TSP:* Kothi - 100.7 µg m-3 (July, 2003)**
- **Max *TSP:* Kothi - June 2003 and Mohal - May, June 2004**

Background and Objectives

Tourism activities in Kullu-Manali complex are affecting the ambient air quality. Especially, the air quality in the region is low during the summers. The different air pollution parameters such as TSP, SO_2, NO_2 and O_3 were monitored at Mohal (1150 m) and Kothi (2530 m) in Kullu valley to derive overall concentration of particulate as well as gaseous pollutants. A minimum of 24-hour sampling from mid-night to mid-night basis was conducted. The study attempted to: (i) investigate ambient air quality trends through TSP and trace gases monitoring particularly O_3 for establishment of the background values in the Himalaya; and (ii) identify the possible sources of pollution and linking of pollution episodes with weather change over Himalaya.

Results and Achievements

1. TSP concentration varied from 24.6 to 771.8 µg m^{-3} at Mohal, and from 0.38 to 305.4 µg m^{-3} at Kothi. The monthly variations are presented (Fig. 28).
2. At Mohal, SO_2 values were maximum (36.1 µg m^{-3}) in May, and minimum (0.6) in November. While at Kothi, the highest values (48.9 µg m^{-3}) were in May 2003 and the lowest (1.35 µg m^{-3}) in January 2004. The highest values of NO_2 at Mohal were 4.2 µg m^{-3} in October 2003, and 2.94 µg m^{-3} at Kothi in May 2003.
3. Values of PM_{10} at Mohal ranged from 0.01 to 270.1 µg m^{-3}. At Kothi, these values ranged between 0.87 µg m^{-3} (July 2003) and 133.7 µg m^{-3} (June 2003). While the average monthly values in 2003 at Mohal remained 18.2 and 63.5 µg m^{-3} in August and May, and at Kothi 8.6 µg m^{-3} and 42.4 µg m^{-3} in August and June, respectively (Fig. 29).

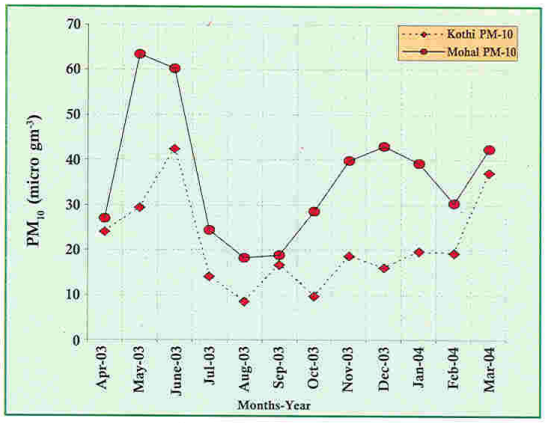


Fig. 28. PM_{10} at Mohal and Kothi from April 2003 to March 2004

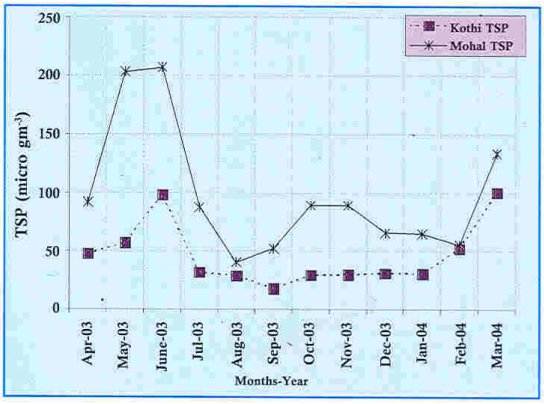


Fig. 29. TSP in Mohal and Kothi (April 2003 - March 2004)

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

Wasteland restoration through silvi-pasture development

Growth and survival of fodder plants

Background and Objectives

In the western Himalaya, people depend upon the forests and community lands for subsistence living. As a result, pressure on these lands has increased considerably and as a consequence in many areas the community lands have degraded and turned into wastelands. Such areas urgently need to be brought under silvi-pasture management through introduction of promising fodder species. This will address the issues of wasteland restoration and fodder production to support livestock component. The aim of this project is to demonstrate wasteland restoration through silvi-pasture approach for wider

extension by the local people. Plantation of fodder trees / grasses in the wastelands was done and monitored for growth and survival, soil fertility and SWC impacts for demonstration and selection of promising fodder plants for restoration of wastelands.

Results and Achievements

- Implementation sites
  - Katarmal village Almora (5 ha)
  - Dobh-Sirkot village, Pauri-Garwal (10 ha)
- *D. sissoo* (survival=88%) was found a promising species

1. Saplings of fodder trees (*Bauhinia variegata, Melia azedarach, Sapindus mukorossi, Quercus leucotrichophora*) and seeds of fodder grasses (*Cenchrus ciliaris, Crotolaria juncea, Panicum maximum, Stylosanthes hamata, Trifolium alexandrium* and fodder maize) were planted at the Katarmal village wasteland. The site was protected and the local people harvested about 87 q fodder grass for their livestock during the year.
2. Out of a total of 2046 fodder / fuelwood seedlings planted in the wasteland at Dobh-Srikot village (Pauri-Garhwal) in August 2003, 1473 saplings of different species were surviving in March 2004. The lowest mortality was recorded for *Dalbergia sissoo* (12%) and the highest for *Cedrela toona* (100%). The 15 households of the stakeholder's community harvested about 100 q fodder grass from this site since August 2003. Mean height of plants of across different species planted at this site (recorded in March 2004) was 102.9±20.2 cm, and the height of saplings ranged from 12.5±2.5 cm (*G. optiva*) to 185.96±8.65 cm (*A. stipulata*).

3.4.8. Geometry, Kinematics and Deformation Mechanisms in Darjeeling-Sikkim Himalaya Using GPS Geodesy *(Collaborative project with C-MMACS, Bangalore; DST funded; Period: 2002-2005)*

Prediction and modeling of geological hazards using GPS geodesy

Background and Objectives

The project aims at understanding the geometry and kinematics of deformation in the Darjeeling-Sikkim Himalaya in the light of modern concepts in fold-and-thrust belt geology. Network of GPS stations established in Darjeeling and Sikkim Himalaya is being used to work out quantitatively the shortening related to compression from the convergence of the Indian and the Tibetan plates across the Darjeeling-Sikkim-Tibet wedge. Contribution of the proposed work towards understanding a significant geological hazard like earthquake and constraining earthquake models in the Himalaya is perceived to aid in better spatial prediction in the long run with desirable socio-economic benefits. Such an 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.

Results and Achievements

- Regional trends in lineament tectonics were investigated
- GPS field campaigns

1. Following image processing of digital data of IRS 1C LISSIII satellite for deriving regional trends of lineament-tectonics, the major orientation was found to be NE-SW in the Sikkim and adjacent West Bengal Himalaya (Fig. 30). Based on the same, stress patterns are being derived to infer significant active tectonics of the region.

2. As per GPS field campaigns in 2003, one epoch of data was processed to provide coordinates for 6 roving stations. Data from November 2003 to March 2004 were generated by the permanent GPS station installed at Pangthang. This shall provide additional fixed station parameters of differential GPS for correlations in the study.

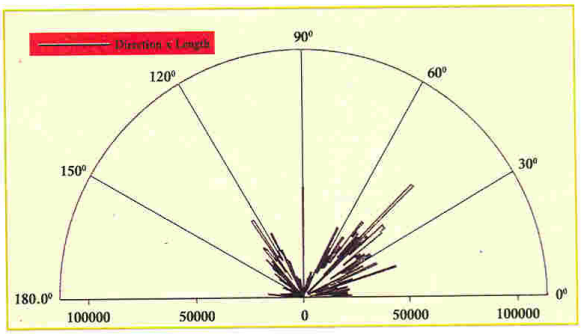


Fig. 30. Rose diagram depicting lineament-tectonics of Sikkim and adjacent west Bengal Himalaya derived from IRS IC LiSSIII satellite data

3.4.9. Technology Vision 2020 Mission Projects on Agriculture Potential– Sikkim Project (*TIFAC, DST funded; Period: 2003-2004)*

Improvement in agricultural potential through productivity enhancing interventions

Hands-on training on agricultural technologies

Background and Objectives

Predominant livelihood options in the rural areas of Himalayan region primarily depend on subsistence farming. Although the traditional farming systems are always favoured due to site-specific compulsions, the scientific interests in these systems have gained momentum during recent years to offer ecological efficiency and sustainability. This project aims to demonstrate the agricultural production potential in farmers' fields with better management and improvised collateral practices. This is being achieved through direct interventions in the farmers' fields to increase the productivity potential of the existing upland on-farm practices and hands-on trainings to the farmers/village youth for motivating them towards improved agricultural technologies; and assessment of the impacts on their socio-economics.

- **Investment: Returns ratio for the trained user grops - 1:3**
- **Inducation of organized vegetable cultivation**

Results and Achievements

1. User groups were trained, motivated and inducted into carrying out the works themselves. This was observed that each 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).
2. Chhamgaon site had never witnessed organized vegetables / seed / seedlings growing earlier which has now started with this intervention due to the provision of water harvesting supplement as poly ponds, bio-composting and poly tunnels as well as composting supplements. Quantifiable results are under analysis on these aspects.

Fig. 31. Site-based results and best practices training/demonstration activities on agricultural production potential, Central Pandam, Sikkim

3.4.10. Disaster Management Faculty – Sikkim State (*In collaboration with Govt. of Sikkim (Ministry of Home Affairs funded; Period: 2003- ongoing)*

Disaster management through prevention and preparedness; training and education

Background and Objectives

The Natural hazard have various forms such as landslides, earthquakes, floods, volcanic eruption, great forest fires, avalanches, hurricanes, droughts, wind storms, and cyclones etc. Some of these hazards are common in the Himalaya causing disasters at different locations. The 1992 Earth Summit underlined the need for focusing on mitigation of the impact of natural hazards/disasters on human settlements, economies and the environment. In view of this and considering the frequency of these hazards in the region, present activity tries to address the issues like- promoting culture of safety, pre-disaster planning and post-disaster reconstruction and rehabilitation with mountain specific considerations. The faculty, thus identified, aims to achieve the goals by awareness generation on disaster management at various levels of the society by imparting appropriate research and training activities.

- **Disaster management through awareness generation and networking with State Govt. and other stakeholders**

Results and Achievements

1. In line with the new culture of disaster management, faculty activities are now centered on the shift in approach to disaster management towards prevention and preparedness rather than relief alone.
2. As per the guidelines suggested during the first advisory committee meeting of the faculty, activities and actions are underway for implementation. Action plan prepared and research is in progress for training modules' development for conducting the training/education activities.

SWC efficiency of grass cultivation in different geometric patterns

3.4.11. Impact Assessment of Land Conservation Measures

Background and Objectives

Soil erosion is one of the major environmental concerns in the fragile Himalayan region. Different methods for controlling soil erosion are known; these can be divided into engineering and biological methods. Amongst biological methods there is a need of identifying plants with fast growth, dense root system, good surface cover, potential to increase fertility of soil, capabilities to promote reestablishment of degraded lands, social acceptance, and have some economic benefit (fodder, fuel, etc.). Field geometry pattern in which the plants are grown also plays a major role in the effectiveness of the erosion control. There can be several arrangements, even along the contours, for growing vegetations and achieve soil and water conservation, which should be quantified with other geometries for comparison and effectiveness for a specific region. With these objectives a study has been initiated in a village wasteland in Kosi-Katarmal and experimental plots are being maintained.

Results and Achievements

- Initial soil physico-chemical attributes investigated
- Evapo-transpiration assessment at Kosi, Almora

1. Physico-chemical properties of the soil of the experimental plots (n=19), on an average, indicated: bulk-density: 1.4 gm/cc; particle density: 2.62 gm/cc; moisture holding capacity: 48%; soil type: sandy soil (sand=91%, silt=6.4%, clay=2.6%). Soil pH ranged from 5.76 – 6.5; OC (0.2 – 2.2%); OM (0.34 – 3.79); P (0.03 –0.2%); and K (1.36 – 2.53%).
2. The pan coefficient (Kp) was determined using local meteorological data collected at the experimental site. A large variation in average monthly Kp values was found (minimum = 0.37 in July; maximum = 1.43 in December). A comparison of reference evapo-transpiration (ET; calculated using Penman-Monteith method) values performed using observed pan evaporation and calculated monthly Kp values showed a strong positive correlation ($y=1.0031x$; $r^2= 0.89$).
3. A relationship was worked out between Penman-Monteith (PM) and Hargreaves-Samani (HS) method for Kosi meteorological station (Fig. 32) for improving the ET results.

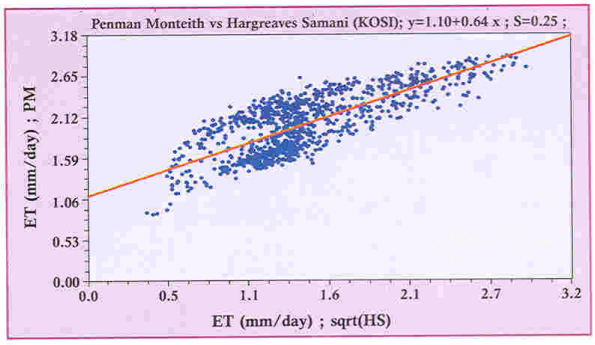


Fig. 32. ET values for Kosi (Almora)

Box - 6

Summary of the Completed Project

(December 2003-March 2004)

Ecological and Economic Impact Analysis of Diversified Agriculture Support Programme in Selected Villages of Uttaranchal

(DASP, Govt. of Uttaranchal funded)

Uttaranchal State is a storehouse of rich diversity of food crops, flora and fauna. The "*Baranaja*" (a mixture of twelve food crops in an annual crop cycle) is a famous example of this rich diversity. The agro-ecosystems in this region until recently were self sustaining and resilient to fluctuations of micro-climate, soil and water conditions, insect-pest diseases etc. and thus provided food security to the natives. But in the recent decades due to various anthropogenic and natural factors the delicate ecological balance between different components of the agro-ecosystem has despaired and food security of the natives is in peril. It is therefore important to restore this ecological balance and make the farming systems sustainable. Through diversified agriculture support programme (DASP) the Uttaranchal Government has focused on "organic farming" and has made some interventions (viz., cultivation of HYVs of food grain, vegetables and fruit plants, introduction of hybrid livestock, use of bio-compost, etc.) in farming systems in selected villages of the state.

- In most of the villages mean output: input ratio in terms of energy (calorie as a currency) across the villages was found 0.85 for wheat and 0.80 for paddy. In terms of rupees this value was 2.1 for wheat and 3.0 for paddy. Amongst the vegetables, cabbage and potato were energy efficient crops (O/I ratio = 1.38 and 1.12, respectively) and tomato, round chili and cabbage were better (mean O/I ratio= 9) in terms of economic efficiency.
- Fruit plants recorded a far better O/I ratio in terms of money as they required least input for cultivation. In terms of money the maximum O/I was recorded for jackfruit (377) and minimum for lemon (22).
- Analyses of people's perception revealed that there has been an increase in crop yield and soil fertility as only bio-compost was applied under this programme. Decrease in land under traditional crops, pressure on surrounding forests for composting material and more human labour involved in farming were the negative impacts of this programme.

Box - 7

Summary of the Completed Project

(2002-2003)

Community Forest Management in Sikkim as Part of Environmental Law Capacity Building Project (W.B. National University funded)

Forest management has been an age-old paradigm and since the days of Kautilya, the forests of India were managed by two distinct entities. One was the state exercising virtually absolute power on the state owned forest lands and the other was the tribal and other forest dwelling communities practicing different forms of "vernacular" forest management systems such as, sacred groves, sacred lakes, supply forests, community grazing reserves in more inhospitable and remote areas. This work aimed to document the impacts of diverse systems of community forest management and their status with special reference to nature of the institutions that govern such management systems, and the legal and associated policy instruments. History and factors that brought about the development of such systems were also investigated. Existing community forest management practices such as sacred landscapes/groves, gumpa (monastery) forests, private forests earlier managed by kazis/royal family members, Taungya, Bhasme and *Dzumsa/pipon* system etc. were field documented. Community management components of the state administered forests in Sikkim like joint forest management (JFM), eco-development committees (EDC) for protected areas, watershed committees and panchayats/mandals were also observed. Practices still in existence, historical perspectives, management mechanism, administering authority, culture/tradition, forest status, traditional ecological knowledge and problems/constraints were assessed. Socio-economic and natural resources interlinking in all the practices was assessed which should be an important factor for environmental law capacity building.

3.5. ENVIRONMENTAL PHYSIOLOGY AND BIOTECHNOLOGY

The performance of a plant is mainly governed by the prevailing climatic conditions. In the Himalayan mountains where the climatic conditions are unfavourable the application of conventional techniques in combination with biotechnology greatly helps in increasing efficiency and productivity of plants. Besides other factors, microorganisms play a significant role in influencing plant growth. In this context, a number of bacteria, isolated from soil, have been developed as inoculants, which exhibited improvement in plant growth and also enhanced seed germination. Efforts are underway to develop propagation protocols using both conventional as well as *in vitro* techniques for economically important species. Successful protocols were subsequently used for large-scale multiplication programmes. Plants were subjected to various types of stress to understand the physiological and biochemical basis of adaptation in relation to water stress that 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. Therefore, attempts are underway to conserve and cultivate such plants.

3.5.1. Rhizosphere Microbiology of Himalayan Plants

Isolation and characterization of microorganisms

Mycorrhizal associations in Himalayan trees

Background and Objectives

Studies were initiated on microflora of Himalayan soils involving the isolation and characterization of three groups of microorganisms, i.e., bacteria, actinomycetes and fungi (including mycorrhizae). These investigations are

mainly based on plant-microbe and microbe-microbe interactions with special reference to their applications. The studies carried out in the reporting year were focused on (i) plant growth promoting rhizobacteria; (ii) characterization of thermophiles; and (iii) mycorrhizal associations in Himalayan trees.

Results and Achievements

- Isolation of bacteria from alpine sites
- Isolation of yeast from soil of hot springs
- Studies on arbuscular mycorrhizal fungi

1. A Gram -ve bacilli that could tolerate the temperature from 0 to 35^{0}C was isolated from alpine location. The species was found to possess the biocontrol property, both antibacterial and antifungal. Production of hydrogen cyanide was detected as one of the mechanisms affecting the suppression of pathogens.
2. A mycelial yeast isolated from a hot spring location in Garhwal Himalaya was characterized for its morphological, biochemical and physiological characters. The yeast possessed amylase activity. This was the only eukaryotic life occurred in the soil samples of the hot spring.
3. The colonization of arbuscular mycorrhizal fungi in rhizosphere of trees of *Abies spp.* and *Betula spp.* of Kumaun region was studied. Trap cultures through suitable hosts have been developed for further investigations.

3.5.2. Large Scale Propagation of Location Specific Elite Plants Using Conventional and Biotechnological Methods

Background and Objectives

Development of propagation protocols

Synthesis of bioactive compounds

There has been always a great demand for large quantities of quality planting material 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. An alternative method of obtaining bioactive compounds through hairy root cultures has been attempted in this study.

Results and Achievements

- Propagation protocols for vulnerable orchid, Rhododendron developed
- Induction of hairy roots in *P. kurrooa* achieved

1. Plants of *Picrorhiza kurrooa* and *Dendrocalamus hamiltonii* were multiplied by *in vitro* methods for large-scale production. Two hundred plants of *P. kurrooa* have been rooted and are being hardened under green house conditions. *In vitro* propagation protocol of *Thunia alba*, a vulnerable orchid of the Himalayan region, has been tried using green pod cultures (Fig. 33).
2. Development of *in vitro* propagation protocol of *Rhododendron maddeni* is in progress. Root initiation has been observed in some of the microshoots and efforts are being made to standardize the rooting steps. Efforts to induce hairy roots in *P. kurrooa*, an endangered medicinal herb, have been attempted.

Fig. 33. Mass multiplication of *Thunia alba*

3.5.3. Impact of Environmental Changes on Growth Performance of Plants

Water relations in plants
Effect of water stress on gas exchange of plants

Background and Objectives

Environmental factors greatly influence plant growth and productivity. High growth and productivity is primarily associated with the ability of the plant to carry out photosynthetic activity over a wide range of environmental conditions. Water is one of the most important environmental factors that influence not only growth and productivity of plants but also their geographical distribution. Plants generally employ different strategies to offset the harmful effects of water stress. Little is known about the water relations of important multipurpose tree species of the region with respect to seasonal oscillations in water regime. Thus during the reporting period, studies were focused on effect of water stress on (i) gas exchange parameters; (ii) growth and morphology; (iii) biochemical processes; and (iv) relative water content, water potential and osmotic potential of some multipurpose tree species of the Himalayan region.

- **Variability among dry matter content of plant leaves**
- **Degree of succulence in leaves varies from one another**

Results and Achievements

1. Considerable differences in percent dry matter content were observed in leaves from mature plants of *Boehmeria rugulosa, Celtis australis* and *Grewia optiva* growing under natural conditions with respect to season (Table 21). While percent dry matter content was considerably high during rainy season in *B. rugulosa*, no such definite trend was observed for other two species. Considerable fluctuation in soil moisture content was also recorded during the study period.
2. Although in all three species relative water content decreased considerably during summer months (May–June), the decline was more in *B. rugulosa* than in *C. australis* and *G. optiva*.

Table 21. Percent dry matter and degree of succulence in leaves of *B. rugulosa* (Br), *C. australis* (Ca) and *G. optiva* (Go) with respect to different soil moisture.

Months	Soil moisture(%)	Percent dry matter			Degree of succulence		
		Br	Ca	Go	Br	Ca	Go
January	18.96±2.90	33.63±3.55	40.99±3.89	42.65±6.06	66.37±6.85	59.09±5.61	57.35±8.03
April	11.92±0.98	31.09±2.49	40.25±4.62	38.20±3.25	68.91±6.13	59.75±6.45	61.80±5.56
July	22.79±2.05	36.84±4.55	39.84±4.73	35.00±3.49	63.16±7.58	60.16±6.64	65.00±6.79
October	33.04±2.97	30.53±4.05	43.77±3.50	43.02±2.58	69.47±6.95	56.23±4.50	56.98±3.42

3.5.4. Study of Plant Performance, Ecology and Interaction in the Himalayan Region

Biomass and regeneration studies on T. baccata, an important medicinal plant

Background and Objectives

The Himalaya harbours high plant diversity, including various medicinal plants. Amongst various high value medicinal plants, *Taxus baccata* L. subsp. *wallichiana* (Zucc.) Pilger has gained considerable importance due to the valued source of the anti-cancer drug taxol ®. It is a medium sized, slow growing tree species and the leaves and bark are used in traditional systems of Unani and Ayurvedic medicine. In recent years information has been collected on various aspects of this species, however, there is general paucity of information on its biomass and productivity. Therefore, investigations were carried out focusing on: (i) field survey of *T. baccata* in different forests; and (ii) biomass estimation in different plant parts.

Results and Achievements

- **Sapling density of *T. baccata* was found low**
- **A 100-yr old tree can yield 6 Kg bark biomass, rich source of cancer drug taxol**

1. Across two sites lying in the elevation range of 1800-1915 m msl with 45-60° slope angles on SW and SE aspect, high density (no./ha basis) of seedlings (range 204-207) and trees (range=55–198) was recorded. However, the density of saplings was low (range=5-16). The total tree basal area for both the sites was 2.90 and 11.1 m^2/ ha, respectively.
2. Circumference at breast height of the tree was positively related to the total bark biomass and the values were recorded in the range of 0.15–8.16 kg/ tree. The study indicated that a tree of 100 years could yield 5.74 kg bark biomass.

3.5.5. Genetic Profiling and Pilot Production of the Identified Elite Species and Quantification of Active Biomolecules *(DBT funded; Period: 2003-2006)*

Quantification of biomolecules of MPs

Cultivation of MPs in field

Background and Objectives

Based on the findings of Ist phase, the IInd phase of this project mainly focuses on selection of elite populations of identified medicinal plants based on their active biomolecules. These identified plant populations would be genetically characterized subsequently. 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 *Picrorhiza kurrooa*, *Aconitum heterophyllum* and *A. balfourii*.

Results and Achievements

- Podophyllotoxin content in rhizomes of *P. hexandrum* varies from one population to another
- Mps in field condition are growing well

1. Podophyllotoxin content in rhizome samples of *P. hexandrum* collected from various populations of Kumaun and Garhwal region indicated a wide variation (0.007–5.45% dry weight).
2. Demonstration plots have been set up in Khaljhuni village (2450 m asl) in Bageshwar district of Uttaranchal. Plants of *P. kurrooa, P. hexandrum* and *A. balfourii* collected from various locations were grown (via seeds and cuttings) and maintained in the field. The *in vitro* raised plants of these species planted in the field condition are growing well (Fig. 34).

Fig. 34. Transplanted plants of *Picrorhiza kurrooa* at Khaljhuni

3.5.6. Selection of Plant Growth Promoting Microbes for their Potential Use in Mountains (*CSIR funded; Period: 2001-2005*)

Studies on VAM for their usefulness in growth promotion

Background and Objectives

The project is focused on the isolation, quantification and selection of plant growth promoting microorganisms including vesicular arbuscular mycorrhizae (VAM) associated with the tree species of temperate and alpine locations.

Results and Achievements

- VAM species isolated from tree root and soil samples

1. Species of VAM isolated from the root and soil samples belonging to five species of rhododendrons and *T. baccata* have been identified. Trap cultures were developed for confirmation of the species.

- *Glomus* species was found dominant in rhizosphere soil

2. Various species of *Glomus* were found to dominate the rhizosphere of these tree species. The species is being developed as monoculture for its further use.

3.5.7. Genepool Preservation and Mass Propagation of Sikkim Himalayan Rhododendrons Using Biotechnological Tools *(DBT funded; Period: 2000-2004)*

Conservation of Rhododendrons using biotechnological and conventional methods

Seed biology of endemic Rhododendrons of Sikkim

Background and Objectives

Rhododendrons consist of a group of plants, which has a rich horticultural value. Sikkim Himalayan rhododendrons are represented by a group of 36 species out of the total 42 Indian species. At present, owing to anthropogenic pressure, populations of these plants are gradually decreasing. With a view to conserve the group, a representative endangered species, *Rhododendron maddeni* was selected under the project on rhododendron conservation in the region. Using both biotechnological and conventional propagation methods this project strives to counter the threat on survival of these plants through: (i) developing protocols for mass propagation of *R. maddeni;* (ii) hardening of mass propagated plants; and (iii) comparative seed biology of all endemic rhododendron species of Sikkim Himalaya in relation to *R. maddeni.*

- Improved shoot multiplication of *R. maddeni* was accomplished
- Seeds of rhododendrons (10 spp.) exhibited morphological variations

Results and Achievements

1. Improved multiplication of shoots of *R. maddeni* was obtained on Anderson medium containing 2iP and various concentrations of gelling agents like agar and phytagel. Higher yield of shoots was obtained with higher concentration of agar (1.3%) and 0.3-0.5% phytagel. These treatments resulted in 20 shoots per original shoot culture within six weeks (Fig. 35). The elongated shoots were first transferred to root induction media supplemented with various combinations of auxins.

Fig. 35. Multiplication of shoots of *R. maddeni* on Anderson medium supplemented with 2iP and phytagel.

2. Micro-and macromorphological variability of seed surface of ten rhododendron species: *R. campylocarpum, R. ciliatum, R. dalhousiae, R. glaucophylum, R. griffithianum, R. lepidotum, R. leptocarpum, R. maddeni, R. niveum* and *R. thomsoni* were measured through SEM. The seeds of rhododendron were clearly distinguished from their outer micro- and macromorphological characters.

3.5.8. Establishment of Biotechnology Complex for Capacity Building and Economic Upliftment with Particular Reference to Women of the Indian Himalayan Region *(DBT funded; Period: 2001-2004)*

Establishment of Rural Biotechnology Complex at Kosi

Training and demonstrations

Background and Objectives

In the Himalayan mountains women are the backbone of agricultural activities. Although, a number of technologies are available to increase production, it is paradoxical that rural women are unaware of most of the advancements and easily available technologies applicable to this sector. Keeping these problems in mind a Rural Biotechnology Complex (RBC) established under this project and the activities were focused on: (i) exploration, documentation and preparation of an inventory of indigenous and modern technologies which are hill-specific, and to supplement and evolve technology packages; (ii) setting up of demonstrations of improved / alternative hill-specific technologies at selected field sites; (iii) capacity building through training / live demonstrations / field exercises of target groups; and training of trainers (TOT); and (iv) guidance and support for field implementation of technology packages and subsequent monitoring.

Results and Achievements

- **Printing and distribution of folders containing low-cost technological packages**
- **Demonstration of the technologies in the rural biotechnology complex at Kosi (Almora)**

1. Informative folders (English / Hindi) and a training manual "*Krashak Margdarshika: Aarthik Evam Paryavaran Samvardhak Saral Taknikein*" were published containing various simple and low-cost technology packages and distributed among different user groups.
2. Regular trainings were conducted for various user groups both at the RBC and in different villages on " see-and-adopt" basis (Fig. 36).

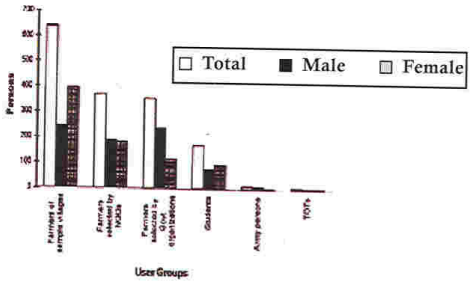


Fig. 36. Training, awareness and capacity building (2003-2004)

3. The potential technological interventions have been demonstrated / housed within the RBC as functional models. Protected cultivation, composting, bio-briquetting, cash crop cultivation, fish farming, water harvesting, horticulture, etc. were the most popular technologies among the farmers.

3.5.9. Characterization and Improvement of Tea through Biotechnological Tools (*DBT funded; Period: 2001-2004)*

Physiological and biochemical parameters for improving tea growth

Testing microbial inoculants

Background and Objectives

India occupies a prestigious place in the world map of tea industry. The tea production for the year 2005 AD has been targeted at 1000 million kg. Due to the constraints of suitable land for growing tea an urgent need to develop stress-tolerant and high yielding clones with superior quality. There is also a need to understand some of the physiological and biochemical parameters that may help in improving yield of existing plantations. In this context biotechnology assumes great significance. The studies carried out in this year were focused on: (i) characterization of existing clones using physiological, biochemical and molecular tools; (ii) standardization of technology for in vitro propagation and field establishment of superior clones; and (iii) development and testing of complete package of microbial inoculants including VAM.

- **Different clones of tea vary in their biochemical constituents**
- **Survival recorded high in nursery conditions**

Results and Achievements

1. 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).

2. Five hundred tea plants were raised in vitro using explants taken from local chinery bushes. Following transfer to field (under shaded condition) in the Institute nursery about 90% survival was observed following 10 months of acclimatization.

3. Experiments related to 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 for mycorrhizal colonization.

3.5.10. Demonstration and Capacity Building of Mountain Farmers and Rural Women on Farm Based Simple Technologies in Sikkim *(DST funded; Period: 2000-2004)*

NRM through community participation

Background and Objectives

This project was formulated for a better use of available physical and biological resources in Mamlay watershed of Sikkim using community participatory methods. Application of minimum locally available resources, farm-based technologies were integrated for feasibility studies. Low-cost biotechnological packages were employed for generating economic incentives. The project was focused 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 for sustainable development; and (iii) capacity building of local people.

Results and Achievements

Use of low cost bio-technological package for income generation

1. Demonstration camp on Farm Based Technologies was organized regularly in collaboration with Indian Agricultural Research Institute, Kalimpong Center. The farmers actively interacted with specialists and learnt on improvement of disease free large cardamom (Fig. 37)

Fig. 37. A demonstration camp on disease control and improvment of large cardamom cultivation

- **Farmers training on large cardamom and mushroom cultivation and bioglobules**

2. Mushroom cultivation was introduced among the rural women through demonstrations at lower Jaubari, South Sikkim. Capacity building of local farmers was continued through training of about 30 farmers of Jaubari block. Different user group and local farmers were trained on bioglobules as alternate fuel for cooking and heating purposes in the rural areas.

Box - 8

Summary of the Completed Project

(2001 –2004)

Microbes in Himalayan Soils: Biodiversity and Potential Applications (DBT funded)

This project was focused on isolation and characterization of microorganisms belonging to the rhizosphere of ten dominant Himalayan trees. Major findings include:

The microbial populations and the rhizosphere effect, in general, were found to decrease with increasing altitude. Out of ten, three species were found to exert a negative rhizosphere effect and developed larger antagonistic populations.

- Bacterial biodiversity indicated the dominance of species of *Bacillus* and *Pseudomonas* in the rhizosphere soils. Besides a number of biochemical growth parameters, these isolates had various beneficial properties, e.g., production of antifungal compounds, effective against a wide range of phytopathogenic fungi, and ability to solubilize tricalcium phosphate, etc.
- Based on petridish assays, bioassays and field assays, three species of bacterial isolates, namely *Bacillus subtilis*, *B. megaterium* and *Pseudomonas corrugata* were found as potential inoculants for mountains.
- The bacterial inoculants were used either as liquid or charcoal based formulations. Initial experiments have indicated that such formulations were effective in seed, cutting and tissue culture raised plants, in respect of improving field establishment and growth of plants.

3.6. INSTITUTIONAL NETWORKING AND HUMAN INVESTMENT

Networking of the existing institutional infrastructure in the Himalayan region is critical for optimal use of the available scientific talent. Through Integrated Ecodevelopment Research Programme (IERP) of the Institute; the infrastructure, expertise and scientific manpower available in the Indian Himalayan region (IHR) are being complimented effectively. This programme supports Institute's role as a facilitator of R&D programmes in the IHR as well as in establishing institutional linkages. As many as 80 projects are currently on going in eight states of the Indian Himalayan region under the IERP of the Institute. During the year 2003-2004, 28 new projects were funded for the execution of location-specific R&D activities. One coordinated programme entitled "*Sacred values, eco-restoration and conservation initiatives in the Indian Himalayan region (IHR)*" was also executed in the states of the H.P., U.A., Assam, Meghalaya and Arunachal Pradesh with the help of identified network partners. In addition to the above, a workshop entitled "*Creation of awareness among the prospective PIs / Groups / NGOs, etc. of the North East region for execution of location-specific action-oriented R&D activities under the IERP of GBPIHED: Project presentation cum evaluation*" was organized at Itanagar. Further, Project Evaluation Committee (PEC) and a three-day on-site training programme at Digoli village of Almora district in Uttranchal, were also organized. Other main activities of the Core included strengthening of the Institute Library, publication of ENVIS Bulletin and making ENVIS Bulletin available on-line through ENVIS-EMCB Node. The Core also participated in a consultancy-based assignment for Watershed Management Directorate, Govt. of Uttaranchal.

3.6.1. Development of a Strategy for Capacity Building of Rural People in the Effective Management of Resources: A Case Study in the Central Himalayan Region

Policy planning for poverty alleviation
- *Poverty status*
- *Social and rural Infrastructure*
- *Gender Poverty status*

Background and Objectives

In the central Himalayan region there is a lack of research and empirically based strategic recommendations to policy planning on: (a) situation of poverty and its ramifications and poverty alleviating measures; and (b) 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. Therefore, this project envisages to investigate: (i) socio-ecological conditioning; (ii) status of current situation, policy and implementation issues associated with poverty and rural infrastructure; (iii) the association between social infrastructures and poverty; (iv) poverty vis-a-vis cultural institutions, value systems, and social exclusion; and (v) the association between poverty and gender focusing on role of women to optimize the management options for effective reduction in poverty.

Results and Achievements

- **BPL families in central Himalaya – 36.4%**
  - **Poverty – maximum (Uttarkashi – 68.7%) and minimum (Hardwar – 17.6%)**

1. Analysis of the secondary information revealed that despite considerable efforts and interventions to alleviate poverty, as much as 36.4% of the families are below poverty line in the Central Himalayan region of India. The level of poverty varies extensively from district to district being as low as 17.6% in Hardwar district and as high as 68.7% in Uttarkashi district.
2. In eight villages, with four each from two districts, i.e., Uttarkashi and Pauri districts, the level of poverty were found quite contrasting, i.e., 68.7% in Uttarkashi and 26.7% in Pauri.

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

Training for capacity building: nursery development, tree plantation and NRM

Background and Objectives

The main objective of this programme is to strengthen interaction with the rural inhabitants / identified target groups of the IHR so as to ensure their capacity building by creating environmental awareness particularly by imparting on-site trainings to the rural inhabitants / identified target groups. This programme also envisages to identify and select individuals / target groups as potential player of dissemination of action-oriented R&D activities of the Institute.

Results and Achievements

On site training (110 participants) at Digoli village, Almora

Background and Objectives

1. A three-day on-site training programme on nursery development, tree plantation techniques and natural resource conservation and management

was organized at village Digoli in Almora district of Uttaranchal in collaboration with NIDHI (a NGO of the Uttaranchal) and LWRM Core of the Institute. The training was imparted to 110 participants including farmers, rural women, ex-service army personnel, students and teachers, and representatives of the NGOs (Fig. 38).

Fig. 38. On-site training programme at Digoli village

3.6.3. Integrated Eco-development Research Programme in the Indian Himalayan Region (IHR)

Provision of extra-mural funding for location specific R&D, scientific capability and infrastructure development and execution of coordinated programmes

Background and Objectives

The Ministry of Environment and Forests, Government of India entrusted the responsibility of Integrated Ecodevelopment Research Programme (IERP) in the IHR to the Institute in 1992. The Institute identified two broad thrust areas, namely Technology Development and Research for Integrated Ecodevelopment and, Technology Demonstration and Extension, under this Programme. 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 in the IHR with the help of identified network partners.

Results and Achievements

- **Twenty eight projects were funded (16 in eastern Himalaya, 8 in central Himalaya and 4 in western Himalaya)**

Based on the recommendations of the Project Evaluation Committee (PEC), following twenty-eight projects were sanctioned and funded during the year 2003-2004.

1. Development of strategies to improve the nutrition of dairy animals in the mountains of Uttaranchal by Dr. Vir Singh, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttaranchal. [Total outlay: Rs. 6,49,520/-].

2. Improvement of community wastelands through the introduction of improved grass and legumes species in sub-montane and low hills subtropical zone of Himachal Pradesh by Dr. Purushottam Kumar, CSK H.P. Krishi Vishvavidyalaya, Palampur, Himachal Pradesh. [Total outlay: Rs. 4,99,560-].

3. Popularization and dissemination of GBPIHED and DARL (DRDO) agro-technology for multipurpose tree plantation through people participation in remote area of Pithoragarh district by Mr. A.S. Bisht, Gramodayog Sewa Kalyan Samiti, Pithoragarh, Uttaranchal. [Total outlay: Rs. 1,98,000/-].

4. Mistletoes heavy loss assessment to fruit and seed production, reproductive value, and progenies of ten important forest trees of Garhwal Himalayas by Dr. Y.P.S. Pundir, DBS Post Graduate College, Dehradun, Uttarachnchal. [Total outlay: Rs. 4,77,800/-].

5. Biodiversity, ecology and conservation of wild silk moths in Nagaland by Dr. Lakhmi Nandan Kakati, Lumami, Mokokchung, Nagaland. [Total outlay: Rs. 5,96,620/-].

6. Development of suitable propagation technologies of three *Terminalia* species by Dr. Subhash Nautiyal, Forest Research Institute, Dehradun, Uttaranchal. [Total outlay: Rs. 5,54,990/-].

7. Vermicomposting from locally available substrate materials and its quality evaluation by Dr. Raj Pal Sharma, CSK H.P. Krishi Vishvavidyalaya, Palampur, Himachal Pradesh. [Total outlay: Rs. 4,98,916/-].

8. Evaluation of superior tea hybrids for adaptability and dissemination of technology to the planters for the development of model tea estate by Dr. Satish Paul, CSK HP Krishi Vishvavidyalaya, Palampur, H.P. [Total outlay: Rs. 5,49,384/-].

9. Micopropagation of important bamboo species for IHR by Dr. Anjuli Agarawal, GBPUA&T, Nainital, Uttaranchal. [Total outlay: Rs. 4,85,300/-].

10. Training cum extension program for organic farming in the border area villages of Uttaranchal by Ms. Rajeshwari Bisht, Bal Vikas Siksha Samiti, Bhetiyara, Uttarkashi, Uttaranchal. [Total outlay: Rs. 4,00,000/-].

11. Establishment of eco-awareness clubs and income generation activities through nursery raising of medicinal plants in primary and upper primary schools of Paubo block of district Pauri Garhwal by Dr. Munna Singh, Institute of Himalayan Awakening and Environmental Research, Dehradun, Uttaranchal. [Total outlay: Rs. 6,00,000/-].

12. Assessment and promotion of economic wetland biodiversity of Manipur : A concern for ecological, ethnical and economical dimensions by Dr. Huidrom Birkumar Singh, Regional Research Laboratory (CSIR), Lamphelpat, Imphal, [Total outlay: Rs. 4,91,200/-].

13. Conservation of biodegradable waste materials of Imphal city into usable compost through vermicomposting by Mr. S. Sanjay Singh, Manipur University Campus, Canchipur, Imphal, Manipur. [Total outlay: Rs. 4,34, 000/-].

14. Screening of suitable genotypes of *Parkia roxburghii* for agroforestry systems in NEH Region by Dr. B.P. Bhatt, ICAR complex, Barapani, Meghalaya. [Total outlay: Rs. 5,74,600/-].

15. Nutritive value, anti-nutritional and toxic factors, and domestication potential of some edible wild foods of Meghalaya by Dr. Dipika Agrahar-Murugkar, ICAR Research complex for NEH Region, Umiam, Meghalaya. [Total outlay: Rs. 5,81,600/-].

16. Exploration of ophidian fauna of Nagaland by Dr. J. Meren Ao, Kohima Science College, Jotsma, Kohima, Nagaland. [Total outlay: Rs. 6,45,150/-].

17. A study on the bio-diversity of Orchids in southern Assam and their conservation by Dr. B.K. Dutta, Assam University, Silchar, Assam. [Total outlay: Rs. 4,98,200/-].

18. Ichthyofaunal diversity and fishery potential in the wetlands of Hajo, Kamrup district, Assam and study of socio-economic status of the fisherman community by Dr. (Mrs.) Sabitry Choudhury Bordoloi, Institute of Advanced Study in Science and Technology, Khanapara, Guwahati, Assam. [Total outlay: Rs. 5,42,294/-].

19. Chemical prospecting of certain less known medicinal plant species of Assam used for anti-fertility [target plant species: *Meyna laxiflora* and *Stephania henandifolia*] by Dr. J. G. Handique, Dibrugarh University, Dibrugarh, Assam. [Total outlay: Rs. 6,45,920/-].

20. Antibacterial activities of folk medicinal plants against the flacherie disease in Muga silkworm *Antheraea assama* (Ww) by Dr. B. G. Unni, Regional Research Laboratory, Jorhat, Assam. [Total outlay: Rs. 4,49,700/-].

21. Vermicomposting and its application in rural agricultural development in Assam by Mr. Sarfraz Haque / Dr. H. Dhattareya, Institute of Integrated Resource Management, Dekargaon, Sonitpur, Assam. [Total outlay: Rs. 3,95,600/-].

22. Conservation of microbial diversity in North Eastern India including Majuli and its potential application in agriculture and industry by Dr. G.N. Bordoloi, Department of Botany, Bahona College, Jorhat, Assam. [Total outlay: Rs. 5,95,200/-].

23. Ecorestoration of degraded sacred groves of Meghalaya by Dr. H.N. Pandey, North Eastern Hill University, Shillong, Meghalaya. [Total outlay: Rs. 5,91,000/-].

24. Ecorestoration and conservation of religious sites in eastern Himalayan region by Dr. C.K. Baruah, Gauhati University, Guwahati, Assam. [Total outlay: Rs. 6,47,450/-].

25. Studies on land use dynamics and environmental restoration in and around Monasteries in Tawang district of Arunachal Pradesh by Dr. A. Arunachalam, North Eastern Regional Institute of Science and Technology, Nirjuli, Arunachal Pradesh. [Total outlay: Rs. 6,48,120/-].

26. Restoration of biodiversity of hills of Kujapuri Siddhapeeth following Badrivan restoration approach by Dr. H.B. Vashistha, Forest Research Institute, Dehradun, Uttaranchal. [Total outlay: Rs. 6,38,480/-].

27. Inventory and spatial mapping and modeling of sacred biodiversity landscapes for conservation in Meghalaya by Dr. Uma Shankar, North Eastern Hill University, Shillong, Meghalaya. [Total outlay: Rs. 5,71,600/-].

28. Eco-restoration and conservation of biodiversity around Shri Baba Balak Nath (Hamirpur) and Shri Naina Devi Ji (Bilaspur) temples in Himachal Pradesh by Dr. S.D. Kashyap, Dr. Y.S. Parmar University of Horticulture and Forestry, Solan, Himachal; Pradesh. [Total outlay: Rs. 6,06,100/-].

In addition to the above, the following activities were also carried out

- **APRs referred for evaluation – 38**
- **FTRs completed – 8**
- **Coordinated programme initiated – 1**
- **Workshop conducted – 1**

1. A coordinated programme on "*Sacred values, eco-restoration and conservation initiatives in the Indian Himalayan region*" was made operational from this year with funding to about 6 projects initially for execution in the states of H.P., U.A., Assam, Meghalaya and Arunachal Pradesh.
2. Annual Progress Reports (APRs) of thirty-eight (38) on-going projects were processed and referred to the subject experts for evaluation. Final Technical Reports (FTRs) of eight (8) completed IERP projects were mailed for follow-up action on the recommendations of the project and also to the subject experts for their comments / suggestions.
3. Thirteenth meeting of the PEC was convened at the HQs (Kosi-Katarmal) of the Institute on March 20-21, 2004 in which 83 project proposals were examined critically by the PEC.
4. An IERP Workshop entitled "*Creation of awareness among the prospective PIs / Groups / NGOs, etc., of the North East region for execution of location-specific action-oriented R&D activities under the IERP of GBPIHED: Project presentation cum evaluation*" was organized at Itanagar in Arunachal Pradesh in which 63 project proposals were evaluated by the experts.

3.6.4. Strengthening and Maintenance of the Central Library at HQs

Total books - 11,990

Subscription of periodicals - 117 (Foreign - 70, Indian - 47)

Dissemination of Newsletter and Annual Report to 2570 organizations and individuals

Background and Objectives

The Central library of the Institute at its headquarters, at the end of financial year 2003-2004, had 11,990 books. The library is subscribing a total of 117

periodicals (70 Foreign and 47 Indian). For management of Library and Information Center, a network version of the software package PALMS, which was developed the Institute, is being used. As a result, the library is providing a number of services such as Article Alert, Current Awareness, Selective Dissemination of Information, Reprographic, Referencing and Indexing, Abstracting and Bibliography, etc., for the development of the human resources. The web site of the library (http://gbpihed.nic.in/libarary.htm) has also been developed and uploaded on the net.

During the reporting year, a Book Exhibition was organized at the Headquarters of the Institute on February 26-27, 2004 and about 618 new books / volumes were added to the library. R&D achievements of the Institute were disseminated through its regular in-house publications, namely *Hima-Paryavaran*- a biannual newsletter; Institute *Annual Report and folders / leaflets* to various academic and scientific institutions, Govt. departments, NGOs, policymakers, planners and individuals working on various aspects of mountain environment and development. During the year, these publications distributed among 2570 organizations and individuals.

3.6.5. Strengthening and Management of ENVIS Center

Background and Objectives

ENVIS inception year – 1992

Focus - Database on Himalayan ecology; Information dissemination

Publication of ENVIS Bulletin 11 (1& 2) - Information available on- line ENVIS Bulletin vol (6- 11)

The Environmental Information System (ENVIS) Center 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 Centers to provide national scenarios to international setup INFOTERRA Programme of UNEP. ENVIS Center essentially helps in handling of huge and varied information relevant to environmental management and development.

The ENVIS Center 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 Center is regularly disseminating all available information free of cost to various stakeholders / users working on various aspects of Himalayan ecology. During this year, volume 11 of the ENVIS Bulletin (in 2 numbers) was published. Development, up-gradation and maintenance of ENVIS Website and Institute website were also continued during the reporting year through EMCB activities. Six volumes of ENVIS Bulletin (Vol. 6 to 11; each in two numbers) were made available on-line through ENVIS-EMCB Node. Under Management Information System, Ph.D. theses on Himalayan eco-system were compiled and uploaded as new modules to the ENVIS website of the Institute.

Box - 9

Summary of the Completed Project

(November 2003 – February 2004)

Development of Environmental and Social Guidelines, Environmental and Social Implementation and Monitoring Manual and Environmental and Social Management Framework for Uttaranchal Decentralized Watershed Development Project *(WMD, UA funded)*

Over extraction of natural resources far beyond their capacity to regenerate has resulted land and biological degradation in many areas of the state of Uttaranchal. In an effort to control this degradation of natural resources and support livelihood activities for the inhabitants, watershed management has been taken up as the functional and planning tool for conservation of natural resources and sustainable development by the Government of Uttaranchal through its Watershed Management Directorate (WMD). However, considering the fragile biophysical and socio-economic fabrics of the region, certain precautions and mitigating measures are needed to be taken care of before execution of the watershed management activities so as to minimize potentially significant negative environmental and social impacts during the course of implementation of the project and enhance the positive impacts of its various components and sub-components. With a request from WMD, Govt. of Uttaranchal the Institute accepted the responsibility of preparing ESGs, ESIMM and ESMF.

- The ESGs describe certain do's and dont's to avoid / minimize any negative environmental and social consequences and also took into consideration of the laws and acts applicable for the watershed management works in mountain ecosystem in general, and for Uttaranchal state in particular.

- ESIMM incorporated implementation and monitoring plan, administrative structure and mechanism for capacity building. Monitoring procedures were developed to be followed in executing the interventions and monitoring their performance over the long-term from an environmental and social perspective.

- ESMF, through five stages, describes the procedure for creation of environmental awareness among various stakeholders, selection, implementation and monitoring of projects within the preview of ESGs and with the help of ESA as a tool. For seeking inputs from various stakeholders (e.g,, rural people, Govt. officials of line departments, NGOs, etc.) a workshop entitled "*Watershed Management and People's Participation*" was organized and their views were incorporated in the documents.

3.7. INDIGENOUS KNOWLEDGE SYSTEMS

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 also 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 analyses of indigenous knowledge and management practices of high altitude societies, and analyses of indigenous agricultural practices in the light of its efficiency and sustainability. This integration will be an appropriate approach for sustainable development of Himalayan societies.

3.7.1. Documentation and Analysis of Indigenous Knowledge and Management Practices of High Altitude Societies

Documentation of methods
Options of value addition

Background and Objectives

The high altitude Himalayan region is characterized by diverse ethnic groups that have developed their own cultures based on available natural resources giving rise to a wealth of cultural diversity at par with the high level of biological diversity found in the region. They are also known to use a number of dry food items without losing the taste and vitality. Similarly, they have excellent systems of preservation of vegetable and meat after drying. The practice of using dry food made them secured from supply shortages 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. Drying of vegetable

and meat makes it possible to store these perishable food items for a longer period of time. The objectives of this study were: (i) documentation of indigenous methods of drying vegetables; and (ii) identification of possible options for value addition to their products.

- Methods of sun drying vegetables
- Storage of vegetables in pits - (Potato, Radish, Ginger)

Results and achievements

1. The high altitude societies cultivate a number of vegetable crops in their kitchen gardens, and also use some wild plants as vegetables. They dry the vegetables for use in the off-season.
2. The process of vegetable drying is quite simple, and does not involve any elaborate arrangement (Fig. 39). The vegetable to be dried is simply cut or sliced into small pieces of the required size depending upon the type of vegetable and exposed to sunlight for drying. Some of the vegetables are stored in pits without any processing. Common among these are: Potato (*Solanum tuberosum*); Radish (*Raphanus sativus*) Gaderi (*Colocacia spp.*) and Ginger (*Zingiber officinale*).

Fig. 39. Vegetable procured for sun drying

3.7.2. Traditional Knowledge of Understanding Indicators of Weather

Perception study of indicators of weather

Indicators documented
- *Lightening and cloud*
- *Reptiles*

Background and Objectives

The people in the rural areas of the Himalayan region have good understanding of weather and climate systems, and accordingly have learnt to utilize a wide range of biological resources in diverse ways. Historically, the natural environments, particularly physiographic and climatic constraints, have strongly influenced their settlement pattern and their resource-use. Their proximity with the natural systems led them to understand the indicators of weather. This study has been initiated as an endeavor in this direction to understand and document this knowledge through social interaction and survey.

- Rainfall forecasting by local inhabitants based on indicators of weather

Results and Achievements

1. Some of the most common indicators reported from majority of individuals in cluster of villages in Bageshwar and Pithoragarh districts for forecasting

of rainfall were: (i) lightening in the north and east without clouds indicates the possibility of rainfall; (ii) reptiles such as snakes, lizards etc. when come out of their burrows due to excessive heat under ground, it is a good indication of rainfall within a short time; and (iii) when there is a circle of thin clouds particularly reddish in colour around moon is an indication of rainfall.

Box - 10

Summary of the Completed Project

(2001-2003)

Indigenous Knowledge and Uses of Medicinal Plants by Vaidyas in Uttaranchal Himalaya (In house activity)

The Himalaya is the storehouse of valuable medicinal plant species and the state of Uttaranchal has a tremendous wealth of such plant species. However, in view of the declining trend in traditional knowledge on medicinal plants therapy, a need was felt to document this valuable traditional knowledge in Uttaranchal. Study objectives included: (i) documentation of various and plant species used in medical formulations prepared by *Vaidyas* for curing different ailments; and (ii) pattern of traditional medical knowledge through generation.

- Semi-structured open-ended questionnaire survey was conducted among knowledgeable traditional *Vaidyas* on the use of medicinal plants and the preparation of various medical formulations.
- A total of 156 medicinal plant species and 243 herbal formulations were documented by interviewing 60 *Vaidyas* during the survey. These formulations were used in the treatment of more than 70 types of ailments.
- The highest number of formulations was documented for curing cough and cold, followed by headache, indigestion and dysentery (Table 22). Number of recognized *Vaidyas* has declined over the years; however, there were a number of women and men in the villages who know the healing properties of some of the medicinal plants. To strengthen the medicinal plant sector there is a need to revitalize the traditional system of Ayurvedic medicine in Uttaranchal.

Table 22. Major ailments cured by *Vaidyas* on the bases of available formulations and species

Diseases	Formulations used	Species used
Cough & cold	12	16
Headache	10	12
Indigestion	8	12
Dysentery	8	9
Toothache	8	7
Kidney stones	7	6
Earache	7	10
Piles	7	9
Sciatica	7	8
Tuberculosis	6	6

4. MISCELLANEOUS ITEMS

4.1. Membership of Professional Societies/Committees

Fellow, Geological Society of India (A.P. Krishna)

Life Member, International Association of Hydrological Sciences, UK (B.P. Kothyari)

Life member, Indian Association of Soil & Water Conservationists, Dehradun, India (B.P. Kothyari)

Annual Member, Indian Association of Soil & Water Conservationists (B.K. Joshi and P. K. Verma)

Life Member, National Institute of Ecology, New Delhi (G.C.S. Negi)

Member, Society of Economic Botany, Lawrence, USA (H.K. Badola)

Member, International Society for Ethnopharmacology, USA (H.K. Badola)

Member, Himalayan Phytochemical and Grower's Association, HP (H.K. Badola)

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

Member, Tropical Conservancy, Ottawa, Canada (H.K. Badola)

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

Annual Member, National Geographic Society (Kireet Kumar)

Member, American Rhododendrons Society, USA (K. K. Singh)

Life Member, Peoples' Association for Himalayan Area Research, Nainital (P.P. Dhyani)

Member, International Society for Tropical Ecology, BHU, Varanasi (P. Ghosh)

Member, Indian Science Congress Association, Kolkata (P. Ghosh)

Member, South Asia Sustainable Use Specialist Group, SSC, IUCN (R.S. Rawal)

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

Life Member Bioved Research Society, Allahabad (U. Dhar)

4.2. Awards and Honours

National Young Woman Bioscientist Award for the year 2003 from Department of Biotechnology, Govt. of India (Anita Pandey)

Member, State Level Expert Committee, Year of Scientific Awareness, 2004, Department of Science & Technology, Govt. of Sikkim (A.P. Krishna)

Member, State Board for Wildlife, Govt. of Sikkim (A.P. Krishna)

Member, Working Group, State of Environment Report for Sikkim State, Deptt. of Forests, Environment & Wildlife, Govt. of Sikkim (A.P. Krishna)

Member, Advisory Board, Small Industries Service Institute (Ministry of Small Scale Industries, Govt. of India), Gangtok (A.P. Krishna)

Member, Project Selection Committee and Project Advisory Committee (Environmental Management), Shastri Indo-Canadian Institute (SICI), Govt. of India (A.P. Krishna)

Member, Governing Body and Executive Committee, State Council of Science and Technology for Sikkim, Govt. of Sikkim (A.P. Krishna)

Associate Editor for the international journal, 'BIODVERSITY, *the Journal of Life on Earth'*, Canada (H.K. Badola)

Honorary member of Editorial Board of Himalayan Phytochemical and Grower's Association, HP (H. K. Badola)

Member, Steering Committee of the Himalayan Phytochemical and Grower's Association, H.P. (H.K. Badola)

Young Scientist Award (2004) by Bioved Research Society, Allahabad (Meena Joshi and Sumit Manjkhola)

Consulting Editor, The Contemporary Who's Who, The American Biographical Institute, USA (P.P. Dhyani)

Member, Uttaranchal Forest Research Advisory Committee, Govt. of Uttaranchal, Dehradun (P.P. Dhyani)

Honoured by the Uttaranchal Sodh Sansthan, Nainital/Rudrapur for outstanding contribution in the field of environment and human resource development (P.P. Dhyani)

ICFRE Award of Excellence (2001-2002) in Forest Conservation (U. Dhar, S.S. Samant, R.S. Rawal and S. Airi)

Nominated member ad-hoc Technical Expert Group on Mountain Biodiversity, CBD Secretariat, Montreal (U. Dhar)

Peer Reviewer - The Northern Range Assessment, Millennium Ecosystem Assessment, USA (U. Dhar)

4.3. Scientific Publications

(I) Scientific Journals

Agnihotri, R.K., L.M. S. Palni, B. Singh and Y.P.S. Pangtey (2003). Evaluation of fodder quality of straw of different landraces of rice (*Oryza sativa* L.) under cultivation in Kumaun region of Central Himalaya. *International Journal of Sustainable Development and World Ecology* 10(4): 391-400.

Badola, H.K. and S. Aiken (2003). The Himalayas of India: A treasury of medicinal plants under siege. *Biodiversity* (4): 3-13.

Bisht, A.K., S. Manjkhola and **M. Joshi** (2003). Comparative account of two high value species of Himalaya. *Angelica glauca* and *Angelica archangelic. Indian Forester* 129: 1241-1248.

Bisht, D., **A. Pandey** and **L.M.S. Palni** (2003). Influence of microbial inoculations on *Cedrus deodara* in relation to survival, growth promotion and nutrient uptake of seedlings and general soil microflora. *Journal of Sustainable Forestry* 17: 37-54.

Critchley, W.R.S., M. Brommer and **G.C.S. Negi** (2003). Mahender Rautela: Water Volunteer. *ILIEA* 19(3): 23-24.

Chandra, B., L. M. S. Palni and **S. K. Nandi** (2003). Foliar application of inhibitors of GA biosynthesis improves tuber size and biomass in seedlings of *Aconitum violaceum:* A critically rare medicinal herb of Himalayan alpines. *Science Letters* 26(7,8): 203-207.

Deb, Panna. and **R. C. Sundriyal** (2003). Namdapha National Park, Arunachal Pradesh, India: An appraisal. *National Park Journal* 47(5): 17.

Dhar, U., (2003). Mainstreaming Mountain Biodiversity Issues in Global Agenda – View from Rome. *Newsletter of the Indian Society for Ecological Economics.* September 3-4.

Ghosh, P. and A.K. Kashyap (2003). Effects of rice cultivars on rate of N-mineralization, nitrification, and nitrifier population size in irrigated rice ecosystems. *Applied Soil Ecology* 24(1): 27-41.

Ghosh, P. and **P.P. Dhyani** (2003). Mixed cropping system reduces weed menace in rain fed hill paddy**.** *Journal of Hill Research* 16 (1): 32-34.

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4.4. Popular Articles

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4.5. Symposia/Conferences/ Training Courses/ Workshops

(I). Organized by the Institute

International day for biodiversity at GBPIHED, Sikkim Unit. May 23, 2003 (A.P. Krishna).

Advisory committee meeting of disaster management faculty, Sikkim at GBPIHED, Sikkim Unit in collaboration with Sikkim Govt. November 17, 2003 (A.P. Krishna).

Project monitoring and review committee meeting at GBPIHED, Sikkim Unit in collaboration with TIFAC, DST and IARI. December 16, 2003 (A.P. Krishna).

Training Programme on nursery development, tree plantation techniques, and natural resource conservation and management, Digoli Village, Almora. February 24-26, 2004 (B. P. Kothyari & P.P. Dhyani).

Exposure training on herbal gardens and conservation, GBPIHED, Himachal Unit, Kullu. June 5, 2003 (H.K. Badola).

Interactive meeting of all India State level officers meeting on conservation of Himalayan medicinal plants GBPIHED, Kullu. June 6, 2003 (H. K. Badola & S.C.R. Vishvakarma).

On-site training and demonstration on medicinal plants cultivation techniques. Village Silha (Kullu). September 8, 2003 (H. K. Badola & Jitendra Singh)

Training workshop on biodiversity and medicinal plant conservation GBPIHED, Kullu. September 27, 2003 (H. K. Badola)

Demonstration camp on farm based technologies at IARI, Kalimpong, West Bengal, May 20-21, 2003 (K. K. Singh).

"A day with students" at GBPIHED, Kosi-Katarmal, Almora. June 5, 2003 (Kireet Kumar).

Training programme for school children at Udiyari village, Almora. August 8, 2003 (Kireet Kumar)

Training on bioglobules as alternative fuel and other purposes in the rural areas, Jaubari village, South Sikkim, August 21, 2003 (K. K. Singh).

Training programme for school children at Manau village, Almora. September 12, 2003 (Kireet Kumar).

Participatory biodiversity and conservation programme at GBPIHED, Pangthang. September 29, 2003 (K.K. Singh).

Field training for farmers on application of SWEET at Katarmal, Almora. December 10, 2003 (Kireet Kumar).

Village level training-cum-workshop on mushroom cultivation, Kalimpong, West Bengal. December 11-13, 2003 (K. K. Singh).

Regional workshop on water, watershed management & people's participation at GBPIHED, Kosi-Almora. December 26, 2003 (P.K. Samal, D.S. Rawat, N. A. Farooquee & G.C.S. Negi).

A study-cum-observation visit on medicinal plant cultivation and conservation, GBPIHED, Garhwal Unit. August 20-28, 2003 (R.K. Maikhuri).

Training on multidisciplinary and sustainable environmental technologies for North-East India, Midphu. September 22-25, 2003 (R. C. Sundriyal & S.C. Rai).

Training programme on medicinal plant cultivation and conservation, Garhwal Unit, GBPIHED at Ramini Village, Chamoli. October 13-14, 2003 (R.K.Maikhuri).

Training programme on medicinal plant cultivation and conservation, by Garhwal Unit of GBPIHED at Rudraprayag, November 21-22, 2003. (R.K.Maikhuri).

Training workshop on Himalay ki jaiv vividhata sanrakshan mei janta ki bhagidari, GBPIHED, Kosi-Almora at Wajjula, Almora. December 1-3, 2003 (R.S. Rawal).

State level seminar on developing medicinal plant sector in Uttaranchal-prospects and constraints of cultivation and marketing, GBPIHED, Kosi, Almora. March 26-27, 2004 (R.S. Rawal).

Training on wasteland development at Chimpu village, Itanagar. December 24, 2003 (R.C. Sundriyal & S. C. Rai).

Training workshop on improvement in traditional methods of replenishing soil fertility vis-à-vis organic farming for food security and biodiversity conservation for Arunachal Pradesh, Midphu. February 6-7, 2004 (S. C. Rai).

Workshop on jaiv vividhata and paryavaran sanrakshan organized at GBPIHED, Himachal Unit, Kullu. March 28-29, 2004 (S.S. Samant).

Orientation course on Himalay ki jaiv vividhata sanrakshan mei janta ki bhagidari, GBPIHED Kosi-Almora at Wajjula, Almora. November 28 -30, 2003 (U. Dhar).

(II). Participation of the faculty – workshop/seminar/ symposia

International workshop on landslides in Darjeeling and Sikkim Himalayas, Gangtok. March 5, 2004 (A.P. Krishna & T. D. Bhutia)

India disaster database workshop, National Institute of Disaster Management, New Delhi. February 16-18, 2004 (A.P. Krishna).

Project inception workshop of Shastri applied research projects, New Delhi. September 1-5, 2003 (A.P. Krishna).

Third International conference on global advances in tea sciences, Kolkata, November 20-22, 2003 (A. Pandey, N. Bag & P. Trivedi).

Presented paper in state level seminar entitled on developing medicinal plant sector in Uttaranchal, GBPIHED, Almora. March 26-27, 2004 (Anil K. Bisht, Subodh Airi & Sumit Manjkhola & G.C.S. Negi as a panelist).

Workshop on molecular taxonomy of the symbiotic fungi, JNU, New Delhi. December 1-2, 2003 (B. Chaurasia, S. Kumar & S. Singh).

Operational planning workshop at ICIMOD, Kathmandu, Nepal. December 9-13, 2003 (B. P. Kothyari).

Workshop on role of women on watershed development activities and International year of water, organized by Agriculture department at Hawalbag. August 16, 2003, (D.S. Rawat).

Project formulation workshop organized by Ministry of Science and Technology at Lohaghat, June 18-20, 2003 (D.S. Rawat).

Workshop on conserving nature and the man, organized by WWF at Rainkhet. April 25-26, 2003 (D.S. Rawat).

Training programme on biodiversity for social scientists, organized by Indian Society for Ecological Economics, Kolkata. December 18, 2003 (G.C.S. Negi).

Presented a paper in Third Biennial Conference of the Indian Society for Ecological Economics, IIM, Kolkata. December 19-20, 2003 (G.C.S. Negi).

Seminar on water and people, organized by Earthcare Foundation, New Delhi. October 17, 2003 (G.C.S. Negi).

Course on remote sensing, image processing and pattern recognition, GIS and their applications at National Remote Sensing Agency, Hyderabad. June 2–August 22, 2003 (J.C. Kuniyal).

Conference on urban air pollution monitoring and management organized by Indian Association for Air Pollution Control, New Delhi. September 22-23, 2003 (J.C. Kuniyal).

Sam Vikas workshop at ATI, Nainital. December 26, 2003 (Kireet Kumar).

Year end workshop on global change impact assessment for Himalayan mountain regions, Institute for Development and Innovation, Kathmandu, Nepal. January 10-12, 2004 (Kireet Kumar & V. Joshi).

Workshop organized by SWAJAL at Nainital. June 10-11, 2003 (Kireet Kumar).

Presented talk in biodiversity conservation workshop at Wajula. November 27–December 2, 2003 (Kireet Kumar, G.C.S. Negi & K.D. Kandpal).

National level awareness workshop in biotechnology and bioinformatics, State Council of Science & Technology, Sikkim. May 15, 2003 (K.K. Singh).

District level science exhibition at Hawalbag, Almora. November 11, 2003 (K.D. Kandpal as a judge).

Presented paper in regional planning workshop on capacity building of advocacy strategies for community based organization in Hindu Kush Himalayas, at Chittagong, Bangladesh. November 3-6, 2003 (Manju Sundriyal).

Training workshop on improvement in traditional methods of replenishing soil fertility vis-a vis organic farming for food security and biodiversity conservation for Arunachal Pradesh, at Midhpu. February 6-7, 2004 (Manju Sundriyal as resource person).

Presented a paper in Indian agriculture and farmer's congress, Bioved research society, Allahabad, February 21, 2004 (Meena Joshi & Uppeandra Dhar).

Presented a paper in convention of Indian association of sedimentologists at Garhwal University, Srinagar. November 28- December 1, 2003 (M. S. Miral).

Interactive workshop for the development of biotechnology in the Uttaranchal, Dehradun. January 29-30, 2004 (M.Joshi and D.S. Bisht).

Seventh world bamboo congress, New Delhi. February 27- March 4, 2004 (N. Bag).

Residential programme on productivity through participation for achieving excellence, Manali, H.P. May 27-31, 2003 (P.P. Dhyani).

Presented a paper in International conference on eco-restoration, New Delhi. October 14-21, 2003 (P. Ghosh).

Training programme on nursery development, tree plantation techniques, natural resource conservation and management, and low cost farm based techniques, Digoli village, Almora. February 24-26, 2004 (P.K. Samal, R.G. Singh & P. Ghosh).

IUCN-WCPA world Heritage Mountain protected area field workshop, Ukhahlamba-Drakensberg, South Africa, September 5-8, 2003 (P.P. Dhyani).

Project evaluation committee under integrated eco-development research programme, Kosi-Katarmal, Almora, Uttaranchal. March 20-21, 2004 (P.P. Dhyani).

IUCN world parks congress, Durban, South Africa. September 15-17, 2003 (P.P. Dhyani).

ENVIS node training programme on designing and management of database, CEE, Pune. April 22-25, 2003 (P.M. Pandey).

Delivered lecture in short term training programme on characterization of wild relatives including vegetatively propagated materials and post collection of germplasm, NBPGR, Shimla. August 4-7, 2003 (R.K. Maikhuri).

Delivered lecture in a NSS camp at Pauri-Garhwal. December 31, 2003 (R.K. Maikhuri).

Delivered lecture on national consultation on medicinal plants: identifying priorities for India, Oxfam GB India, New Delhi. September 19, 2003 (R.K. Maikhuri).

Delivered lecture in training programme on promotion of cultivation of medicinal and aromatic plants and orientation on financing, organized by

NABARD and HAPPRC at Srinagar-Garhwal. September 24-27, 2003 (R.K.Makhuri).

Delivered a lecture in training programme on energy plantation, gasifires, non-renewable technologies of Himalayan trees, HAPPRC, Garhwal University, Srinagar. September 9-10, 2003 (R.K.Maikhuri).

Delivered a lecture in regional workshop of IUCN SE Asia commission on education at Regional Cancer Research Center, Trivandrum. October 30-31, 2003 (R.S. Rawal).

State-level sensitization workshop on need of training for rural development and training need analysis, State Institute of Rural Development, Arunachal Pradesh. September 3-5, 2003 (R.C. Sundriyal as resource person).

Regional awareness-cum-training workshop for preparation of people's biodiversity registers, Indian Institute of Science, and Biotech Consortium India Ltd. Guwahati. November 8-10, 2003 (R.C. Sundriyal as resource persons).

Delivered a lecture in integrated watershed management for implementation of hill area development programme and western ghat development programme, National Institute of Rural Development at Guwahati. November 10-15, 2003. (R.C. Sundriyal as key note speaker).

Start up workshop on conservation and sustainable management of belowground biodiversity, JNU, New Delhi. May 29-31, 2003 (R.K. Maikhuri).

Convention of Indian Association of Sedimentologists at Garhwal University, Srinagar- Garhwal. November 29-30, 2003 (R.K. Maikhuri).

Delivered a keynote speech in a seminar on watershed development, Parvatiya Jan Kalyan Sansthan at Srinagar-Garhwal. November 23, 2003. (R.K. Maikhuri)

Training programme on watershed management, The Energy and Resources Institute, Guwahati. February 16-18, 2004 (R.C. Sundriyal as resource person).

National workshop on biodiversity research: challenges, strategies and future prospects, Arunachal University, Itanagar. November 26-27, 2003 (R.C. Sundriyal).

Workshop for developing joint S&T based developmental programme amongst State S&T councils and departments of mountain region, at Itanagar by APCST and DST, New Delhi. February 13, 2004 (R.C. Sundriyal as resource person).

Jawaharlal Nehru National science exhibition organized by UA Government and NCERT, at Dehradun. November 17-22, 2003 (R.G. Singh, S.S. Bisht, C.P. Kala & Sachin Gupta).

Workshop on creation of awareness among the prospective PIs/Groups/ NGOs, etc., of the North East region for execution of location-specific action-oriented R&D activities under the IERP of GBPIHED: Project presentation-cum-evaluation, NE Unit–GBPIHED, Itanagar. January 29-30, 2004 (R.C. Sundriyal & P.P. Dhyani).

Presented paper in Indian science congress association, Chandigarh. January 30, 2004 (P. Ghosh).

Regional workshop on water, watershed management and peoples' participation, Kosi-Katarmal, Almora. December 26, 2003 (R.G. Singh).

Delivered lecture in training programme on micro planning in Arunachal Pradesh, State Forest Research Institute, Itanagar. May 22-25, 2003 (S.C. Rai).

Conservation assessment and management prioritization workshop for selected medicinal plants species, organized by UNDP, GEF, and FRLHT, Bangalore at Shimla. May 22-25, 2003 (S.S. Samant as an expert).

Performance evaluation workshop of ENVIS nodes, CPR Environmental Education Centre, June 13-16, 2003 (S. Nandy).

Short term training course in bioinformatics, Institute of Himalayan Bioresources Technology, Palampur. June 23–26, 2003 (S. C. Joshi).

Delivered lecture in workshop-cum-training on medicinal and aromatic plants cultivation and management for sustainable development in East Kameng District, District Horticulture and Agriculture Development Society, Sepa. July 14–15, 2003 (S.C. Rai).

Training course on DNA based markers technologies and its application in plant biology. The Energy and Resource Institute, New Delhi. July 21-31, 2003 (S.K. Nandi, Anil Kumar & Sachi Shah).

Delivered lecture in foundation course on planning and management of rural development programmes to the farmers and BDOs of Arunachal Pradesh, State Institute of Rural Development, Itanagar. August 25-29, 2003 (S.C. Rai).

Environmental statistics training porgramme, NEHU, Shillong. September 23-28, 2003 (S. Nandy).

Training on cultivation and conservation of medicinal plants in Garhwal Himalaya at village Ramni, Chamoli. October 13-14, 2003 (S. C. Joshi).

National symposium on improving crop productivity in an ecofriendly environment: physiological and molecular approaches, G. B. Pant University of Agricutlure & Technology, Pantnagar. October 15-17, 2003 (S.K. Nandi, Anil Kumar, M. Nadeem & R.K. Agnihotri).

National seminar on north-eastern region insurgency, economy and society, organized by ICSSR, New Delhi at Itanagar. November 17-18, 2003 (S.C. Rai).

Delivered lecture in training workshop on various aspects on medicinal plants, organized by Centre for Sustainable Environment and Heritage, New Delhi at Tharas village, Kullu. November 27-29, 2003 (S.C.R.Vishvakarma).

Delivered lecture on in workshop on jaiv vividhata and paryavaran sanrakshan, GBPIHED, Himachal Unit. March 28-29, 2004 (S.C.R. Vishvakarma).

Asia Pacific conference on operational research: emerging paradigm on information technology, New Delhi. December 8-10, 2003 (S. Nandy).

Training on cultivation and conservation of medicinal plants in Garhwal Himalaya at Guptakashi, Rudraprayag. December 22-23, 2003 (S. C. Joshi)

National seminar on biodiversity characterization at landscape level for bioprospecting. Department of Biotechnology, New Delhi. December 31, 2003 (S. Sharma).

Training on cultivation and conservation of medicinal plants in Garhwal Himalaya at Khirsu, Pauri-Garhwal. March 23-24, 2004 (S. C. Joshi).

Regional kisan mela and garlic seminar organized by Hill Agricultural Research and Extension Centre, Bajaura (Kullu). March 24, 2004 (S.S. Samant)

Delivered lecture in training programme on wasteland development, organized by Government of Arunachal Pradesh at Tawang and Lumla. March 10-12, 2004 (S.C. Rai).

Workshop on awareness building for disaster management, organized by Arunachal University. March 18, 2004 (S.C. Rai).

International conference on managing seismic risks in developing countries, Disaster Management Institute, Bhopal. March 17-19, 2004 (T. D. Bhutia)

Review meeting for participating schools, technical resource center, and DST under U-PROBE Programme at Almora. February 16, 2004 (U. Dhar).

Workshop on landslide hazard and risk analysis in selected road corridors of Uttaranchal, IIRS, Dehra Dun. February 14, 2004 (V. Joshi).

(III). Participation of the faculty- meetings

State organizing committee meeting for observation of the year of scientific awareness 2004, DST, Govt. of Sikkim, Gangtok. January 30, 2004 (A.P.Krishna).

Project advisory and monitoring committee meeting, GPS Programme, DST at Manipur University, Imphal. March 22-23, 2004 (A.P. Krishna).

Project monitoring and review committee meeting of technology vision 2020-agriculture mission projects, organized by TIFAC, DST at Pangthang, Sikkim. December 16, 2003 (A.P. Krishna & K.K. Singh)

Project advisory committee meeting on environmental management of Shastri applied research projects, New Delhi. September 4, 2003 (A.P. Krishna).

Advisory committee meeting of disaster management faculty, Sikkim state, Pangthang. November 17, 2003 (A.P. Krishna).

Project selection committee meeting on environmental management of Shastri applied research projects, New Delhi. May 30-31, 2003 (A.P. Krishna).

Access meeting (common resources) at ICIMOD, Kathmandu, Nepal. December 6-8, 2003 (B. P. Kothyari)

Steering committee meeting of national bioresource development board, DBT, New Delhi. July 23, 2003 (D.S. Rawat, M. Joshi & M. Nadeem).

Presented project proposal in DST meeting at INSA, New Delhi. February 21, 2004 (G.C.S. Negi).

Technical advisory committee meeting of India Canada Environment Facility, New Delhi and INHERE, Masi. April 23 and November 20, 2003 (G.C.S. Negi).

Discussion meeting with Hon,ble Minister of Environment and Forests, Govt. of Uttaranchal, on Action Plan of Barwa village. May 21, 2003 (Kireet Kumar).

Proceedings of the staff research council meeting at National Research Center for Orchids, Pakyong, Sikkim. September 15, 2003 (K. K. Singh).

Proceeding of the research council meeting and technical programme at Spices Board, Govt. of India, Sikkim. September 19, 2003 (K. K. Singh).

Meeting of APN project at National Physical Laboratory, New Delhi. July 14 & November 7-8, 2003 (Kireet Kumar & V. Joshi).

Paper presentation at PAMC meeting of DST at IITM, Pune. January 28, 2004. (Kireet Kumar).

Environmental and social guidelines and environmental and social implementation and monitoring manual, Watershed Management Directorate, Dehra Dun. November 8, 2003 & December 5, 2003 (P.K.Samal, D.S.Rawat, N.A. Farooquee & G.C.S. Negi).

Environmental and social management framework for watershed management in Uttaranchal meeting at world bank, New Delhi. November 10, 2003 & January 15-19, 2004 (P.K. Samal & G.C.S. Negi).

Expert committee meeting on Vishnuprayag catchment area treatment project, Joshimath, Chamoli. October 21-24, 2003 (P.K. Samal).

Project evaluation committee meeting, GBPIHED, Almora. March 20-21, 2004 (P.K. Samal).

TSBF/GEF project discussion meeting, JNU, New Delhi. June 30-31, 2003 (R.K. Maikhuri).

Preparation of state of art report on environment meeting, Uttaranchal Government, Dehradun. July 26, 2003 (R.K. Maikhuri).

Meeting on state of art report on environment and pollution organized by Uttaranchal Govt., Dehradun. August 25, 2003 (R.K. Maikhuri).

Jalandolanmeeting, Garhwal University, Srinagar. August 26, 2003 (R.K. Maikhuri).

Consultation meeting on threat status of medicinal plants of the western Himalaya, Wildlife Institute of India, Dehradun. January 31, 2003 (R.K. Maikhuri).

Meeting on world environment day at village Dagar, Tehri-Garhwal. June 5, 2003 (S. C. Joshi). Meeting of task team for the research project on snow and glacier.

Meeting of expert group on bamboo improvement and production through biotechnological approaches, DBT, New Delhi. August 14, 2003 (S. K. Nandi).

Task force meeting on network programme on improvement of tea through biotechnological approaches, DBT, New Delhi. September 23, 2003 (S. K. Nandi & Anita Pandey).

Interactive meeting on DBT funded project on genetic profiling and pilot production of the identified elite species and quantification of active biomolecules, Delhi University, Delhi. September 24, 2003 (S. K. Nandi, Hemant Pandey & B. Chandra).

State level stakeholders consultation meeting for the state of environment report, Academy for Mountain Environics and M/S Infrastructure Development Finance Company at Gairsen, Chamoli. November 15-16, 2003 (S. C. Joshi).

Interactive meeting on projects of bioprospecting and molecular taxonomy programme, M. S. Swaminathan Research Foundation, Chennai. December 5-6, 2003 (S. K. Nandi).

Task Force meeting on Bioprospecting and Molecular Taxonomy programme held at DBT, New Delhi. August 18, 2003 & March 15-16, 2004 (S. K. Nandi)

Block level executive committee meeting- DFID- Phase II HPFSRP, H.P. Forest Department, Kullu. March 26, 2004 (S.S. Samant).

Environment and Forests, organized by SAC, Ahmedabad. May 7, 2003 (V. Joshi).

Discussion meeting of world bank mission on SWAJAL, Dehra Dun. June 5, 2003 (V. Joshi).

Meeting on development of Barwa village organized by Uttaranchal Govt. at village Barwa, Dehra Dun. July 19, 2003 (V. Joshi & K.D Kandpal).

APN project meeting for RCM data at IITM, Pune. August 5-6, 2003 (V. Joshi).

Discussion meeting of world bank mission on SWAJAL, Dehra Dun. September 30- October 1, 2003 (V. Joshi).

Expert team visit to Uttarkashi landslide organized by DST, New Delhi. October 6-9, 2003 (V. Joshi).

Participated in a brainstorming session on hydrology of glacierized basins organized by National Institute of Hydrology, Roorkee. March 4, 2004 (V. Joshi).

National committee meeting on GPS organized by Manipur University, Imphal. March 22-23, 2004 (V. Joshi).

(IV). Delivered Lectures as Resource Person

Delivered talk on World Environment Day, All India Radio, Gangtok. June 5, 2003 (A.P. Krishna).

Delivered a lecture to schoolchildren and the villagers on strengthening hydropower projects in the mountain environment, Bershaini and Pulga, Kullu. November 1-2 & 22, 2003 (J.C. Kuniyal).

Delivered a lecture to the farmers of the Kullu district in a training programme organized by Centre for Sustainable Environment and Heritage, New Delhi at Kullu. November 27-29, 2003 (J.C. Kuniyal).

Delivered lecture on medicinal plant cultivation and marketing at Forest Training Institute, Haldwani. April 28, 2003 (S.S. Samant).

Participated as scientist expert (Biodiversity and Ecology) for Nanda Devi National Park biodiversity monitoring expedition 2003, organized by Government of Uttaranchal. June 18, 2003-July 8, 2003 (S.S. Samant & H.C. Joshi).

Delivered a lecture in National symposium on improving crop productivity in an eco-friendly environment: physiological and molecular approaches at G.B. Pant University of Agriculture & Technology, Pantnagar. October 15-17, 2003 (S. K. Nandi).

Delivered lecture to NGOs and Farmers on medicinal plants at Kametdevi, Bageshwar. November 2, 2003.

Delivered lecture to teachers in the orientation workshop on Himalay ki jaiv vividhata mei janata ki bhagidari at Wajjula, Almora. November 27-December 4, 2003 (S.S. Samant).

Delivered guest lecture at DPAP workshop at Hawalbag, Almora. February 11, 2004 (K.D. Kandpal).

Delivered lecture in the training workshop on jaiv vividhata and paryavaran sanrakshan at Kullu, Himachal Pradesh. March 28-29, 2004 (S.S. Samant).

M/s S P M G & COMPANY
(Formerly known as Sharad Paddar Associates)
CHARTERED ACCOUNTSANTS
"ASHARWAD" 7, RAJ VIHAR
P.O. F.R.I., DEHRADUN-248 006
Phone: 0135-2760402
Email: spoddar@vsnl.com

THE DIRECTOR,
G.B. PANT INSTITUTE OF HIMALAYAN
ENVIRONMENT & DEVELOPMENT,
KATARTMAL, KOSI,
ALMORA- 263 643 (UTTARANCHAL)

Dear Sir

We have audited the Balance Sheet of G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT, KOSI-KATARMAL, ALMORA (UTTARANCHAL) which are in agreement with the books of accounts, maintained by the Institute as on 31st MARCH, 2004

We have obtained all the information & explanations, which to the best of our knowledge and belief were necessary for the purpose of audit. In our opinion, proper books of accounts, as required by the law have been kept by the Head Office and the Units of the above named Institute, so far as appears from our examination of the books. Proper returns adequate for the purpose of audit have been received from Units not visited by us, subject to the Notes on Accounts and comments given below: -

As per notes on accounts/observations

In our opinion, and to the best of our information and according to the explanations given to us and subject to the notes forming part of accounts the said accounts give the true and fair view: -

i) In the case of Balance Sheet of the State of Affairs of the above named Institute as on 31st MARCH, 2004 and

ii) In the case of Income & Expenditure accounts of the INCOME of its accounting year ending 31st MARCH, 2004.

For S P M G & Company
(Formerly know as Sharad Poddar Associates)
CHARTERED ACCOUNTANTS

Sd/-
(VINOD GUPTA)
F.C.A. PARTNER
DATED : 14-08-2004
PLACE : DEHRADUN

SEAL

M/s S P M G & COMPANY
(*Formerly known as Sharad Paddar Associates*)
CHARTERED ACCOUNTSANTS
"ASHARWAD" 7, RAJ VIHAR
P.O. F.R.I., DEHRADUN-248 006
Phone : 0135-2760402
Email: spoddar@vsnl.com

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

BALANCE SHEET AS ON 31ST MARCH 2004

PARTICULARS	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
CORPUS/ CAPITAL FUND		13742521.64	11095876.97
RESERVE AND SURPULES		375147059.84	355045298.84
EARMARDED / ENDOWMENT FUNDS		28285346.28	24612698.36
SECURED LOANS & BORROWINGS		0.00	0.00
UNSECURED LOANS & BORROWINGS		0.00	0.00
DEFERRED CREDIT LIABILITIES		0.00	0.00
CURRENT LIABILITIES AND PROVISIONS		29424859.05	21539283.39
TOTAL		**446599786.81**	**412293157.56**
ASSETS			
FIXED ASSETS		313542595.84	355045298.84
INVEST. FROM EARMARKED/ENDOMENT FUND		6464718.00	4570315.00
INVEST. OTHERS		0.00	0.00
CURRENT ASSETS, LOANS, ADVANCES ETC.		126592472.97	52677543.72
MISCELLANEOUS EXPENDITURE			
TOTAL		**446599786.81**	**412293157.56**

SIGNIFICANT ACCOUNTING POLICIES

CONTINGENT LIABILITIES & NOTES ON ACCOUNTS

AUDITOR'S REPORT
As per our separate report of even date annexed.
For S P M G & COMPANY
CHARTERED ACCOUNTANTS

Sd/-
(VINOD GUPTA)
F.C.A. PARTNER
DATED : 14-08-2004
PLACE : DEHRA DUN

SEAL

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

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

Sd/-
(SURYA KANT)
(FINANCE OFFICER I/C)

M/s S P M G & COMPANY
(Formerly known as Sharad Paddar Associates)
CHARTERED ACCOUNTSANTS
"ASHARWAD" 7, RAJ VIHAR
P.O. F.R.I., DEHRADUN-248 006
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G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT KATARMAL KOSI (ALMORA) UTTARANCHAL

INCOME & EXPENDITURE A/C FOR THE YERA ENDED 31ST MARCH 2004

PARTICULARS	SCHEDULE	CURRENT YEAR	PREVIOUS YEAR
INCOME			
Income form Sales/Services		151935.00	27000.00
Grants/Subsidies		80897489.00	76991941.10
Free/ Subscriptions		0.00	100257.00
Income from Investments (Income on Invest. from earmarked/endow Fund transferred to funds)		0.00	0.00
Income form Royalty, Publication etc.		320.00	475.00
Interest Earned		690186.97	1130250.42
Other Income		1804202.70	1897067.00
Increase (decrease) in stock of Finished goods and work in Progress)		0.00	0.00
TOTAL (A)		**83544133.67**	**80146990.52**
EXPENDITURE			
Establishment Expenses: a) Institute		13609150.00	12943415.00
b) Projects (As per Annexure)		6754234.00	5759294.00
c) F.C.(Projects)		2060481.00	1826358.00
Administrative Expenses: a) Institute		36592929.00	7479669.50
b) Projects (As per Annexure)		11419023.00	11314290.00
c) F.C.(Projects)		1252574.00	1645822.00
Expenditure on Grants, Subsidies etc.		9209098.00	6023092.60
Interest			0.00
Depreciation (Net at the year-end-as-per Schedule 8)			0.00
TOTAL (B)		80897489.00	76991941.10
Balance being excess of Income over Expenditure (A-B)		2646644.67	3155049.42
Transfer to special Reserve			
Transfer to/from General Reserve			
BAL. BEING SURPULUS TRF. TO CORPUS/CAPITAL FUND		**2646644.67**	**3155049.42**

SIGNIFICANT ACCOUNTING POLICIES
CONTINGENT LIABILITIES & NOTES ON ACCOUNTS

AUDITOR'S REPORT
As per our separate report of even date annexed.
For S P M G & COMPANY
CHARTERED ACCOUNTANTS

Sd/-
(VINOD GUPTA)
F.C.A. PARTNER
PLACE : DEHRA DUN

SEAL

DATED : 14-08-2004

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

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

Sd/-
(SURYA KANT)
(FINANCE OFFICER I/C)

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

RECEIPTS & PAYMENTS A/C FOR THE YEAR ENDED 31ST MARCH 2004

RECEIPTS	CURRENT YEAR	PREVIOUS YEAR	PAYMENTS	CURRENT YEAR	PREVIOUS YEAR
I. Opening Balances			**I. EXPENSES**		
a) Cash in hand	339.05	9342.05	a) Establishment Expenses (Corresponding to Schedule 20)	13542112.00	12093070.00
b) Bank Balances			b) Administrative Expenses (Exclusive Of Capital Exp.) (Corresponding to Schedule 21)	26445884.00	25342645.50
i) In current accounts	3964241.53	1776108.50	c) Payments for current liabilities.	35974.70	
ii) In deposit accounts			**II. Payments made against funds for various proj.**	27382355.00	23096676.60
iii) Saving accounts	11871981.74	12986112.34	**III. Investments and deposits made**		
c) Advances & Others (As per annexure Attached)	32634818.42	28267702.53	a) Out of Earmarked/Endowment funds		0.00
II. Grants Received			b) Out of Own Funds (Investments Other)		0.00
a) Form Government of India			c) General Fund	3100000.00	2400000.00
i) Institute	63500000.00	58367000.00	**IV. Expenditure on Fixed Assets & Capital W.I.P.**		
ii) Projects	28466786.00	22303522.00	a) Purchase of Fixed Assets	9819561.00	12066786.00
b) From State Government		0.00	b) Expenditure on Capital Work-in-progress	8000000.00	7500000.00
c) From other sources [form FC]	0.00	232297.86	**V. Refund of Surplus money/Loans**		
III. Income on Investments from			a) To the Government of India	49161.00	211099.00
a) Earmarked/ Endow. Funds	389459.75	638616.39	b) To the State Government	0.00	0.00
b) Loans, Advances etc.		0.00	c) To the provident of funds	0.00	0.00
IV. Interest Received			d) To others [security/ caution money]	10580.00	7750.00
a) On Bank deposits	598835.97	1035541.42	**VI. Finance Charges (Interest)**		
b) Loans, Advances etc.	91351.00	94709.00	**VII. Other Payments (PF TRf./ Withdrawals etc.)**	409980.00	371521.00
V. Other Income (As per annexure Attached)	1956457.70	2024799.00	**VIII. Closing Balance**	30308.05	339.05
VI. Amount Borrowed	0.00	0.00	a) Cash in hand		
VII. Any other receipts.			b) Bank Balance		
a] (As per annexure Attached)	4007151.17	3803877.67	i) In current accounts	1744153.85	3964241.53
b] Transferred to Advances	0.00	21300.08	ii) In deposit accounts	0.00	0.00
			iii) Savings accounts	17200659.70	11871981.74
			c) Advances & Others (As per annexure attached)	39710693.03	32634818.42
TOTAL	**147481422.33**	**131560928.84**	**TOTAL**	**147481422.33**	**131560928.84**

AUDITOR'S REPORT
As per our separate report of even date annexed.
For S P M G & COMPANY
CHARTERED ACCOUNTANTS

Sd/-
(VINOD GUPTA)
F.C.A. PARTNER
DATED : 14-08-2004
PLACE : DEHRA DUN

SEAL

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

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

Sd/-
(SURYA KANT)
(FINANCE OFFICER I/C)

M/s S P M G & COMPANY
(Formerly known as Sharad Paddar Associates)
CHARTERED ACCOUNTSANTS
"ASHARWAD" 7, RAJ VIHAR
P.O. F.R.I., DEHRADUN-248 006
Phone : 0135-2760402
Email: spoddar@vsnl.com

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

STATEMENT OF OPENING & CLOSING BALANCES

PARTICULARS	OPENING AMOUNT	CLOSING AMOUNT
Cash & Bank Balances		
Cash in Hand:		
Srinagar	39295.07	0.09
Sikkim	666.00	0.00
Kullu	5357.17	7.36
Itanagar	53824.27	12540.27
Cash at Bank Balances		
SBI Almora A/c No. 01170003256 (Endo)	34014.72	35548.47
SBI Tandong A/c No. 01000050044	484041.92	37489.92
SBI Kullu A/c No. 01100076038	1252955.01	12800.82
SBI Itanagar A/c No. 01100050337	573682.39	284396.39
SBI Srinagar A/c No. 01100030433	121906.97	1333399.21
SBI Almora PF A/c 01100003255 (PF)	234861.64	1317476.81
Advances		
House Building Advance	2956737.00	2932967.00
Motor cycle / Car Advance	214386.00	158127.00
Festival Advance	20100.00	18450.00
PF Advance	444733.00	677678.00
G.S.L.I	799.14	398.50
C.P.F	36.00	36.00
Revenue Stamp Recovery	(2.00)	(3.00)
Units of Institute		
Sikkim Unit	37294.10	42957.10
HP Unit	(29173.00)	0.00
Garhwal Unit	258009.02	(306774.24)
NE Unit	(5427.00)	(34232.67)
Fixed Deposit		
With SBI Endowment Fund	4570315.00	6464718.00
Interest Accrued on FDR (General Fund)	1809638.00	303161.00

Contd.....

PARTICULARS	OPENING AMOUNT	CLOSING AMOUNT
SBI PF	10264281.00	11042365.00
CBI PF	5196185.00	5696185.00
Interest Accrued on FDR (PF)	2058670.00	2748214.00
FDR (Margin Money / LC A/C)		
Biotech - XIII	0.00	2424000.00
Institute	1519256.00	2828256.00
BIOTECH- XI	67732.00	67732.00
BIOTECH - XII	758.00	758.00
Due Staff/ other IC A/C		
Dr. Mukesh Joshi (Bitech-XII)	0.00	(1000.00)
Allen Press Inc (SDRE)	7711.00	7711.00
M/S Amersham Bio Sciences (EPB)	0.00	147759.00
A.S.Parihar	389.00	0.00
Post Master G.P.O. Almora	13846.00	10052.00
M/S Bio-red Laboratories, Australia	0.00	81344.00
Employment News	18287.00	13287.00
Sigma Aldrich Chemicals	10590.00	10590.00
Siltap Chemicals Ltd. (Biotech-III)	408.00	408.00
NRSA Hyderabad	8400.00	8400.00
R.K.Nanda & Sons	28517.00	28517.00
Elsvier Science (CSIR-AP)	9500.00	9500.00
S.K.Gurani (IERP)	(75.00)	(75.00)
NRSA Hyderabad (MOE& F-KSR)	138000.00	138000.00
M/s Environmental Data Pvt. Ltd.	0.00	153503.00
M/s TKA Wasse Stockland Germany	0.00	351000.00
NIC New Delhi	0.00	495000.00
Sh. Chander Lal (LTC)	0.00	838.00
Sh. Suraj Lal(LTC)	0.00	1296.00
Dr. Varun Joshi (DST-KK-II)	0.00	9000.00
M/s Bio-Rad Scientific (Biotech- XIII)	0.00	68148.00
Garden Supdt., Ranikhet (Apple-UD)	0.00	8250.00
NRSA Hydrabad (ISRO-GBP-SS)	0.00	40000.00
NRSA Hydrabad (DST-KK-I)	0.00	22200.00
Allen Press Inc (KANSAN)	5813.00	5813.00
M/s Backman Coultr. Intl. Switezerland	206000.00	0.00
F.C.Inter A/C	2500.00	2500.00
TOTAL	**32634818.42**	**39710693.03**

M/s S P M G & COMPANY
(*Formerly known as Sharad Paddar Associates*)
CHARTERED ACCOUNTSANTS
"ASHARWAD" 7, RAJ VIHAR
P.O. F.R.I., DEHRADUN-248 006
Phone : 0135-2760402
Email: spoddar@vsnl.com

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

SCHEDULE OF FIXED ASSETS AS ON 31 st MARCH 2004

PARTICULARS	COST AS ON 1/4/2003	ADDITION DURING THE YEAR	COST OF SALES/ TFD. DURING THE YEAR	TOTAL
Land:	**75639.23**	**0.00**	**0.00**	**75639.23**
Building	**152108848.00**	**0.00**	**0.00**	**152108848.00**
Furniture & Fixture:	**13635966.40**	**1159314.00**	**0.00**	**14795280.40**
(Details)				
Institute	13618359.40	1159314.00	0.00	**14777673.40**
ICIMOD SALT	11000.00	0.00	0.00	**11000.00**
ICIMOD ISSMA	6607.00	0.00	0.00	**6607.00**
Scientific Equipment:	**84072542.11**	**8729696.00**	**0.00**	**91422194.11**
(Details)				
Institute	63347682.19	6511240.00	0.00	**69858922.19**
DST (RSR)	7415.00	0.00	0.00	**7415.00**
BIOTECH-I	1840346.00	0.00	0.00	**1840346.00**
BIOTECH-II	4029751.00	0.00	0.00	**4029751.00**
BIOTECH-III	2129381.00	0.00	0.00	**2129381.00**
UNDP (HAIGAD)	70960.00	0.00	0.00	**70960.00**
CSIR (RCS)	137948.00	0.00	0.00	**137948.00**
DST (SKB)	808564.00	0.00	0.00	**808564.00**
FAO-BIO-DIVERSIT	132792.00	0.00	0.00	**132792.00**
ICAR (ES)	174507.00	0.00	0.00	**174507.00**
ENVIS	242380.00	0.00	0.00	**242380.00**
NWDPRA	64858.00	0.00	0.00	**64858.00**
IEG PROJECT	52465.00	0.00	0.00	**52465.00**
DST (SKN)	323172.00	0.00	0.00	**323172.00**
BIOTECH (V)	112159.00	0.00	0.00	**112159.00**
WWF (CBD)	7700.00	0.00	0.00	**7700.00**
HAIGAD II	115438.00	0.00	0.00	**115438.00**
NORAD	1921158.00	0.00	0.00	**1921158.00**
ICIMOD (SALT)	216447.92	0.00	0.00	**216447.92**
INDO CANDIAN	180076.00	0.00	0.00	**180076.00**
ICIMOD ISSMA	67161.00	0.00	0.00	**67161.00**
ECO-TOURISM	75738.00	0.00	0.00	**75738.00**
MACARTDER UNESCO	63450.00	0.00	0.00	**63450.00**
ICIMOD (PARDYP)	349590.00	0.00	0.00	**349590.00**
ICIMOD (CBD)	52801.00	0.00	0.00	**52801.00**
ICIMOD (FIBRE)	216882.00	0.00	0.00	**216882.00**
MRE	2450.00	0.00	0.00	**2450.00**
ICIMOD-GIS EQUIPME	148800.00	0.00	0.00	**148800.00**
BIOTECH (IV)	244811.00	0.00	0.00	**244811.00**

Contd.....

PARTICULARS	COST AS ON 1/4/2003	ADDITION DURING THE YEAR	COST OF SALES/TFD. DURING THE YEAR	TOTAL
BIOTECH (VI)	701137.00	0.00	0.00	**701137.00**
BIOTECH (IX)	1122815.00	347673.00	0.00	**1470488.00**
BIOTECH (XI)	495039.00	0.00	0.00	**495039.00**
BIOTECH (XII)	1287008.00	6695.00	0.00	**1293703.00**
BIOTECH (XIII)	0.00	135763.00	0.00	**135763.00**
CSIR (AP)	105004.00	0.00	0.00	**105004.00**
DST (HCR)	106144.00	0.00	0.00	**106144.00**
DST (KK)	508702.00	0.00	0.00	**508702.00**
CSIR (SCR)	507339.00	0.00	0.00	**507339.00**
MOE&F (RSR)	13541.00	0.00	0.00	**13541.00**
MED.ARO. PLANT	76320.00	0.00	0.00	**76320.00**
ISRO (APK)	135667.00	0.00	0.00	**135667.00**
SRO-GBP	0.00	212190.00	0.00	**212190.00**
MOE&F (NDMD)	148900.00	0.00	0.00	**148900.00**
DST (GCSN)	52281.00	0.00	0.00	**52281.00**
BIOTECH VIII	145850.00	0.00	0.00	**145850.00**
MOE&F (US)	11076.00	0.00	0.00	**11076.00**
DST(MANJU SUND)	29877.00	0.00	0.00	**29877.00**
ICAR-NATP (RCS)	961067.00	6508.00	0.00	**967575.00**
CSIR (RKM0	149400.00	0.00	0.00	**149400.00**
DST (SCR)	57242.00	0.00	0.00	**57242.00**
DST KK II	33000.00	56790.00		**89790.00**
ICAR (NATP) KSR	100776.00	20155.00		**120931.00**
ENVIS II	119200.00	0.00		**119200.00**
MED PLANT B. (UD)	52000.00	10900.00		**62900.00**
DST (KKS/SCR)	16274.00	41738.00		**58012.00**
DST-UD	0.00	136323.00		**136323.00**
DST-JCK	0.00	826184.00		**826184.00**
DST-VJ	0.00	100470.00		**100470.00**
DST-RKM	0.00	177115.00		**177115.00**
DST-APPLE (UD)	0.00	83624.00		**83624.00**
DST-DEEPA BISHT	0.00	14000.00		**14000.00**
BIOTECH-XIV	0.00	42328.00		**42328.00**
Office Equipments :	**5911558.35**	**320440.00**	**0.00**	**6231998.00**
Institute	5646214.35	320440.00		**5966654.35**
I.E.R.P.	265344.00	0.00		**265344.00**
Fire Fighting Equipment :	**60962.00**	**0.00**	**0.00**	**60962.00**
Library :	**36804881.50**	**1828567.00**	**0.00**	**38633448.50**
Vehicles :	**5201856.25**	**0.00**	**279224.00**	**4922632.25**
(Details)				
Institute	3393403.30	0.00	0.00	**3393403.30**
ICIMOD SALT	279224.00	0.00	279224.00	**0.00**
TSBF	280475.00	0.00	0.00	**280475.00**
MACARTHER UNESCO	290375.00	0.00	0.00	**290375.00**
ICIMOD	233589.95	0.00	0.00	**233589.95**
Biotech XII	724789.00	0.00	0.00	**724789.00**
Glass/Net House :	**3568581.00**	**342968.00**	**0.00**	**3911549.00**
(Details)				
Institute	1517793.00	0.00	0.00	**1517793.00**
BIOTECH (III)	2050788.00	0.00	0.00	**2050788.00**
DST-TIFEC (SIKKIM)	0.00	342968.00		**342968.00**
TOTAL RS.	**301440834.84**	**12380985.00**	**279224.00**	**312162551.84**

INSTITUTE SUPPORTING STAFF

Head Quarters	
K.K. Pande	A.O. (I/C)/A/c..O.
Suryakant Langyan	O.S. (A)
Sanjeev Hingis	Estate Manager
Mritunjay Anand	Library Assistant
L.M.S. Negi	UDC
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	LDC
S.K. Gurani	L.D.C.
Suraj Lal	L.D.C.
Jagdish Singh Bisht	L.D.C.
R.C. Bhatt	Driver
Chandra Lal	Driver-Cum F.A.
Pan Singh	Peon
K.N. Pathak	H.K/Att.
G.D. Kandpal	Peon/Mali
Nathu Ram	Peon/Mali
Ganga Joshi	Peon
Kashi Ram	Peon/Mali
Sikkim Unit	
R.K. Das	L.D.C.
Sabita Krishna	L.D.C.
Musafir Rai	Peon
Shyambir	Peon
Jagnnath Dhakal	Field Asstt.
P.K. Tamang	Peon
Garhwal Unit	
D.P. Kumeri	L.D.C.
M.P. Nautiyal	Driver
R.C. Nainwal	Field Asstt.
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 Engineering; 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; Photography, Social Science
Subrat Sharma	Tech-B	Agro Ecology; Remote Sensing/GIS
North East Unit		
D. Choudhury	Scientist-D	Animal Biology; Entomology
S.C. Rai	Scientist-C	Rural Geography; Hydrology
Sikkim Unit		
A.P. Krishna	Scientist-D	Geotechnical Engineering; Impact Assessment
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. Vishvakarma	Scientist-D	Plant Ecology; Rural Ecosystems
S.S. Samant	Scientist-D	Plant Taxonomy; Conservation Biology
H.K. Badola	Scientist-C	Morphoanatomy; Conservation Biology
J.C. Kuniyal	Scientist-B	Development Geography; Waste Management

(Arranged alphabetically within positions; * presently on deputation; **on lien)

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