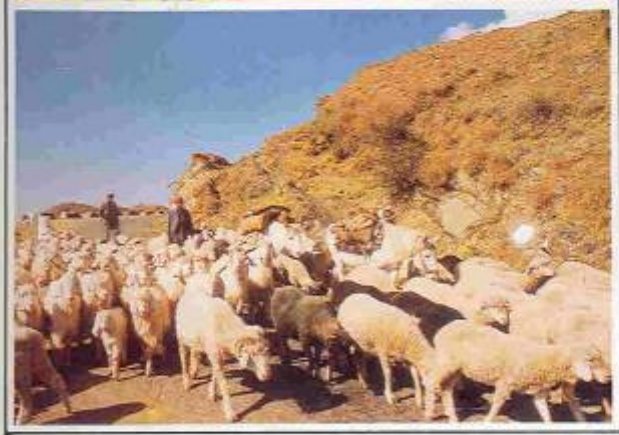

ANNUAL REPORT
1998-99

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

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ANNUAL REPORT

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

CONTENTS

THE YEAR 1998 – 99 : AN OVERVIEW

On reflection, the year 1998-99 has been full of academic activity, infrastructure expansion, creation of new facilities, initiation/strengthening of collaboration with national and international agencies. A number of training programmes for farmers and school children were held at different locations with emphasis on medicinal plant cultivation, biocomposting, protected cultivation and conservation of biodiversity. In all these programmes, a conscious effort is made to supplement local knowledge and indigenous practices, rather than sudden introduction of alien concepts and technologies, in order to ensure peoples participation. Our Networking with NGOs and the educational Institutions is getting strengthened day by day. The improved residential facilities and hostel accommodation have helped increase opportunities for interaction by way of training programmes, workshops and seminars. The VIII G.B. Pant Memorial Lecture and a number of academic activities of the Institute were the most notable events of the year under reporting.

The Institute has moved from descriptions to demonstrations. Some of the major achievements include demonstration of eco-tourism model achieved through peoples participation, and use of bioengineering technologies for slope stabilisation. Institute has completed and started many projects which have a strong research base but also have a major bearing on the developmental approaches and focus on their social values; details are available in Institute publication "Research for Mountain Development". The Institute has further strengthened its ties with a number of National and International institution by signing MOUs, e.g., with the Wadia Institute of Himalayan Geology for scientific collaboration on projects of common academic interest. Our collaboration with ICIMOD continues to grow. Funding of new projects by the Departments of Biotechnology, Science and Technology, Govt. of India is indicative of the increasing scientific capabilities of the Institute. In addition to the six ongoing core programmes it is envisaged to start a new core programme on Indigenous Knowledge Systems during the plan period. The Institute has also added four more publications to its credit during the year, three of which were released during the Annual Day function at Mohal, Kullu in November 1998, and the fourth one by the Hon'ble Minister of Environment and Forests, and the President of G. B. Pant Society during the Society meeting on 15 February 1999. The milestone events, mentioned in subsequent pages in this report, clearly specify the important achievements made in 1998-99. Comments and suggestions of all those interested in the welfare of Himalaya and its inhabitants would be most welcome.

L.M.S. PALNI

Director

MAJOR ACHIEVEMENTS

- ◊ Compilation of existing data on diversity, distribution and potential values of Himalayan Medicinal Plants.
- ◊ Establishment of over ten demonstration sites for addressing small hill slope instabilities using bioengineering measures.
- ◊ Strengthening and reorientation of Himalayan Biodiversity Conservation programme for the school children.
- ◊ "Mitigating disasters in the Himalaya" – 8th Pt. G.B. Pant Memorial Lecture by Prof. V.K. Gaur.
- ◊ Establishment of tissue culture and green house facility and rural technology park in the Headquarters at Katarmal.
- ◊ Preparation of water management plan for selected micro-watersheds of Garhwal Himalaya.
- ◊ Promotion of conservation through enhancing biodiversity values in large Cardmom agroforestry system in Sikkim.
- ◊ Demonstration of Technology packages in Sikkim and North East India.
- ◊ Compilation of results of various ongoing and completed projects "Researches for Mountain Development" for publication and dissemination.
- ◊ Establishment of demonstration models for on site training of farmers and NGOs on soil stabilization and fertility improvement through introduction of hedge-rows in Arunachal Pradesh.
- ◊ Compilation of up-to-date information on Biosphere Reserves and Management in India.
- ◊ Publication of Perspectives for Planning and Development in North-East India based on the outcome of an interactive workshop organized earlier.
- ◊ Completion of office and residential building complex of H.P. Unit at Mohal, Kullu.

Brief Summary of Research and Development Activities

In order to achieve the sustainable development of the Indian Himalaya, research and development programmes of the Institute have been based on a multi-disciplinary and holistic approach with particular emphasis on interlinking of natural and social sciences. In this effort special attention is placed on the preservation of fragile mountain ecosystems, indigenous knowledge and customs. A conscious effort is made to ensure participation of local population for long term acceptance and success of various programmes. The R & D activities of the Institute are centered around six core programmes.

Land and Water Resource Management : Land and water are the two basic resources on which the survival of mankind depends. In the Himalaya management of these important natural resources is a difficult and complex problem. The Himalayan region is characterized by sparse population, undulating terrain, tiny and scattered land holdings. The cultivation is done on slopes with shallow and gravely soil, scanty or no irrigation as the agriculture is largely rainfed, with agro-pastoral economy, etc. In the last few years, institute is engaged in the study of some of these basic characteristics and problems related to its present utilization patterns. Following research programmes were under progress during the year.

Documentation of resource utilization patterns in the two micro-watersheds of Garhwal Himalaya with baseline data collection related to soil and water. Data compilation on Govt. managed schemes to study the existing irrigation systems and rural water supply and selection of sites for field studies. Demonstration of agroforestry model in Mamlay watershed was started as Phase II of the completed activity. Detailed mapping of changes in land use patterns using IRS data has been initiated.

Sustainable Development of Rural Ecosystems : The programmes under the mandate of this core are designed to provide some solutions to location specific problems of natural resource management. To study the availability, use, requirements and prospects of managing currently available resources more judiciously so as to reduce the pressure on limited resources. In Himachal the ability of pine forests to provide required organic resources needed for crop production and horticulture are being studied. In U.P. hills attempts were continued to assess the impact of restoration models on soil physico-chemical characteristics which will lead to understanding the suitability of tested species for agroforestry.

In Arunachal the transhumant community dependence on natural resources as well as their management strategies were assessed. A focussed study on Nanda Devi Biosphere Reserve buffer zone villages was undertaken on peoples participation in natural resource management, prospects of commercial utilization of agricultural diversity and landuse/ cover change database for analysing its impacts. Similar strategies are being tested in a development block (Hawalbagh block) where conservation priorities are not imposed to assess the natural resource based planning prospects.

Conservation of Biological Diversity : The importance of maintaining Himalayan Biodiversity not only for the present but also for posterity is now well recognized. The core is strengthening its activities by developing both short (location specific) and long (broader spatial scale) term programmes. All activities are responsive to contemporary global thinking on the subject matter. It is in this context that the frame work of different projects are developed as per the guidelines provided by National Action Plan (NAP) and AGENDA 21 in conjunction with the Convention on Biodiversity. It aims in harnessing potential bio-resources equitably and also in halting the increasing pressure on biological assets. Following research programmes are under progress.

Documentation and prioritization of important components of biological diversity; programme to identify and monitor 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 ensure peoples' participation in biodiversity conservation.

Ecological Economics and Environmental Impact 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 activities in the Himalaya need to be evaluated and monitored in terms of comprehensive Environmental Impact Assessment (EIA) framework and scientific system of natural resource accounting, making EIA a basic tool for decision making at various levels, i.e., local, regional and national.

To study the carrying capacity with respect to tourism in Kullu Manali complex, tourist flows and use of various modes of transport have been documented. Subsequently, recommendations for solid waste management Kullu Dussehre has bee finalized and submitted to District Administration. Similarly, the Pindari region and its surroundings, well known for famous glaciers viz., Pindari and Kaphani have also been studied for solid waste characterization. To study the concentrations of air pollutants, study is under progress for assessment and monitoring of atmospheric chemical transformations. The inter-links of community resources with socio-economics, culture and environment have been recognized, but, they have not been articulated in terms of clear policies and programmes. Hence, a study was carried out in the Central Himalayan region amongst Bhotiyas and Jaunsaries to understand integrated nature of tribal culture and its influences on resources use and management.

Environmental Physiology and Biotechnology : Plants being the primary producers, a thorough understanding of the factors which govern their productivity and functioning is of paramount importance, especially in the light of severe climatic conditions prevailing in the Himalaya, and current concern about the global climatic change. Judicious use and application of conventional techniques with the sophistication of biotechnology will help increase efficiency and productivity as well as environmental health.

A number of bacteria (isolated from soil) have been developed as inoculants and shown to be beneficial for plant growth as well as for increasing per cent seed germination. Microorganisms obtained from various experiments are being maintained. Nitrogen accretion studies and phosphorus solubilization by symbiotic N_2 fixers are being studied in perspective for their use in agroforestry management. Efficacy of N_2 fixing *Alnus nepalensis* for improving productivity of large cardamom has been demonstrated. In order to supplement production of quality planting material, propagation protocols have been developed using vegetative as well as *in-vitro* methods for bamboo, oak, Bulgarian rose, and some Himalayan medicinal plants. Significant improvement in seed germination was achieved using chemical treatments including plant growth regulators. In view of the predicted rise in atmospheric CO_2 and consequent global warming, short term effect of increasing CO_2 and other environmental factors on photosynthetic characteristics of plants have been assessed. Increased biotic pressure has threatened the survival/existence of Himalayan yew, an important medicinal plant; methods have also been developed for assessing canopy loss of this species. The role of fire in ecosystem processes has also been examined. Demonstrations on simple technological innovations/improvements, e.g., polypit, polyhouse, biocomposting, biofencing, protected cultivation, etc. were conducted for betterment of rural people.

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. Peoples' perception of environment and development activities are considered important for involving them in the effective management of natural resources. The Core serves as a nodal point for networking with associated Institutions/ Universities/ NGOs/ Voluntary agencies working on problems relevant to the Indian Himalayan region. Based on the recommendations of the Project Evaluation Committees 12 projects were sanctioned and funded during the year. Environmental awareness on various aspects of the Himalayan environment and development was created among the people/organizations/NGOs during the year by organising various meetings with the people/organizations, etc.

1. INTRODUCTION

The reporting year 1998-99 is the tenth financial year of research and development activities being carried out by the Institute at various locations in Himalaya, intune with regional issues, and endeavouring to seek practical and workable solutions to specific problems. These activities include programmes supported through core funds provided by the Ministry of Environment and Forests, Govt. of India to the Institute and projects financed by external agencies, both national and international. The Institute is also supporting activities of various partner Institutions in various Himalayan states through IERP Programme. The Science Advisory Committee of the Institute provides approval, general guidance and help for all programmes *ab initio*.

At present, the activities of the Institute are centered around six designated core programmes; a new programme on "Indigenous Knowledge Systems" is likely to be initiated in the near future. Some projects were successfully concluded during the year, summaries of these are placed 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 1998-99 on various ongoing and newly initiated projects and brief account of academic and other activities, along with the statement of accounts, has been presented in this report. We would be most grateful for critical comments, suggestions for improvement and for indication of our shortcomings by anyone interested in the well-being of Himalaya and its people.

2. MILESTONE EVENTS

The Institute celebrated its Annual Day Function in the Himachal Unit Campus at Mohal, Kullu on November 30, 1998. Mr. R.H. Khwaja, IAS, Joint Secretary, Ministry of Environment and Forests, Government of India, New Delhi was the Chief Guest. Other dignitaries included Professor V. K. Gaur, FNA; Professor P.K. Khosla, Members of Governing Body & Science Advisory Committee. A large number of scientists and academics, officers of district administration, senior citizens and the local people attended the function. The highlight of the function was VIII G.B. Pant Memorial Lecture entitled "Mitigating disasters in the Himalaya : a basic agenda for development" delivered by Prof. V.K. Gaur. He dwelt on different aspects of landslides in the Himalayan region and net impact on the environment and its people. He mentioned that most of these episodes are related basically to the slow inexorable earth processes that have raised and keep aloft these mighty ranges against the equally inexorable wearing down processes of erosion. Later, three publications of the Institute namely Perspectives for Planning and Development in N.E. India, Biosphere Reserves and Management in India and Medicinal Plants of Indian Himalaya were released on this occasion.

Collaboration between G.B. Pant Institute of Himalayan Environment and Development, and Wadia Institute of Himalayan Geology, Dehradun has been formalized through an MOU to facilitate undertaking of joint projects of common interest, and to supplement each others expertise. In continuation to an earlier ICIMOD sponsored project Phase II of Sloping Agricultural Land Technology (SALT) has been started in June 1998 through NE Unit of the Institute in and around Itanagar. A number of workshops including National Workshop on Planning and Development in North East India; Farmer's Training on Biocomposting and Polypit; Farmer

to Farmer Training on Medicinal Plants; Workshop on Himalayan Medicinal Plants; Workshop on People's Participation were organised at various locations by the Institute.

3. RESEARCH AND DEVELOPMENT PROGRAMMES

In order to achieve the sustainable development of the Indian Himalaya, research and development programmes of the Institute have been based on a multi-disciplinary and holistic approach with particular emphasis on interlinking of natural and social sciences. In this effort special attention is placed on the preservation of fragile mountain ecosystems, indigenous knowledge and customs. A conscious effort is made to ensure participation of the local population for long term acceptance and success of various programmes. The R & D activities of the Institute are centered around six core programmes, viz., Land and Water Resource Management, Sustainable Development of Rural Ecosystems, Conservation of Biological Diversity, Ecological Economics and Environmental Impact Analysis, Environmental Physiology and Biotechnology and Institutional Networking and Human Investment. The achievement of goals and progress made in various projects during the year has been placed under appropriate core programmes in the text. The project implementation sites are carefully selected keeping in view the heterogeneous heritage of the Himalaya along with specific needs and aspirations of the local inhabitants. All activities are need based, target oriented and time bound; efforts are made to provide practicable solutions rather than theoretical prescriptions. To meet the targets, and accomplish the objectives well equipped laboratories and computer facilities have been established. Rigorous data collection, development modification and demonstration of science and technology inputs, 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 were also initiated; most projects are now in their third or fourth year of operation. Highlights of the progress made during the year 1998-99, along with a brief, conceptual background, specific objectives and major achievements are summarized for individual projects. Brief summaries of projects completed during the year are placed in the text and detailed findings will be made available subsequently.

3.1 LAND AND WATER RESOURCE MANAGEMENT

3.1.1 Integrated Watershed Management : A case study in Sikkim Himalaya (Phase II, 1994-98)

Background

The second phase of the project has been initiated in the year 1994 as a follow up action with a view to develop a model at the farm level for demonstration and to continue data acquisition for long-term studies. Based on the results of first phase of the study as well as farmer's priorities, agroforestry models have been developed at two different villages (one each in subtropical and temperate zones) of the watershed. Various interventions in the form of technology packages, such as intensification of traditional crops, strengthening of fodder components, biocomposting, use of symbiotic nitrogen fixers and root associated diazotrophs for crop improvement, germination and growth of rate and potential wild edible species, introductory trials of some high value cash crops and resource management have been made. Apart from the above studies relating to two basic resources (soil and water) are being carried out further at the watershed level for

better utilization and management. The natural resources of the watershed has been studied in greater details using satellite digital data, and a complete resource inventory is being made. A monitoring of landslide stabilization is also made. Environmental impact assessment of construction of a motorable road within the watershed is being carried out.

Objectives

1. Estimation of runoff and erosion in improved cropping practices. In addition, soil, water and nutrient conservation under different cropping systems will also be studied.

2. Use of Nitrogen accretion in upland farming systems.

3. Study of the role of bund species on conservation and their competition with crops, and identification of ecologically and economically useful agroforestry trees for the region.

Results and Achievements

1. Agroforestry model development work was continued at two different sites, viz. at Chhamgaun for temperate region since 1994 and at Debrong for subtropical region since 1995. Assessment on some of the trials are in progress.

2. Considering the land use/cover as the most conspicuous and primary surface manifestation of natural resources of the watershed, land use/cover change assessment was done using RS and GIS. Multidate Status of 1990 was derived by visual interpretation of SPOT satellite scenes and that of 1997 was derived by image processing of IRS LISSIII digital data. The land use/cover information thus obtained for these two periods were subjected to data automation in a GIS by digitising for the creation of digital database. This was followed by map crossing operations leading to detection of land use/cover changes over this period. Over the study period 1990 to 1997, the negative and positive variations in the different land use/cover classes observed are: dense forest (-13.07%), open forest (-2.69%), degraded forest (+1.49%), forest blanks (+10.51%), sal (*Shorea robusta*) forest (-14.81%), scrub land (+0.59%), rainfed cropland (+4.14%), irrigated cropland (+8.04%), fruit orchards (+2.58%), settlements (+10.85%), rock outcrops (+0.17%) and landslides (+89.58%). The significant conversions observed are: dense forest to open forest, open forest to degraded forest, open forest to scrub land, open forest to rainfed cropland, degraded forest to scrub land, rainfed cropland to irrigated cropland, encroachment of rainfed croplands by village settlements and rainfed cropland to landslides. Other minor status changes were also noticed as open forest to irrigated cropland, village settlements and dense forest, sal forest to scrub land, dense forest to rainfed cropland and forest blanks, degraded forest to landslides, rainfed crop land, irrigated cropland and open forest, rainfed cropland to open forest land and fruit orchards, and scrub land to settlements and rainfed cropland.

3. Upper Kamrang landslide/gully erosion control experiment in the Mamlay watershed was monitored during the second calendar year in terms of hydrological measurements in the field covering the site itself and the control plots under different land use classes in the near vicinity. This is continuing as a long term experiment with an aim to get a

concrete result over the years. Bio-engineering measures provided on the site were monitored during the year for observing the plant survival and replacements as well as additional reinforcing requirements. Such additional measures include trial with *Stylosanthes hamata* with good rooting properties and brush wattle with *Alnus nepalensis* and *Ficus spp*.

4. The mean surface flow (% of rainfall) was highest in intensive cropped field (0.86%), and lowest in cardamom based agroforestry system (0.42%). Best infiltration characteristics was greatest in temperate natural forest (79%), followed by cardamom based agroforestry (63%), cropped field (37%) and least in sub-tropical natural forest (2%). The soil loss was greatest in cropped area 100 kg/ha, followed by mandarin based agroforestry 65 kg/ha, sub-tropical natural forest 31 kg/ha, temperate natural forest 28 kg/ha, and lowest in large cardamom based agroforestry 18 kg/ha in three rainfall events.

5. The infiltration rate was measured in the different land-use/cover of the watershed in 0-20 cm, 0-30 cm, and 0-45 cm using double ring infiltrometer. Infiltration rate was higher in temperate natural forest compared to the sub-tropical natural forest. The agriculture field at temperate Jaubari was also higher compared to sub-tropical Kamrang field. The agroforestry based large cardamom as well as mandarin showed relatively faster rate of infiltration.

6. The phosphorus level of the soil is an important parameter that influences P-loads measure in overland flow and infiltration. The concentration of phosphorus in surface and subsurface hydrological pathways was determined during three events in rainy season from different land-use/cover pattern to obtain phosphorus loss. The total phosphorus loss (%) through eroded soil was recorded highest in maize field (0.11±0.05) followed by mandarin based agroforestry (0.07±0.04), sub-tropical natural forest (0.045±0.006), temperate natural forest (0.032±0.005) and least in cardamom agroforestry (0.016±0.09). Available phosphorus loss was highest in subtropical natural forest (0.004±0.002), followed by temperate natural forest (0.0034±0.0014), maize cropped area (0.003±0.001), large cardamom based agroforestry (0.0026±0.001) and lowest in mandarin based agroforestry (0.0023±0.001). Phosphate-phosphorus loss through surface flow and sub-surface flow was recorded very high in sub-tropical natural forest (1.05 mg/l and 0.56 mg/l), followed by temperate natural forest (0.89 mg/l, and 0.45 mg/l), large cardamom based agroforestry (0.82 mg/l, and 0.43 mg/l), maize cropped area (0.77 mg/l and 0.51 mg/l) and lowest in mandarin based agroforestry system (0.70 mg/l and 0.48 mg/l).

3.1.2. Resource Utilisation Models for Himalayan Watersheds: A case study in Garhwal Himalaya

Background

Land use practices exert a deciding role on the soil and water conservation, particularly in mountains. Soil erosion and water yield are directly affected by vegetative cover, which dissipates much raindrop energy and promotes high infiltration. Runoff generation in natural catchments due to storm rainfall is highly complex and spatially and temporally heterogeneous. In the fragile Himalayan

mountains conservation of forests into wastelands are held responsible for high rates of soil erosion and disrupting the hydrological regime. Use of multipurpose tree species, which could be one of the feasible options to cover the wastelands and achieve soil and water conservation.

Objectives

1. To generate baseline data on hydrometeorology of micro-watersheds having different land uses and to understand watershed-level hydrologic processes which control the soil and water loss.

2. Performance evaluation of vegetative measures for conservation of land and water resources.

3. To carry out cost-benefit analysis and environmental impact studies of the R & D interventions.

Results and Achievements

1. Annual streamflow from Dugar Gad micro-watershed (50.9% of the total rainfall) was 1.4 times more than the Srikot Gad micro-watershed. The sediment loss was recorded 9.5 and 6.4 t/ha/yr for these two micro-watersheds, respectively. A summary of hydrological data across five years indicates that significant year-to-year variations exist between the watersheds (Table 1). However, the soil and water retention in Srikot Gad watershed (which has about 50% area under forests) was markedly higher compared to Dugar Gad watershed (with only 10% forested area).

2. Total quantity of rolling load in the stilling basin of Dugar Gad silt and runoff observation post was measured 2112 kg for two years. Particle size analysis of the rolling load indicated 57.2 per cent particles of above 10 mm size, 13.1 per cent of 5 -10 mm size, 17.4 per cent of 2 -5 mm size, 6.5 per cent of 0.2 -2.0 mm size and 5.8 per cent of below 0.02 mm size. Average length and width of the stones isolated from the stilling basin was found 13.2 ± 0.45 and 5.4 ± 0.29 cm, respectively.

3. After four years of plantation of multipurpose tree species in the LWRM demonstration site at Dugar Gad, the maximum survival (77%) was recorded for *Dalbergia sissoo* and the minimum (25%) for *Alnus nepalensis* and *Quercus incana*. Maximum height growth was attained by *A. nepalensis* (447 cm) and the minimum by *Grewia optiva* (84 cm). The average survival for all the species planted in 1994 was 51.7 per cent and the average height was 183 cm. Survival of the plants more or less stabilized after two years of plantation. Similarly, the height growth was also sharply attained only after two years of plantation.

4. A total of 5.1 t ground fodder was produced in the LWRM demonstration site in 1998 that was used by the watershed people. The *Thysanolaena maxima* (162 bushes) produced 56 brooms and total fodder yield from these bushes was estimated to 0.39 t.

5. Environmental impact assessment of the land and water management activities carried out under the project in Dugar Gad water shed indicate that the tangible (fodder/fuelwood/water) and intangible benefits (wasteland rehabilitation and environmental awareness) accrued during the project encouraged about 82 per cent households for physical participation in future watershed programmes.

Table 1. Hydrometeorological characteristics of two micro-watersheds of different land use in Garhwal Himalaya

Watershed Year	Rainy days	Rainfall (mm) A	Pan Evaporation (mm)	Runoff (% of A) B	Water yield ($x10^3 m^3$)	Sediment loss ($t\ ha^{-1} yr^{-1}$)
Dugar Gad						
1994	84	1824	-	36.5	2047.5	10.8
1995	93	1564	-	47.0	2258.8	6.5
1996	95	1919	806	17.6	1039.4	6.3
1997	99	1841	574	26.1	1478.0	5.9
1998	84	2222	723	50.9	3463.7	9.5
Average	91+3.0	1874+105.6	701+67.9	35.6+6.2	2057.5+411.7	7.8+1.0
Srikot Gad						
1994	68	2230	-	13.8	893.5	1.7
1995	78	2496	-	21.9	1567.7	7.7
1996	65	1186	-	24.6	835.5	6.2
1997	73	1404	672	12.3	1059.6	2.1
1998	79	1591	753	36.2	1603.9	6.4
Average	73+2.7	1781.4+249.6	713+40.5	21.8+4.3	1192.0+165.0	4.8+1.2

3.1.3. Management of Irrigation Water and Rural Water Supply in the Himalaya

Background

In the Himalayan region, irrigation and rural water supply are traditionally managed as an integrated system. With the introduction of Government sponsored schemes , the responsibility of their management was given to different departments. The role of farmers and local people was neglected which has been one of the main reasons for poor performance of these schemes in many areas. The effectiveness of any system depends upon three main factors, i.e. (i) suitable design of a system (ii) the method of execution; (iii) proper system operation and maintenance. Study of the role of these factors in efficient water resource planning and management is of prime importance for suggesting some corrective measures for future projects of irrigation and rural water supply.

Objectives

1. Field evaluation of the performances of existing irrigation and water supply schemes.
2. To study the hydrological aspects of streams and springs with reference to their role as the existing sources of water.
3. To assess the water supply and demand gap by the water balance studies in representative watershed.
4. Development and demonstration of location specific models for sound management of rain water, soil moisture,

surface water and sub-surface water (springs).

Results and Achievements

1. Rural water supply schemes were studied in one of the representative watersheds of the mid-elevation zone of the Central Himalaya. The basis of selection of the watershed (Nanakosi in Almora district) is the average population density, type of water sources used, demography and availability of past hydro- meteorological data. On an average per capita water consumption is recorded as 2.17 l/d for drinking purposes and 40.68 l/d for other usage. About 61.61 per cent population is still dependent on steams and springs for water supply and only about 44.76 per cent families are benefited by tap water supply schemes in the watershed in 1998-99 (Table 2).

Table 2. Sources for rural water supply in the study area.

Source	Population served No.	in %	Household served No.	in %
Springs	378	36.10	49	34.26
Tap supply	402	38.39	64	44.76
Stream (gad)	267	25.51	30	20.98

2. The Study of cropping system of the area has been completed. Wheat (30.05 % area), and barley (19.96 % area) are the main rabi crops and paddy (39.98 % area), finger-millet (30.02 % area) are the main kharif crops. Most of the agriculture is rainfed and potato is the main crop grown in available irrigated land.

3. To study the hydrological behavior of watershed four hydro- meteorological stations are installed in the watershed. Rainfall, runoff, evaporation and temperature data are being collected regularly. The results will be utilised for the assessment of the water budget.

4. Studies under the project is also continuing in Garhwal Himalaya. Based on the spring discharge studies, a household water utilisation plan has been prepared (Table 3). Spring can meet the household water needs in dry period of the year (summer) provided the storage of outflow from the spring is ensured.

Table 3. Spring discharge and water availability in Dugar Gad micro-watershed

Name of the spring (village)	Popula -tion	Spring discharge (l/d)			Water availability (l/capita/day)			Deficit (-) /surplus (+) from normal consumption (lpcd) summer
		Summer	Rain	Winter	Summer	Rain	Winter	
Ali	167	2885	11910	4908	17.3	71.3	29.4	-9.7
Bhimli Malli	142	10005	29162	11364	70.5	205.4	80.0	+43.5
Bhimli Talli	398	5044	13449	6099	12.7	33.8	15.3	-14.3
Palsain	250	845	11689	4020	3.4	46.8	16.1	-23.6
Sainchar	-	3380	12015	4542	3.5	12.6	4.8	-
Average/Total	957	22159	78225	30933	23.2	81.7	32.3	-0.3

5. The "spring sanctuary development" work carried out in the Dugargad watershed of Garhwal Himalaya has shown an increase in the yield of near extinct spring from 1055 l/d (in summer 1995) to 4439 l/d (during summer 1998). However, the rainfall was also high in 1998 summer (243 mm; 18 rainy days) in comparison to 1995 (110 mm; 12 rainy days).

6. Analysis of spring water collected during rainy season revealed that chemical characteristics of water vary from one spring to another (Table 4). However, the water quality was found well within the WHO permissible limits for drinking. A high concentration of Ca^{++}, Mg^{++}, hardness and EC revealed by Bhimli Malli, Srikot and Barsuri springs indicate that these springs are structurally controlled and the seepage along the fracture/joints could be due to longer distance and dissolution of excess salts from bed rocks.

Table 4. Water quality analysis of different springs during rainy season 1998 in Dugar Gad and Srikot Gad micro-watersheds

Spring/Village	pH	EC (μS)	Ca^{++} (mg/l)	Mg^{++} (mg/l)	SO_3^{--} (mg/l)	Fe^{--} (mg/l)	Cl^{-} (mg/l)	NO_3^{-} (mg/l)	Total hardness (mg/l)	T.D.S.* (g/l)
Ali	7.63	71	10.93	2.84	2.2	0.055	8	0.017	40	0.20
Bhimli Malli	7.56	122	16.82	6.72	3.0	0.085	6	0.040	72	0.10
Bhimli Talli	7.42	92	10.09	3.31	2.4	0.092	6	0.028	40	0.10
Sainchar	7.53	87	11.77	1.03	2.8	0.072	14	0.055	34	0.05
Srikot	7.45	133	14.40	5.61	2.2	0.075	17	0.43	66	0.20
Barsuri	7.51	265	25.23	6.04	2.4	0.079	24	1.00	90	0.20

* Total dissolved solid

3.1.4 Performance study of the existing soil and water conservation practices in Himalaya

Background

Several traditional practises are used by the farmers to meet the objectives of soil and water conservation in their agricultural fields. Most of these measures are low cost mechanical measures such as terrace bunding, brushwood structures, slope reduction by bench terraces, etc. In some cases biological measures are also used through agro-forestry practices.

3. performance evaluation of low cost bio-engineering SWC measures.

An attempt of quantitative and qualitative assessment of traditional and modern conservation practices is needed to suggest the most appropriate technology for different regions of Himalaya.

Objectives

1. To identify and document the traditional and other existing soil and water conservation (SWC) practices in Himalaya.

2. Quantification of soil loss in different land uses with or with out SWC measures and

3. To estimate the suitability of the conservation practices in terms of techno-

4. economic feasibility and sustainability for development of a demonstration model .

Results and Achievements

1. An attempt has been made to evaluate performance of low cost bioengineering measures for controlling man induced soil erosion from steep hill slopes. Locally available waste material such as gunny bags filled with soil and brush wood structures were used as physical measures along with vegetative measures (selected on the basis of their soil binding ability and adaptability to local conditions) in four study plots of 20m X 5 m size on a steep slope (60%) created by dumping of excavated soil during construction of buildings. Initial cost of these treatment ranged from 0.050 to 0.068 in terms of man hour required per sq. m.

2. A comparison of these plots with the control plot during the first year of study indicated appreciable reduction in soil loss from treated plots. Bioengineering measures were more effective in controlling the soil loss due to low intensity rainfall (below 5mm/h). Brushwood structures supplemented with vegetative measures showed better performance than embedded gunny bags, both for erosion control and reduction in runoff (Table 5).

3. The good survival rate of planted species was found to be responsible for efficient erosion control (Table 6). This is an ongoing study to continuously assess the effectiveness of vegetation growth on soil loss and runoff pattern.

Table 5. Runoff and Soil Loss from Study Plots during Aug. 97 - July 98 and Cost of Bioengineering Measures

Plot No.	Treatment done	Total Runoff (in mm) for I_{av} values		Total Soil Loss (in t/ha) for I_{av} values		Cost in Man hrs./sq.m*
		<5 mm/h	5-10 mm/h	<5 mm/h	5-10 mm/h	
P 1	Control plot	3.02	45.95	0.144	0.706	--
P 2	Gunny bags with vegetative measures (3 tree and 2 shrub species)	1.46	31.86	0.026	0.355	0.067
P 3	Gunny bags with vegetative measures (3 shrub and 2 tree species)	1.89	22.89	0.025	0.301	0.068
P 4	Brushwood with vegetative measures (3 tree and 2 shrub species)	1.29	22.38	0.012	0.222	0.051
P 5	Brushwood with vegetative measures (3 shrub and 2 tree species)	1.69	32.22	0.014	0.240	0.050

I_{av} is average intensity (averaged for the duration of rainfall in a day).
1 man hr. is equal to Rs. 8.75.

Table 6. Per cent Survival of Planted Species in the Plots (One Year after Plantation).

Name of Species / Plots	P 2	P 3	P 4	P 5	Method of Plantation in plots
Thysanolaena maxima	73	35	100	62	Through rhizome slips
Alnus nepalensis	35	-	15	-	Transfer of 1 year old seedling
Leucaena leucocephala	-	62	-	42	Transfer of 1 year old seedling
Robinia pseudoacasia	-	88	-	88	Transfer of 1 year old seedling
Agave americana	100	100	100	100	Transfer of 1 year old bulb raised plants
Crotalaria tetragona	-	100	-	100	Seed sowing
Morus alba	100	-	100	-	Direct plantation of cuttings
Salix tetrasperma	100	-	100	-	Direct plantation of cuttings

3.1.5. Mountain Risk Engineering in the Indian Himalayan Region

Background

In view of the accelerated soil erosion rates and mass wasting processes and the growing concern for effective stabilisation of hill slope instability, a consensus is developing regarding the urgent need for co-ordinated efforts. This has helped in the development of the concept of Mountain Risk Engineering (MRE). The subject is considered as the science and art of engineering mountain infrastructure giving due consideration to natural and human processes, and the tolerable risks to and from infrastructures. MRE is being practised in mountainous regions of various counties for few years now. With this background, initiatives were taken in 1998-99 to form a multidisciplinary team comprising of Core members of the Institute which is trained on the integrated approach of MRE for testing of framework of MRE along with development of suitable approach to be adopted for local community participation in the stabilisation work.

Objectives

1. To stabilise identified small to medium hill slope instabilities adopting principles and practices of MRE.

Results and Achievements

1. This study was carried out in two villages (i.e., Joshiyana and Khoont) of Kumaun Himalaya in order to implement various practices and objectives of Mountain Risk Engineering (MRE) with emphasis on low cost biological and physical measures. A total of 11 small to medium hill slope instabilities were stabilised. Figure 1 presents a view of few of the treatments adopted for hill slope stabilisation.

2. One of the major achievements of this study is successful peoples' participation in the various activities of hill slope stabilisation.

3. Rate analysis norms have been developed for various low cost physical and biological measures and same are presented in Table 7.

4. Another important outcome of the work is identification of suitable bio-engineering treatments for the region along with suitable plants species and their functions in slope stabilisation as given in Table 8.

Table 7. Rate analysis for various bioengineering activities.

Activity	Quantity	Amount (Rs)
Grass planting	1000 slips	743.5
Seedlings raised in seed beds	500 nos.	1905.3
Seedlings raised in polybags	500 nos.	2670.9
Horticultural plants	100 nos.	1180.0
Planting of tree cuttings on site	1000 nos.	1071.0
Brush layering	per metre	15.8
Vegetative palisade	per metre	9.2
Jute netting	per square metre	36.0
Gabion works	per cubic metre	939.0
Rip-rap drain	per metre	63.6
French drain	per metre	489.5
Stone masonry with Cement	per cubic metre	1044.0

3.1.6. Badrivan Restoration Programme

Background

Badrinath Dham is situated in the gorge of sacred Nar and Narayan hills at an elevation of 3,133 m above mean sea level (amsl) and remains closed between middle of November to middle of April/May. This shrine has been perennial source of attraction and pilgrimage to the inhabitants of Indian sub-continent from time immemorial. The mythological/cultural, historical and scientific evidences indicate that this shrine had dense vegetation/forest around it in the past. However, at present there is hardly any trace of forest around this shrine. In recent past, some government organizations have attempted tree plantations around the shrine and other adjoining areas. However, there has been hardly any success. One of the reasons for this failure may be incorrect selection of tree/shrub species and the age of the seedlings/saplings at the time of plantation. Probably the species planted earlier in Badrinath valley did not tolerate the harsh climatic conditions during winter months. In view of the above, initiation of mass scale afforestation programme (based on scientific, cultural and spiritual/religious values) around Badrinath shrine was considered the need of the hour.

Objectives

1. To involve pilgrims and local people in environmental conservation and promote environmental awareness.

2. To prevent soil erosion and stabilize soil in and around Badrinath area.

3. To revive Badrivan (the ancient sacred forest of Badrinath) at Badrinath in Chamoli Garhwal.

Table 8. Various species used for bio-engineering activities.

Species	Local name	Elevation (m)	Site condition	Bioengineering structure	Functions	Other uses	Methods of propagation
Eulaliopsis binata	Babila	Upto 1500	Dry	Diagonal grass planting	Armour, catch, reinforcement	Broom	Slips
Heteropogon contortus	Kumeria	Upto 2100	Dry	-do-	-do-	Fodder	Slips/seeds
Thysanolaena maxima	Kuchi	Upto 2000	Moist	-do-	-do-	Fodder	Rhizome
Pennisetum purpureum	-	Upto 1700	Dry	-do-	-do-	Fodder	Rhizome/cutting
Amomum subulatum	Bara elachi	Upto 1700	Swamp	-do-	-do-	Cash crop	Rhizome
Arundinaria falcata	Ringal	Above 1600	Moist	-do-	Catch, armour, reinforce, support	Handicraft	Rhizome
Crotalaria tetragona	-	Upto 1600	Dry		-do-	Soil fertility	Seed
Vitex negundo	Siwai	Upto 1500	Moist to dry	Live check dam, brush layering	Support, catch, reinforce	Biofencing	Cutting
Woodfordia fructicosa	Dhoul	Upto 1500	Dry	Plantation	-do-	Fuel	Seed
Alnus nepalensis	Utis	900-2700	Moist to Wet	Plantation	Anchor, catch, armour, reinforce, support, drainage	Fuel	Seed
Bauhinia variegata	Quairal	Upto 1200	Moist	Plantation	-do-	Fodder	Seed
Dalbergia sisoo	Sheesham	Upto 1500	Dry	Plantation	-do-	Timber	Seed
Dendrocalamus hamiltonii	Bans	Upto 1300	Moist to wet	Plantation, check dam	Armour, catch, reinforce, support, transpires	Handicraft/ pulp	Nodal segment
Grewia optiva	Bhimal	Upto 2100	Dry to moist	Plantation	Anchor, catch, armour, drainage, support	Fodder	Seed
Juglans regia	Akhrot	1000-3300	Dry to moist	Plantation	-do-	Fruit	Seed
Melia azedarch	Backaino	Upto 1800	-do-	Plantation	-do-	Timber	Seed
Morus alba	Kimu	Upto 3300	-do-	Plantation	-do-	Fodder	Cutting, seed
Quercus glauca	Phlyat	600-2000	Moist	Plantation	-do-	Fodder	Seed
Salix tetrasperma	Bains	Upto 1800	Moist	Live check dam, brush layering	Support, catch, reinforce	-	Cutting
Sapium insigne	Khin	Upto 1800	Dry	Live check dam, brush layering,	-do-	-	Cutting

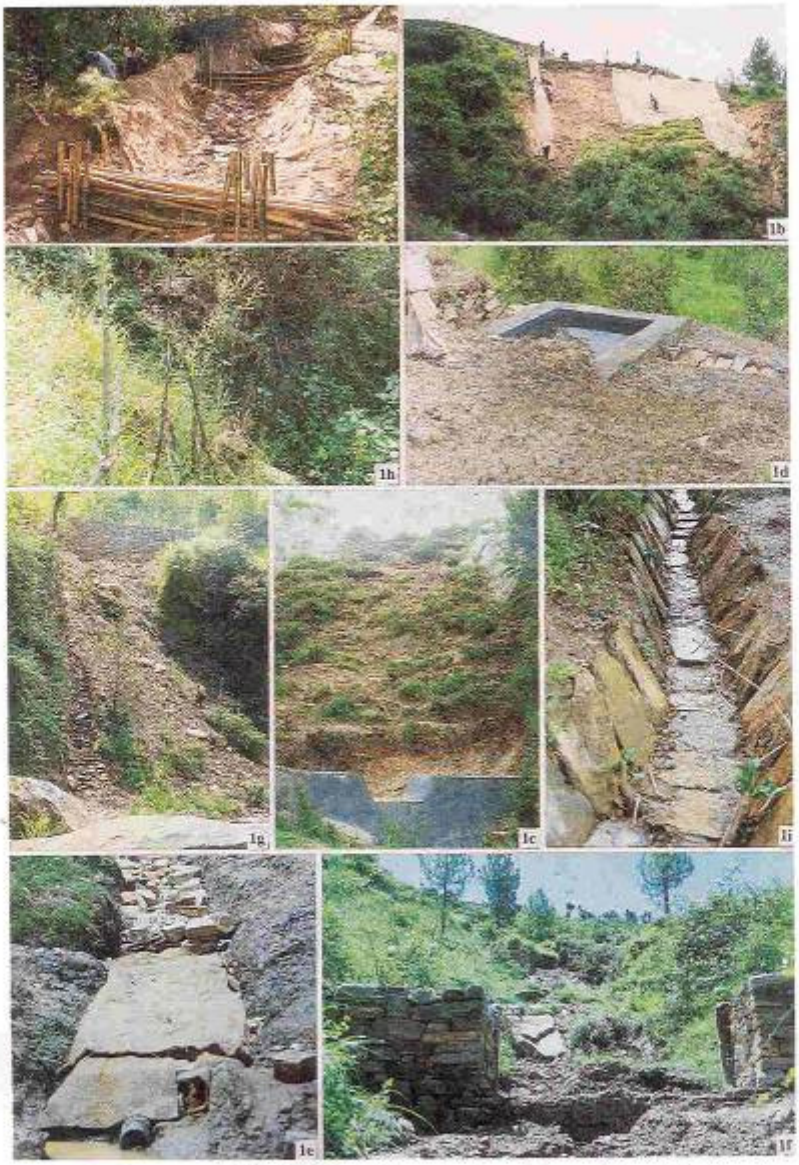

Figure 1. View of the low cost biological and physical measures. 1a. Brush layering after slope trimming at site J1. 1b. Laying of jute geo-grid for grass plantation at site J2. 1c. Stone masonry check dam, jute geo-grid & brush layering at site J2. 1d. Water collection chamber of French drain at site J3. 1e. Construction of French drain at site J3. 1f. Gabion check dam at site J3. 1g. Gabion toe wall, rip-rap drain & live stakes at site K1. 1h. Live check dam at site K1. 1i. Rip-rap drain with live pegs at site K2.

Results and Achievements

1. The nursery of high altitude trees/shrubs at Hanumanchatti (2,500 m amsl) in Chamoli Garhwal was strengthened and maintained successfully during the year (i.e. from the first week of May 1998 to the third week of November 1998; the opening period of the site). Eleven thousand and two hundred eighty eight (11,288) seedlings of five high altitude trees/shrubs (namely, *Alnus nitida, Betula utilis, Hippophae salicifoila, Prunus cornuta* and *Quercus incana*) were raised during the year at Kosi nursery (1,120m) of the Institute and subsequently transported to Hanumanchatti nursery for their hardening and acclimatization. Furthermore, twenty nine thousand and four hundred ninety (29,490) seedlings of 12 high altitude trees/shrubs (namely, *Aesculus indica, Alnus nitida, Betula alnoides, Betula utilis, Cedrus deodara, Hippophae salicifolia, Juglans regia, Pinus excelsa, Prunus armeniaca, Prunus cornuta, Quercus incana* and *Viburnum cotinifolium*) were also raised at Hanumanchatti nursery during the year. Two thousand and sixty (2,060) cuttings of *Populus ciliata* and two thousand and five hundred (2,500) of *Salix elegans* were also raised at Hanumanchatti nursery. In all, Hanumanchatti nursery was enriched by 45,338 seedlings/cuttings of 14 high altitude trees/shrubs during the year.

2. Out of 28,591 seedlings/cuttings of 14 high altitude trees/shrubs, which were available in Hanumanchatti nursery up to November 1997, only 25,768 seedlings/cuttings of trees/shrubs survived at the nursery in Hanumanchatti up to the middle of May 1998. Ten thousand and seven hundred thirty seven (10,737) well established seedlings/cuttings of 14 high altitude trees/shrubs were planted at different project sites (including Hanumanvan) during the year whereas two thousand and seven hundred thirty nine (2,739) well established seedlings of high altitude trees/shrubs were distributed during the year, free of cost, to various NGOs/Army regiments and villagers, etc. for plantation purpose in high altitude areas. Fifty seven thousand and six hundred thirty (57,630) seedlings/cuttings of various high altitude trees/shrubs were available in Hanumanchatti nursery before the closure of the site (i.e. November 1998).

3. Project site development work for the development of Hanumanvan was also carried out at Hanumanchatti during the year. Three thousand and four hundred (3,400) well established seedlings/cuttings of fourteen (14) high altitude trees/shrubs were also planted at this project site. Data on height and growth of the seedlings survived at Hanumanchatti project site were also recorded. The project site was also strengthened and maintained successfully during the year. Survival potential of the trees/shrubs, which were planted at Hanumanvan project site before November 1997, was also monitored in the month of May 1998 and 90 per cent plants were observed well survived.

4. All the Badrivan project sites at Badrinath Dham were also strengthened and maintained successfully during the year. Seven thousand and three hundred thirty seven (7,337) well established seedlings/cuttings of twelve (12) high altitude trees/shrubs were planted at different project sites in Badrinath valley during the year. Survival potential of the trees/shrubs, which were planted in Badrinath valley before November 1997, was also monitored in May 1998 and 59 per cent plants were observed well survived.

Data on height and growth of the plants survived at different project sites in Badrinath valley were also recorded during the year.

Figure 2. High altitude trees (A, *Betula utilis*; B, *Populus ciliata*) growing and surviving well in Badrinath valley.

5. Seeds of 21 promising high altitude trees/shrubs (namely, *Abies spectabilis, Acer accuminatum, Acer sterculiacium, Aesculus indica, Berberis* spp., *Betula alnoides, Betula utilis, Cedrus deodara, Cotoneaster affinis, Cotoneaster disticha, Cotoneaster* spp., *Cupressus torulosa, Hippophae salicifolia, Juglans regia, Piptanthus nepalensis, Prunus cornuta, Ribes glaciale, Rhododendron campanulatum, Sorbus microphylla, Taxus baccata* and *Viburnum mullaha*) were also collected during the year and subsequently sown at Hanumanchatti nursery (2,500m) in the month of November 1998. Moreover, seeds of 19 plant species were sown at Mana nursery (3,133m) in the month of November 1998 and of 20 species at Kosi nursery (1,120m) in the month of December 1998. Observations on germination of seeds at Kosi nursery are being recorded whereas at Mana and Hanumanchatti nurseries these will be recorded only after the start of growing season (i.e. May '99 onwards).

6. In addition to the above, the project entitled " Badrivan restoration programme - Maintenance and expansion of nursery at Hanumanchatti" was concluded successfully during the year. This project was sanctioned by the Mountain Institute, USA for a period of seven months.

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

Background

The overall goal of the project is to improve the understanding of environmental and socio - economic processes associated with degradation and rehabilitation of mountain ecosystems and to generate wider adaptation of proposed solutions by the stakeholders. For achieving this goal, this project has a vision of a long term - commitment to foster better field work, more appropriate interventions, enhanced participation, and wider communication between researchers, policymakers and the communities. The watersheds selected for the studies and programme implementation are Bheta - Gad and Garur - Ganga watersheds (29° 50' and 29° 55' N and 79° 2' to 79° 30' E) in U.P. central Himalaya. Bheta - Gad has been selected for detailed studies, whereas, Garur - Ganga socio - economic studies and changes in landuse etc. during last 30 - 40 years.

Objective

1. To generate relevant and representative information and technologies about water

balance and sediment transport related to degradation on a watershed basis.

2. To identify technologies and strategies to improve soil fertility and to control erosion and degradation processes in a farming systems' approach.

3. To generate socio - economic information on resource management and degradation.

4. To systematically apply community - based participatory generation, testing and evaluation of natural resources' management strategies and technology.

Results and Achievements

1. The study area (Garur - Ganga watershed) has been mapped using GIS technique. Out of the total geographical area 55.58 per cent is under forest cover, 42.34 per cent under cultivation and 1.32 per cent barren (1996). Analysis of landuse changes show an increase of 7.37 per cent area under agriculture / settlement, 5.07 per cent decrease in forest cover, and 2.31 per cent decrease in barren land, between 1963 - 1996.

2. Hydrometeorological studies are confined to Bheta - Gad watershed. The watershed received 1071.23 mm rainfall during the water year 1998 (Oct'1st, 1997 to Sep'30th, 1998). 66.3 per cent precipitation occurs during monsoon season. Runoff begins to take place when the minimum rainfall intensity is 3.2 mm/hr. Out of total 1671.3 mm precipitation, 1389.3 mm was effective causing soil erosion. Maximum soil loss is recorded from grazed pine forest (6.518 t/ha/year).

3. Based on primary survey of 10 key villages in Garur - Ganga watershed, it is found that per capita cultivated land is 0.135 ha, per capita livestock is 0.56 units, average male literacy is 82.5 per cent and female literacy is 62.9 per cent, average household size is 6.7. 60.77 per cent of main workers are engaged in agriculture and 65.15 per cent of the agriculture workers are females. Out of total migrants, 69.19 per cent were male and 30.81 per cent female.

4. A new site (4.5 ha), belongs to a group of villagers, was selected for rehabilitation work in 1998. Before initiation of rehabilitation activities, the area was extensively grazed & average biomass was 10 - 40 grams / 0.25 M^2. Plantation of preferential species was done through people's participation.

5. Under On - Farm Trials, a piece of waste land, belonging to a marginal farmer, was upgraded for off - season vegetables / nursery development, which has given a produce worth Rs 11,960 during the year. The site has become an example for other farmers of the watershed to reap goods from existing resources.

6. Utility of bio - fertilizers (*Azatobacter chroococcum* CBD 15 and M_4 from IARI, New Delhi) were tried on farmers fields. Farmers were given every opportunity to assess the impacts. CBD-15 was applied to local 'Boranne' and improved VL-221 varieties of Rice and M_4 on Amber Popcorn maize. CBD - 15 was found more effective on local variety (26%) than on improved VL - 221 (15.6%) in producing more biomass.

7. On farm training and farmers exchange programme have given opportunity to number of local farmers to adopt/adapt

polyhouses, compost management, polypits, etc. for improving their livelihood conditions. PARDYP has helped them by providing polythene, technical assistance and monitoring / documentation, etc.

8. PARDYP has established close linkages with a few other NGOs and one Mahila Mangal Dal through meetings, discussions & on farm trainings to understand the system and real needs of the people. First round of PRA surveys in four villages has been useful for further prioritization of community needs. Linkages with the Dept. of Forest, ICAR have proceeded fruitful for solving a few problems. Preparation of microplans for these four villages is in progress.

3.1.8 Hydrometry and estimation of sediment load of Gangotri Glacier, Garhwal Himalaya

Background

The Himalaya constitute one of the most important glacier systems in the world. The glaciers are an important source of fresh water, stored in solid state. The Himalaya ranges with average height of 6000 m (a s l) are the repositories of some of the highest and biggest glaciers of the world. It has been estimated that 38221 Sq.Km. of Himalayan ranges are glaciated. There are more than 5222 glaciers in Himalaya scattered in three river basins i.e. Indus, Ganga and Brahmaputra. These glacier contribute about 60-70 per cent fresh water to these main river systems of Indian sub-continent. Thus they form an important sources of water, capable of water supply throughout a long hot dry summer months. Himalayan glaciers are receding rapidly on an average of 15 m/year. Gangotri glacier (one of the biggest glacier of Garhwal Himalaya) is itself receding at the rate of 27 -33 m/year. The rapid recession and overall decrease in the volume of glacier is adding to the total area of erosion every year. It generates large amount of suspended sediment load which is carried from the glacierized basin. It is either deposited in the Himalayan foot hills and Indo-Gangatic plains or discharge into the Bay of Bengal and Arabean sea. In glacierised catchment, melt water stream sediment load have been used for many years as a means of estimating glacier erosion. The assessment and quantification of suspended sediments in Himalayan streams is, therefore, of great significance and forms an integral part for planning and designing of hydro power project and multipurpose schemes in glacierised basin.

Objectives

1. To collect hydro-meteorological data of Gangotri glacier.

2. To measure the meltwater discharge and quantum of suspended sediment load of the glacier and their relationship during the melt water season.

3. To assess the rate of erosion of the glacier.

4. To evaluate the sediments source area, production mechanism and transport pathways of the suspended and dissolved load of the glacier.

Results and Achievements

1. This project is initiated in Jan. 99. Till March 99, the process of material procurement and recruitment of project staff was initiated. The actual field work will start in April 99 during the ablation season of the year.

3.1.9. Hydro-Ecological Linkages of Carbon Dynamics in Relation to Land-Use/Cover Change in a Himalayan Watershed

Background

There has been a large scale conversion of forests to other land-uses in the past few decades from the Himalayan region. This has disrupted the hydrological cycle and a great loss of carbon is envisaged. This study will cover change of land-use from forest to agriculture and wastelands, and in the process study carbon dynamics and hydrological process change in various land-uses. The hydrological parameters such as stream discharge, sediment concentration, overland flow, sediment loss, partitioning of precipitation pathways and nutrient loss from different land-uses will be estimated. The soil organic carbon, carbon in litter and humus layer, and in various plant components will be estimated. Carbon is a good indicator of systems stability and change in land-use and its carbon dynamics will reflect its sustenance. Watershed is regarded as a unit for development in hills. The resource mobilization and settlement pattern in hills is governed by watershed functioning. Therefore this study on hydrology and carbon dynamics in a series of transformed land-uses will be studied in a watershed in Sikkim Himalaya.

Objectives

1. Estimation of land-use/cover change detection over a period of time using satellite imagery in a selected watershed of Sikkim.

2. Budgeting of carbon in various ecological compartments in different land-uses. Carbon flux between these compartments along with carbon fixation, loss through respiration, harvest flux, land cover change combustion emission and agricultural change emissions will be estimated.

3. Hydrological studies such as overland flow, soil erosion, carbon loss through soil erosion, sediment concentration in stream water, and discharge will be carried out on land-use basis. Hydrological processes will be correlated with ecological dimensions.

4. Land-use sustenance will be studied taking soil carbon levels as an indicator.

5. Quantification of ecological and hydrological inter-linkages using mathematical models.

Results and Achievements

1. Mamlay watershed in the South Sikkim has been selected for this study. This watershed has been selected with the purpose that already data base on various ecological parameters are available which would add the current study. A preliminary survey of the watershed was made and sites for study on specific land-uses have been identified.

2. Different land-uses viz., temperate natural forest, sub-tropical natural forest, large cardamom based agroforestry, mandarin based agroforestry, fodder based agroforestry, temperate agriculture field, sub-tropical agricultural field and wastelands have been identified as replicate plots for carbon dynamics study. Major streams and sampling points for hydrological studies have been identified.

3. Soil sampling at different land-uses with depths has been made and organic carbon has been estimated. A soil carbon depth partitioning has been developed.

3.2. SUSTAINABLE DEVELOPMENT OF RURAL ECOSYSTEM

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

(a) Natural Resource Management for Sustainable Development

Background

This project was initiated in 1992-93 for imparting advanced training to some of the Institute's staff for advancing scientific knowledge on watershed processes and, for developing and demonstrating the utilization of local resources for sustainable rural development based on participatory approaches.

Objectives

1. To quantify soil loss, run-off and productivity in the selected watersheds

2. To survey and review land use practices in the region in view of prevailing socio-economic conditions for groups and individuals including issues for entitlement, equity and gender.

3. To work out tree-crop-animal interactions in different agroforestry systems, need of the people and ecological and economic potential.

Results and Achievements:

For Himachal case study

1. Litter decomposition (*Pinus wallichiana* needles), nutrient release and its use in agriculture system were studied under 3 winter crops (wheat, barley and lentil) in Rolgi (2200m) and Tichi (1600m) villages. The study was conducted from February 1998 to May 1998 through litter bag techniques. Remaining weight in litter bags in the end of May 1998 were relatively higher in Rolgi than in Tichi village. There was no much difference between remaining weights in bags kept under wheat and barley in both the villages. However, average remaining weight was relatively higher under lentil crop than under wheat and barley. In the end of May 1998, ~63% of initial weight was remaining in Rolgi and ~53% in Tichi village after a period of 4 months. In the begging (February), rate of weight loss was much faster than the middle (March) and later phases (April & May) of the experiments.

2. Under cereal crops, rate of weight loss was more or less comparable (0.102±0.006 to 0.115±0.004 gm day^{-1} in Rolgi and 0.125±0.006 to 0.145±0.003 gm day^{-1} in Tichi). However, under lentil crop, weight loss was nearly half of the cereals in both the villages. In the following months rate of weight loss declined and on an average, rate of weight loss was much lower (0.038±0.001 to 0.044±0.001 gm day^{-1} in Rolgi and 0.049±0.001 to 0.056±0.001 gm day^{-1} in Tichi villages).

3. Vegetative growth and agronomic yield of wheat barley and lentil were always higher with litter than controlled conditions. Agronomic yield of cereals ranges from 9.7% to 14.4% per plant higher under litter conditions. However, agronomic yield of lentil crop was enhanced 5.8% only.

4. Considering the remoteness of Tichinal watershed area, farmers were given walnuts and pecanuts saplings to develop nuts as major cash crops in the watershed. Sapling

establishment patterns showed that in the altitudinal range of <1800m establishment and survival were maximum (63.0±3.5%), followed by 1800m to 2200m altitudinal range (53.0±3.5%) and >2000m altitudinal range (43.2±3.7%) On the watershed basis, 53.5±3.2% sapling establishment was noted (Table 9).

5. The energy economics of cash crops (vegetables) showed that French bean (6.85), tomato (3.87), potato (3.43) and pea (1.60) in Tichinal watershed were profitable in energy term as compared to apple (0.20-0.25) and food grains. Fingermillet was the only crop having the highest output/input value (1.20) among food grains. So it is suggestive that based on total output/input ratio, vegetable crops should be extensively grown as off season cash crops rather than adhering only to coarse food grains and apple in Tichinal watershed.

Table 9. Altitudinal distribution of walnut saplings and survival patterns in Tichinal watershed of Kullu valley

Altitude	No. of villages	House holds	Sapling given	House holds sapling taken (%)	Survival (%)	Dead (%)
>2000m	8	57	170	58.6±9.0	43.2±3.7	56.8±3.7
1800-2000m	10	127	460	70.6±7.9	53.2±6.0	46.8±6.0
<1800m	8	127	499	89.9±4.1	63.0±3.5	37.0±3.5
Total /Average	26	311	1129	73.39±4.9	53.5±3.2	46.5±3.2

(b) Agroforestry and Restoration Models for U.P. and H.P. Hills

Background

Agroforestry is argued to be a sound land management option meeting both environmental and developmental imperatives in the hills, particularly on the slopes. Agriculture, forests and animal husbandry are interlinked across the Himalaya. However, the nature and magnitude of these linkages vary. Agriculture in the Himalaya continues to be of subsistence type and productive potential of cropland depends upon the organic inputs derived directly from the forests in the form of litter or indirectly through animal dung. There is a need to evaluate the costs and benefits of introducing trees in croplands, identifying potential species, standardizing the propagation and cultivation techniques of the identified species and rejuvenating the traditional agroforestry systems with appropriate science and technology inputs.

Objectives

1. To identify agricultural land use practices suited to the ecological and socio-economic attributes of the area and their implementation in the field on experimental basis.

2. To evaluate the acceptability of the identified management practices by the people.

3. To undertake fundamental researches so as to design refinements in the existing/identified agricultural land use practices for sustainable development.

Results and Achievements

For U.P. Himalaya case study

1. Site and species related differences in growth magnified with increasing age of the plantation. *Albizia lebbek* and *Pyrus pasia* did not show any significant difference ($P>0.05$) in height between the agroforestry and restoration sites. All other species grew taller ($P<0.05$) at the agroforestry site as compared to the restoration site, after 7 years of plantation, average height of *Boehmeria rugulosa, Celtis australis, Ficus glomerata, Grewia optiva* and *Sapium sebiferum* at the agroforestry site was nearly twice of that at the restoration site as compared to less than 1.5 fold difference in *Alnus nepalensis, Dalbergia sissoo* and *Prunus cerasoides*. Similar differences in girth of the species were observed higher in agroforestry site than the restoration site.

2. After 7 year of plantation, crown depth circumference and number of branches per tree were lower at the restoration site as compared to the agroforestry site in all the species but the magnitude of difference varied among species. Site effect was most marked in *C. australis, F. glomerata, G. optiva* and *S. sebiferum* in respect of crown depth (0.7-2.9 fold difference between mean crown depth at the two sites), in *B. rugulosa, C. australis, G. optiva* and *S. sebiferum* in respect of canopy circumference (3-6 fold difference between mean values at the two sites) and in *B. rugulosa, F. glomerata, G. optiva* and *P. Cerasoides* in respect of mean number of branches per tree.

3. *Alnus nepalensis* showed the highest level of mean annual bole biomass increment or carbon sequestration followed by *Dalbergia sissoo* at both the sites (Table 10). Total carbon accumulation in bole at the agroforestry site (0.915 t ha^{-1} yr^{-1}) was about 3 times of that at the restoration site (0.326 t ha^{-1} yr^{-1}). Increase in soil carbon (2.2 t ha^{-1} yr^{-1}) was over two times of that in bole at the agroforestry site and over four times of that in bole at the restoration site (1.46 t ha^{-1} yr^{-1}). Total carbon sequestration at the agroforestry site was about 1.5 times of that at the restoration site.

4. Magnitude of cation return (K, Ca and Mg) through litter on agroforestry site for six different species showed different trends. Maximum amount ($g/m^2/yr$) of K was returned through the litter by *Ficus glomerat*, and CA and Mg by *Boehmeria rugulosa*.

For Himachal case study

1. Fairly good numbers of tree sapling were found regenerating under indigenous agroforestry systems of Bajaura (1100m), Garsa (1200m), Phojal (1400m), Baregran (1600m) and Malana (2700m) villages of Kullu valley. Farmers maintain required numbers of tree saplings on the edges of terraces or on wide inter-spaces of two terraces and unwanted saplings are uprooted. The highest sapling density was found in Baregran (2.7 saplings 100^{-1} m^2), followed by Phojal (1.6 saplings 100^{-1} m^2), Garsa (1.5 saplings 100^{-1} m^2) and Bajaura (1.2 saplings 100^{-1} m^2). The lowest sapling density (0.8 saplings 100^{-1} m^2) was noted in Malana village.

Table 10. Carbon sequestration at agroforestry and restoration sites.

Component	Mean annual carbon sequestration (t ha^{-1} yr^{-1})	
	Agroforestry site	Restoration site
Albizzia lebbek	0.052	0.030
Alnus nepalensis	0.256	0.119
Boehmeria rugulosa	0.060	0.008
Celtis australis	0.063	0.014
Dalbergia sissoo	0.141	0.072
Ficus glomerata	0.113	0.022
Grewia optiva	0.042	0.009
Prunus cerasoides	0.067	0.018
Pyrus pasia	0.040	0.016
Sapium sebiferum	0.081	0.018
Total in plantation (bole biomass)	0.915	0.326
Increase in soil carbon stock	2.210	1.462
Total carbon sequestration	3.125	1.788

2. Landuse and village structure of all the 5 villages were studied in detail. On an average, per family member ranges from 6 to 5 persons from Bajaura (1100m) to Malana (2700m). A declining trend in per family numbers of individuals was seen with increase in altitude in the valley. On percentages basis, 53:47 male and female ratio was found.

3. In Bajaura, Garsa and Malana villages, from 80.1 to 89.9 % of total land was under subsistence agriculture (Table 11). In Phojal and Baregran villages, horticultural crops occupied 31.4 and 39.5 % of total village land that was ~5 times more than the horticultural areas of Bajaura and Garsa villages. In Malana village, horticultural crops were not introduced due to difficult terrain and remoteness. Under government owned land, but under use of the villages, grasses were maintained as fodder in maximum areas.

4. Per unit area, fodder production declined with increase of altitude from Bajaura (6128 kg ha^{-1}) to Malana (3986 kg ha^{-1}) villages. Fodder production rate of the other villages falls in between ranges of above two villages. Per unit area, fuel-wood production also followed the same pattern. On village level, total fodder (473495 kg y^{-1}) and fuel-wood (298134 kg y^{-1}) productions were maximum for Malana village due to its relatively higher village area (118.8 ha - approximately 5-8 time more than the other villages.)

5. With increase of altitude, per family fodder consumption was increased due to higher numbers of sheep and goats in high altitude villages like Baregran and Malana. In these villages, fuel-wood consumption was also high as compared to Bajaura, Garsa and Phojal; higher requirement of wood energy for room heating and other domestic uses were observed during prolonged winter months.

6. On village level, 9.9%, the highest and 4.1% the lowest of total annual fodder requirements were met from indigenous agroforestry systems in Bajaura and Malana villages, respectively (Figure. 3). However, contribution of the agroforestry system of reaming 3 villages for fodder falls in between these two villages. In case of fuelwood, ~21% of total requirement was met from agroforestry system in Bajaura, followed by Garsa (13.2%), Malana (12.9%) Phojal (10.7) and Baregran (9.1%) of total annual requirement.

Table 11. Land-use (%) of study area* under indigenous agroforestry systems in Kullu valley

Land-use types	Land-use area (%)				
	Bajaura (1100m)	Garsa (1200m)	Phojal (1400m)	Baregran (1600m)	Malana (2700m)
A: Private land (%)					
Agriculture land	86.9	80.1	63.4	55.3	89.9
Apple orchard	6.0	6.5	31.4	39.5	0.0
Fodder tree	0.0	6.0	0.0	0.6	0.0
Grass	0.0	0.0	0.0	3.3	0.0
Total	92.9	92.5	94.8	98.6	89.9
B: Govt. land (%)					
Fodder tree	0.0	0.0	0.0	0.0	0.9
Grass	4.5	3.5	0.0	0.0	6.8
Barrenland	2.6	4.0	5.2	1.4	2.4
Total	7.1	7.5	5.2	1.4	10.1

** Village area - Bajaura, 24.6 ha; Garsa, 14.0 ha; Phojal, 17.8 ha; Baregran, 26.4 ha and Malana 118.8 ha.*

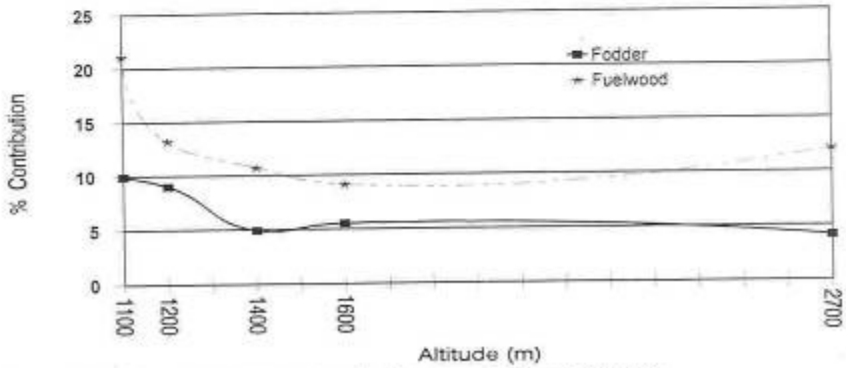

Figure 3. Altitudinal contribution of agroforestry system in total requirement of fodder and fuelwood (%) on village level in Kullu valley

(c) Resource use pattern of transhumant pastoralists

Background

Transhumance is a historical phenomenon evolved as an adaptation to extremities of physical environment in remote and high Himalayan mountains. It encompasses essentially varying degrees of dependence on agriculture and pastoralism to secure human beings. The very existence if this life support system and preservation of cultural values by the societies practicing them for centuries offer a scope for deeper understanding of sustainability and for getting an integrated view of the social, cultural, economic and environmental facets of development.

Objectives

1. To compile and analyze the historical accounts of social, cultural, religious, political and economic setup of these transhumanic people.

2. To analyze the spatial patterns and temporal trends of the fundamental requirements of these people.

3. To estimate the efficiency of resource use in terms of both economic and ecological costs, and to analyze the question of their sustainability.

Results and Achievements

1. Amongst the transhumant Monpa pastoralists women folk do not go to graze the yak herd in the forests, they spent their maximum time in kitchen garden and little agriculture in their villages. It was found that the male spent their maximum time in grazing yak, collecting fuelwood and in the barter exchange of their milk products.

2. One of the major factor that influenced the yak herders to migrate were the big size of yak holdings, decreasing size of grazing lands and heavy pressure on forests by the cattle of non-transhumant Monpas who are semi-agriculturists.

3. As a result of heavy out-migration of young members of their family to urban areas in search of employment opportunities, their is shortage of labour force in the family, which has resulted in the heavy decrease of sheep population. Most of the pastoral families have totally left sheep grazing, but do have few goats which does not require much care and guidance during their grazing.

4. Unproductive and old yaks are used as a good source of protein, and are utilized by the community for meat. Killing of yak for meat is done on collective basis, and are guided by the village council in the regulation of yak killing for meat. New yaks are brought from Bhutan and China during summer but breeding of yak is practised in the community also.

3.2.2. Designing, Developing and Testing Sustainable Natural Resource Management Models through Peoples' Participation in Critical Villages in Nanda Devi Biosphere for Achieving the Objective of Conservation of Biological Resources in the Himalaya

Background

Reconciling economic development with biodiversity conservation has become one of the

most important elements in the search for sustainable development. This problem is particularly acute in remote rural areas of the country where biodiversity is concentrated and where poverty tends to be pervasive. Facing a range of developmental crises with limited public funds, most of the region/area has invested little in biodiversity conservation as is the case of Nanda Devi Biosphere Reserve. Partly as a result, fragile and unique ecosystems are being degraded or converted to agricultural use on a large scale. As the habitats are destroyed, countless plant species face considerable danger of extinction. Many of these species may be unknown to science fully, their potential benefits therefore remain unknown or unrealized.

Objectives

1. To design, develop, and field test natural resource management models.

2. To study qualitative and quantitative changes of resources.

3. To study socio-economic impacts of various programs on the development of the rural systems.

Results and Achievements

1. The livestock population of different categories (cattle, sheep, goat, horse, mules, yak) declined drastically in the four buffer zone villages during the short period of two decades (1970-75 to 1990-95). Sheep and goat populations have declined, by 82% and 73% respectively. In Lata and Tolma villages, the population of horses and mules has also declined, whereas in other two villages (Dronogiri and Malari) the population of these animals remained more or less static.

2. Maximum quantity of fodder and its energy equivalent was consumed by the livestock of Lata village followed by Malari, Tolma and Dronagiri villages. Among the various sources fodder, maximum quantity was obtained from crop by-products (58%) and minimum through green grasses (15%) which were collected from agricultural fields and village surroundings. The livestock of Lata village depend more on forests (broad leaf fodder) than other villages whereas in Dronagiri village (higher region) the dependency on the fodder observed least because sheep and goat population mostly graze on alpine pastures.

3. A variety of forest products were consumed/collected although the year by the villagers (Table 12). Vegetables collected from wild are consumed in large quantities in all the villages as compared to other plant products. It is consumed maximum in Malari and Tolma villages (19 kg/capita/yr) and least in Dronagiri village. However, the collection of medicinal and aromatic plants was recorded highest in Lata village and least in Tolma village. The total monetary equivalent form all these wild products was recorded maximum in Malari village whereas least in Tolma village.

4. Family wise as well as per capita fuelwood consumption rate was recorded highest during summer season for Dronagiri village followed by Malari and Lata villages, respectively. However, in Lata village the fuelwood consumption rate during winter was recorded 1.7 fold higher than that of summer season.

5. About 52% of the total food energy consumed by the people comes alone from agriculture. The Tolma village depended least on market for food grain import. The

food from animal husbandry and from wild consumed maximum in the Tolma village whereas least in the Dronagiri village (Table 12).

6. Food and fuelwood is the major energy inputs to provide the labour used to support agriculture, animal husbandry, forest products collection and many other activities related to village ecosystem function. The energy efficiency of the domestic sector was greatest for Tolma village and lowest for Dronagiri. The monetary efficiency ratio did not show much variation amongst the village and ranged between 0.31 to 0.45.

Table 12. Food energy consumed (MJ/capita/yr) by the villagers of the buffer zone of NDBR. Values within parentheses are of quantity (kg or lit/yr).

Source	Villages			
	Lata	Tolma	Dronagiri	Malari
Agriculture				
Grain/tuber	1552.0 (92.0)	2970 (180.0)	1295.0 (84.6)	1571 (97.0)
Fruits	80.9 (5.3)	475.0 (18.0)	-	-
Edible oil	3.3 (0.082)	5.5 (0.13)	-	-
Kitchen garden Vegetable	1112.5 (113.5)	1005.0 (100.5)	1130.0 (113.0)	31.0 (31.0)
Animal husbandry				
Milk	218.0 (75.0)	371.0 (180.0)	212.0 (73.0)	214.0 (73.7)
Meat	69.0 (4.1)	89.0 (5.2)	63.2 (3.7)	50.0 (2.9)
Forest				
Wild food (Plants origin)	185.0 (18.5)	241.0 (24.0)	48.0 (4.8)	194.0 (19.0)
Sub-total	3219.0 (308.4)	5156.0 (507.0)	2885.0 (280.0)	3244.0 (214.0)
Imported				
Rice/wheat/pulses	1675.0 (1.2)	307.0 (19.5)	1976.0 (121.0)	1650.0 (101.0)
Edible oil	427.0 (10.8)	427.0 (10.8)	507.0 (13.0)	507.0 (13.0)
Total	5321.0 (419.0)	5890.0 (537.0)	5370.0 (412.0)	5400.0 (328.0)

3.2.3. Inventory, Commercial Utilization and Conservation of Agrobiodiversity for Sustainable Development of the Buffer Zone villages of Nanda Devi Biosphere Reserve.

Background

Traditional crops constitute an important component of the agriculture of the buffer zone villages of Nanda Devi Biosphere Reserve (NDBR). These crops, though low yielding, are preferred because they are stress-tolerant, resistant to disease and pests, have a good nutritional qualities and adapted to crude agronomic practices, and dependable. These crops have not been so tested for their potential and no attention has been paid for their improvement. But in recent years the agro-diversity of this region is under severe threat of depletion. There are several interacting factors that are directly and indirectly responsible for

this genetic erosion and for creating an imbalance in traditional agro-ecosystems of this region. With rapid depletion of genetic diversity of crop plants there is considerable interest in traditional under-utilized crop of food value for meeting the needs of increasing population, particularly in the developing world.

Objectives

1. To survey all plant species of potential food value which have been domesticated by the traditional societies.

2. To work out the extent of area under cultivation with the allocation of land to traditional under-utilized crops by individual families in relation to the total cultivable land of a family.

3. To analyze the land management cultural practices and eco-physiological requirements of traditional under-utilized crops and their comparison with common crop agro-ecosystems.

4. To study the contribution of traditional under-utilized crops in meeting the food requirements of traditional societies in terms of quantity, energy and protein.

5. To compare the nutritional attributes of the traditional under-utilized crops with those of common food and cash crops.

6. To identify strategies for yield improvement and conservation of the traditional under-utilized crops.

Results and Achievements

1. In the entire buffer zone, the rainfed agriculture on steep terraces is the predominant form of land use, while only about 22.4 ha (7.8% of the total cultivated land) land is irrigated. Irrigation is practiced only in one village (Malari) which is situated at an altitude of 3200 m amsl in the buffer zone. All the households of the region were found involved in agriculture. Average land holding is estimated about 0.67 ha/household.

2. Majority of crops are grown in monoculture whereas few of them are grown in mixtures. In the lower region of the buffer zone, *Triticum aestivum* and *Phaseolus lunetus* cover maximum area under cultivation whereas in higher region *Solanum tuberosum* and *Fagopyrum* spp. covered the largest area under cultivation.

3. Crop grown in mixed and monocropping under rainfed condition at higher region showed almost similar trend in the crop yield as practiced in the lower region. Crop by-product yield was obtained maximum for monocropping of *P. milliceum* followed by mixed cropping of potato+kidney at higher region whereas at lower region highest crop by-product yield was produced by amaranth and mixed cropping of potato+kidney bean+amaranth and amaranth+kidney bean.

4. A variety of crops were cultivated in the irrigated land between May and September in the Malari village of the higher region. Among the crops, potato in pure form exhibited highest yield followed by *Solanum+Phaseolus* combination and *Fagopyrum esculentum* (pure), whereas, least by *Brassica compestris*. However, crop by-product yield was recorded highest for *P. miliacium* and least for *S. tuberosum*.

3.2.4. An assessment of agricultural production and strategy for sustainable development of bioresources.

Background

Keeping in view the ever increasing population of human and livestock in the rural mountain areas, it has become imperative to assessed the production of Bioresources such as agriculture, fodder and fuel in the different geo-environmental conditions. It is not possible to study and quantify the entire mountain region, hence, a representative site Hawalbagh block of Almora district has been selected for the detailed study. In order to assess the production of Bioresources, the whole block has been divided into three altitudinal zones, and around 13 villages in each zones have been selected for the detailed study.

Objectives

1. To quantify the agricultural production in the existing prevailing conditions.
2. To assess the contribution of agricultural production to the total food requirement.
3. To quantify the total production and consumption of fuel and fodder resources.
4. To assess the total production of different land use category.
5. To identify the possible alternate for improving the productivity of these landuse categories.

Results and Achievements

1. For the identification of problems, resource use pattern, actual resources availability and agricultural, livestock and allied production, etc. the whole block has been divided into three altitudinal zones, i.e., less then 1400m, 1400 to 1600 m and more than 1600m. About 13 representative villages from each zone have been selected for detailed study.
2. Zone wise secondary data regarding demography (1951 to 1991), livestock population and types (1978 to 1993), agricultural production, area under different land use categories (1982 to 1993) and thematic data of landuse (1963, SOI toposheet and 1996, remote sensing data) have been collected and compiled.
3. Primary survey of 32 villages for demography(number, male and female, education, occupation, food requirements, cast groups etc.) livestock (population, types, production, fodder requirement, source of fodder, availability of fodder, etc.), cultivated crops production, area under different crops, consumption of fuel, source of fuel, etc. have been collected. Verification and resurvey of 22 villages have been completed. Compilation of primary data and primary survey of rest 7 villages are in progress.

3.2.5. Farmers Field School-Cum- Training Programme

Background

The Institute (GBPIHED) Kosi-Katarmal, Almora, had initiated a programme under the broad umbrella of FARM (Farmer Centred Agricultural Resource Management) programme (specifically the ABB; Asian Biotechnology and Biodiversity sub-programme) since the end of November, 1994 in a mountain site (Haigad watershed) in India.

Since one of the main objectives of the programme was to demonstrate technologies to the farmers for adoption, GBPIHED has successfully demonstrated and implemented a number of proven technology packages in the selected watershed. Keeping in view the successful of the programme DBT of Biotech node had provided some fund through FAO (India Office) for organising Farmers Field School-cum-Training Programme in two watershed of the Indian mountain site, where the Institute had carried out some demonstration work. This training was organised in Khulgad watershed of District Almora and Haigad watershed of recently created district Bageshwar on 18-19, May and 28-29, May 1998, respectively.

Objectives

1. To demonstrated simple, cheap and useful technologies to the farmers

2. To aware the farmers from different technology packages

3. To demonstrate sustainable management of resources

Results and Achievements

1. A total of 25 (male and female) local farmers from different caste groups of eight villages were invited for the training. Farmers were selected on the basis of their economic status/ work performance and their participation during the implementation of earlier activities carried out through the FARM programme. In addition, school teachers, children, village Pradhans, other farmers, etc. also participated in this programme and were given practical inputs. In order to reduce the dependence on traditional FYM, drudgery of women and to increase crop production of farmers with limited livestock, a simple and cheap technology for bio-composting was first demonstrated to the participating farmers and then each of the was asked to make bio-composting pits in their own farm yards. Only reinforced polythene sheet were provided. Protected cultivation in polypit and polyhouse technology were provided to the farmers. A total of four polyhouses and two polypits were made by the farmers with technical guidance from the Institute team.

2. A simple and cheap water harvesting technology through the use of polypond was demonstrated for harvesting of rain water/ discharge from natural springs for minor irrigation as well as other domestic work. Technologies for management and improvement of under utilized land also explained as following: (a) propagation and multiplication technology for Large cardamom- a perennial cash crop was shown to farmers for optimum land utilization, (b) to meet the fodder requirement, the value of silvi- pastoral system was explained to the participating trainees. The fodder /fuel wood tree species of multiple use were suggested for plantation with herbaceous pasture vegetation on moderate to steep slopes, (c) A simple technology package for the multiplication of bamboo was provided; this innovative technology is based on the "sugar cane" like method of propagation, (d) introduction of fodder, fiber, horticultural tree, medicine and various other products of local importance were screened for plantation with the rain fed agriculture system as a agro-forestry system. Further, the following concepts were also discussed and their value explained as nursery technology, bio-fencing, social fencing, site improvement/

green manuring, soil conservation measures, etc.

3. In addition, practical training and demonstrations are regularly imparted to farmers on their fields and informal discussions are also held with the villagers, from time to time, in groups or individually.

3.2.6. Management Information System (MIS) for Land use / cover change analysis in relation to conservation oriented land use priorities in Nanda Devi Biosphere Reserve Buffer zone.

Background

To conserve biodiversity in the country, a network of protected areas has been set up by the Union Government. However, these areas report people management authority conflicts as the subsistence needs of people are over looked during the planning and implementation phase. Effective mitigation measures could be taken if the management authority have reasonably good decision support system or management information system.

Objectives

1. To prepare a management information system for land use / cover change in buffer zone.

2. To transfer such systems to management authority after testing.

Results and Achievements

1. Spatial information of the Nanda Devi Biosphere Reserve from the Indian Topographical sheets viz.; 53N10, 53N14, 53N11, 53N15, 53N16, 53N12, 62B2, 62B3 and 62B4 on the scale 1: 50,000 are being collected. The themes include land use / land cover of 1963, drainage network, elevation map, road network, infrastructure, geo-features and geology. The digitization of the base layers are also in progress using ARC/INFO, 3.4 (ESRI, U.S.) software.

2. For analysis of land use / land cover change, digital data of IRS - IC, LISSIII of 1998 for path row 98-49 and 98-50 have been acquired and are being processed.

3. Secondary information regarding demographic trends and socio-economic changes are being analyzed.

3.3. CONSERVATION OF BIOLOGICAL DIVERSITY

3.3.1. Studies on Biodiversity, Habitat Fragmentation and Conservation in the Protected and Ecologically Sensitive Habitats of the Himalaya

Background

The identification and characterization of habitats of the Himalaya, especially those supporting sensitive biota is of paramount importance for identifying the disruptions and magnitude of pressures leading to habitat degradation and extirpation of important species. Index of change in a system can effectively be monitored and conservation measures adopted when habitats are taken as study units. The project was initiated to study the habitat diversity, distribution pattern of native and non-native species and monitor changes in protected areas of Kumaun (Askot Wildlife Sanctuary, AWLS) and Himachal Pradesh (Kanawar Wildlife Sanctuary, KWLS).

Objectives

1. Identification, classification and mapping of important habitats.

2. Identifying degree of biotic and anthropogenic pressures causing fragmentation.

3. Identifying habitats that support important taxa.

4. Narrowing the gulf between in-situ and ex-situ conservation by developing techniques for enhanced economic utilization of in-situ resources in ex-situ situations.

Results and Achievements

Askot Wildlife Sanctuary - Studies in Panchchuli Basin

1. The Darma valley, hitherto unexplored area of AWLS, was investigated for structural/compositional diversity patterns in vegetation and changes in soil characters across changing vegetation.

2. In the context of forest type representation of AWLS- *Pinus wallichiana, Tsuga dumosa* and *Taxus baccata* subsp. *wallichiana* stands are particularly important.

3. Spatial patterns of distribution and analytical features of different dominant types (Table 13) revealed that (a) tree density varied between 360-1240 ind/ha. *Taxus, Pinus* and *Betula* stands on relatively higher elevations were thickly populated; (b) total basal area values declined gradually beyond 2200 m, with a sharp drop towards forest limit (*Pinus wallichiana* 11.7m^2/ha; *Betula* - *Rhododendron* 13.3m^2/ha); (c) total sapling density (120-2360 ind/ha) was consistantly low. *Alnus nepalensis* (180 ind/ha) and *Aesculus indica* (120 ind/ha) stands were poorly represented by saplings; (iv) seedling density was low (320-2180 ind/ha).

4. Two types of forest level population structures were apparent (i) frequently reproducing- with a large number of individuals in smaller cbh class and progressive decline in larger size class (all forests except *Aesculus indica* mixed forest); (ii) infrequent reproducing forests with interrupted population structure individuals accumulating in higher classes (*Aesculus indica*) .

5. Among dominant taxa of different forests *Alnus nepalensis, Betula alnoides, Quercus floribunda , Aesculus indica, Tsuga dumosa* exhibited interrupted population and/or infrequent regeneration suggesting possible replacements of these taxa.

6. Definite trend of soil texture, pH, organic carbon and nitrogen was not observed across the elevational range. Therefore, it was concluded that the soil characteristics were more influenced by the forest composition rather than the elevation.

(ii) Studies on Herbaceous Flora

7. A total of 46 sites along the altitudinal range (1000-2500m) were studied for investigating the patterns of native/non native species distribution and to explore relationship between various ecological parameters of herbaceous flora with the altitude.

Table 13. Spatial distribution and compositional features of different dominant types in Darma valley

Forest/ dominant type	Elevation range (m)	T.B.A. (M^2/ha)	Tree density(Ind/ha)	Sapling density (Ind/ha)	Seedling density (Ind/ha)
Alnus nepalensis-mixed broadleaved	1760-2000	40.8	680	180	380
Quercus floribunda mixed broadleaved	1900-2200	37.5	620	1000	1120
Aesculus indica-mixed broadleaved	2000-2400	49.4	360	120	320
Tsuga dumosa-mixed coniferous	2100-2600	75.1	670	1300	1180
Taxus baccata subsp. *Wallichiana*-mixed coniferous	2280-2480	55.9	1100	340	2100
Quercus semecarpifolia mixed broadleaved	2300-2780	41.4	780	1080	2180
Pinus wallichiana	2600-2950	11.7	820	760	1340
Abies pindrow	2750-3000	22.4	520	2180	1640
Betula utilis	3000-3400	22.2	1240	1760	1764
Betula utilis-Rhododendron	3000-3480	13.3	1140	2360	1740

8. Across different sites in different seasons a total 214 species were recorded. Initiation period (April-May) accounted for maximum (174) species richness. However nativity was maximum (27%) in post rainy season.

9. Along elevational gradient native species richness ($r=0.709$, $P<0.01$) increases significantly (Figure. 4). In general following relationships were apparent in the area (i) relative density of natives increases with elevation ($r=0.573$, $P<0.01$); (ii) proportion of non-natives declines with increasing soil moisture ($r=-0.635$, $P<0.01$).

10. Considering the community types, most of the sites were dominated by non-native types (*Arundinella-Imperata-Pilea* being most frequent). Bouldery riverine slopes, mixed broadleaved forest and chir-pine forest sites supported the frequent proliferation of non-native taxa.

Kanawar Wildlife Sanctuary (HP)

1. Inventory of 131 medicinal plants – MPs (30 annuals, 101 perennials) belonging to 50 families and 105 genera was prepared. Families Rosaceae (10 spp.) and Ranunculaceae (9 spp.) showed maximum diversity; >71% families supported 1-2 taxa.

2. Altitude zone (2500-3000m) exhibited maximum (77%} and the zone above 4500m (4.6%) minimum species richness. Two transition zones, viz. 2500-3000m and 3000-3500m have been identified for their maximum species transaction, i.e. 40 and 45, respectively.

3. The nativity of medicinal flora was high (51.15%), and exhibited increasing trend along increasing altitude. About 63% of native taxa were endemics (Table 14).

4. The use pattern of the species indicated that about 58 species were ethno-medicinal and commercially medicinal.

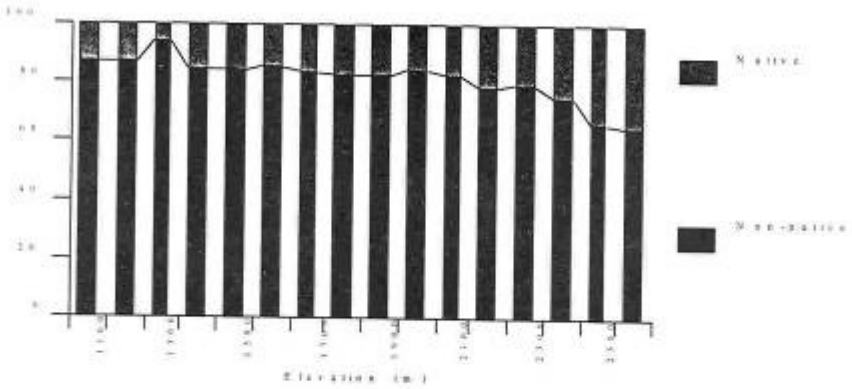

Figure 4. Proportional distribution of native and non-native species along elevational gradient.

5. Survey of medicinal taxa in upper zone (UZ), lower zone (LZ) and outer village (OV) revealed *Aconitum heterophyllum, Angelica glauca, Dactylorhiza hatagirea, Morchella esculenta, Picrorhiza kurrooa and Thymus serphyllum* were amongst the preferred taxa.

6. About 86%, 60% and 89% households (HHs), respectively from UZ, LZ and OV, were involved in trade for 1997-98. The UZ villages had the highest average income from MPs (i.e. Rs. 7,457 per HH/annum), followed by Rs. 6,352 from OV and Rs. 1,939 from LZ.

7. Annual extraction of medicinal plants indicated that *Dioscorea deltoidea* (38.1 kg/HH, UZ; 22.7 kg/HH, OV), *Jurinea dolomiaea* (26.9 KG/HH, UZ; 51.2 Kg/HH, OV), *Nardostachys grandiflora* (25.5kg/HH, LZ) and *Picrorhiza kurrooa* (41.6 Kg/HH, UZ; 38.2 Kg/HH, OV) were amongst top extracted taxa.

8. The fuel wood preference, use and consumption in outer village was assessed. *Aesculus indica* (71% preference, 42% use), *Indigoferea heterantha* (93% preference, 69% use), *Picea smithiana* (93% preference, 89% use), *Pinus wallichiana* (76% preference, 62% use) were amongst the preferred taxa.

9. Medicinal plants nursery was developed at Kasol (Parvati valley). Low cost polyhouse (7X4.75X2.32m) model using commonly available structural materials has been developed. About 10 species are being tried in nursery.

Table 14. Distribution of endemic and other medicinal plants within different life forms in KWLS.

Life form	Endemics (no)	Near endemics (no.)	Others (no.)	Total taxa (%)
Tree	0	9	17	26 (19.85)
Shrub	1	10	18	29 (22.14)
Herb	1	21	54	76 (58.01)
Total	2	40	89	131 (100.00)

3.3.2. Bioresource Inventory of the Himalaya.

Background

Adequate base line data on biological resources of any biogeographical region help in the identification of species, population, communities, habitats, landscape elements and ecosystems. As such, it is imperative to develop a computerized data base of existing bioresources of the Himalaya. So far, comprehensive baseline data for the Himalayan bioresources is not available. Therefore, preparation of inventory of bioresources (family wise, rare-endangered, ethnobiological, endemics, key stone species) has been initiated. The analysis of the data generated so far has proved useful.

Objectives

1. Develop a computerized database of all species and their habitats.
2. Identify gaps therein.
3. Draw information about various attributes of specific habitats/species.
4. Prioritization of species and sites for conservation.

Results and Achievements

Family: Apiaceae

1. Family Apiaceae in the Indian Himalaya was analyzed for species richness, nativity and endemism. It was represented by 161 taxa (143 species+18 var.) in 49 genera. Nearly 47% of these genera were monotypic. *Bupleurum* (18); *Heracleum* (9); *Pimpinella* (13); *Pleurospermum* (15), *Selinium* (7) and *Acronema* (7) were species rich.

2. Indian Himalayan Apiaceae revealed high proportion of native (72%) taxa. Across biogeographic provinces, species representation declined from Trans/Northwest (65.2%) and West (59.6%) to Central/East Himalaya (36.6%).

3. Along altitudinal range family was best represented in temperate (80.7%) and alpine zones (63.9%). Both the extreme zones i.e. sub tropical (23.6%) and high alpine (19.9%) were relatively species poor. However, proportional representation of native taxa increases significantly ($p<0.01$) with increasing elevation. The high alpine umbel flora being 100% native.

4. Over 90% of native Apiaceae represents Himalayan endemics (34.3%) and near endemics (65.7%). Proportional endemism in different provinces of the Indian Himalaya is given (Figure. 5).

5. Despite the fact that Apiaceae is relatively more diverse in neighbouring areas (West Pakistan 178spp., erstwhile USSR 888spp., Europe 571spp.), the extent of endemism (sensu lato) in Indian Himalaya (65.2%) was high.

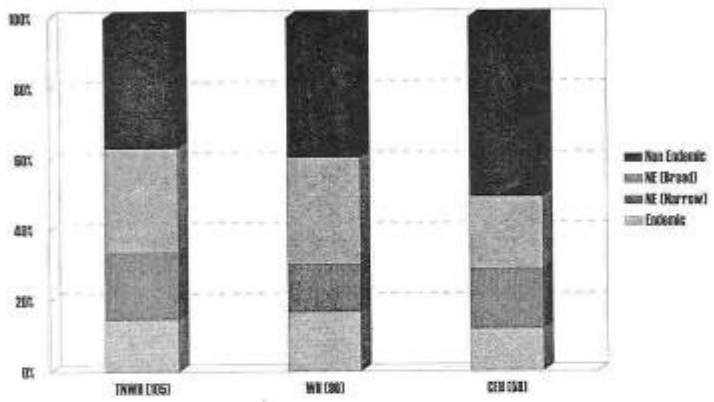

Figure 5. Representation of endemics and near endemics in family Apiaceae of Indian Himalaya.

Medicinal Plants (MPs) of Indian Himalaya

1. The medicinal plants (1748 spp.) of Indian Himalaya were analyzed for nativity, endemism, rarity, potential values and wild relatives of crop plants. Of the total, 25.80% species were native to Himalayan region and 5.66% species native to Himalayan region and other biogeographic domains.

2. Across the biogeographic provinces maximum percentage (13.67%) of the native MPs were used in Trans, North West, followed by West (11.90%), East (10.58%) and Central Himalaya (4.69%).

3. Sixty two (3.55%) MPs were endemic to Indian Himalaya and 208 (11.90%) species with extension in adjacent areas like Pakistan, Tibet, Afghanistan (Himalayan range), Nepal, Bhutan and also adjacent states of India, were considered near endemics.

4. The utilization patterns of endemics and near endemics indicated that the East Himalaya accounts maximum utilization of endemics (48.39% of the total endemics), followed by Trans, North West (27.42%), Central (16.13%) and West Himalaya (12.90%). However, maximum near endemics (57.21%) were used in Trans, North West Himalaya, followed by West (50.96%), East (18.27%) and Central Himalaya (13.46%).

5. Seventeen MPs have been listed in the Red Data Book of Indian Plants (Table 15), and 62 (including Red Data Book entries) have been categorized as critically rare (27 spp.), endangered (16 spp.), vulnerable (14 spp.), low risk-near threatened and low risk-least concern (1 sp. each). Over 200 MPs were

found edible, >30 species have multiple utility, 82 species yield fatty and essential oils and >30 species are traded.

6. Over 70 species were identified as wild relatives of crop plants. Majority of the species were represented in the families: Rosaceae, Moraceae, Rutaceae, Malvaceae, Rhamnaceae, Fabaceae, Solanaceae, Cucurbitaceae, Tiliaceae, Brassicaceae, Alliaceae, Poaceae, Cordiaceae, Myrtaceae, Myricaceae., Anacardiaceae, Euphorbiaceae, Araceae and Ebenaceae.

7. Review of medicinal plants under cultivation, with known propagation protocols, pharmacology, pharmacognosy and phytochemistry, Organizations/Institutions working on medicinal plants was also carried out.

Table 15. Rare Endangered Medicinal Plants of Indian Himalaya recorded in Red Data Book (RDB) of Indian Plants.

Taxa	Altitude range (m)	RDB Status	Endemism
Aconitum deinorrhizum	3000	V	NE
A . falconeri var. *latilobum*	>3000*	V	E
A.. ferox	2100-3800	V	E
Allium stracheyi	3500-4500	V	E
Angelica nubigena	3800	I	E
Berberis affinis	2500	V	E
B. kashmiriana	2000-3300	R	E
Coptis teeta	2500-3000	V	E
Codonopsis affinis	2500-3500	R	E
Dioscorea deltoidea	450-3100	V	-
Inula racemosa	2500-3700	V	E
Nardostachys grandiflora	3200-5,000	V	-
Panax pseudoginseng	2000-2500	V	NE
Pittosporum eriocarpum	600-1800	I	E
Picrorhiza kurrooa	3300-4800	V	-
Saussurea costus	3000-4000	En	-
S. bracteata	3500-4500	R	E

Abbreviations used: V = Vulnerable; I = Indeterminate; R = Rare; En = Endangered; E= Endemic; NE = Near endemic.

3.3.3. Establishment and Maintenance of Functional Arboreta in the Himalaya

Background

In order to develop a germplasm bank of Himalayan species and ensure ex-situ conservation, enrichment of germplasm in arboretum at Kosi-Katarmal (Kumaun Himalaya) and maintenance of *Rhododendron arboretum* at Sikkim are continuing. The project is envisaged to be extended to Himachal Pradesh and North-East region of Indian Himalaya. The activity will not only serve as a gene bank of different

Himalayan life forms but also provide opportunities for facilitating research, training and development activities.

Objectives

1. Developing a gene bank of Himalayan species including economically important taxa.

2. Developing propagation protocols for locally acceptable species for sustenance and conservation value.

3. Large scale multiplication of species and making the saplings available to local people and also for rehabilitating degraded lands.

Results and Achievements

Kosi-Katarmal, Kumaun Himalaya

1. Infrastructural facilities such as extension of arboretum area for plantation and nursery was carried out.

2. Propagules of various species including medicinal plants, ferns etc. were collected. Seeds were sown in the nursery and monitored for germination and survival. *Butea pellita* (62.2%), *Erythrina arborescens* (55.67%) and *Heynea trijuga* (47%) showed fairly good germination whereas *Rhus wallichii, Euonymus pendulus* and *Murraya paniculata* showed no germination. After germination of the species, maximum survival was observed in *Celtis australis* (87.63%), *Erythrina arborescens* (86.53%), *Ehretia laevis* (80.95%), *Emblica officinalis* (80.36%), *Leucaena leucocephala* (76.47%) and *Quercus semecarpifolia* (75%), respectively. The arboretum was also enriched through introduction of threatened medicinal plants such as *Podophyllum hexandrum, Nardostachys grandiflora, Aconitum balfourii, Rheum australe, Dactylorhiza hatagirea* and *Angelica glauca.*

3. Over 6,000 seedlings were planted in the arboretum sites and Institute campus. About 1200 seedlings of 14 species were distributed to schools/colleges of district Pithoragarh for the development of conservation models. Also, seedlings of various multipurpose species were distributed to local inhabitants through various projects of the Institute.

4. Twelve species of medicinal plants were tested for cultivation. Among the species *Senecio nudicaulis, Origanum vulgare, Thalictrum foliolosum, Saliva lanata, Valeriana wallichii, Potentilla fulgens, Bergenia ligulata, Centella asiatica* and *Verbascum thapsus* showed good performance.

5. Growth performance of 20 species in the arboretum site was monitored. Among all the species *Betula alnoides, Dalbergia sericea* and *Aleurites mollucana* attained maximum whereas *Olea glandulifera, Bischoffia javanica, Ligustrum nepalense, Castanopsis tribuloides* minimum growth.

6. Three sets (small, medium and large) of seeds considering size and weight of five species were sown in glass house, net house and nursery conditions and monitored for germination and growth. The germination performance of the species in various conditions is presented (Table 15).

7. The seedlings emerging from the large seeds of all the species attained maximum growth in all the conditions. Among the species *Celtis australis* attained maximum height (55.6cm) in polyhouse and *Erythrina*

arborescens in net house (33.4cm) and nursery (39.0cm) conditions, whereas, *Terminalia chebula* attained minimum height in all the conditions, i.e. polyhouse (14.3cm), net house (9.6cm) and nursery conditions (15.5cm).

Table 15. Germination performance of species across the seed size and weight classes in different conditions.

Species	Poly house			Net house			Nursery		
	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
Terminalia chebula	11.8	6.3	11.1	5.9	6.3	23.5	5.9	13.3	17.6
Erythrina arborescens	93.9	94.3	94.1	72.7	85.7	87.9	50.0	47.1	57.6
Celtis australis	6.3	33.3	11.8	6.3	23.5	17.6	18.8	11.8	12.5
Fraxinus micrantha	-	18.2	26.5	3.1	21.2	38.2	-	3.0	-
Elaeagnus umbellata	-	2.9	2.9	-	-	-	-	-	-

Sikkim Himalaya

1. Sites were prepared according to the master plan assigning different sites to different sets of plants. The footpaths were constructed in a network to make access all the sites within the Arboretum. The arboretum was strengthend through introduction of various tree species, bamboo (8spp.), medicinal plants (7 spp.), orchids (23 spp.) and rhododendrons (26 spp.).

2. *In situ* study was made on the rhododendrons and a baseline report was prepared. It covers habit, habitat and availability of the rhododendrons in Sikkim along with the different types of anthropogenic pressure.

3. The seedlings of fuel and fodder tree species developed in the Arboretum nursery were distributed to the inhabitants in the vicinity. For rapid and optimum growth of the seedlings, polyhouse technology was used. A total of 5 different designs were used in experimenting the size, shape and the structural components involved.

3.3.4 Initiating Biodiversity Conservation Through Peoples' Participation in the Himalaya

Background

Biodiversity conservation programmes are being pursued across the Himalaya by both the Government and Non-Government agencies. Presently, such initiatives are restricted to identification of surveys, inventorization of biological resources, strengthening the net work of Protected Areas, conservation of threatened species and ex-situ germplasm maintenance. It has been argued that conservation action needs to be promoted and implemented by bringing local people into the conservation movement and considering them as potential allies. Since these aspects are not adequately focused in the Himalaya, an initiative in this direction was taken

to bring the target groups in to the conservation movement.

Objectives

1. Promote and strengthen interactions with the target groups.
2. Promote conservation science especially among School/College students.
3. Impart on site training on collection, storage and propagation methods of target species focusing on teachers and students.
4. Obtain and analyze response of different target groups with respect to location specific conservation option/priorities.
5. Establish preservation models in college/community lands depicting locally important bioresources.
6. Prepare easy to grasp print material for target groups focusing on locally available biodiversity, their importance and methods for value addition.

Results and Achievements

1. Efficient and coordinated follow-up action of previous training workshops was ensured by strengthening preservation models at G.I.C. Narayan Nagar, G.I.C. Lohaghat and G.H.S Pati. Participants feedback was obtained on possibilities for reorientation of programme features.
2. Review of programme features was accomplished, and with desired re-orientation of programme features, the V Training Workshop was organized at G.I.C. Narayan Nagar (November 19-21, 1998). Over 60 participants (18 teacher and 42 students) from 11 educational Institutions participated in the Workshop.
3. Most important features of the Workshop was: (i) volunteers from participants assumed lead role in training, (ii) all participants were involved in information generation on biodiversity, (iii) pre and post workshop analysis was conducted for impact assessment.
4. Analysis of questionnaires used for information generation revealed that >80% participants (n=26) from natural system (forest), and >63% participants (n=27) from village system, were able to generate desired and utilizable information.
5. Analysis of responses (Pre and Post Workshop) suggested that the training Workshop had considerable impact on participants understanding (Table 16).
6. A meeting of Principals of participating institutions was conducted during the Workshop. Future strategies for strengthening the activity in different institutions were discussed. Institutions were advised to prepare small projects wherein the activities for 2-3 years are defined. Three project proposals were received and reviewed . Targets for concerned institutions (G.H.S Pati, G.H.S Chaumel and G.I.C. Narayan Nagar) have been finalized.

Table 16. Impact of training Workshop on Participants understanding of Biodiversity.

Subject/ Concerns	Responses			
	Pre workshop		Post workshop	
	Teachers (n=18)	Students (n=42)	Teachers (n=18)	Students (n=42)
Biodiversity as Resource	33.3	38.1	38.9	59.5
Alertness about bioresources	44.4	4.8	61.1	38.9
Conservation concerns	44.4	14.3	83.3	30.9
Subject knowledge				
What is biodiversity?	27.8	11.9	72.2	50.0
Levels of biodiversity?	00.0	2.3	22.2	9.5
Importance of biodiversity?	33.3	19.0	72.2	38.1
Protected Areas?	50.0	16.7	50.0	23.8
Value addition?	00.0	2.4	55.6	54.8
Role of tissue culture/Remote sensing?	16.7	2.4	77.8	45.2
Genetic and species diversity concept?	00.0	00.0	27.8	11.9
Sustainable use and conservation?	77.8	52.4	77.8	59.5
Possible role in biodiversity study?	61.1	21.4	61.1	31.0
Use of biodiversity for sustenance?	44.4	57.1	66.7	66.7

3.3.5. Prioritization of Conservation sites in Timberline Zone of west Himalaya.

Background

Timberline represents a transition between high temperate and low alpine zone across the Himalaya. In the west Himalaya it is a cradle of high temperate and low alpine sensitive elements of tremendous biological value. The area is also subjected to anthropogenic disturbances of various types and magnitudes, reflected at different organizational levels. In view of the rich biological diversity it supports, it is important to assess the threats to the ecotone. The data available on realized and potential value of biodiversity elements and the nature and extent of pressure on the ecotone is not adequate.

Objectives

1. To develop an update inventory on biodiversity elements of timberline zone of west Himalaya.
2. To select sites for prioritization on the basis of biodiversity and socio-economic value.
3. To prioritize strategies for conservation of selected priority sites and stretches.
4. To develop participatory methodology for prioritizing sites and strategies.

(Summary of completed project)

All across the timberline zone of West Himalaya twenty clusters or sites were identified. The clusters were further prioritized following four levels of prioritization : (i) identification and

ranking of priority clusters on the basis of the proportional representation of cumulative features of biodiversity attributes of clusters with respect to those of timberline area of west Himalaya; (ii) identification of unique clusters on the basis of proportional representation of attributes with respect to an identified cluster; (iii) ranking of representative and unique clusters; (iv) identification of most representative grid with maximum species, natives, endemic and rarities was identified within each prioritized cluster of multiple grids. The approach of prioritization has narrowed and sharpened the focus on representative grid unit of a prioritized site (cluster) for initiating appropriate conservation action.

3.3.6. Biodiversity Studies Using Remote Sensing in Indian Himalaya

Background

Remote sensing and GIS could help in identifying the areas of high pressure and also the gradients of the disturbances across different landuse categories. In view of this, ICIMOD, Nepal and GBPIHED, India have initiated a collaborative project, which envisages to coordinate remote sensing and ground truth data for studying different aspects of Biodiversity at macro, regional and micro levels.

Objectives

1. Macro level: using coarse resolution satellite data (IRS-1C, WIFS) for field work and vegetation assessment.

2. Regional level: mapping the landuse classes, habitat types and forest types using high resolution (LISS-III and LANDSAT-TM) digital/hard copy satellite data.

3. Micro level: detailed mapping and classifying intensive sites (e.g. forests, landuse and habitats) at level lower than the regional level.

Results and Achievements

1. Landuse/landcover maps for 1988 and 1996 were prepared using image data of IRS-1A LISS II and IRS-1C LISS III, respectively at 1: 50,000 scale. A total of 9 landuse/landcover classes were delineated and finally digitized. Comparative chart of manually calculated area and GIS based area was prepared. It was observed that greater difference was apparent in classes having patchy, random distribution with more number of polygones.

2. Changes in different landuse/landcover classes over 8 years 1988-1996 were analyzed (Table 17). Maximum change was observed in forested area.

3. IRS-IC LISS III (band 1-4) November 1996 digital data was used for generation of spatially defined spectrally homogenous samples (SSS) and digitally classified landuse/landcover maps of same dataset was used to cross check the separability. Based on these information the spectral separability of various landuse/landcover types were identified in each SSS. Detailed information for each band was prepared.

3.3.7. Wild Edible Plants of Food Value, Their Nutrient Status and Regeneration in Sikkim Himalaya (1995-98)

Background

Sikkim is a hill state and has a very rich plant diversity of over 6000 plants. The state has

sub-tropical to temperate and alpine type of climatic conditions in an elevation range from 300-8500 m above sea level. Low lands are utilised for double crop production but most of the high lands have monocropping system. In the Sikkim Himalaya a large number of wild plant species are used as food, medicine beverages, fish poisoning, dyes, oil, timber, firewood, fodder and various other purposes. These plants have got little attention despite their various uses. There is need to do further survey to see more species of potential uses, their growth as well as nutritional status.

Table 17. Landuse/landcover change during 1988-1996 in Askot Wildlife Sanctuary

Landuse/landcover	Area % (1988)	Area % (1996)
Chir pine forest	22.8	21.7
Oak forest	37.7	35.6
Mixed forest	7.0	6.3
Settlement/agriculture	13.4	15.5
Scrub/degraded	2.7	3.6
Grassland	9.9*	3.5
Barren land	3.2	3.6
Snow cover	2.1	9.1*
River/water bodies	1.1	1.1

*Temporary change depends on season.

Objectives

1. To examine conservation status of various wild edible species.
2. To know viability, dormancy and germination of seeds of some selected wild edible species.
3. To find out calorific values of some selected wild edible species.
4. To know the micro and macro nutrient composition of some selected wild edible species.

(Summary of completed project)

Inventorisations of the wild edible species are continued and till date a total of 190 species have been screened for their food value. Six most potential wild edible species (*Spondias axillaris, Eriolobus indica, Machilus edulis, Bassia butyracea, Elaeagnus latifolia* and *Baccaurea sapida*) have been selected for detailed study. Per tree fruit productivity for *Baccaurea sapida* varied from 5 kg (tree girth 25cm cbh) to 106 kg (cbh 186 cm), *Spondias axillaris* is from 1.43 to 185 kg per tree (cbh from 90 cm to 250 cm), *Eriolobus indica* from 6.19 to 56.64 kg per tree (cbh 62 to 130 cm), *Machilus edulis* from 5.16 kg per tree in 135 cm cbh class to 57 kg per tree in 410 cm cbh, and for *Bassia butyracea*, the fruit productivity per tree ranged from 3.08 kg in 80 cm to 155 kg per tree in 165 cm cbh size. *Elaeagnus latifolia*, a liana, showed fruit production, which varied from 20-200 kg per plant from 96 to 193 cm cbh size girth class plants. Seed germination of *Baccaurea sapida* started after 30 days of sowing and most of the seeds completed germination after 50 days of sowing

(seed viability 22-35%). For seeds of *Machilus edulis*, 100% germination was recorded after two months of sowing. In case of *Elaeagnus latifolia* about 60% seeds germinated. Seeds of *Bassia butyracea* started germination after 12 days of sowing and the germination percentage was observed to be 82%.

3.3.8. Sikkim Biodiversity and Ecotourism

Background

The rich natural and cultural heritage of Sikkim makes this small Himalayan state in north-eastern India an attractive destination for international and domestic tourists. Tourism is rapidly becoming an important economic activity for Sikkimese. Ecotourism, with its focus on environmentally sound practices and generating widespread economic incentives to conserve, offers an opportunity for Sikkim to improve mountain livelihoods and protect its unique heritage. The Sikkim Biodiversity and Ecotourism Project is a collaborative initiative designed to conserve the biological diversity of key destinations. Working with communities, the private sector and government, the project builds upon their skills, interests and knowledge.

Objectives

1. Increasing community and private sector biodiversity conservation initiatives.
2. Increasing economic returns from community-based and travel-agent ecotourism.
3. Improving and contributing to policy-making on conservation and ecotourism. Scientific and participatory monitoring of biodiversity.

Results and Achievements

1. Training was imparted to Porters', Lodge Operators', Trek-Cooks', Transport Sectors' and farmers for micro-enterprises like off-season vegetable production and vegetable seed production. Most of the training activities have now been taken over by Yuksam based NGO, the Khangchendzonga Conservation Committee (KCC).
2. During 1996 and 1998, an increase of 37% household involved in tourism was recorded, where by the income level increased by 57%. About 300 individuals from the community received skill development from the project. Local community initiated and organized various conservation activities which has increased by 28% during the project implementation.
3. The hydrology and nutrient dynamics of Khecheopalri lake were studied. The lake watershed has broad-leaved mixed forest and agriculture land, two perennial and five seasonal inlets, and one major outlet. Annual inflow was 1103×10^6 l while outflow was 4279×10^6 l. About 70% of its water were from subsurface flow and seepage. Sediment flow to the lake was 346 t yr^{-1} and outflow 316 t yr^{-1}. The remaining 30 t was deposited in the lake. High sediment runoff in the rainy season turned the lake turbid and caused expansion of the bog (Figure. 6). The nutrient (dissolved oxygen, carbon dioxide, total-N, Ammonium-N, Phosphate-P and chloride) levels of the lake, inlets and outlet varied between seasons and sites. Plankton productivity ranged from 16 mg C m^{-2} day^{-1} in winter to 247 mg C m^{-2} day^{-1} in the rainy season. Its respiratory loss was 12 mg C m^{-2} day^{-1} in winter and 160 mg C m^{-2} day^{-1} in

the rainy season. Religious activities, agriculture, cattle grazing and forestry in the watershed should be controlled for maintaining the longevity of the lake.

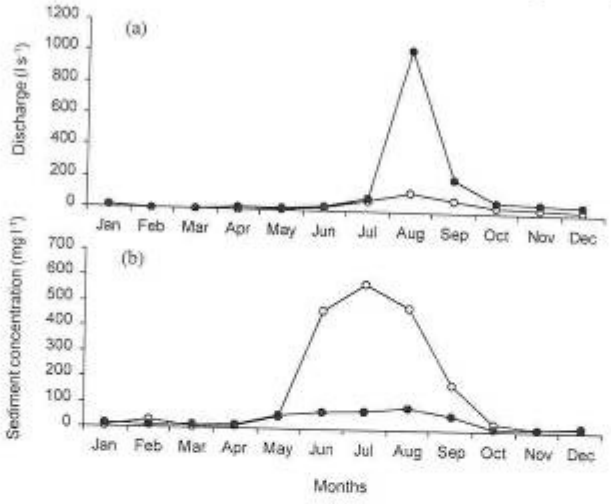

Figure 6. Discharge (a) and sediment concentration (b) during 1997 at the Khecheopalri lake in west Sikkim.

4. Forest cover types, user groups, tree species diversity and structure, net primary productivity and woody biomass extraction rates were studied along Yuksam-Dzongri trekking corridor in the Khangchendzonga National Park of Sikkim. Remarkably high firewood extraction pressure was observed at lower forest and on the medium sized trees. Selective harvest of preferred tree species caused depletion risk for sustainable use along the corridor. Compliance to the code of conduct by all stakeholders especially for alternative use of firewood can promote conservation and maintenance of biodiversity to make it an attractive destination.

5. A list of birds (192 species) was compiled from records gathered during the field study and prepared information on their status, habitat and localities.

6. An extensive floristic survey was conducted for three years (1996 to 1998) in the alpine pastures (3800-5000 m amsl) of the Khangchendzonga National Park of the Sikkim Himalaya. A total number of 83 species of flowering plants belonging to 28 families have been identified and classified under different taxonomic/lifeform groups.

7. Grazing impact assessment showed that aboveground biomass of 540 g m^{-2} and belowground biomass of 830 g m^{-2} in exclosure plot, while 256 g m^{-2} and 612 g m^{-2} respectively, in corresponding open-grazed plot. Under grazing condition 53% of aboveground biomass has been removed and present stocking rate was 3.9 cows unit per hectare. The potential stocking rate has been found to be 4.4 cows unit per hectare

considering 60% aboveground biomass utilization.

3.3.9. Standardization of Hardening System for Transfer and Establishment of Planting Material of Selected Multipurpose Trees for the Waste and Marginal Lands of Central sub Himalayan Hills

Background

Hardening of *in vitro* raised plantlets and their subsequent performance in the field condition are the most important factors determining the success of *in vitro* protocols. The study aims to optimize the hardening process of selected multipurpose trees (MPTs) and also standardize their performance in field conditions. Large scale depletion of vegetal cover has substantially increased the gulf between demand and supply of fuel wood and fodder. It is in the context, scaling up production of planting material and their plantations in demonstration plots will not only help the mountain people to augment their day to day requirements of fuel wood and fodder but also, importantly, explore possibilities of income generation. Besides the advantage of increasing productivity, the study will also popularize the techniques among rural mountain inhabitants.

Objectives

1. To monitor the survival and growth performance . of *in vitro* raised plantlets during hardening process.

2. To establishing *in vitro* raised high yielding superior plant material initially in experimental plots in arboretum.

3. To scale up production of plant material developed through *in vitro* and conventional means.

4. To establish demonstration plots in identified sites through active collaboration of local NGO's.

5. To monitor the performance of the planting material through active participation of local community groups.

6. To organize training workshop on methods of propagation and monitoring focusing on identified target groups.

Results and Achievements

1. Forty five fully acclimatized plantlets were kept under different environmental conditions to standardize suitable *ex vitro* condition for micropropagated plants of *Sapium sebiferum*. Plantlets showed better performance (plant height and leaf no.) in glasshouse condition as compared to nursery and net house condition.

2. Conventional propagation protocol were developed for *Bauhinia vahlii*. Response of different population, season and application of various type and concentration of auxin were studied. The spring season alone resulted into optimum rooting (60%) with the intervention of growth hormones.

3. Experiments were carried out to improve the reported protocol of *B. vahlii* for scaling up the production of planting material. The maximum number of shoots (12.6 shoots/explant) were obtained in MS supplemented with TDZ and Kin.

4. Different carbohydrate concentrations were tried to improve the quality of *in vitro* raised

plantlets of *B. vahlii*. The preconditioned plants in sucrose solution did not show any effect on percent survival but better quality of shoots were produced. Shoot length, shoot fresh weight and shoot dry weight of preconditioned plantlets were significantly better as compared to control.

5. Several experiments were conducted to study the effect of nutrient composition on explant establishment and multiplication of *Diploknema butyracea*. Various concentration of nitrates were incorporated in the MS medium. Incorporation of nitrates showed better results compared to original MS medium.

3.3.10. Seed Setting, Germination and Seedling Growth in *Mesua ferrea*

Background

Mesua ferrea, locally known as 'nahor' is an evergreen tree. The species is extensively used for avenue plantations in north east India. The seed contains a non edible oil which is used in soap industry. The seeds from avenue plantations have vast potential of exploitation for commercial extraction of oil. If germination is found satisfactory seed crop from natural populations can be harvested partly.

Objectives

1. To analyze patterns of seed setting within a fruit.

2. To examine their relation with the germination percentage and seedling growth.

Results and Achievements

1. A total of 535 fruits were sampled from five *Mesua ferrea* trees. A fruit may contain 1,2,3, or 4 seeds developing out of four ovules. Based on the number of seeds within a fruit, four seediness classes were identified. Aberrations were noticed when 2, 3, or 4 seeds developed out of six ovules. Such fruits were termed as "Abnormal", and classified into a fifth seediness class that was depicted by the letter "A".

2. The frequencies of fruits in five seediness classes (1,2,3,4 and A) showed a positively skewed distribution with predominance of 2-seeded fruits for all the five trees. The pooled data for five trees also revealed a positively skewed distribution ($P<0.01$). Similarly, five seediness classes exhibited a positively skewed distribution with a predominance of 2-seeded seeds for all the five trees. The pooled data for the five trees revealed positively skewed distribution ($P<0.01$) with 50% seeds belonging to 2-seeded fruits.

3. With 4 ovules in each fruit (and 6 ovules in 6 abnormal fruits), a total of 2,152 seeds should have been produced if all ovules were matured into seeds. But only 48.5% ovules succeeded to mature into seeds, amounting to only 1044 seeds.

4. The distribution of weights of all 1044 seeds was near-normal ($P<0.01$). About 98.8% seeds weighed between 1 and 7g, and thus three equi-distant weight classes, namely, light (1 to <3g), medium (3 to <5g) and heavy (5 to <7g) could be signified. Only 4 seeds were <1g and 8 seeds were >7 g. The medium weight seeds dominated with 67.8%, light seeds 15.4% and heavy seeds 16.8%.

5. The frequency distribution of seed weights in three weight categories individually for five seediness classes showed a clear dominance of medium-weight seeds in all five seediness classes.

6. Seed number per fruit had no effect on germination percentage. The germination percentage was high (>80%) in all the seediness classes and was 100% for abnormal seeds. The germination percentage increased with seed weight.

6. The time taken from germination to the first leaf flush varied from 10 to 13 days for the five seediness classes. Across weight classes, leaf flush time declined from 15 for light through 11 for medium-weight to 8 for heavy seeds.

7. The study suggests that the seed weight is a more important variable than seed number in *Mesua ferrea*. The viability of seeds lasts quite long in the soil and the germination percentage is high. The sowing of medium-weight or heavy seeds is recommended in March when temperature begins to rise following winter.

3.3.11. Exploration, Quantification and Use of Agricultural Diversity, and Folk Knowledge in a Remote Landscape of the Central Himalaya

Background

Conserving biodiversity of plant and animal species is essential to maintaining a productive and sustainable environment for agriculture and other human activities. There is a threshold of diversity below which most ecosystems can not function. Greater effort is also needed to conserve the genetic diversity that exists in crops worldwide. The existing diversity has proven extremely valuable in improving crop productivity through the development of high yielding, disease resistant and stress tolerant varieties.

Objectives

1. to explore the biodiversity and its management in a remotely located agricultural landscape

2. to identify species rich spots of agricultural diversity in village and their role in conservation,

3. to explore local land races of crops, their use, and to establish linkages between the use of agricultural biodiversity and functioning of village ecosystem,

4. documentation of folk and indigenous knowledge and dissemination of knowledge for wider use

Results and Achievements

1. Among the various crops paddy is known to having various landraces in the world. The same is true for Central Himalayan region. In an altitudinal study between 1100m and 2200 m more than thirty landraces were collected in a catchment, however, the altitudinal variation for a particular variety varies with in 100 m altitude along an elevation.

2. These landraces have different morphological attributes. The seed weight varies between 0.015 gm and 0.037 gm, however, the grain weight ranges from 0.013 gm to 0.031 gm per seed. Agronomic productivity between the various landraces ranges from 741 kg to 4827 kg per ha. The total crop productivity of these paddy landraces was observed between 29.3 qu. and 174.1 qu. per ha.

3. Among the other crops, various varieties of bean were collected. The seed weight among the various landraces varies between 0.245 gm and 0.772 gm per seed.

3.3.12. Studies on the Structure, Composition and Changes of the Vegetation in Nanda Devi Biosphere Reserve of West Himalaya.

Background

The protected areas of the Himalaya represent unique species, habitats, communities and ecosystems. In most of the protected areas comprehensive studies have not been carried out so far. Therefore, focused studies on the structure and composition of vegetation, delineation of forest communities, human dependence on the biological resources including the extent of extraction, species preference, changes in the structural and compositional patterns of vegetation and identification of rare endangered species and their habitats is required. The project was initiated to undertake studies in these directions in Nanda Devi Biosphere Reserve of West Himalaya.

Objectives

1. To delineate communities along an elevational gradients and assessing their compositional and structural patterns.

2. To assess human dependence on different communities.

3. To analyze changes of the vegetation.

4. To identify conservation priorities and mapping.

Results and Achievements

1. Pindari area of the buffer zone was surveyed and sampled along an altitude gradient for the quantification of vegetation. Twenty habitats/plots (50x50m) were sampled for the quantification of forests and 20 habitats/plots (20x20m) were for alpine vegetation. Data were analyzed for density, total basal area, IVI and diversity.

2. Twelve forest communities were identified between 2000-3600m based on dominant type. These were *Aesculus indica, Alnus nepalensis* (represented in 3 habitats each), *Hippophae salicifolia, Acer villosum, Acer acuminatum, Rhododendron arboreum* (represented in 2 habitats each), *Ulmus wallichiana, Quercus floribunda, Q. semecarpefolia, Taxus baccata* subsp. *wallichiana, Prunus cornuta* and *Betula utilis* (represented in 1 habitat each) communities.

3. Composite samples from each habitat were collected and analyzed for physical and chemical characteristics. The moisture content within the habitats varied between 1.08-38.08%; pH 4.6-6.0; nitrogen 0.33-6.47%; phosphorus 0.12-0.22%; organic carbon 0.803-7.651% and potassium 0.043-0.246%.

4. Participatory Rural Appraisal (PRA) technique was used for human dependence study in Khati village. Participation of the villagers including women was ensured by organizing meetings. The dependence of inhabitants on the forests communities and alpine meadows was discussed and information was gathered.

5. About 75 species (30 trees, 23 shrubs and 22 herbs) were used by the inhabitants for various purposes as medicine (26 spp.),

edible (40 spp.), fodder (23 spp.), fuel (29 spp.), house building (9 spp.), agricultural tools (12 spp.), religious purposes (12 spp.) and few species for fibre, enterprise development, coal and many other purposes. About 20 species were identified as multipurpose species.

3.3.13. Effect of Seed Weight, Light Regime and Substratum Microsite on Germination and Seedling Growth of *Quercus semiserrata* Roxb.

Background

Oaks show wide variation in seed size within a species. Seedlings emerging from seeds of varied sizes exhibit differential competitive performance due to variation in emergence time and growth rate. Large and heavy seeds have better seedling fitness than small seeds. On the contrary, small seeds confer the advantage of greater dispersal efficiency. Thus conflicting selection pressures for two components of fitness, namely, seedling establishment and dispersal efficiency, have the potential to maintain variability in seed size. The study aims to test that: (i) by the virtue of greater food reserves, heavy seeds will confer greater seed germination and seedling fitness, (ii) for the capacity of holding greater moisture, moss layer will favour germination over litter or soil surface and, (iii) being the late successional species, shaded habitats or low intensity light will favour germination and growth of seedlings.

Objectives

1. To study the effect of seed weight, light regime and substratum microsite on the germination and seedling growth.

Results and Achievements

1. The distribution of seed weight, seed weight range, mean seed weight and relative proportion, proportion of predated seeds and viability of seeds of *Q. semiserrata* is presented (Table 18). The ash content and the reserves of protein, carbohydrate, lipid and energy increased significantly ($P<0.05$) with seed weight.

2. Germination of *Q. semiserrata* in laboratory was >50%. The germination percentage was exponentially correlated ($P<0.001$) with seed weight. The heavy seeds attained up to 87% germination, against 70.2% for medium and 51.2% for small seeds. The analysis of variance yielded a significant effect of seed weight on germination percentage ($P<0.001$) and on the time taken for germination ($P<0.001$).

3. The percentages of seed germination in green house were lower than in laboratory. Differences in seed germination due to a 3-way factorial design (seed weight, light regime and substratum microsite) were significant ($p=0.001$). The effect of seed weight was the strongest, followed by substratum microsite and light regime.

4. Differences in seed germination due to substratum microsite were highly significant ($p<0.001$). Seeds of all weight classes under all light regimes showed maximum germination when sown on the moss layer and under litter (Figure. 7).

5. Two-way analysis of variance showed that the seedling survival was significantly ($P<0.001$) affected by seed weight and light regime and dry matter yield was also significantly ($P<0.001$) affected by seed weight and light regime. Seedlings that

emerged from heavy seeds (W_3) and grown under half intensity light (L_2) produced the maximum phytomass.

6. The study suggests that the optimal conditions for seed germination and seedling establishment and growth may be shaped by an interaction of seed weight, microsite type and light regime.

Table 18. Seed weight classes of *Q. semiserrata* with their relative proportion in seed sample, proportion of predated seeds and viability. (The values are mean ± sd. The unidentical superscripts within a column indicate significant difference ($P < 0.05$) between the mean values, as obtained by the Tukey's multiple range test).

Seed weight class	Seed weight range (g)	Mean seed weight (g)	Relative proportion %)	Proportion of predated seeds (%)	Viability (%)
Small (W_1)	3.5-4.6	4.05 ± 0.31^a	20.6 ± 5.0^a	44.1 ± 4.2^a	65.2 ± 4.0^a
Medium (W_2)	5.8-7.3	6.58 ± 0.46^b	47.0 ± 6.5^b	35.7 ± 3.7^b	73.6 ± 5.2^b
Heavy (W_3)	9.6-11.8	10.56 ± 0.69^c	32.4 ± 6.6^c	20.2 ± 3.4^c	84.6 ± 2.1^c

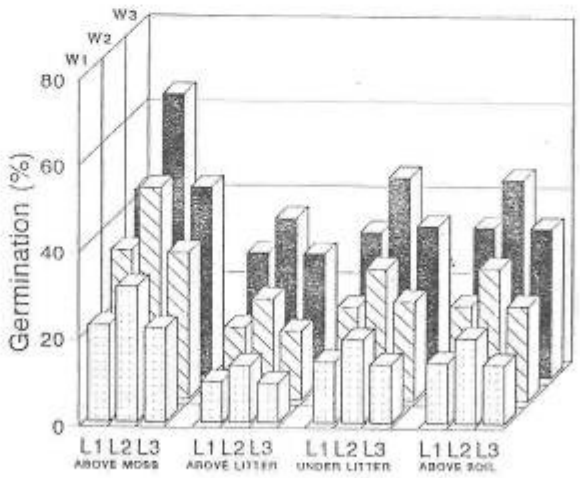

Figure 7. Germination performance of seeds in different micro sites and light regimes.

3.3.14. Utilization of Bamboo and Cane by the Apatani Tribe in Arunachal Pradesh

Background

The Ziro Valley in Lower Subansiri district of Arunachal Pradesh is the home of the Apatani Tribe. The Apatani follows a settled pattern of life and are basically an agrarian society. They have a keen sense of landuse and depend mostly on their well-kept plantations rather than the forest for basic needs. This practice distinguishes them from most of the tribes of the north-east India.

Objectives

1. To inventorise bamboo and cane resource base in the Ziro Valley

2. To study utilization pattern of bamboo and cane resources by the Apatani Tribe.

Results and Achievements

1. The study explored 9 bamboo species in the Apatani valley (Table 19). The Apatanis heavily depend on *Phyllostachys bambusoides* for housing, fencing and craft needs. The straight length, smooth and toned skin and short internode render this bamboo a priority species.

Table 19. An inventory of bamboo and cane resources in the Apatani valley.

Species	Local name	Food value	Other use
Bamboo			
Phyllostachys bambusoides	Bije	Edible fresh	Housing, fencing, craft,fuel
Dendrocalamus hamiltonii	Yayi	Edible	Mugs, food from shoot
Chimonobambusa callosa	Tabyo	Not eaten	Fencing, flooring, ceiling
Chimonobambusa sp.	Rijang	Not eaten	Fencing, but rarely used as fuel
Chimonobambusa sp.	Tapyu	Edible	Not used anymore
Cephallostachium capitatum	Yabing	Edible	Loin loom component, craft
Pleioplastus simonii	Hebing	Not eaten	Not used
Arundinaria sp.	Tador	Not eaten	Not used
Unidentified species	Tajar	Not eaten	Shrine ornament for mithun Puja
Cane			
Plectocomia himalayana	Tarpi	Not eaten	Housing, fencing, twine, craft
Calamus acanthospathus	Tasurr	Not eaten	Craft and traditional rituals
Calamus khasianus	Tikhe/ Takhe	Not eaten	Rarely used as twine

2. The Apatanis have a unique tradition of bamboo farming, particularly of *Phyllostachys bambusoides*. Every household owns at least one bamboo plantation locally called as "bije". A plantation may vary from 1 to 5 acres, and is interspersed with a few blue pine or oak trees.

3. An average bamboo plantation can produce about 5000 bamboo per hectare. About 1000 bamboo can be harvested in a year since the maturity period is about 5 years. The average

annual requirement has been estimated at 393 bamboo household^{-1}. This bamboo stocking exceeds the requirement, and therefore is a sustainable land use pattern.

4. For the Apatanis, cane such as *Plectocomia himalayana*, *Calamus acanthospathus* and *Calamus khasianus* are as important as bamboo. *P. himalayana* is most commonly used for housing and fencing. *C. acanthospathus* is good for craft and also used in traditional rituals. *C. khasianus* is rare and used for craft and twine.

5. The Apatani craft products included a variety of baskets, storage containers, beer filters, grain drying mats, backpacks, raincoat, fishing traps, arrows, mugs, cooking spoons and hunting traps. These Apatani craft products are traded in local and outside markets. A 15-20 m long coil of *C. acanthospathus* is sold for Rs. 150 within the village.

6. The study estimates that about 192 houses yr^{-1} are built in the Apatani plateau requiring about 6.1 lakh bamboo and 21 lakh meters of cane (*P. himalayana*).

3.3.15. Khangchendzonga Biosphere Reserve (Proposed) – Landscape Change, Resource Status and Human Dimensions

Background

For a clear understanding of the total biosphere system functioning insight into the various inherent natural cycles and its associated auxiliary cycles is primary. Towards this holistic understanding of the Khangchendzonga Biosphere Reserve is planned through this research project. Khangchendzonga is a unique mountain ecosystem falling in three different national boundaries of India, Nepal and Tibetan Autonomous Region. This mountain ecosystem encompasses subtropical to alpine zones housing a large number of flora and fauna and makes it a hot-spot of biodiversity. In this mountain ecosystem, there is great variations in elevation, climate, landscape, habitat and vegetation types. It has a rich ethno-cultural diversity and the socio-economic attributes of the people living in and around this mountain ecosystem are location specifically variable and unique.

Objectives

1. Assessment of landscape change.

2. Man-animal-biosphere interaction on specific places.

3. Specialized habitat monitoring for identification of keystone species with respect to habitat change.

4. Functional understanding of vegetation types based on altitudinal distribution.

5. Evaluation of buffer and manipulation zones for sustainable resource management.

Results and Achievements

1. Landscape change assessment work has been initiated. The biosphere area has been mapped. Marked the different ecological zones for natural resources status evaluation. Identified the human habitation locations in the fringes of the biosphere for man-animal buffer zone interaction.

2. Vegetation types such as alpine pastures, sub-alpine conifer-rhododendron forests, cool temperate broad leaf forest, warm temperate broad leaf forest have been

identified for detailed work. Grazing impact assessment has been planned for buffer zone locations.

3.4. ECOLOGICAL ECONOMICS AND ENVIRONMENTAL IMPACT ANALYSIS

3.4.1. Carrying Capacity Assessment of Kullu Manali Complex : A study of Tourism Sector

Background

This study was initiated in 1993-94, keeping in view the inputs to tourism planning in the area. In the first phase, an assessment with respect to tourism accommodation were7 carried out at Kullu and Manali. Also the tourist flows and use of various modes of transport were documented. It was noted that Kullu Valley is facing various infrastructural constraints. Major ones being solid waste management and architectural and landuse control over hotel construction. During 1995-96, recommendations for Kullu Dussehra were finalized and submitted to District Administration. In Mohal, solid waste sampling and perception study surveys was carried out largely to access women's perception about their wastes and their willingness to participate in the process of management.

Objectives

1. To carry out survey with greater emphasis on the views of women to ascertain their perceptions on wastes and level of participation in its management at Mohal (Kullu).

2. To estimate quantity of solid wastes and its characteristics.

3. To initiate waste management activities in Manali.

Results and Achievements

1. Kullu Dussehra is an important tourist event in Kullu valley during which local infrastructures and amenities are needed considerably to meet the requirement of increased number of festivities and tourists and are put to test. The study was conducted at two periods, i.e., in 1994 and 1998 with a gap of five years in order to trace the nature of change in the composition and management of solid wastes. The Dussehra festival is celebrated in the Dhalpur ground with an area of 1.5 km^2 for seven days in the month of October every year. The comparative data showed that about 74 and 43 metric tonnes of solid wastes from Dhalpur ground were dumped close to river Beas and its tributary- Sarwari in 1994 and 1998, respectively.

2. The proportion of Readily Biodegradable Wastes (RBW), mainly comprising edibles which decompose rapidly, has declined from 72% in1994 to 53% in 1998 (Figure 8). Biodegradable wastes (BW), also prone to bacterial action like RBW, take relatively more time for decomposition of than RBW. They comprise, primarily, paper, cloth, *etc*. BW, unlike RBW, increased in proportion from 11% in 1994 to 28% in 1998. This increase in BW category was probably due to increase in paper wastes. Non-biodegradable wastes (NBW) do not biodegrade under normal conditions and , therefore, are of more concern. It is contending that, proportion of NBW remained almost same, i.e., 17% and 19.4% in 1994 and 1998, respectively. Overall waste generation in 1998 decreased by weight but increased by volume due to papers.

3. Open air defecation, a common practice, was being practised by nearly 72% of the individuals in both the years (Figure 9). Nearly 35% visitors in 1998 and 58% in 1994 stated water supply as a problem. Management of solid waste continued to be perceived as a problem by the visitors. Electricity supply was found satisfactory by 62.2% and 78.4% of the visitors in 1994 and 1998, respectively. The visitors opined hat overall infrastructure situation has improved to certain extent.

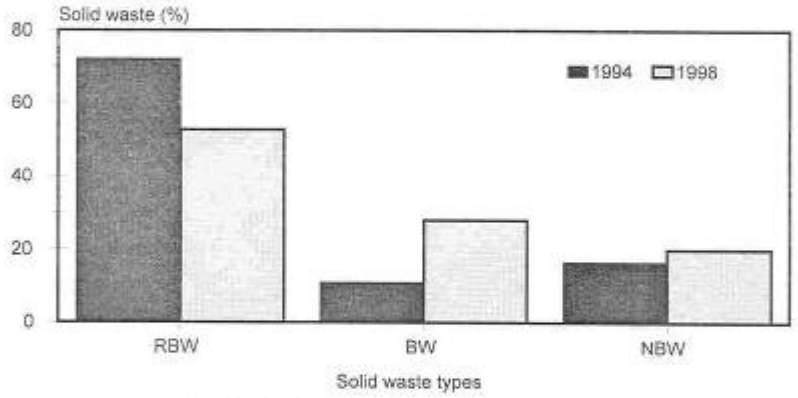

Figure 8. Solid waste characterisation change during Kullu Dussehra

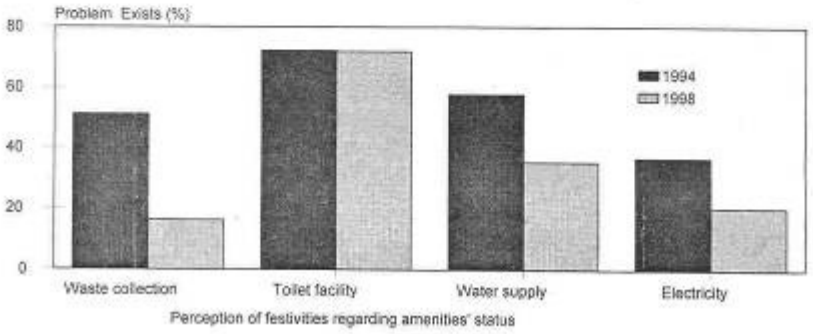

Figure 9. Change in available amenities during Kullu Dussehra

4. Top priority, as assessed, is to increase the number of toilets with assured water supply. It is also recommended that that segregation of wastes may be attempted by placing three separate bins for RBW, BW and NBW at the source of wastes generation. Appropriate biocomposting and/or biogas options for bio-degradables and reuse and recycling options for non bio-degradable need to be promoted.

3.4.2. Ambient Air Quality Monitoring in Kullu Valley

Background

Initially, a project on bio-geochemical cycles was conceptualized in collaboration with Indian Institute of Tropical Meteorology, Pune to study interaction in biochemical cycles in Himalayan ecosystem. As it comprises of ambient air quality monitoring, revised title is more representative of the work. The present area of study namely Kullu Valley is an important tourist destination in western Himalaya. It has experienced tremendous growth in tourism over past five years. The valley is a 100 km. long stretcing from Aut (south) near Pandoh dam upto Rohtang Pass (north).

Objectives

1. Assessment of background concentrations of air pollutants.

2. Atmospheric chemical transformations in the Himalayan Eco-systems.

Results and Achievements

1. Total suspended particulate (TSP) at Mohal during May 1998 (171.8 $\mu g/m^3$) crossed pristine level (i.e., 100 $\mu g/m^3$). The same trend was observed in April and December at Mohal. At Manali, May, November and December showed 150.1, 113.5 and 150.75 $\mu g/m^3$ TSP, respectively. High concentration during these months at both the locations may be due to increased tourism activities, soil erosion and biomass burning in the region. The TSP in October was 90.35 $\mu g/m^3$ and 151.7 $\mu g/m^3$ at Kullu and Manali, respectively. During June and July, the peak tourist season in entire Kullu valley, TSP was in moderate level at Mohal. However, during June at Palchan (Manali), TSP values crossed again pristine level showing 135.1$\mu g/m^3$. The same trend was observed in August and July. Low concentration during monsoon season, was because of washout effects. In essence, concentration of TSP is steadily increasing in the region.

2. Aitken Nuclei were recorded 3.20 (5 a.m.) to 9.18 $Nx10^3/cm^3$ (2 p.m.) at Mohal and 1.8 (4 a.m.) to 4.92 (1 p.m.) at Manali. The photochemical reactions of gas-to-particle conversion and biomass burning might be the reasons for steady increase of Aitken Nuclei around noon and evening. Mass size distribution of aerosol at Mohal also depicted that 5.80 μm diameter was occupying 16.32% concentration compared to 6.62% at 0.65 and 0.43 μm diameter of aerosol. There is a marginal increase of fine size particles and marginal decrease of coarse size particle from the previous years indicating that man made activities are increasing in the region.

3. Among average trace gases, NO_2 was 4.10 and 4.50 $\mu g/m^3$ in between 1800-2100 hrs during a day in May; NH_3 was 1.20 and 48 $\mu g/m^3$ and oxidant was 40 and 45 $\mu g/m^3$ in between 1200-1500 hrs at Mohal and Kullu respectively. Diurnal variation of surface ozone during May 1998 was detected 15 and 41.4 ppb at 4 a.m. and 4 p.m at Mohal.

These values remained 15.5 and 44 ppb at 4 a.m. and 5 p.m. at Manali.

3.4.3. An Empirical Study of Development of Tribal Communities from Eco-cultural Perspectives: A Study in the Central Himalayan Region of India

Background

Starting with the post independence era, planning and efforts for the development of tribal people of India have been accelerated and a number of intervention packages have been designed and implemented. However, It is felt that, though, the interlinks of community resources with socio-economics, culture, and environment have been recognized, they have not been articulated in terms of clear policies & programmes. The traditional tribal culture - political, organizational & societal - and their intricacies in the process of resource management & tribal perception of development have been ignored by attempting to achieve development by drawing replications from external reasoning. This study was carried out in the central Himalayan region of India covering two tribal communities viz., the Jaunsaries & the Bhotias, in order to understand integrated nature of tribal culture & its influences on resource use & management, tribals' perception of development, linkages between culture & development, impact of planned interventions, etc. In the previous issues we have discussed the demographic, socio-economic and impact of development interventions on the these two tribes. This issue focuses on peoples' perception of development.

Objectives

1. To study the integrated nature of tribal culture & its influences on resource use & management,
2. To understand the concept development from tribals' perception,
3. To trace the linkages between culture & development,
4. To identify markers for sustainable development and nature of variation of these markers in different tribal communities and thereby to trace the differential development, and
5. To quantify the degree of diffusion of development interventions and their impact on important demographic variables and community culture.
6. The study, in brief, aimed at addressing the imaginary & realistic goals of sustainable development, i.e., is sustainable development in tribal areas merely a subject of argument or an objective to achieve?

Results and Achievements

1. Emphasising on the actual perception, understanding and requirements of the studied tribes, certain facts and figures are represented here as such so as to project an useful image. In order to understand the perception of development of both Jaunsaries & Bhotias, the word development was not used; rather more realistic and need-based analysis of their total requirements was done from the perspectives of infrastructure, economy & culture with due regards to life process, resource base and eco-cultural adaptation.
2. Infrastructure : The perception of the studied communities has been found to have direct bearing on the immediate nature, resource use pattern and socio-cultural factors. It is quite interesting to note that due to extreme

remote settlements and high rate of literacy and employment among the Bhotias, they had perceived that road leads to all other developmental activities, and more than 80.0 per cent of them regarded road as their first priority of development. On the other hand, a majority of Jaunsari villages were already connected with road or were very close to road head. About 85 per cent of them had regarded school as their first priority of development. Though, both held hospital next to road and school in terms of their priority, about 30 per cent of Bhotia respondents regarded hospital as their third priority against 18 per cent of Jaunsaries. The other indicators of development such as portable water supply, electricity, veterinary hospital and small scale industry had got less than 20 per cent of response in both the communities. It was worth mentioning that the order of priorities accorded by both tribal communities in infrastructural facilities were based on their immediate felt needs rather than any influence. Therefore, these infrastructures are the markers of development for the two tribal groups. Illiteracy has been perceived as the major cause for the snail-paced rate of development by both the communities. Bhotias, do also, alleged lack of agriculture as the other inhibiting factor for their development (Table 20).

3. Economy : It was interesting to note that infrastructural development was given precedence over economic development by both the communities as about 60 per cent of Jaunsaries and 50 per cent of Bhotias had opted in this direction. The perception about the potential scope of income generation was so good and practical that they suited maximum to environmental & social conditions. Potato cultivation was identified by them as a potential production system. In addition, the Bhotias had identified animal husbandry, cottage and woollen industry as other potential avenues of income generation which appeared to be conditioned by availability of grazing resources and suitability of climatic conditions. The Jaunsaries had identified apple, ginger, peas, soya bean and french bean as other potential cash crops. Some of the major priorities for farm input as identified by both the communities ware the availability of HYV seeds, fertilizers, irrigation and marketing facilities.

4. Social : The process of social transformation had been more rapid in case of the Bhotias than the Jaunsaries. This was due to their enterprising nature, i.e., upward looking attitude & mobility to flourish their traditional trade, that facilitated exposure to education and employment. Contrary to the Bhotias, the Jaunsaries remained more traditional & conservative due to their way of life which was highly loaded with conservative cultural traits like polyandry, belief & superstition. They remained educationally backward than the Bhotias. It was interesting to note that the Bhotias, despite being very open to change, had retained their traditional form of medication and still depended on it, while Jaunsaries had lost its traditional form of health care and depended more on government aided allopathic treatment. Bhotias were convinced that out migration can not be stopped. The felt that better opportunities of job, living conditions, business and education would always result in out migration. But Jaunsaries felt that local facilities, local employment opportunities and more education could reduce out migration. Both the communities strongly felt about goodness of their culture

5. Political : In both the communities, the village council played an important role in the socio-economic and cultural life. The participation of villagers in the village council affairs, and the acceptance of its decision was reflected in their preference as more than 67.0 and 40.0 per cents of the Bhotias & the Jaunsaries, respectively, opted to settle the conflicts by it. The desire to become member of village council in both the communities was almost same; nearly 42.0 per cent of total respondents in both communities showed their willingness to become member of the village council. Thus, inspite of the desires of both communities to bring the infrastructural and economic change, they had shown strong faith and satisfaction in their traditional village council rather than government sponsored village council.

Table 20. Perception Regarding State of Development

	Jaunsari	Bhotia
Neglected by Government	10.3	14.5
Lack of Agricultural Development	11.0	20.0
Illiteracy	22.7	26.7
Lack of Employment	10.6	6.7
Lack of Awareness	7.5	13
Others	7.1	5
Don't Know	30.8	14.1

Source: Primary Survey, 1995-98

3.4.4. The Socio-economic and Development Problems and Prospects of Raji (Van Rawats) Tribe of Central Himalaya.

Background

The Rajis, socially and economically, are the most under-developed tribal community of the Central Himalayan region of India. They were recognized as a scheduled tribe in 1967 and subsequently as a primitive tribe in 1975. They are also described as Van Rawats (king of forest), Van Raji (royal people of forest) or Van Manush (wild man or man of forest). They are a primitive and numerically very small tribal community with a population of about 500 only. The tribe is in a phase of transition undergoing structural changes in the spheres of culture, tradition and livelihood patterns including property rights. Under the influence of development initiatives, the tribe is gradually changing from nomadic to agriculturist. However, the tribe appears to be in peril and seized within, as its population continues to decline. .The most critical issue of this tribe is the problem of its declining growth rate as it is presently facing the grave concern of depopulation, apart from its socio-economic backwardness and primitive way of life. In an effort to understand the reasons for the depopulation of the tribe, the Institute has undertaken a study focusing on socio-economic realities, demographic issues and developmental problems.

Objectives

1. To have a true census of the population and to understand he demographic behaviour of the tribe.

2. To find the socio-economic realities.

3. To quantify the level of changes/impact that have occurred under developmental and technological interventions.

Results and Achievements

1. Before three to four decades, the Rajis were totally nomads pursuing a life of hunter gatherers taking shelter in caves or temporary huts. The traditional economy of the Rajis was primarily built around the forests. Abrogation of the forests and their resources under systematic management of the state has been the prime factor forcing this nomadic tribe to change its lifestyle. Traditional forest rights of the Rajis which were considered as `rights and privileges' in the Forest Act of 1894 of India became `rights and concessions' in the Forest Act of 1952.

2. All the households are marginal landholders having less than 1 ha of cultivated land. About 12.07 per cent of the families are landless, 37.93 per cent have less than 0.1 ha of land, 20.69 per cent have less than 0.2 ha of land and rest 29.31 per cent of families have more than 0.2 ha of land but less than 1 ha. Their livelihood is more dependent on earning from daily wage labour and forest produce than agriculture. The average annual income per family was estimated to be Rs. 6188. All most all the families were below poverty line taking into account the India Government's consideration of a family with less than Rs. 11000/ per annum below poverty line which was based on price index of 1992.

3. The major problems of the tribe, identified by this study, are: depopulation; high rate of infant and child mortality; acute sex ratio; dwindling economy and food insecurity; lack of cultivated land; lack of will power in the government machinery to allot land to the families of the tribe; lack of avenues for occupational diversification and employment;); extensive dependency on forest and forest produces; disappearance of art and craft and disintegration of culture; indebtedness and exploitation by money lenders; lack of basic social and physical infrastructure, i.e., medical facility, drinking water, educational infrastructure, housing, etc. (Social inrastructure) and transportation, communication, electrification, etc. (Physical infrastructure lack of awareness of education and non-willingness to learn; lack of awareness of developmental privilege; apathy of development agents with target oriented development efforts that lack focus; persistence of superstitious attitude;

4. From 1969 to 1981 the annual growth rate of the tribe was 3.88 which declined to 3.31 during 1981-1991 and further declined to 1.24 from 1991-1996. Interestingly, the decline growth rate was in contrast to the high fertility behaviour of the tribe. Crude birth rate of the tribe was 49.42 against India's 30.5, Crude death rate of the tribe is 24 against India's 10.2 and infant mortality rate (IMR) for the tribe was 192 against India's 91.

5. Reviewing the policies and programs undertaken during various Plans, it is concluded that efforts so far made for social and economic development of the tribe did not bring about appreciable changes in their livelihood. The plan programs largely failed to take into account the actual needs of this tribal people who are at lowest socio-economic level of development. Co-operatives could not eliminate saukars (money lenders) from this tribal society. The major bottlenecks in the program

implementation were lack of political will among the decision makers, leakage at the level of functionary, lack of inter-departmental co-ordination and lack of committed personnel. It was felt that to ensure a balanced economic development of the tribe, a different approach would be necessary in the forthcoming development initiatives.

3.4.5. Solid Waste Management in and around the Pindari Valley

Please see section on quick appraisal studies

3.5. ENVIRONMENTAL PHYSIOLOGY & BIOTECHNOLOGY

3.5.1 Rhizosphere microbiology of Himalayan plants

Background

Plant growth promoting rhizobacteria improve plant growth by colonizing the root/system. The beneficial effects on plant growth due to inoculation of these bacteria have been reported through various mechanisms viz. (1) biological nitrogen fixation, (2) production of antibiotics and siderophores, (3) secretion of growth promoting substances including phytohormones, and (4) solubilization of rock phosphates. The bacteria and blue green algae are capable of fixing nitrogen from atmosphere and are therefore applied as source of fixed nitrogen. The mycorrhizae can solubilize the rock phosphate and thus make available to the plants usable phosphorus. Most studies on the rhizosphere have been carried out on short duration plant species. The microbial community in an established tree rhizosphere should be more specific owing to the prolonged length of time occupied by the plant species, and due to the interaction amongst various microbial communities. Therefore, identification of existing microbial communities in soil, studying plant-microbe and microbe-microbe interactions, and isolation and selection of beneficial microbes would be highly relevant. The selected beneficial isolates can be developed as inoculants for better plant performance at higher elevations.

Objectives

1. Isolation and selection of plant growth promoting bacteria.
2. Studies on rhizoflora associated with conifers.
3. Selection of phosphate solubilizing microorganisms and mycorrhizae in conifers.
4. Microbial interactions in tea rhizosphere.
5. Maintenance of useful microbial cultures of Himalayan region.

Results and Achievements

1. Studies in relation to tea rhizosphere are being conducted. A number of bacteria have been selected and are being developed as inoculants. The selection of inoculants is basically based on the (a) plant growth promotor, and (b) biocontrol properties. The inoculation experiments have been carried out using seed raised, cutting raised and tissue culture raised plants. Encouraging results are being recorded.
2. Inoculation experiments using pure microbial cultures as well as rhizosphere soil are being carried out in three conifers, namely *Pinus*, *Cedrus* and *Taxus*. Improvement in percent seed germination

and subsequent growth is being recorded. Use of antagonistic microorganisms resulted in control of various root associated pathogens.

3. Microbial isolations have been carried out from various altitudes (ranging from 1000 to 3500 m amsl). This study also includes rhizosphere soil samples of nine plant species. The major objectives of the study are: (a) to understand the microbial diversity along an altitudinal gradient, (b) to work out the rhizosphere effect created by the various tree species of Himalayan region, and (c) to study the microbe-microbe and plant-microbe interactions.

4. Microorganisms obtained from all the experiments are being maintained using appropriate methods.

3.5.2. Large scale propagation of location specific elite plants using conventional and biotechnological methods

Background

There has always been a need to undertake studies for development of methods for large scale propagation of location specific elite plants. One of the major constraints in undertaking large scale plantation work with regard to rehabilitation of degraded/waste land, afforestation programmes and introduction of high value plants is the lack of sufficient quantities of good quality planting material. In view of the above, a study has been initiated to address the above question. For this, conventional methods of seed germination (and overcoming the problems of poor viability, dormancy, etc.), vegetative/clonal propagation are equally important, and can be supplemented by the development of newer technology of plant tissue culture for target taxa of each region.

Objectives

1. To identify physical and chemical treatments, including plant growth regulators, for successful rooting of cuttings and to standardize techniques for large scale applications.

2. Developing *in vitro* protocols for selected plant species.

3. Conservation of endangered/ threatened species.

4. To understand the problem of seed germination in selected forest species.

Results and Achievements

1. A complete protocol for rooting of microshoots of *Rosa damascena* has been developed and the rooted plants have been successfully transferred to pots following hardening.

2. The effect of gelling agents (phytagel and agar) and light source on the growth and multiplication of the cultures of *R. damascena, Rhynchostalis retusa* and *Gladiolus* spp. indicated better growth on media containing phytagel and cultures kept under PAR lights.

3. *In vitro* protocol for mass scale propagation has been developed for *Thamnocalamus spathiflorus*, an evergreen temperate bamboo. Multiple shoot formation was optimized on MS medium supplemented with 5 uM BAP and 1.0 uM IBA by using germinating excised embryos. About 90%

explants proliferated in this medium producing an average of 30 shoots per explant in 8 weeks; the clumps of microshoots (Figure 10) could be subsequently rooted on plant growth regulator medium. Almost 100% rooting was recorded with an average of 4-5 roots per plant. Such well rooted plants have been successfully transferred to soil and their survival has been satisfactory.

Figure 10. Multiple shoot formation in *Thamnocalamus spathiflorus*.

4. To identify elite and suitable clones for propagation, samples of *Taxus baccata* subsp. *wallichiana* and *P. hexandrum* collected from various locations/populations are being evaluated for active ingredient content.

5. Attempts are in progress to standardize micropropagation protocols for *Aconitum balfourii*, *A. heterophyllum* and *Taxus baccata* subsp. *wallichiana*. Multiple shoot formation was achieved in *A. balfourii* in MS medium supplemented with BAP; these shoots were subsequently rooted and transferred to pots. Efforts are continuing to obtain differentiation in callus cultures (obtained earlier) of *T. baccata* and *A. heterophyllum* by using various hormonal combinations.

3.5.3. Impact of stress and environmental changes on growth performance of plants

Background

A large number of environmental factors influence growth and development of plants. Rising concentration of atmospheric CO_2 has become a serious global problem, because in addition to its effect on growth, physiology and photosynthesis of plants CO_2 is the most important greenhouse gas that contributes to planet's warming, which is predicted to be greater than at anytime in the last 100,000 years. This could have major habitat implications for animal and plant species, including those of Himalayan region, sensitive to even relatively small changes in temperature. Therefore, a knowledge of plant responses to increased CO_2 concentration may be useful to predict which plants or group of plants will benefit more from increased CO_2, stress and other environmental changes.

Objectives

1. Short-term effect of rising CO_2 concentration on physiological attributes of plants.

2. Combined effect of rising CO_2 and other environmental factors on photosynthetic characteristics of plants.

Results and Achievements

1. Comparison of photosynthesis and other related data for three different plant species from each vegetational zones, namely tropical, temperate and alpine reveal not

only differential responses of various vegetational types to elevated CO_2 and temperature but also existence of considerable variation in responses among the species from the same vegetational zone (Table 21).

Table 21. Increase and/or decrease (%) in photosynthesis and related parameters under elevated CO_2 (averaged across all temperature and light levels) in three vegetational zones. Each value represents mean (± SD) of three plant species with 3 or 4 replicates per plant species.

Vegetational zone	Photosynthesis	Stomatal conductance	Transpiration	Water use efficiency
Tropical	42.82±7.03	-67.71±10.34	-33.97±11.79	91.5±10.11
Temperate	45.07±26.21	-25.04±2.80	-36.71±9.93	90.29±46.85
Alpine	29.16±8.26	-15.37±7.58	-15.93±1.06	55.57±21.78

2. Though there were no considerable differences in the photosynthetic response of tropical and temperate plants, variation in photosynthesis was maximum in temperate species. A similar trend was also observed for their water use efficiency.
3. Tropical plants exhibited maximum reduction in stomatal conductance than temperate and alpine plant species, however, the latter showed highest variation.
4. Both tropical and temperate plant species exhibited almost similar reduction in transpirational water loss but variation was maximum for tropical plants.
5. Overall increase and/or decrease in photosynthesis and related parameters was surprisingly lower in alpine plants.

3.5.4 Study of plant performance, ecology and interaction in the Himalayan region

Background

Due to dramatic differences in elevation (within a map distance of 100-200 km), climate, physiography and soil, the Himalaya harbours, perhaps the premier vegetational gradient on the earth and is considered world's largest plant diversity centre. This plant diversity is critical to the survival of human being and exists at the level of an individual, population, community and ecosystem. Increased biotic pressure (mainly in terms of logging, crown removal and root harvesting) has caused either threatening of the survival/existence or extinction of various plant species. Further, severe exploitation of one species may affect the growth and development of other species by affecting specific microsite and ecological niche of that species. Therefore, there is an urgent need to undertake studies on performance, ecology, canopy loss and interactions of various plant species in the Himalayan region.

Objectives

1. To study the role of rural biotechnology for sustainable use of various plant species.
2. To determine physiological processes and their effect on productivity at community level.

3. To study plant soil interactions and role of fire in ecosystem processes.

4. Recruitment and plant behaviour in nature and/or modified environment.

5. To explore the relationship between forests and agricultural productivity.

Results and Achievements

Amongst various high value medicinal plants of the Himalayan region *Taxus baccata* L. subsp. *wallichiana* (Zucc.) Pilger (the only *Taxus* species in India) has gained considerable importance due its uncontrolled harvesting from the Himalayan wilds for the extraction of anticancer drug taxol® (Paclitaxel). In view of its importance a study has been undertaken to analyse seedling growth and biomass in relation to age, and recruitment of seedlings.

1. Age of the seedlings was positively related to various studied parameters like shoot height, shoot diameter, leaf number, total leaf area and root length.

2. Total seedling height was minimum for 1 yr old seedlings and maximum for 10 yr old seedlings.

3. Total seedling biomass ranged from 0.06 g/seedling for 1 yr old to 14.42 g/seedling for 10 yr old seedlings.

4. Various leaf characteristics (e.g. area, length, weight and chlorophyll) were found significantly lower for 1-5 yr old seedlings as compared to 6-10 yr old seedlings.

5. The age structure (based on data from 9.54 ha area) of seedlings indicates a general decline in the number of seedlings with increasing age (Figure 11).

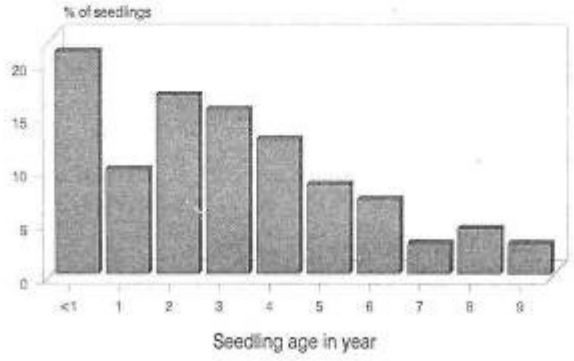

Figure11. Distribution of Taxus baccatasp wallichiana seedlings different age classes

3.5.5. Network programme for mass propagation and improvement of tree species of the Himalayan region

Background

Based on the recommendations of a Brain Storming Session held in the Department of Biotechnology in December, 1992 a net work programme for improvement and mass propagation of Himalayan tree species has been initiated, using a multidisciplinary approach. It envisaged that core facilities will be developed by making use of both conventional and biotechnological approaches.

Objectives

1. To develop practicable methods for mass propagation of selected tree species, using tissue culture and conventional methods.

2. Large scale propagation of selected plants for which tissue culture protocols have been developed.

3. Studies in tree seed biology in relation to seed maturation, viability/storage, seed germination and seedling establishments.

4. To impart training to interested persons from the Himalayan region.

Results and Achievements

1. Complete protocol has been developed for *in vitro* propagation of mature and elite plants of maggar bamboo (*Dendrocalamus hamoltonii*).

2. High frequency and reproducible somatic embryogenesis achieved in tea and *Quercus*.

3. *In vitro* raised plants of tea, maggar bamboo and oak have been transferred to field conditions with satisfactory survival.

4. Encapsulation of somatic embryos into synthetic seeds has been standardized for tea and maggar bamboo; conditions being optimized for improving germination.

5. Work on the expression of proteins specific to somatic embryogenesis and *in vitro* rooting of microshoots have resulted in the identification of few protein bands expressed specifically during these morphogenetic events in cultures of tea.

6. Two strains of *Agrobacterium rhizogenes* (R-1000 & MTCC 2364) were tested in cuttings of poplar for the induction of roots. These strains are being tested in *Quercus* spp. and *Cedrus* also.

7. A number of beneficial micro-organisms (mycorrhizae, *Trichoderma* sp. and various rhizobacteria) are being used as seed inoculants for biocontrol and growth promotion in *Cedrus deodara*. Major causes of seedling mortality were found to be (a) fungal infection and (b) cut worms. While all the inoculants resulted in growth promotion over control, bacterial inoculations gave promising results in terms of disease control.

8. Bacteria associated with tea rhizosphere, have been selected for inoculations in tissue culture raised and seed raised tea plants. In case of tissue culture raised tea plants bacteria provide protection against various soil fungi during their lab to land transfer. In case of seed raised plants, the bacterial inoculations benefit the plants in terms of significant growth promotion over control.

3.5.6. Seedling development and subsequent growth in relation to cotydedonary senescence in two alpine rosettes

Background

Two herbaceous dicots, namely *Podophyllum hexandrum* Royle (Podophyllaceae) and *Aconitum heterophylum* Wall (Ranunculaceae) which grows in the Himalyan alpine and sub-alpines, are of tremendous medicinal and export value, and are presently endangered. Although these plants perennate through underground parts (containing active principles of medicinal value), the period of active growth is confined only to a few summer months. In view of the medicinal importance and commercial relevance of these plants, it would be appropriate to estimate the endogenous plant growth substances in seeds, cotyledons and to experimentally influence seed germination and stimulate seedling growth.

Objectives

1. To initiate growth of plumule in the 1 year itself by chemical means in order to hasten the growing cycle.

2. Comparisons to be made with another species of *Aconitum*, namely *A. balfourii* where inhibitory influence of the cotyledon is not present.

3. To influence seed germination by chemical means.

(Summary of completed project)

Viability test indicated that seeds of *Podophyllum hexandrum*, *Aconitum hetrophyllum* and *Aconitum balfourii* may not remain viable for extended periods (up to 12 months) even following storage at 4° C. Under natural conditions the seeds experience sub-zero temperatures and freezing conditions and therefore, low seed viability may be one of the reasons for poor germination in nature. In order to understand the hormonal (endogenous) basis of cotyledonary control of development of the apical meristem, seeds and cotyledons of *P. hexandrum* have been analysed for plant growth substance levels. Bioassay results indicated some activity. Furthermore, to examine the inhibitory role of cotyledons and subsequent leaf emergence, cotyledons were excised from seedlings and external application of some plant growth substances at cut ends resulted in growth of the plumule. In order to influence germination, presoaking treatement of seeds of all the 3 target species with various chemicals resulted in enhanced and better germination in some treatments. Germination was significantly improved in *P. hexandrum* following treatment with 250 uM GA_3 (54% compared to 30% in control). GA_3 (250 uM) and BAP (250 uM) were found to enhance germination in *A. balfourii* and *A. heterophyllum*, respectively. It is interesting to observe that two nitrogenous compounds, namely thiourea and KNO_3 markedly enhanced germination (70 and 80%, respectively, compared to 27.5% in control) in *A. balfourii*; in *A. heterophyllum* only thiourea was effective although to a lesser extent while KNO_3 was ineffective. All these treatments have been found also to advance the time of germination in all the 3 species. The results of this study do imply that presoaking treatment of seeds could be exploited for application at commercial scale following trials. Further, seed germination and subsequent seedling establishment have a hormonal control (Supported by DST).

3.5.7. Effects of N_2-fixing *Alnus* on the mechanisms of accelerated phosphorus cycling in large cardamom agroforestry in the Sikkim Himalaya

Background

Mixtures of N_2-fixing and non-N_2-fixing species differ from other sets of species by the direct and indirect effects of increased nitrogen supply. Nitrogen cycling in such stands have been observed to accelerate which is attributed to nitrogen fixation. The rates of phosphorus have also been shown to increase under the influence of N_2-fixing species, however there is no understanding on the mechanisms that give rise to greater availability and accelerated phosphorus cycling. The project envisages to fill the above gap. The work emphasizes to test the following 2 hypotheses related to the mechanisms on ecosystem biogeochemistry as an effect of N_2-fixing species: (1) increased availability, and cycling of phosphorus under the influence of *Alnus* may cause a shift from sparingly available geochemical pools to rapidly cycling organic phosphorus pool, and (2) soil acidification due to rapid accumulation of nutrient cations in biomass may cause soil exchange complex to become more dominated by H^+. Nitrate leaching may also cause accumulation of H^+ in the soil. These hypotheses will be tested in large cardamom based agroforestry system where N_2-fixing *Alnus nepalensis* is extensively planted as associate shade tree. *Alnus* has a symbiosis with *Frankia* and is efficient in N_2-fixation. Large cardamom (*Amomum subulatum*) is the most important perennial cash crop of the Sikkim Himalayan region. The capsule (fruit) of the cardamom is used as a spice-condiment. It is cultivated usually on steep hill slopes under tree cover either in natural forest or plantation that forms a traditional agroforestry system in the region.

Objectives

The main objective of the project is to know the effects of N_2-fixing species on biogeochemical influences with particular reference to phosphorus at the ecosystem level. *Alnus-Amomum* agroforestry system in Sikkim will be investigated for the following specific objectives

1. To estimate the shift of sparingly available geochemical pools to rapidly cycling organic pools of phosphorus under the influence of *Alnus*.

2. To characterize the major pools of phosphorus and examine the processes involved in the rate of release of phosphorus from the above pools.

3. To quantify the level and causes of soil acidification in *Alnus-Amomum* plantations, and to correlate with phosphorus availability.

Results and Achievements

1. Three different stands with plantation treatments such as (a) *Amomum* and N_2-fixing tree mixed (b) *Amomum* and non N_2-fixing tree mixed and (c) N_2-fixing *Alnus* pure selected at three different locations namely, (i) Kabi, North Sikkim, (ii) Central Pandem, East Sikkim, and (iii) Pangthang, East Sikkim were investigated for soil nutrients on seasonal basis.

2. Soil pH, organic carbon, total nitrogen, total phosphorus and available phosphorus were estimated seasonally at two soil depths viz., 0-15 and 15-30 cm. Soil pH varied significantly between stands, seasons and depth. *Alnus*-cardamom stand was more

acidic than *Alnus* pure and mixed species-cardamom stand showed relatively higher pH. Organic carbon, total nitrogen and total phosphorus also varied significantly between stands, seasons and depth, and these parameters were always higher in mixed species-cardamom stand. However available phosphorus showed a different trend which was higher in all seasons and depths at *Alnus*-cardamom stand followed by *Alnus* pure stand and least in mixed species-cardamom stand clearly showing that *Alnus* solubilize phosphorus. Available phosphorus varied significantly between stands, seasons and depths, and there was significant interaction between stand, depth and season.

3. Organic carbon, oxalate, microbial-P and available-P were estimated in bulk soil, *Alnus* young rhizosphere, *Alnus* medium rhizosphere, *Alnus* old rhizosphere, *Alnus*-cardamom rhizosphere, cardamom rhizosphere and mixed tree species rhizosphere of *Alnus*, mixed tree species and cardamom based agroforestry systems. These estimates were done on seasonal basis. Oxalates were higher in *Alnus* medium rhizosphere, *Alnus* old rhizosphere and *Alnus*-cardamom rhizosphere, whereas microbial biomass was higher in *Alnus* and cardamom stands except for old *Alnus* rhizosphere. Available-P in *Alnus* and cardamom rhizosphere were much lower compared to bulk and mixed species cardamom rhizosphere soils indicating uptake of solubilize phosphorus.

4. Bulk and rhizospheric fractionated phosphorus under *Alnus*, mixed tree species and cardamom in large cardamom based agroforestry systems varied significantly while soil pH did not show any significant differences.

5. Phosphatase and phytase activity estimation of soil organic matter has been standardized. Shift of inorganic soil-P to rapidly available organic pool is under process of estimation.

3.5.8. Farmer Centered Agricultural Resource Management (FARM) Programme: Khulgad Watershed (Mountain site in India)

Background

The Himalaya constitute a unique geographical and geological entity comprising a diverse social, cultural, agro-economic and environmental setup. Like in other parts of the Himalayan region majority of population (about 70%) of U.P. Himalaya is engaged in agricultural and allied activities. However, due to limited irrigation, marginal and scattered landholdings, lack of technical know-how, lower crop productivity, etc. agriculture does not provide income generating opportunity to the farmers. As a result substantial number of able bodied men migrate to other parts of the country in the lookout for employment opportunities. In the above context, the work was sponsored by Soil Conservation section of the *Krishi Nideshalaya* for Hill through the Soil Conservation Department Almora, under the Farmer Centered Agricultural Resource Management (FARM) Programme of FAO through the Ministry of Agriculture, Govt of India for developing a sustainable and realistic, eco-friendly alternate model for sustainable development of the region.

Objectives

1. To demonstrate simple, cheap and replicable technologies in the watershed

2. To improve the quality of life of the people living in the area through efficient management of resources and to sustain optimum yield over a period of time

3. Documentation of the existing germplasm and conservation practices.

Results and Achievements

1. Based on the topography, soil fertility status, crop production, demands of the local people, various simple, cheap and replicable technologies were demonstrated in the farmers field; these are two bio-composting pits were set up in the farmers fields and their values were explained. The bio-composting helps to maintain soil fertility and improves the physical properties of soil. Through this simple technology, both the composting period as well as loss of nutrients (as in the case of traditional FYM) can be reduced considerably. Similarly, for preparation of traditional FYM the same technology can be used by the farmer, and the composting period and loss of nutrients can be reduced by simply dumping the material inside a pit and covering it with a polythene sheet.

2. Due to severe winters and prevailing frost very low productivity of vegetables has been reported in the hills. Due to low temperature and frost, there is a delay in germination and subsequent growth resulting in high mortality and poor plant quality causing overall low productivity. However, these problems can be overcome by setting up of low cost polypits and polyhouses. This is because the temperature and humidity inside these structures are generally much higher compared to outside (ambient conditions) and also protect plants from frost; the added advantage is CO_2 fertilization effect and much reduced need for watering. In these structures high value vegetables can be produced during the off-season. This method of vegetable cultivation is useful for the poor farmers to improve their nutritional requirements and to boost their economy.

3. Due to a number of biotic and abiotic factors, a major area of the village ecosystem falls under the category of cultivable waste/grazing/barren lands, etc. At present, this area is used for the collection of grass during rains (mid June to September) and for open free livestock grazing during rest of the year. It is clear that this category of land is not being utilized to its full potential for production of optimum biomass. This under utilized land was put to much better use to optimize production, to minimize environmental degradation and at the same time to enhance the economic condition of the inhabitants by application of dry land horticulture, agro-forestry, cash crop plantation, multi-propose tree plantations, silvi- pastrol system, etc.

4. Due to environmental heterogeneity, inaccessibility and other socio-economic factors, the native traditional practices of hill farmers continue to favour high crop diversity to meet their needs and minimise the risk of crop failures. Documentation of the existing germplasm of the area has been completed and a total of 98 plant species have been recorded. On the bases of cultivated area these can be divided into four categories as (a) crop fields, (b) agro-forestry, (c) home garden and (d) other.

5. This model has been designed and developed with the aim of bringing change, over a period of time, leading to improvement in the economic status of the

inhabitants, generation of employment, reduction of environmental degradation and promotion of sustainable use of resources.

3.5.9. Productivity, energetics and maintenance of soil fertility in agroforestry systems of Sikkim

Background

In Sikkim, there are mainly three types of agroforestry systems, i.e. (i) large cardamom based, (ii) mandarin orange based, and (iii) fodder-fuel tree based. Large cardamom (*Amomum subulatum*) is the most important perennial cash crop of the Sikkim Himalayan region that is cultivated in 26000 ha of Sikkim and Darjeeling between 600-2000 m elevation. Out of 23000 ha area of large cardamom cultivation in Sikkim state, 1316 ha of reserve forest is used for under canopy large cardamom cultivation on lease to farmers and remaining area is under private large cardamom based agroforestry. Large cardamom is a low volume, high value and non-perishable crop that is providing ecological and economical benefits to the mountain people in Sikkim. There is no information on large cardamom and *Alnus nepalensis* based agroforestry system with respect to aging of both cardamom and *Alnus*. Therefore, this study was planned to see the influence of both *Alnus* and cardamom age on the crop yield, biomass productivity and nutrient dynamics to examine the sustainability of the combination and practice.

Objectives

1. Extensive studies on agronomic yield, biomass, productivity and energetics in age series of 5-, 10-, 15-, 20-, 30- and 40-years of *Alnus*-cardamom plantations.
2. Study of bio-geochemical cycling of nutrients, litter decomposition rates and nutrient release and back translocation in age series of *Alnus*-cardamom plantations.
3. Estimation of N_2-fixation efficiency, nitrogenase activity and nitrogen accretion in *Alnus* (*Frankia* symbiosis) - *Amomum* (cardamom) plantations.
4. Evaluation of the role of N_2-fixing *Alnus* in age series of *Alnus*-cardamom plantations on the maintenance of soil fertility.
5. Estimation of metabolites in large cardamom crop under different levels of *Alnus* shade.

Results and Achievements

1. Three sites namely Thekabong, Kabi and Sumik were selected for site replication. These sites are about 80 km apart from each other but with similar elevational range (1400 to 1600 m). At each of the sites six age group (5-, 10-, 15-, 20-, 30- and 40-year-old *Alnus*-cardamom) stands were selected. Plots measuring 30 x 40 m were marked in each age stand at all sites, and productivity, yield and nutrient study related samplings were carried out within these plots.
2. At all the sites in each age group plots, all the shade trees were marked, their girth at breast height were measured, and cardamom tiller numbers were recorded. Agroforestry floor litter standing state was quantified. Litter samples (*Alnus* leaf, *Alnus* twig, cardamom leaf and cardamom pseudo-stem) were placed in litter-bags and placed in the agroforestry and retrieved samples at 3 and 12 months were analyzed. The percentage of both the nutrients decreased with time interval as evaluated from the zero time.

Estimation of ash content, lignin and ash-free mass of retrieved litter samples are in progress.

3. Total nitrogen estimation in all the seasons in an age series (5-,10-,15-,20-,30- and 40 years of *Alnus*-cardamom agroforestry system) from all the sites and stands were carried out at two different depths. The obtained data shows a consistent decrease of percentage of total nitrogen at lower depths. The estimation of inorganic nitrogen and rate of mineralization was done seasonally.

4. Total phosphorus, organic, inorganic and available phosphorus of soil in three replicate sites with six age groups of *Alnus*-cardamom agroforestry systems was estimated seasonally. The data obtained show a marked difference at two depths. Soil organic carbon in the soil of an age series was estimated seasonally. Soil organic carbon is low at lower depths.

5. Soil pH of all the study sites was also recorded at two depths seasonally which ranged between 3.7 to 5.7 and did not show any significant difference between the depths. Soil moisture decreased in lower depths (15-30 cm) compared to the upper layer (0-15 cm).

6. *In situ* nitrogenase enzyme activity in an age series of *Alnus*-cardamom agroforestry systems was estimated seasonally. Nitrogenase enzyme activity was higher in young nodules and decreased in medium and old nodules, respectively. Nitrogen and phosphorus of young, medium and old nodules of all the age series were also estimated. Nitrogen concentration in the root nodules varied inversely with nodule age and hence inversely related nitrogenase activity.

7. Nutrients (N, P) were estimated in different plant components viz., *Alnus* leaf, twig, branch, bole, branch and roots. Component wise nutrient analysis of cardamom plants was also carried out. Shade effect of *Alnus nepalensis* with age series stands were estimated taking parameters such as total chlorophyll, total protein and total nitrogen content of the large cardamom leaf.

3.5.10. Bioprospecting of biological wealth using biotechnological tools: *Sub programme* - Chromosome fingerprinting and DNA bank-net of Himalayan endangered species

Background

The Department of Biotechnology (DBT) sponsored a multi institutional project on bioprospecting of biological wealth, concerned with application of conventional, molecular and flow cytogenetics approaches to fingerprint chromosomes for systematic, analytical and transparent investment in conservation and sustainable use of biodiversity programmes of high priority endangered species like *Valeriana jatamansi*, *Rheum emodi*, *Gentiana kurroo*, *Coptis teeta*, *Aconitum* species, *Podophyllum hexandrum*, *Polygonatum cirrhifolium*, *Picrorhiza kurrooa*, *Orchis latifolia* and *Thymus serphyllum* of medicinal, aromatic and other values. These investigations will also provide potential guidelines for the concerned species recovery and genetic enhancement programmes. The research work related to molecular aspect is being carried out at Delhi University and is assisted by two satellite units, one in Solan (H.P.) and another at GBPIHED, Kosi- Katarmal, Almora.

Objectives

1. Plant collection, herbariam vouchers, initial field notes and ethnobotanical data.

2. Storage of DNA rich materials.

3. Preliminary cytological studies.

4. Breeding systems and phytochemical work.

Results and Achievements

1. As part of the ongoing programme on germplasm collection, various alpine and subalpine regions of Kumaun and Garhwal Himalaya were surveyed for the collection of plant material(s); material(s) collected is being maintained in the laboratory/nursery/green house. All the target species like *Aconitum* spp., morphological variants of *P. hexandrum, Picrorhiza kurrooa, Nardostachys jatamansi, Valeriana jatamansi, Dactylorhiza hatajirea*, etc. were collected in the form of seeds and tubers.

2. *In vitro* propagation protocols are being developed for large scale multiplication of *P. hexandrum* and *A. balfourii*. In addition to this, multiple shoot formation has been achieved in *P. kurrooa*.

3. When Rhizomes of *P. hexandrum* and tubers of *A. heterophyllum* and *A. balfourii* were treated with various solutions of plant growth substances (PGSs) marked effect on induction of flowering and synchronization of sprouting were observed at lower altitudes. This kind of study can be exploited for breeding programme of rare and endangered medicinal taxa.

4. Basic chromosome counts were made for *P. hexandrum, A. heterophyllum, A. balfourii* and preparation of karyotypes are in progress.

5. The rate of seed germination in *P. kurrooa* was markedly influenced by GA_3 treatment.

6. Podophyllotoxin analysis is under progress for the selection of elite plants from the various populations of Kumaun and Garhwal Himalaya.

3.6. INSTITUTIONAL NETWORKING AND HUMAN INVESTMENT

3.6.1. Integrated Eco-development Research Programme (IERP) in the Himalayan Region

Based on the recommendations of the Project Evaluation Committees (PECs), following 12 projects (four to NGOs, four to Universities and four to Govt. Institutions/Autonomous Organizations) were sanctioned and funded during the year.

1. To increase proficiency in cultivation of medicinal and aromatic plants for ecological sustenance by Dr. S.K. Sharma, Arunodaya Resource Management Foundation (ArmF), Rohit Deep, Saproon, Solan, H.P.

2. *Argeli (Daphne) se hast nirmit kagaz nirman ki yojana* by Mr. P.S. Puspwan, Vihan Gramothan Prashikshan evam Sodh Sansthan, Srinagar, Pauri Garhwal, U.P.

3. Limnological investigations on lake Naukuchiya Tal (Kumaon Himalaya) with reference to its management by Dr. P.K. Gupta, Department of Zoology, DSB

Campus, Kumaun University, Nainital, U.P.

4. Study and cultivation of endangered medicinal plants of Darjeeling Himalayan region by Dr. R.B. Bhujel, Kalimpong College, Darjeeling, W.B.

5. Health status and genetics of the Kuki Hill tribes of Loharbond in Assam by Dr. D. Kar, Conservation Forum, Silchar, Assam.

6. High Altitude plant species response in the Himalayan region to global climatic change by Dr. R.R. Yadav, Birbal Sahni Institute of Palaeobotany, Lucknow, U.P.

7. Phenology of certain ferns in relation to West Himalayan floristic diversity by Dr. N. Punetha, Department of Botany, Govt. P.G. College, Pithoragarh, U.P.

8. Diatom biodiversity in the Himalayan lotic systems by Dr. P. Nautiyal, Department of Zoology, HNB Garhwal University, Srinagar, Pauri Garhwal, U.P.

9. Studies on diversity of wild roses of H.P., their cultivation, conservation and utilization by Dr. D. Dhyani, Institute of Himalayan Bioresource Technology (IHBT), Palampur, H.P.

10. Natural resource management for rehabilitation of degraded lands using Slopping Watershed Environmental Engineering Technology (SWEET) by Dr. S.S. Masand, Department of Soil Science, H.P. Krishi Vishvavidyalaya, Palampur, H.P.

11. Recycling of organic wastes and its utilization in agriculture in Himalchal Pradesh by Dr. (Mrs.) K. Kanwar, Department of Soil Science, H.P. Krishi Vishvavidyalaya - Regional Research Station, Dhaulakuan, Sirmaur, H.P.

12. *Prodhyogiki pradarshan evam prasar pariyojana* by Mr. B.S. Khati, Jai Nanda Utthan Samiti, Bhimtala, Chamoli Garhwal, U.P.

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

1. Twenty six (26) fresh project proposals, which were received for funding during the year, were screened carefully and subsequently processed/referred for preliminary evaluation to the subject experts. Twenty five (25) project proposals were evaluated by the experts during the year.

2. Ninth (IX) PEC meeting was convened at the Headquarters of the Institute (Kosi-Katarmal, Almora) on March 12, 1999 for the finalization of 29 pending project proposals. Seven members attended the meeting. Follow-up action on the decisions of the VIII PEC meeting was completed during the year. Follow-up action on the recommendations of 9th PEC meetings was also initiated during the year.

3. Funds for twenty seven (27) ongoing projects were released during the year after careful examination of the Utilization Certificates and Statement of Expenditures. In addition to this, first instalments of grant of 12 sanctioned projects were also released during the year.

4. Annual Progress Reports (APRs) of twenty seven (27) on-going projects, submitted by the PIs during the year, were processed for evaluation and referred to the subject

experts. The comments of the subject experts as obtained in most of the cases were communicated to the PIs for follow-up action.

5. Final Technical Reports (FTRs) of six (6) projects were received during the year. Subsequently, these reports were mailed to the concerned Departments/Institutions and State Governments etc. for follow-up action/utilization of research findings. The FTRs were also referred to the subject experts for their comments/suggestions.

6. The executive summaries of four (04) completed projects were submitted to the SIC, ENVIS, GBPIHED for the favour of publication in the ENVIS Bulletin of the Institute.

7. The executive summaries of eight (8) completed projects were published by the ENVIS Centre of the Institute in its ENVIS Bulletin. The bulletin was also distributed to the concerned user agencies etc. by the ENVIS Centre of the Institute.

8. Follow-up actions on sixty two (62) project files (old/fresh/on-going etc.) was initiated/completed during the year.

3.6.2. Environmental Awareness Programmes

Environmental awareness on various aspects of the Himalayan environment and development was created among the people /organizations/NGOs during the year by attending various meetings with the people/organizations etc. and also by organizing on-site training programmes on the aspects of farm based techniques, nursery development, tree plantation techniques, and natural resource conservation and management to the farmers, rural women, students, ex-service army personnel and NGOs. In all, environmental awareness was created among more than 450 persons during the year by the scientists of the INHI Core of the Institute.

3.6.3. On-site Training Programme

Two day on-site training programme (seventh of its kind) on nursery development, tree plantation techniques and natural resource conservation and management to the farmers, rural women, students, ex-service army personnel and NGOs was organized by the INHI Core of the Institute from March 22 to 23, 1999 at Lawbanj village (District - Almora) of Uttar Pradesh. In all, 54 participants from Almora and Bageshwar districts attended this short term on-site training programme. The programme was inaugurated by Capt. J.B.S. Dosad, Block Pramukh, Garur and presided over by the District Project Officer, Bageshwar. Closing ceremony of this programme was presided over by Mrs. Dhani Devi (the oldest woman of the village of Lawbanj). The participants were trained by the staff of the INHI Core and PARDYP project. The trainees welcomed this activity of the Institute and their positive response indicated further continuance of such programmes particularly in the remote areas of Indian Himalaya.

In addition to the above, two on-site training programmes for farmers and rural women on farm based techniques (polyhouses, polypits, biocompost, biofertilizer and water harvesting) were also organized by the staff of PARDYP project and INHI Core from 9th to 10th November 1998 and 25th to 26th December 1998 at Talla Nakuri (PARDYP project demonstration site) near Kausani. In all, 47 farmers including rural women were trained during these two on-site training programmes. The techniques demonstrated by the staff at the

site are now being adopted by the farmers of nearby villages for their economic upliftement. Farmers to farmers exchange programme from one village to another and vice versa in Garur Ganga watershed of Almora district was also initiated during the year.

3.6.4. Dissemination of Information through Networking

The INHI Core of the Institute is actively involved in the dissemination of knowledge through its in-house publications (i.e. Hima-Paryavaran (a biannual newsletter) and Institute Annual Report). Two volumes of Hima-Paryavaran (9(2), 1997 and 10(1), 1998) and Institute Annual Report (1996-97) were distributed during the year to almost 650 persons/individuals and subject experts working on various aspects of Himalayan environment and development at various academic and scientific institutions including government departments and NGOs etc.

R&D inputs of the Institute on various aspects of the Himalayan environment and development were also provided by the scientists of the INHI Core to the representatives of 19 academic and scientific instituions including government departments, 42 NGOs and also to more than 450 persons (farmers/rural women/ex-service army personnel/pilgrims and in-service persons etc.) during the year. Scientific and technical inputs to the officials of Garhwal Scouts, Joshimath for the strengthening of Manavan and Rakshavan at Badrinath shrine and to the officials of Parmarthlok, Badrinath for the expansion of Parmarthlokvan in the premises of Parmarthlok at Badrinath Dham were also provided by the scientists of the Core from time to time during the year.

3.6.5. Strengthening of Central Nursery at the Headquarters

Central nursery at the Kosi campus of the headquarters was strengthened and maintained successfully during the year. Seeds of twenty two (22) promising mountain trees (namely, *Aesculus indica, Albizzia lebbek, Alnus nepalensis, Bauhinia retusa, Bauhinia variegata, Cedrela toona, Celtis australis, Cupressus torulosa, Dalbergia sissoo, Ehretia laevis, Grewia oppositifolia, Grevillea robusta, Jacranda mimosifolia, Ligustrum nepalense, Melia azedarach, Phyllanthus emblica, Prunus puddum, Quercus glauca, Quercus leucotricophora, Quercus semecarpifolia, Sapindus mukorossi* and *Thuja orientalis*) were collected in large quantities during the year from time to time and subsequently sown in the nursery beds/seedlings trays and polybags at the nursery. Cuttings of six (6) promising mountain trees/shrubs (namely, *Largerstroemia indica, Morus alba, Nerium* spp., *Populus nigra, Rosa* spp. and *Salix* spp.) were also collected in large quantities during the year and planted in the beds at the nursery. Twenty thousand and five hundred (20,500) seedlings/cuttings of various promising mountain trees/shrubs were raised in the nursery during the year. Four thousand (4,000) seedlings/cuttings of various trees/shrubs were distributed during the year, free of cost, to the farmers, rural women, students and NGOs for plantation purpose whereas six thousand (6,000) seedlings/cuttings of different trees/shrubs were distributed to various academic and scientific institutions during the year for R&D purpose. Four thousand (4,000) seedlings/cuttings of different trees/shrubs were also used for plantation in and around the old and new premises of the Institute. During the year, two thousand and two hundred (2,200) seedlings/cuttings of various promising mountain trees/shrubs were also sold by the

Institute to the various organizations. The central nursery of plants at Kosi (Almora) remained income generating during the year.

QUICK APPRAISAL STUDIES

Solid Waste Management in and around the Pindari Valley

Background

The Pindari region and its surroundings are the sources of well-known world famous glaciers *viz.*, Pindari, Kaphani and underdhunga. Recently, due to high biotic pressures, Pindari glacier is receding. Solid waste characterisation was carried out in the valley at selected points from 2210m (Khati) up to the height of 5300m (at Camp 2 or advanced base camp) during an expedition conducted from 25 August to 28 September 1998. About 40 samples were collected and analysed.

Results and Achievements

1. The results showed that ~66% wastes belonged to non-biodegradable waste (NBW; Figure 11). Readily bio-degradable waste (RBW) and bio-degradable waste (BW) constituted ~18% and 16%, respectively. The major NBW compositions worth for reuse and recycling were glass, polythene and tin consisting of 30.3%, 10.0% and 9.5%, respectively. These wastes could directly be re-used if those would have been assessed as valuables by the users at the time they threw it as wastes.
2. RBW, largely comprising edibles, had large share of wastes likes vegetables (7.4%), food (3.6%) and fruits (2.6%). These wastes do not create much of the environmental pollution if kept in covered furrows and ditches in the trekking areas. They decompose automatically and enrich to soil nutrients. However, RBW can deteriorate the glaciers and augment its snow melting rate in the areas near to the snow (Camp 2 or Camp 3 during expeditions). Therefore, RBW need to be brought back downward or should be covered in ditches away from the snow.
3. BW, mostly comprising paper (~11%) and rags/cloths (~5%), require proper care from environmental management point of view. Paper included maximum cartoons for packaging edibles.
4. It is recommended that a successful management of indisposed solid wastes in the trekking areas of Pindari valley, initially, requires mass level cleaning programme. All the NBW wastes either covered or uncovered in ditches need to be brought back to down bellow. Then, possible recycle options which have economic returns may be thought of. It might be required to constitute a controlling body by the district administration who will examine and certify the types of edibles to be carried by the tourists. The tourists should be accountable to bring back few wastes, particularly NBW.

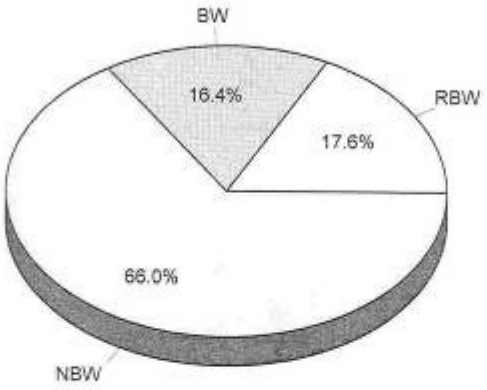

Figure 11. Solid waste characterisation in and around the Pindari valley (1998)

4. MISCELLANEOUS ITEMS

4.1. Addition to the Library

Addition of 873 books during the financial year 1998-99, the total number of books available in the Library, is 8958. A total of 139 periodicals (Foreign 82, Indian 57) are being subscribed in the Library including 9 periodicals subscribed by the ENVIS Centre on Himalayan Ecology at the Institute. Year wise volumes of published research papers, popular articles, and books (1989-98) have been updated. Articles Alert Services, Bibliographic Services, Current Awareness Services and Computerised Selective Dissemination of Information (SDI) Services are being provided by the library. Some books also received from International Centre for Integrated Mountain Development (ICIMOD), Kathmandu. Library is also receiving complimentary copy of international journal "Mountain Research and Development" from the ICIMOD. Six set of computer systems including the Server have been procured and installed in Network Environment. A fully menu driven and most user friendly software package for Library Networking **PALMS** (Prasad Automated Library Management Systems) has been developed by Dr. R.C. Prasad, Scientist (Library & Documentation). All the Databases of library have been transferred on the network and updated.

4.2 Infrastructure

Plant tissue culture facility has been established in the new campus of the Institute. For this a constant temperature room has been established for maintenance and growth of plant cultures with culture rack, temperature and light controls. In order to support tissue culture and microbiology work, a heavy duty (18 KW) Horizontol Autoclave has also been commissioned.

Plant growth cabinets with advanced micro-processor controlled facilities have been

installed. The chambers are illuminated with built-in-timer, featuring dual programme selector dials, allowing control of two temperature conditions, adjustable and programmable tempertature (5-50 degreeC), humidity (50-95%) and light (by PAR and fluorescent lights). These facilities will facilitate work on mass multiplication of selected species both by biotechnological and conventional methods, and greatly help in the hardening and acclimation of tissue culture raised plants (Figure 12).

4.3. Membership of Professional Societies/ Committees

Member, Plant Tissue Culture Association, India (**L.M.S. Palni**)

Life Member, Indian Science Congress Association (**D. K. Agrawal, D.S. Rawat, H.C. Rikhari, S.K. Nandi, S.S. Samant & Uma Shankar**)

Life Member, Indian Society of Remote Sensing (**D K Agrawal & D.S. Rawat**)

Life Member, Indian Society of Ecological Economics, New Delhi (**U. Dhar & K.S. Rao**)

Member, Research Board of Advisors, The American Biogeographical Institute, North Carolina, USA (**S.S. Samant**)

Founder Member, Association for Plant Taxonomy, Calcutta (**S.S. Samant**)

Life Member, Peoples Association for Himalayan Area Research, Nainital (**R.S. Rawal & G.C. S. Negi**)

Member Indian Society of Seed Research, New Delhi (**Uma Shankar**)

Member, Sikkim Science Society, Sikkim (**H.C. Rikhari & Subrat Sharma**)

Member, Indian Society of Tree Scientists (**H.C. Rikhari**)

Member, Ecological Society of America (**K.K. Singh & Subrat Sharma**)

Member, International Association for Landscape Ecology (**Subrat Sharma**)

Member, Association for the Promotion of DNA Fingerprinting and other DNA Technologies (**Anil Kumar, M. Nadeem & Hemant Pandey**)

Member, International Association of Plant Tissue Culture and Biotechnology (**Anil Kumar**)

Life Member, International Society of Environmental Botanists, Lucknow (**P.P.Dhyani**)

Life Fellow of Indian Academy of Social Sciences (**Nehal A. Farooquee & P.K. Samal**)

Indian Association of Soil and Water Conservationists (**G.C.S. Negi & V. Joshi**)

Central Himalayan Environment Association (**G.C.S. Negi**)

Geological Society of India (**V. Joshi**)

Society of Green World (**S.C. Joshi**)

Member, Governing Council of Sikkim Manipal University of Health and Technological Sciences (**E. Sharma**)

Member, IEEE Geoscience and Remote Sensing Society (GRSS), USA (**A.P. Krishna**)

Member, Institute of Landscape, Ecology and EKISTICS (**D.S. Rawat**)

4.4. Awards and Honours

Honorable Mention Paper Award for 1999 by Soil and Water Conservation Society, USA with respect to paper entitled " Hydrology and Nutrient Flux in an Agrarian Watershed of the Sikkim Himalaya" Journal of Soil and Water Conservation USA 53(2): 125-132, 1998 for the best paper of the journal in 1998 **(S.C. Rai and E. Sharma)**

Elected as a member to the Editorial Board of the - The Anthropology : International Journal of Contemporary & Applied Studies of Man **(P.K. Samal)**

Awarded medal of excellence in P.G. Diploma Course on Remote Sensing and Geographic Information System from Centre for Space Science Tecnology and Education in Asia and Pacific (affiliated to United Nations), Dehradun, 1997-98 batch **(Subrat Sharma)**

4.5. Publications of the Faculty

4.5.1. Scientific papers

Agrawal D.K. & H.C. Rikhari (1998). Mountain Risk Engineering : Low Cost Biological and Physical Measures for Control of Small Hill Slope Instabilities. In : *Research for Mountain Development : Some Initiatives and Accomplishments*, Gyanodaya Prakashan, Nainital, India. pp. 119-144.

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4.5.2. Popular Articles

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4.6. PARTICIPATION IN TRAINING/ WORKSHOPS / SYMPOSIA / CONFERENCES

Workshop on Mountain Ecosystem and Sustainable Population organized by Sri Bhubhneshwari Mahila Ashram, Anjanisain, Tehri-Garhwal. 4 April 1998 **(G.C.S. Negi & V. Joshi)**.

Tree Science Conference – 98, WWF Auditorium, New Delhi, 10-13 April, 1998 **(S.K. Nandi & H.C. Rikhari)**.

Participated in Panchchuli Multidimensional Expedition launched by Corps of Engineers, Army H.Q., New Delhi, April 14-May 23, 1998 **(R.S. Rawal)**.

As an expert in Conservation Assessment and Management Plan workshop for High Altitude Medicinal Plants of North-west Himalayas, Kullu, organised by Foundation for Revitalisation of Local Health Traditions, Bangalore. 16-18 April, 1998. **(H.K. Badola).**

International Conference on Disaster Management organized by Tejpur University, Guwahati (Assam). 23-26 April 1998 **(V. Joshi)**.

National Workshop on Perspectives for Planning and Development in North East India: Identifying R&D priorities, NERIST Campus, Itanagar, 27-29 April 1998 **(E. Sharma, P.P. Dhyani, K.S. Rao, K. Kumar, S.C. Rai, K.K. Singh, Y.K. Rai , G. Sharma, S.C.R. Vishvakarma, S.K. Nandi)**.

Participated in the 15 day Study tour on *Bio-engineering for road sector* to Department of Roads, Nepal and ICIMOD in April-May, 1998 **(D.K. Agrawal & H.C. Rikhari)**.

National Environment Awareness programme organized by Local NGO Chaurikhal, Pauri. 11 May 1998 **(R.K. Maikhuri & G.C.S. Negi)**.

National Seminar on Land use Management and Sustainable Development in U.P. Himalaya organized by Department of Geography and Rural Technology, HNB Garhwal University, Srinagar-Garhwal. 10-11 June 1998 **(G.C.S. Negi & V. Joshi)**.

Convened & coordinated the Orientation Workshop under Summer Programme-98 for students from Canadian Universities organized by GBPIHED, Almora from June 16-18, 1998 **(P.K. Samal, D.S. Rawat & Nehal A. Farooquee)**.

National Seminar on Environmental Changes and Sustainable Development in 21st Century: Uttarakhand Himalayan Perspective organized by Dept. of Geography, HNB Garhwal University, Srinagar-Garhwal. 19-21 June 1998. (**R.L. Semwal, V. Joshi, R.K. Maikhuri & K.S. Rao**).

Workshop of All India Co-ordinated Research Project on Application of Plastics in Agriculture, VPKAS, Almora, 26 & 27 June, 1998 (**L.M.S . Palni & S.K. Nandi**).

Attended Third Meeting of the Task Force on Plant Biotechnology, Department of Biotechnology, New Delhi, July 1998 (**U.Dhar**)

Consultative Workshop of Kullu Forest Circle, *Participatory Forest Management*, Kullu. 20 July, 1998.(**H.K. Badola**)

Technical Workshop on Inventory Control and Material Management (Organised by the Institute of Socio-economic Research and Action, New Delhi), SCOPE Complex, New Delhi, 21 & 22 July, 1998 (**S.K. Nandi & K.K. Pant**).

Attended the First Meeting f the Study Advisory Group of Sahayog on July 30, 1998 (**P.K. Samal**)

Global Positioning System (GPS) Data Analysis Course organised by C-MMACS, Bangalore, August 17 - 26, 1998 (**K. Kumar, A. P. Krishna, B.S. Adhikari & G.S. Satayal**)

Meeting on Snow, Ice and Glacier: A Himalayan Perspective. Geological Survey of India, New Delhi. 26 August 1998 (**V. Joshi**).

"*Sukhomukhi chetriya vikas karikaram*" organised under DPAP by District Administration, Almora, September 4, 1998 (**D.S. Rawat**)

Participated in the Short-term training course on Management of Natural Resources and Environment, conducted by the Indian Institute of Public Administration, New Delhi, September 14-18, 1998 (**S.C. Rai & H.K. Badola**)

Presented paper in the " Interaction Meeting on Biligiri Rangan Hills, Karnataka" at Bangalore, September 17-18, 1998 (**Uma Shankar**).

Participated in the National Seminar on "Rivers of the Northeast and their impact on the Environmental Development of the Region" at the Department of Geography, St. Mary's College, Shillong, September 24-25, 1998. (**D. Choudhury**).

Inaugural meeting of South Asian Chapter of International Society of Ecological Economics at India International Centre, N. Delhi. September 24, 1998 (**K.S. Rao**)

Participated in a workshop on classical Indian Legal Concerns on Environmental Protection, National Law school and Open University, Bangalore, September 26 - 27, 1998 (**K.S. Rao**)

Uttaranchal ke santulit evam samagra vikas ke liye parvatiya bazar kasba adhyan prastutikaran organized by U.P. Academy of Administration, Nainital. 30 September 1998, HAPPRC, Srinagar-Garhwal. (**S.C. Joshi**).

Mountain Meet 98, International Symposium on Environmental Management in Mountainous Regions organized by Department of Botany, P.G. College, Rishikesh, U.P. 4-6 October 1998 (**G.C.S. Negi & V. Joshi**).

Himalayan Ecosystem-Alaknanda Project Meeting, SAC, Ahmedabad. 9 October 1998 (**L.M.S. Palni & V. Joshi**).

Farmer-to-Farmers Training programme on Medicinal Plant Cultivation, Nanda Devi Biosphere organized by G.B. Pant Institute of Himalayan Environment and Development, Garhwal Unit, Srinagar-Garhwal, Tolma (a buffer zone village). 16-18 October 1998. (**R.K. Maikhuri, K.S. Rao, R.L. Semwal, U. Rana, S. Nautiyal & S.D. Tiwari).**

National Seminar on Role of microbes in Environmental Protection & Rural Development, NEHU, Shillong, 23-25 October, 1998 (**L.M.S. Palni**)

Participated in the Workshop on "Role of Microbes in Rural Development" at Shillong, October 25-27, 1998 (**Uma Shankar**).

Regional training programme on "Application of GIS, GPS and Remote Sensing in planning for mountain agriculture and landuse management". Organised by ICIMOD, Kathmandu, November 2 - 27, 1998 (**D.S. Rawat**)

International Forest Canopies - 1998 conference, organised by Selby Botanical Gardens, Sarasota, Florida, USA, November 4-9, 1998 (**K.S. Rao & H.K. Badola**)

National Worshop on Himalaya Medicinal Plants: Potential and Prospects organized by G.B. Pant Institute of Himalayan Environment and Development, Kosi-Katarmal, Almora. 5-7 November 1998. (**L.M.S. Palni, U. Dhar, P.P. Dhyani, S.K. Nandi, R.K. Maikhuri, S.S. Samant, R.S. Rawal, S. Airi, V. Naithani, I.D. Bhatt, D. S. Mehta, H.C. Joshi, S.C. Arya & G. Bisht**)

Participated in the National Seminar on "Environmental Problems in Northeast India", Department of Geography, Assam University, Silchar, November 6-7, 1998 (**D. Choudhury**)

Attended International Workshop-cum-Training Programme on Landslide Hazard & Risk Assessment and Damage Control for Sustainable Development, New Delhi, November 6-11, 1998 (**A.P. Krishna**)

Seminar on Environment and Development organized by Jai Bharat Sewa Samiti, Srinagar-Garhwal, Silkakhal, Tehri-Garhwal. 15-16 November 1998. (**R.K. Maikhuri**).

Participated in the Training Workshop on Jav Vividhata Sanrakshan Mei Janata Ki Bhagidari, organized by GBPIHED at G.I.C. Narayan Nagar, Pithoragarh, November 19-21, 1998 (**U. Dhar, S.S. Samant, R.S. Rawal, B.S. Adhikari, Subodh Airi, Varsha Naithani, I.D. Bhatt, H.C. Joshi, D.S. Mehta and G. Bisht**).

Presented a paper in the Meeting on Recent Landslides of Malpa and Ukhimath organised by DTRL, New Delhi, November 24, 1998 (**K. Kumar & G. S. Satyal**)

Participated in the Training Workshop on " Applications of Electron Microscopy in Entomology", Regional sophisticated Instrumentation Centre, NEHU, Shillong, November 27-28, 1998 (**D. Choudhury**)

Seminar on Wasteland Development organized by Deptt. of Forestry, HNB Garhwal University, Srinagar-Garhwal, Guptakashi, Rudraprayag. 24-25 December 1998. (**R.K. Maikhuri**).

Presented paper in the 86th session of the Indian Science Congress at Chennai, January 3-8, 1999 (**Uma Shankar**)

PRA Training organized by GBPIHED-ICIMOD under PARDYP from January 4-12, 1999 (**B.P. Kothyari, S.S. Bisht, S.K. Bhuchar, B.S. Bisht, Pushpa Pant, Y.S. Topal, B.K. Joshi & A.K. Mishra**)

Delivered lectures on environmental impact analysis to the forest officials of State of Uttar Pradesh at Forest & Forest Council Training Institute, Haldwani on January 16 & February 27, 1999 (**P.K. Samal**).

Meeting on Women and Environmental Degradation organized by Bagri- Juna group of villages, February 12, 1999 (**Pushpa Pant**)

Expert Meeting on Data Requirements and Opportunities for Land Use/Land Cover Change (LUCC) on South Asian Mountain Regions (Hindu-Kush Himalaya). 15-19 February 1999, Kathmandu, Nepal (**E. Sharma, K.S. Rao, R.K. Maikhuri, S.C. Rai, A.P. Krishna, Nehal A. Farooquee & G.C.S. Negi**).

Delivered a lecture on "Clonal Propagation of Forest Trees" at the Forest Training Institute, Haldwani, February 20, 1999 (**S.K. Nandi**)

Delivered a lecture on "Role of Mountain Risk Engineering in hill slope stabilization" at the Forest Training Institute, Haldwani, February 27, 1999 (**D.K. Agarwal**)

Delivered a lecture on "Simple Technologies for Sustainable development of rural Ecosystem" at the Forest Training Institute, Haldwani, February 27, 1999 (**D.S. Rawat**)

Final Workshop on People and Resource Dynamics in Mountain Watersheds of Hindu-Kush Himalaya, Baoshan, P.R. China, March 1-6, 1999 (**B.P. Kothyari & S.K. Bhuchar**)

Participated as special Invitee, Meeting of District Paryavaran Vahini, Cachar District, Silchar. March 2, 1999 (**D. Choudhury**)

Attended Brain Storming Meeting on Bio-Geo Data Base and Ecological Modelling of the Himalaya organised by DST, GOI, National Committee on IGBP (INSA) and India International Centre (March 4-5, 1999), N. Delhi. (**K.S. Rao, R.K. Maikhuri, S.C.R. Vishvakarma, G.C.S. Negi, J.C. Kuniyal, E. Sharma, A.P. Krishna and S.C. Rai**)

Seminar on The Development of Uttarakhand organized by Uttarakhand Seva Samiti, Ahmedabad Gujrat in Ahmedabad. 6-7 March 1999. (**R.L. Semwal**).

Symposium on Snow, Ice and Glaciers- a Himalayan Perspective organized by GSI, Lucknow. 9-11 March 1999 (**V. Joshi**).

Attended the Project Development Workshop at Indira Gandhi Institute of Development

Research, Mumbai, March 11-13, 1999 (**P.K. Samal & D.S. Rawat**)

Attended Fourth Meeting of the Task Force on Plant Biotechnology, Department of Biotechnology, New Delhi, March 1999 (**U. Dhar**)

Rashtriya Paryavaran Jagrukta Abhiyan organized by Lok Chetna Manch (NGO), March 12, 1999 (**B.S. Bisht**)

Aaj Ka Bharat: Vividh Ayaam Tatha Jan Vigyan Andonlan (Uttaranchal Ke Vishesh Sandarbh Mein) organized by Bharat Jan Gyan Vigyan Samiti, U.P, HNB Garhwal University, Srinagar-Garhwal, 13-14 March 1999 (**R.K. Maikhuri & G.C.S. Negi**).

Presentation in Indian National Science Academy for Young Scientists Medal 1999 at New Delhi, March, 15, 1999 (**Uma Shankar**)

Seventh On-site Training Programme on Nursery Development, Tree Plantation Techniques and Natural Resource Conservation and Management organized by INHI Core at Lawbanj, Almora, March 22-23, 1999 (**P.P. Dhyani, B.P. Kothyari, R.G. Singh, S.K. Bhuchar, Y.S. Topal & A.K. Mishra**)

Workshop on Landscape Strategy-Nanda Devi Cluster organized by Forest Department, U.P. under World Forestry project, Gopeshwar, Chamoli. 23 March 1999 (**R.K. Maikhuri**).

I. C. Sanghal, B.Com.(Hons), L.L.B., F.C.A.
A.K. Jain, B.Com., F.C.A.

I.C. Sanghal & Co.
Chartered Accountants
17, Rajpur Road, Dehradun - 248 001
Phone (0135) 654607, 653402
Fax (0135) 723831

THE DIRECTOR,
G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT,
KATARMAL, KOSI,
ALMORA-263 643.

Dear Sir,

We have examined the Balance Sheet of **G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT, ALMORA**, as on 31-3-99, which are in agreement with the books of accounts, maintained by the said Institution.

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 said Head Office and the Units of the above name 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 :-

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

i) In the case of Balance Sheet of the State of Affairs of the above named Institution as on 31-3-99; and

ii) In the case of Income & Expenditure Account of the INCOME of its accounting year ending on 31-3-99.

For I.C. Sanghal & Co.
Chartered Accountants.

Seal

-Sd-
(I.C. SANGHAL)
Partner

17-Rajpur Road, Dehradun
Dated : 14-8-1999

I. C. Sanghal, B.Com.(Hons), L.L.B., F.C.A.
A.K. Jain, B.Com., F.C.A.

I.C. Sanghal & Co.
Chartered Accountants
17, Rajpur Road, Dehradun - 248 001
Phone (0135) 654607, 653402
Fax (0135) 723831

NOTES FORMING PART OF THE REPORT ON THE STATEMENT OF ACCOUNTS OF **G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT AND DEVELOPMENT, KATARMAL, KOSI, ALMORA,** FOR THE YEAR ENDING 31-3-1999 AND ANNEXED TO AND BALANCE SHEET OF EVEN DATE.

1. Books of Accounts have been maintained in cash basis, subject to Para 4 below.
2. Depreciation has not been provided on Fixed Assets in the accounts and value has been shown at cost.
3. All purchases of consumables, laboratory expenses, chemicals, glass-wares, stores and stationery etc. have been charged to the Income & Expenditure A/c at the time of purchase.
4. Interest on Fixed Deposits has been provided on accruals basis.
5. Stock registers of assets have been maintained by the institution for movement of assets, stores, vehicles, which have been physically verified at regular intervals.
6. Provident Fund liabilities and investments of the institute has been incorporated in the statement of accounts.
7. Fixed Assets except vehicles and Electric Sub-station have no insurance cover to provide security against any loss, considering the accumulated value of assets, appropriate insurance cover be obtained.
8. Outstanding entries pending adjustments in the Bank Reconciliation Statement needs to be adjusted.
9. Deposits of **Rs. 16,45,63,464/-** for Construction, with CCU (MOE & F), New Delhi, needs to be adjusted for the work which has already been completed.
10. Annexure '1' to '47;' are integral part of the Statement of Accounts prepared for the year.

For I.C. Sanghal & Co.
Chartered Accountants

Seal

-Sd-
(I.C. SANGHAL)
Partner

17-Rajpur Road, Dehradun
Dated : 14-8-1999

In respect of point 10 above, it is to be mentioned that Annexure 1-47 are available in the Institute as well as in the Ministry of Environment and Forests, Govt. of India, New Delhi.
For saving space only the most essential Annexures form part of the Statements of Accounts printed in the Annual Report.

G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT

KATARMAL, KOSI (ALMORA)

BALANCE SHEET AS ON 31st MARCH 1999

PARTICULARS	ANN	AMOUNT	AMOUNT
SOURCES OF FUNDS			
General Fund :			
Last Balance :		2131500.99	
Addition during the year		1084506.50	**3216007.49**
Endowment Fund :			
Last Balance:		3819612.15	
Interest Earned		394773.00	**4214385.15**
Fixed Assets Fund :			
Last Balance		84597378.61	
Addition during the year		13879117.23	
		98476495.84	
Less : Sale during the Year :		380559.00	**98095936.84**
Construction Fund :			
Last Balance:		150023964.00	
Addition during the Year:		14539500.00	**164563464.00**
Provident Fund :			
Last Balance		5111639.40	
Addition during the Year		2422374.00	
		7534013.40	
Less : Payment during the year		259300.00	**7274713.40**
Project Funds :	1		
MOE & F : Research & Development Fund:		980126.90	
Construction Fund (GH/NH)		48583.00	
IERP Project Fund		8.06	
ENVIS Project Fund		90784.00	
NEC Shillong Project Fund		(6981.00)	
DST (RSR) Project Fund		1032.00	
CSIR (HCR/GCSN) Project Fund:		2761.00	
BIOTECH (I) Project Fund		668.00	
BIOTECH (II) Project Fund		97179.00	
BIOTECH (III) Project Fund		(107371.00)	
IEG Project Fund		147.00	
UNDP (Haigad) Project Fund		(28035.00)	
Balance Carried Forward		**1078901.96**	**277364506.88**

Seal

G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT

KATARMAL, KOSI (ALMORA)

BALANCE SHEET AS ON 31st MARCH 1999

PARTICULARS	ANN	AMOUNT	AMOUNT
Balance Brought Forward		**1078901.96**	**277364506.88**
CSIR (RCS) Project Fund		45.00	
DST (SKN) Project Fund		(66087.00)	
AGRICULTURE BIO DIV. Project Fund		55806.00	
LAND USE Project Fund		60.00	
WWF (CBD) Project Fund		(5065.00)	
ICAR (ES) Project Fund		229468.00	
NDBR WORKSHOP		(139119.00)	
MOE & F (RKM) Project Fund		82509.00	
BIOTECH (IV) Project Fund		155710.00	
FAO BIO-DIVERSITY Project Fund		99248.00	
BIOTECH (V) Project Fund		14993.00	
MOE & F (SSS) Project Fund		155376.00	
CSIR (RS) Project Fund		56605.00	
ALAKNANDA VALLEY Project Fund		168040.00	
CSIR (SCR) Project Fund		470050.00	
DST (KK) Project Fund		887540.00	
MOE & F (KSR) Project Fund		184132.00	
MOE & F (KBR) Project Fund		47500.00	
CSIR (M.NADEEM) Project Fund		8878.00	
DOS (DBT) Project Fund		86820.00	
NATIONAL WORKSHOP (N.E.UNIT)		(52332.00)	
MEDICINAL PLANT WORKSHOP		3193.00	
UNESCO (Expert Fee)		63300.00	
ICIMOD Project Fund		43151.05	
TSBF Project Fund		158966.00	
INDO CANADIAN Project Fund		3.00	
INDO CANADIAN SUMMER PROGRAMME		25651.00	
ICIMOD (SALT) Project Fund		221554.21	
ICIMOD ISSMA Project Fund		(66353.00)	
MACARTHER UNESCO Project Fund		33182.64	
ECO TOURISM (SIKKIM) Project Fund		72734.00	
ICIMOD (FIBRE) Project		4260.00	
ICIMOD (PARDYP) Project Fund		27993.00	
ICIMOD (CBD) Project Fund		146456.00	
ICIMOD (LAND SLIDE) Project Fund		19521.00	
SALT FARMERS TRAINING		159956.00	
MRE WORKSHOP Fund		(169.00)	
MRE Project Fund		(2920.00)	**4429557.86**
Balance Carried Forward			**281794064.74**

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

BALANCE SHEET AS ON 31st MARCH 1999

PARTICULARS	ANN	AMOUNT	AMOUNT
Balance Brought Forward			**281794064.74**
Other Liablities :			
Advance K.S.Rao		1990.00	
Security Payable		450.00	
Salary Payable		5466.70	
Medical Claim Payable		230.00	
E.M.D. Payable		115044.41	
Advance (SALT) NE UNIT		2503.39	
Caution Money		7600.00	**133284.50**
TOTAL LIABILITIES RS..			**281927349.24**
APPLICATION OF FUNDS :			
Fixed Assets :	**45**		98095936.84
Deposits With :			
CCU for Constructions			164563464.00
Security Deposits			45843.00
Closing Balances	**47**		19222105.40
TOTAL ASSETS RS..			**281927349.24**

-Sd-
(Finance Officer)

-Sd-
(D.D.Officer)

-Sd-
(Director)

Seal

As per our separate report of even date.

-Sd-
(I.C. Sanghal)
Partner
I.C. Sanghal & Co.
Chartered Accountants
17-Rajpur Road, Dehradun
Dated : 14-08-1999

G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT
KATARMAL, KOSI (ALMORA)
INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDING 31st MARCH 1999

PARTICULARS	ANN	AMOUNT	AMOUNT
A) INCOME :			
Grant In aid :			
Designated Project Grant For :			
MOE & F : RESEARCH & DEV./OTHER EXPENSES		35500000.00	
CONSTRUCTION WORK		9500000.00	
IERP Project		4173083.67	
ENVIS Project		491000.00	
BIOTECH (III) Project		441000.00	
MOE & F (RKM) Project		170000.00	
CSIR (RCS) Project		66900.00	
WWF (CBD) Project		37205.00	
CSIR (RS) Project		117335.00	
BIOTECH (IV) Project		119000.00	
BIOTECH (V) Project		120000.00	
MOE & F (SSS) Project		155000.00	
FAO BIO DIVERSITY Project		30000.00	
AGRICULTURE BIO-DIVERSITY Project		140000.00	
ALAKNANDA VALLEY Project		200000.00	
CSIR (SCR) Project		511667.00	
DST (KK) Project		900000.00	
MOE & F (KSR) Project		280000.00	
MOE & F (KBR) Project		80000.00	
CSIR (M.NADEEM)		92860.00	
DOS-DBT Project		156450.00	
NATIONAL WORKSHOP (N.E.)		219307.00	
MEDICINAL PLANT WORKSHOP		200000.00	
UNESCO (Expert Fee)		63300.00	
ICIMOD (CBD) Project		300258.00	
TSBF Project		667594.00	
ICIMOD (SALT) Project		503497.00	
MACARTHER UNESCO Project		356126.64	
ECO TOURISM Project		1574863.00	
ICIMOD (PARDYP) Project		1219288.00	
INDO CANADIAN Project Fund		49058.00	
INDO CANADIAN SUMMER PROGRAMME		370410.00	
SALT FARMER'S TRAINING PROGRAMME		163054.00	
MRE Project		333408.00	**59301664.31**
Balance Carried Forward			**59301664.31**

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G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT

KATARMAL, KOSI (ALMORA)

INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDING 31st MARCH 1999

PARTICULARS	ANN	AMOUNT	AMOUNT
Balance Brought Forward			**59301664.31**
Less : Tfd. To Designated Funds For :			
MOE & F : RESEARCH & DEV./OTHER EXPENSES		35500000.00	
CONSTRUCTION WORK		9500000.00	
IERP Project		4173083.67	
ENVIS Project		491000.00	
BIOTECH (III) Project		441000.00	
MOE & F (RKM) Project		170000.00	
CSIR (RCS) Project		66900.00	
WWF (CBD) Project		37205.00	
CSIR (RS) Project		117335.00	
BIOTECH (IV) Project		119000.00	
BIOTECH (V) Project		120000.00	
MOE & F (SSS) Project		155000.00	
FAO BIO DIVERSITY Project		30000.00	
AGRICULTURE BIO-DIVERSITY Project		140000.00	
ALAKNANDA VALLEY Project		200000.00	
CSIR (SCR) Project		511667.00	
DST (KK) Project		900000.00	
MOE & F (KSR) Project		280000.00	
MOE & F (KBR) Project		80000.00	
CSIR (M.NADEEM)		92860.00	
DOS-DBT Project		156450.00	
NATIONAL WORKSHOP (N.E.)		219307.00	
MEDICINAL PLANT WORKSHOP		200000.00	
UNESCO (Expert Fee)		63300.00	
ICIMOD (CBD) Project		300258.00	
TSBF Project		667594.00	
ICIMOD (SALT) Project		503497.00	
MACARTHER UNESCO Project		356126.64	
ECO TOURISM Project		1574863.00	
ICIMOD (PARDYP) Project		1219288.00	
INDO CANADIAN Project		49058.00	
INDO CANADIAN SUMMER PROGRAMME		370410.00	
SALT FARMER'S TRAINING PROGRAMME		163054.00	
MRE Project		333408.00	**59301664.31**

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G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT

KATARMAL, KOSI (ALMORA)

INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDING 31st MARCH 1999

PARTICULARS	ANN	AMOUNT	AMOUNT
Interest From Banks			**331341.00**
Other Income :			
Sale of Vehicle		380559.00	
Licence Fee		73937.00	
Water Testing Fee		17700.00	
Nursery Sale		2200.00	
Institutional Charges		347653.00	
Guest House/ Hostel Charges		63898.00	
Royalty		25512.50	
Miscellaneous Income		138065.00	
Sale of Tender Form		5700.00	**1055224.50**
Designated Grant Utilised For :	1		
MOE & F : RESEARCH .& DEV. / OTHER EXPEN.		30120640.89	
IERP Project		4173123.00	
ENVIS Project		360766.00	
ICAR (ES) Project		131167.00	
DST (SKB) Project		222.00	
DST (RKM) Project		5869.00	
CSIR (HCR/GCSN) Project		2000.00	
BIOTECH (II) Project		172365.00	
BIOTECH (III) Project		3725438.00	
MOE & F (RKM) Project		113255.00	
NDBR (WORKSHOP)		69070.00	
IEG Project		38872.00	
CSIR (RCS) Project		101229.00	
WWF (CBD) Project		16320.00	
CSIR (RS) Project		81400.00	
AGRICULTURE BIO-DIVERSITY Project		88342.00	
BIOTECH (IV) Project		222763.00	
HAIGAD II (FARM) Project		60647.00	
BIOTECH (V) Project		195588.00	
ALAKNANDA VALLEY Project		31960.00	
CSIR (SCR) Project		41617.00	
FAO-BIODIVERSITY Project		102232.00	
DST (KK) Project		12460.00	
MOE & F (SSS) Project		89624.00	
MOE & F (KSR) Project		95868.00	
MOE & F (KBR) Project		32500.00	
CSIR (M.NADEEM)		83982.00	
DOS-DBT Project		69630.00	
NATIONAL WORKSHOP (N.E.)		271639.00	
Balance Carried Forward		**40510588.89**	**1386565.50**

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G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT
KATARMAL, KOSI (ALMORA)
INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDING 31st MARCH 1999

PARTICULARS	ANN	AMOUNT	AMOUNT
Balance Brought Forward		**40510588.89**	**1386565.50**
MEDICINAL PLANT WORKSHOP		196807.00	
TSBF Project		320626.00	
INDO CANADIAN Project		125961.00	
INDO CANADIAN SUMMER PROGRAMME		384096.00	
ICIMOD (SALT) Project		353759.00	
MACARTHER UNESCO Project		553844.00	
ECO TOURISM (SIKKIM) Project		1998464.00	
ICIMOD FIBRE Project		205255.00	
ICIMOD (PARDYP) Project		1800101.00	
ICIMOD (CBD) Project		343211.00	
ICIMOD (GIS) EQUIPMENT		148800.00	
SALT FARMER'S TRAINING PROGRAMME		23093.00	
MRE WORKSHOP		28441.00	
INHI BADRIVAN Project		159885.00	
MRE Project		469049.00	**47621980.89**
TOTAL INCOME (A) RS...			**49008546.39**
B) EXPENDITURE :			
Revenue Expenditure :			
MOE & F : RESEARCH & DEV./ OTHER EXPEN.	**2**	20489785.66	
IERP Project	**3**	4173123.00	
ENVIS Project	**4**	360766.00	
DST (SKB) Project	**5**	222.00	
DST (RKM) Project	**6**	5869.00	
CSIR (HCR/GCSN) Project	**7**	2000.00	
ICAR (ES) Project	**8**	129480.00	
BIOTECH (II) Project	**9**	7774.00	
BIOTECH (III) Project	**10**	381404.00	
MOE & F (RKM) Project	**11**	113255.00	
NDBR (WORKSHOP)	**12**	69070.00	
IEG Project	**13**	5272.00	
CSIR (RCS) Project	**14**	83039.00	
WWF (CBD) Project	**15**	16320.00	
CSIR (RS) Project	**16**	81400.00	
AGRICULTURE BIO-DIVERSITY Project	**17**	88342.00	
BIOTECH (IV) Project	**18**	222763.00	
HAIGAD II (FARM) Project	**19**	60647.00	
BIOTECH (V) Project	**20**	149469.00	
ALAKNANDA VALLEY Project	**21**	31960.00	
CSIR (SCR) Project	**22**	41617.00	
Balance Carried Forward		**26513577.66**	

Seal

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

INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDING 31st MARCH 1999

PARTICULARS	ANN	AMOUNT	AMOUNT
Balance Brought Forward		**26513577.66**	
FAO-BIODIVERSITY Project	23	55640.00	
DST (KK) Project	24	12460.00	
MOE & F (SSS) Project	25	89624.00	
MOE & F (KSR) Project	26	95868.00	
MOE & F (KBR) Project	27	32500.00	
CSIR (M.NADEEM)	28	83982.00	
DOS-DBT Project	29	69630.00	
NATIONAL WORKSHOP (N.E.)	30	271639.00	
MEDICINAL PLANT WORKSHOP	31	196807.00	
TSBF Project	32	320626.00	
INDO CANADIAN Project	33	125961.00	
INDO CANADIAN SUMMER PROGRAMME	34	384096.00	
ICIMOD (SALT) Project	35	265551.00	
MACARTHER UNESCO Project	36	540344.00	
ECO TOURISM (SIKKIM) Project	37	1998464.00	
ICIMOD FIBRE Project	38	6095.00	
ICIMOD (PARDYP) Project	39	1711571.00	
ICIMOD (CBD) Project	40	290410.00	
SALT FARMER'S TRAINING PROGRAMME	41	23093.00	
MRE WORKSHOP	42	28441.00	
INHI BADRIVAN Project	43	159885.00	
MRE Project	44	466599.00	**33742863.66**
Capital Expenditure :	45		
MOE & F -RESEARCH & DEVELOPMENT			
Library		4123958.00	
Scientific Equipments		2154551.00	
Office Equipment		1328942.00	
Furniture & Fixture		1911765.00	
Land		75639.23	
Building		36000.00	**9630855.23**
Balance Carried Forward			**43373718.89**

Seal

G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT
KATARMAL, KOSI (ALMORA)
INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDING 31st MARCH 1999

PARTICULARS	ANN	AMOUNT	AMOUNT
Balance Brought Forward			**43373718.89**
Scientific Equipments:			
BIOTECH (II) Project		164591.00	
BIOTECH (III) Project		1293246.00	
BIOTECH (V) Project		46119.00	
CSIR (RCS) Project		18190.00	
FAO BIODIVERSITY Project		46592.00	
IEG Project		33600.00	
ICAR (ES) Project		1687.00	
ICIMOD (SALT) Project		88208.00	
MACARTHER UNESCO Project		13500.00	
ICIMOD (FIBRE) Project		199160.00	
ICIMOD (PARDYP) Project		88530.00	
ICIMOD GIS EQUIPMENT		148800.00	
ICIMOD (CBD) Project		52801.00	
MRE Project		2450.00	**2197474.00**
Glass House/ Net House			
BIOTECH (III)			**2050788.00**
Loss on Sale of Assets			**302059.00**
TOTAL EXPENDITURE RS.. (B)			**47924039.89**
SURPLUS (A - B)			**1084506.50**
EXCESS OF INCOME OVER EXPENDITURE (TFD.TO GENERAL FUND A/C)			
TOTAL RS...			**49008546.39**

-Sd-
(Finance Officer)

-Sd-
(D.D.Officer)

-Sd-
(Director)

Seal

As per our separate report of even date.

-Sd-
(I.C. Sanghal)
Partner
I.C. Sanghal & Co.
Chartered Accountants
17-Rajpur Road, Dehradun
Dated : 14-08-1999

G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT

KATARMAL, KOSI (ALMORA)

RECEIPT & PAYMENT ACCOUNT FOR THE YEAR ENDING 31st MARCH 1999

PARTICULARS	ANN	AMOUNT	AMOUNT
RECEIPT :			
Opening Balance :	46		**16051515.91**
Grant In Aid For :			
MOE & F : RESEARCH & DEV./OTHER EXPENSES		35500000.00	
CONSTRUCTION WORK		9500000.00	
IERP Project		4173083.67	
ENVIS Project		491000.00	
BIOTECH (III) Project		441000.00	
MOE & F (RKM) Project		170000.00	
CSIR (RCS) Project		66900.00	
WWF (CBD) Project		37205.00	
CSIR (RS) Project		117335.00	
BIOTECH (IV) Project		119000.00	
BIOTECH (V) Project		120000.00	
MOE & F (SSS) Project		155000.00	
FAO BIO DIVERSITY Project		30000.00	
AGRICULTURE BIO-DIVERSITY Project		140000.00	
ALAKNANDA VALLEY Project		200000.00	
CSIR (SCR) Project		511667.00	
DST (KK) Project		900000.00	
MOE & F (KSR) Project		280000.00	
MOE & F (KBR) Project		80000.00	
CSIR (M.NADEEM)		92860.00	
DOS-DBT Project		156450.00	
NATIONAL WORKSHOP (N.E.)		219307.00	
MEDICINAL PLANT WORKSHOP		200000.00	
UNESCO (Expert Fee)		63300.00	**53764107.67**
Interest From Bank :			
Institute		331341.00	
Endowment Fund		394773.00	**726114.00**
REFUND AGAINST ADVANCE OF LAND			4360.77
CAUTION MONEY			7600.00
PROVIDENT FUND CONTRIBUTION RECEIVED			2422374.00
E.M.D.RECEIVED			115044.41
TFD.FROM F.C.A/C			66568.00
Other Income :			
Sale of Vehicle		78500.00	
Licence Fee		73937.00	
Water Testing Fee		17700.00	
Nursery Sale		2200.00	
Institutional Charges		347653.00	
Guest House/ Hostel Charges		63848.00	
Royalty		25512.50	
Miscellaneous Income		137895.00	
Sale of Tender Form		5700.00	**752945.50**
TOTAL RECEIPTS RS..			**73910630.26**

Seal

G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT

KATARMAL, KOSI (ALMORA)

RECEIPT & PAYMENT ACCOUNT FOR THE YEAR ENDING 31st MARCH 1999

PARTICULARS	ANN	AMOUNT	AMOUNT
PAYMENT :			
Project Payment For :			
Project Expenditure (Revenue)			
MOE & F : RESEARCH & DEV./OTHER EXPENSES	2	20490456.66	
IERP Project	3	4173123.00	
ENVIS Project	4	360766.00	
DST (SKB) Project	5	222.00	
DST (RKM) Project	6	5869.00	
CSIR (HCR/GCSN) Project	7	2000.00	
ICAR (ES) Project	8	129480.00	
BIOTECH (II) Project	9	7774.00	
BIOTECH (III) Project	10	381404.00	
MOE & F (RKM) Project	11	113255.00	
NDBR (WORKSHOP)	12	69070.00	
IEG Project	13	5272.00	
CSIR (RCS) Project	14	83039.00	
WWF (CBD) Project	15	16320.00	
CSIR (RS) Project	16	81400.00	
AGRICULTURE BIO-DIVERSITY Project	17	88342.00	
BIOTECH (IV) Project	18	222763.00	
HAIGAD II (FARM) Project	19	60647.00	
BIOTECH (V) Project	20	149469.00	
ALAKNANDA VALLEY Project	21	31960.00	
CSIR (SCR) Project	22	41617.00	
FAO-BIODIVERSITY Project	23	55640.00	
DST (KK) Project	24	12460.00	
MOE & F (SSS) Project	25	89624.00	
MOE & F (KSR) Project	26	95868.00	
MOE & F (KBR) Project	27	32500.00	
CSIR (M.NADEEM)	28	83982.00	
DOS-DBT Project	29	69630.00	
NATIONAL WORKSHOP (N.E.)	30	271639.00	
MEDICINAL PLANT WORKSHOP	31	196807.00	**27422398.66**
Capital Expenditure :	45		
MOE & F : RESEARCH & DEVELOPMENT			
Library		4123958.00	
Scientific Equipments		2154551.00	
Office Equipment		1328942.00	
Furniture & Fixture		1911765.00	
Building		36000.00	**9555216.00**
Balance Carried Forward			**36977614.66**

Seal

G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT

KATARMAL, KOSI (ALMORA)

RECEIPT & PAYMENT ACCOUNT FOR THE YEAR ENDING 31st MARCH 1999

PARTICULARS	ANN	AMOUNT	AMOUNT
Balance Brought Forward			**36977614.66**
Scientific Equipments:			
BIOTECH (II) Project		164591.00	
BIOTECH (III) Project		1293246.00	
BIOTECH (V) Project		46119.00	
CSIR (RCS) Project		18190.00	
FAO BIODIVERSITY Project		46592.00	
IEG Project		33600.00	
ICAR (ES) Project		1687.00	**1604025.00**
Glass House/ Net House			
BIOTECH (III) Project			**2050788.00**
ADVANCE ADJUSTED INSA/DST			12422.00
CONTRIBUTION TO PROVIDENT FUND TFD./REFUNDED			259300.00
G.S.L.I.			3080.10
C.P.F.			1364.00
E.M.D./SECURITY REFUNDED			78500.00
SECURITY DEPOSIT			500.00
ADVANCE ADJUSTED (SALT)			8077.00
TFD.TO CCU FOR CAPITAL EXPENDITURE			14539500.00
Closing Balances : (IC A/C)			
Cash & Bank Balances :			
Cash in Hand :			
Almora:		10490.55	
Srinagar		185.64	
Sikkim		3515.02	
Kullu		1300.17	**15491.38**
Cash at Bank :			
CBI Kosi A/c No.CD-14		882343.46	
SBI Almora A/c No.22752		2779453.33	
SBI Almora A/c No.23884		28778.15	
SBI Tadong A/c No.CA/4/65		648310.00	
SBI Kullu A/c No.50201/7		187219.81	
SBI Srinagar A/c No.3/615		43462.57	
SBI Almora P.F.A/c No.22021		18425.40	**4587992.72**
Advances :			
House Building Advance		1326194.00	
Motercycle/Car Advance		437360.00	
Festival Advance		13200.00	
Provident Fund Advance		206549.00	
G.S.L.I.		224.90	
C.P.F.		36.00	
Units of Institute :			
H.P.Unit		5000.00	
Garhwal Unit		54277.00	**2042840.90**
Balance Carried Forward			**62181495.76**

Seal

G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT

KATARMAL, KOSI (ALMORA)

RECEIPT & PAYMENT ACCOUNT FOR THE YEAR ENDING 31st MARCH 1999

PARTICULARS	ANN	AMOUNT	AMOUNT
Balance Brought Forward			**62181495.76**
Fixed Deposits :			
With SBI Endowment Fund :		4127883.00	
Intt.Acc.on FDR (Endowment Fund)		57724.00	
SBI Provident Fund		4808923.00	
CBI Provident Fund		1761416.00	
Intt.Acc.on FDR (P.F.A/C)		479471.00	
F.D.R. (Margin Money L/C A/c)		66000.00	
F.D.R. (Margin Money L/C A/c) SK UNIT		157000.00	**11458417.00**
Due Staff/Others :			
Klenzaids Con.Controls (P) Ltd., (BIOTECH I)		56880.00	
Director- IARI		26.50	
A.S.Parihar		389.00	
B.P.Kothyari		6000.00	
R.K.Nanda & Sons		28517.00	
Pertech Computers		2000.00	
Employment News		5050.00	
Sigma Aidrich Chemicals		10590.00	
Siltap Chemicals Ltd. (BIOTECH III)		408.00	
N.R.S.A.Hyderabad		74800.00	
Klenzaids Con.Controls (P) Ltd.		57175.00	
M.P.C.B.		16382.00	
Hindustan Times		10000.00	**268217.50**
F.C.Inter A/c			2500.00
TOTAL PAYMENTS RS...			**73910630.26**

-Sd-
(Finance Officer)

-Sd-
(D.D.Officer)

-Sd-
(Director)

Seal

As per our separate report of even date.

-Sd-
(I.C. Sanghal)
Partner
I.C. Sanghal & Co.
Chartered Accountants
17-Rajpur Road, Dehradun
Dated : 14-08-1999

G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT

KATARMAL, KOSI (ALMORA)

SCHEDULE OF FIXED ASSETS AS ON 31st MARCH 1999

ANNEXURE '45'

PARTICULARS	COST AS ON 1/4/98	ADDITION DURING THE YEAR	COST OF SALES /TFD DURING THE YEAR	TOTAL
Land :	**0.00**	**75639.23**	**0.00**	**75639.23**
Building	**2713848.00**	**36000.00**	**0.00**	**2749848.00**
Furniture & Fixture:	**6699904.40**	**1911765.00**	**0.00**	**8611669.40**
(Details)				
Institute	6682297.40	1911765.00	0.00	8594062.40
ICIMOD SALT	11000.00	0.00	0.00	11000.00
ICIMOD ISSMA	6607.00	0.00	0.00	6607.00
Scientific Equipments :	**48588953.11**	**4352025.00**	**0.00**	**52940978.11**
(Details)				
Institute	37902252.19	2154551.00	0.00	40056803.19
DST (RSR)	7415.00	0.00	0.00	7415.00
BIOTECH-I	1840346.00	0.00	0.00	1840346.00
BIOTECH-II	3865160.00	164591.00	0.00	4029751.00
BIOTECH-III	836135.00	1293246.00	0.00	2129381.00
UNDP (HAIGAD)	70960.00	0.00	0.00	70960.00
CSIR (RCS)	119758.00	18190.00	0.00	137948.00
DST (SKB)	808564.00	0.00	0.00	808564.00
FAO-BIO-DIVERSITY	0.00	46592.00	0.00	46592.00
ICAR (ES)	0.00	1687.00	0.00	1687.00
ENVIS	242380.00	0.00	0.00	242380.00
NWDPRA	64858.00	0.00	0.00	64858.00
IEG PROJECT	18865.00	33600.00	0.00	52465.00
DST (SKN)	323172.00	0.00	0.00	323172.00
BIOTECH (V)	0.00	46119.00	0.00	46119.00
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)	71866.92	88208.00	0.00	160074.92
INDO CANADIAN	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
MACARTHER UNESCO	49950.00	13500.00	0.00	63450.00
ICIMOD (PARDYP)	0.00	88530.00	0.00	88530.00
ICIMOD (CBD)	0.00	52801.00	0.00	52801.00
ICIMOD (FIBRE)	0.00	199160.00	0.00	199160.00
MRE	0.00	2450.00	0.00	2450.00
ICIMOD-GIS EQUIPMENT	0.00	148800.00	0.00	148800.00
Balance C/F	**58002705.51**	**6375429.23**	**0.00**	**64378134.74**

Seal

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

SCHEDULE OF FIXED ASSETS AS ON 31st MARCH 1999

ANNEXURE '45' Contd...

PARTICULARS	COST AS ON 1/4/98	ADDITION DURING THE YEAR	COST OF SALES /TFD DURING THE YEAR	TOTAL
Balance B/F	**58002705.51**	**6375429.23**	**0.00**	**64378134.74**
Office Equipments :	**2480392.35**	**1328942.00**	**0.00**	**3809334.35**
Fire Fighting Equipments :	**60962.00**	**0.00**	**0.00**	**60962.00**
Library :	**18599765.50**	**4123958.00**	**0.00**	**22723723.50**
Vehicles :	**3935760.25**	**0.00**	**380559.00**	**3555201.25**
(Details)				
Institute	2852096.30	0.00	380559.00	2471537.30
ICIMOD SALT	279224.00	0.00	0.00	279224.00
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
Glass/Net House :	**1517793.00**	**2050788.00**	**0.00**	**3568581.00**
(Details)				
Institute	1517793.00	0.00	0.00	1517793.00
BIOTECH (III)	0.00	2050788.00	0.00	2050788.00
TOTAL RS.	**84597378.61**	**13879117.23**	**380559.00**	**98095936.84**

Seal

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

ANNEXURE '46'

PARTICULARS	ANN	AMOUNT	AMOUNT
Opening Balances : (IC A/C)			
Cash & Bank Balances :			
Cash in Hand :			
Almora:		632.55	
Srinagar		97.64	
Sikkim		136.31	
Kullu		1393.17	**2259.67**
Cash at Bank :			
CBI Kosi A/c No.CD-14		600603.75	
SBI Almora A/c No.22752		2191336.35	
SBI Almora A/c No.23884		1495712.15	
SBI Tadong A/c No.CA/4/65		395059.71	
SBI Kullu A/c No.50201/7		16260.81	
SBI Srinagar A/c No.3/615		37119.57	
SBI Almora P.F.A/c No.22021		22686.40	**4758778.74**
Advances			
House Building Advance		510524.00	
Motercycle/Car Advance		476000.00	
Festival Advance		12440.00	
Provident Fund Advance		122905.00	
Units of Institute :			
Sikkim		12422.00	
Srinagar		11015.00	**1145306.00**
Fixed Deposits :			
With SBI Endowment Fund :		2323900.00	
SBI Provident Fund		3175000.00	
CBI Provident Fund		1200000.00	
Intt.Acc.on FDR (P.F.A/C)		591119.00	**7290019.00**
Balance Carried Forward			**13196363.41**

Seal

G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT

KATARMAL, KOSI (ALMORA)

DETAILS OF OPENING BALANCES

ANNEXURE '46' Contd.

PARTICULARS	ANN	AMOUNT	AMOUNT
Balance Brought Forward			**13196363.41**
Due Staff/Others :			
Klenzaids Con.Controls (P) Ltd., (BIOTECH I)		56880.00	
Director- IARI		26.50	
G.C.S.Negi (CSIR)		2000.00	
A.S.Parihar		389.00	
B.P.Kothyari		6000.00	
J.M.S.Rawat		4382.00	
S.P.Maikhuri (TTA)		7400.00	
R.K.Nanda & Sons		28517.00	
Pertech Computers		2000.00	
Employment News		14150.00	
Sigma Aidrich Chemicals		10590.00	
Siltap Chemicals Ltd. (BIOTECH III)		16320.00	
Employment News (DST/SKN)		900.00	
N.R.S.A.Hyderabad		74800.00	
Shivalik Agro Products		677.00	
Klenzaids Con.Controls (P) Ltd.		57175.00	
M.P.C.B.		16382.00	
Airport Handling Services		35000.00	
Foss Tecator		35528.00	
Nat Steel Pvt.Ltd., Hyderabad		225172.00	
Saveer Gewachshaws		1640630.00	
Saveer Biotech Ltd.		509893.00	
Research Software Design Portland		4841.00	
H.K.Pandey		3000.00	
C.C.U. (Electric Sub Station)		100000.00	**2852652.50**
F.C.Inter A/c			2500.00
TOTAL RS...			**16051515.91**

Seal

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

CLOSING BALANCE AS ON 31st MARCH 1999

ANNEXURE '47'

PARTICULARS	ANN	AMOUNT	AMOUNT
Closing Balances (IC A/C) :			
Cash & Bank Balances :			
Cash in Hand :			
Almora:		10490.55	
Srinagar		185.64	
Sikkim		3515.02	
Kullu		1300.17	**15491.38**
Cash at Bank :			
CBI Kosi A/c No.CD-14		882343.46	
SBI Almora A/c No.22752		2779453.33	
SBI Almora A/c No.23884		28778.15	
SBI Tadong A/c No.CA/4/65		648310.00	
SBI Kullu A/c No.50201/7		187219.81	
SBI Srinagar A/c No.3/615		43462.57	
SBI Almora P.F.A/c No.22021		18425.40	**4587992.72**
Advances			
House Building Advance		1326194.00	
Motercycle/Car Advance		437360.00	
Festival Advance		13200.00	
Provident Fund Advance		206549.00	
G.S.L.I.		224.90	
C.P.F.		36.00	
Units of Institute :			
H.P.Unit		5000.00	
Garhwal Unit		54277.00	**2042840.90**
Fixed Deposits :			
With SBI Endowment Fund :		4127883.00	
Intt.Acc.on FDR (Endowment Fund A/C)		57724.00	
SBI Provident Fund		4808923.00	
CBI Provident Fund		1761416.00	
Intt.Acc.on FDR (P.F.A/C)		479471.00	
F.D.R. (Margin Money L/C A/c)		66000.00	
F.D.R. (Margin Money L/C A/c) SK UNIT		157000.00	**11458417.00**
Balance Carried Forward			**18104742.00**

Seal

G.B.PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT

KATARMAL, KOSI (ALMORA)

CLOSING BALANCE AS ON 31st MARCH 1999

ANNEXURE '47' Contd.

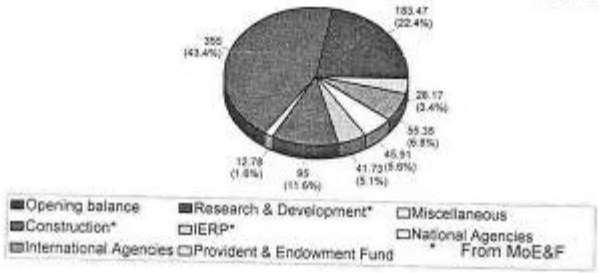
PARTICULARS	ANN	AMOUNT	AMOUNT
Balance Brought Forward			**18104742.00**
Due Staff/Others (IC A/c)			
Klenzaids Con.Controls (P) Ltd., (BIOTECH I)		56880.00	
Director- IARI		26.50	
A.S.Parihar		389.00	
B.P.Kothyari		6000.00	
R.K.Nanda & Sons		28517.00	
Pertech Computers		2000.00	
Employment News		5050.00	
Sigma Aidrich Chemicals		10590.00	
Siltap Chemicals Ltd. (BIOTECH III)		408.00	
N.R.S.A.Hyderabad		74800.00	
Klenzaids Con.Controls (P) Ltd.		57175.00	
M.P.C.B.		16382.00	
Hindustan Times		10000.00	**268217.50**
F.C.Inter A/c			2500.00
Closing Balance (F/C A/C)			
Cash & Bank Balances :			
Cash In Hand		386.00	
With SBI A/c No.20910		754928.90	**755314.90**
Advances :			
N.E.UNIT (SALT)		19445.00	
E.T.& T.N.DELHI		23040.00	
SIKKIM UNIT (ECO TOURISM)		23346.00	
N.R.S.A.HYDERABAD (PARDYP)		14500.00	
N.R.S.A.HYDERABAD (CBD)		11000.00	**91331.00**
TOTAL RS...			**19222105.40**

Seal

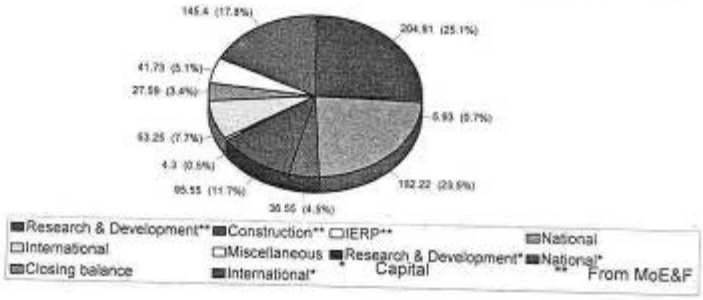
SUMMARY OF FUNDS RECEIVED AND EXPENDITURE FOR 1998-99

(Rs. in Lakhs)

(A) RECEIPTS

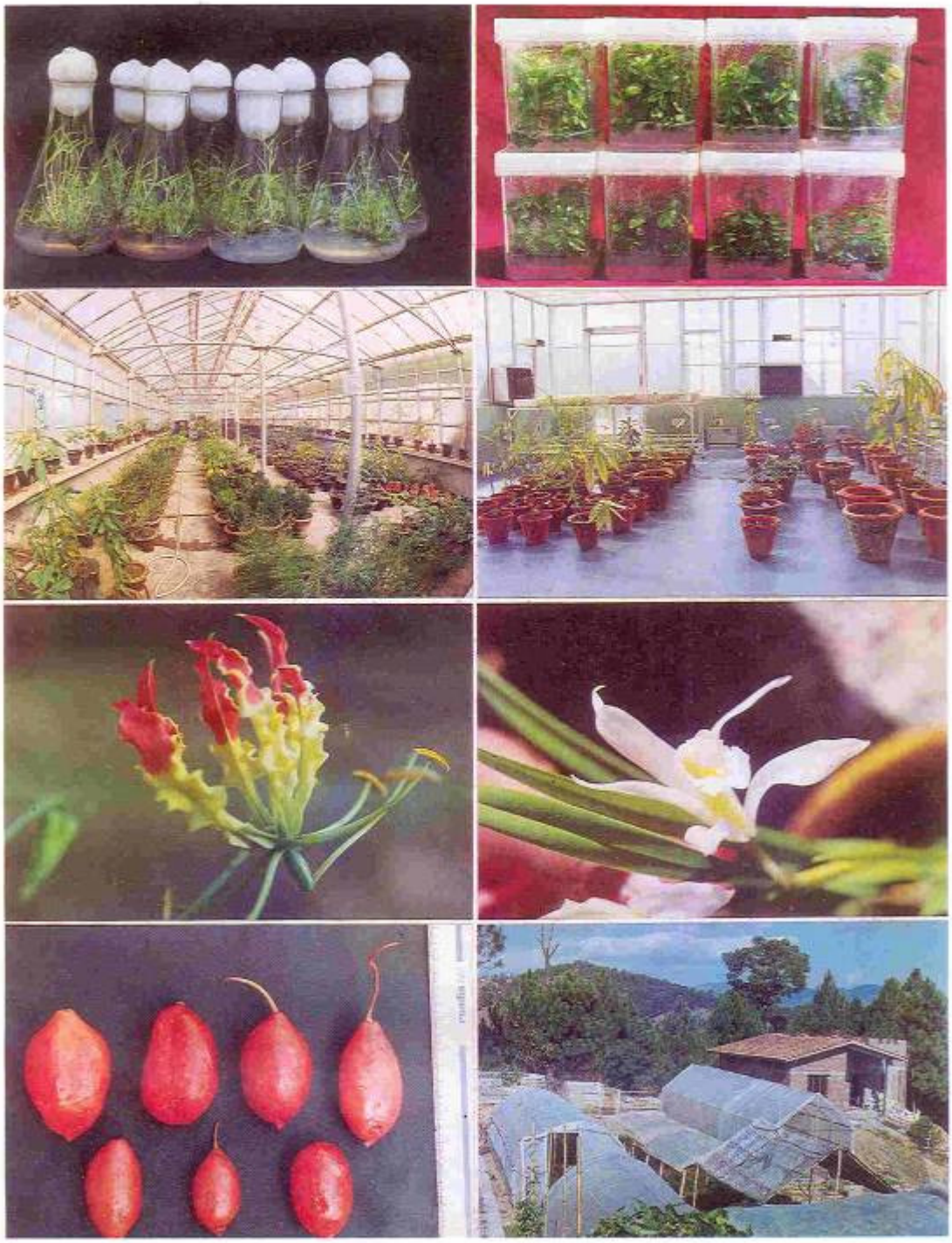


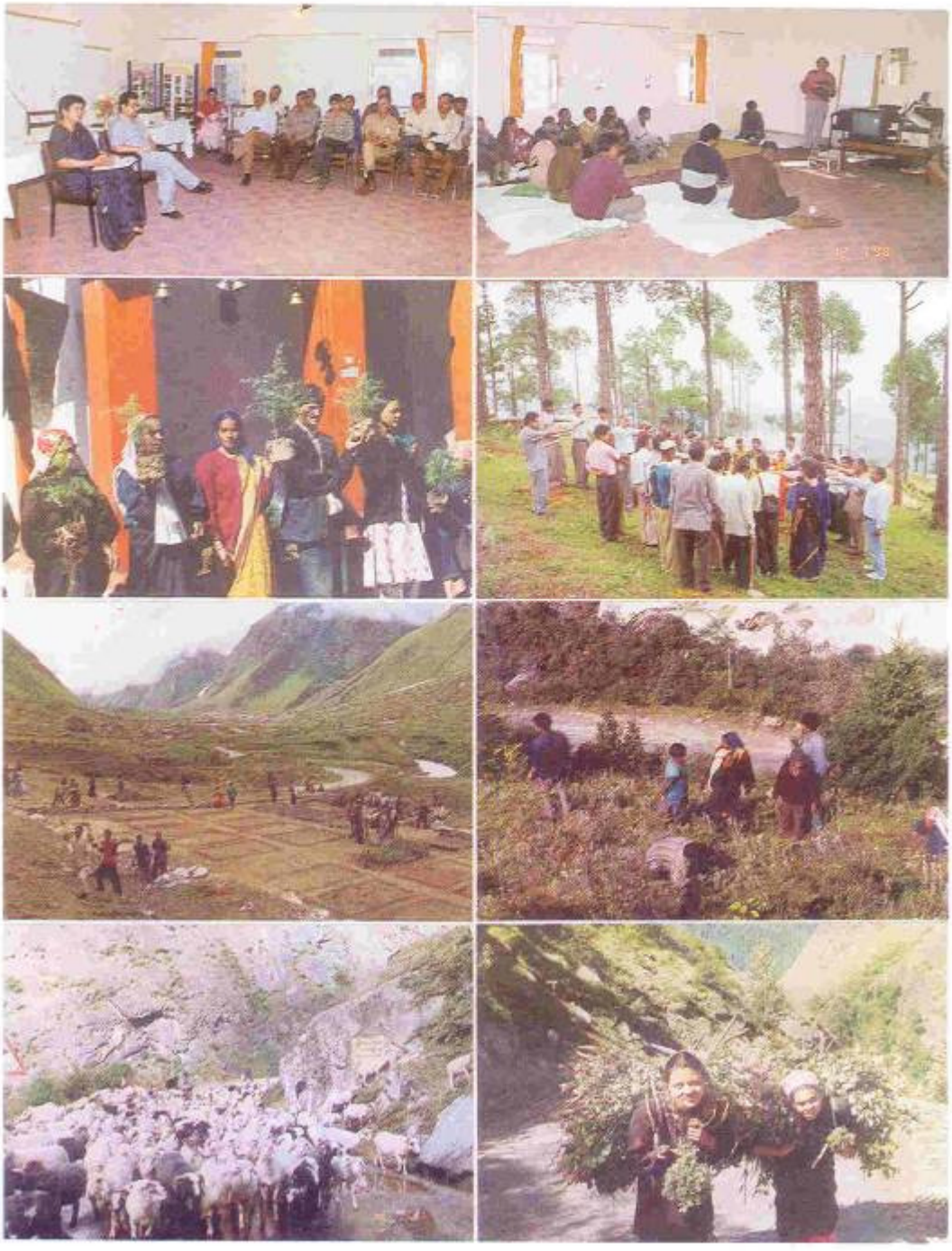
(B) EXPENDITURE

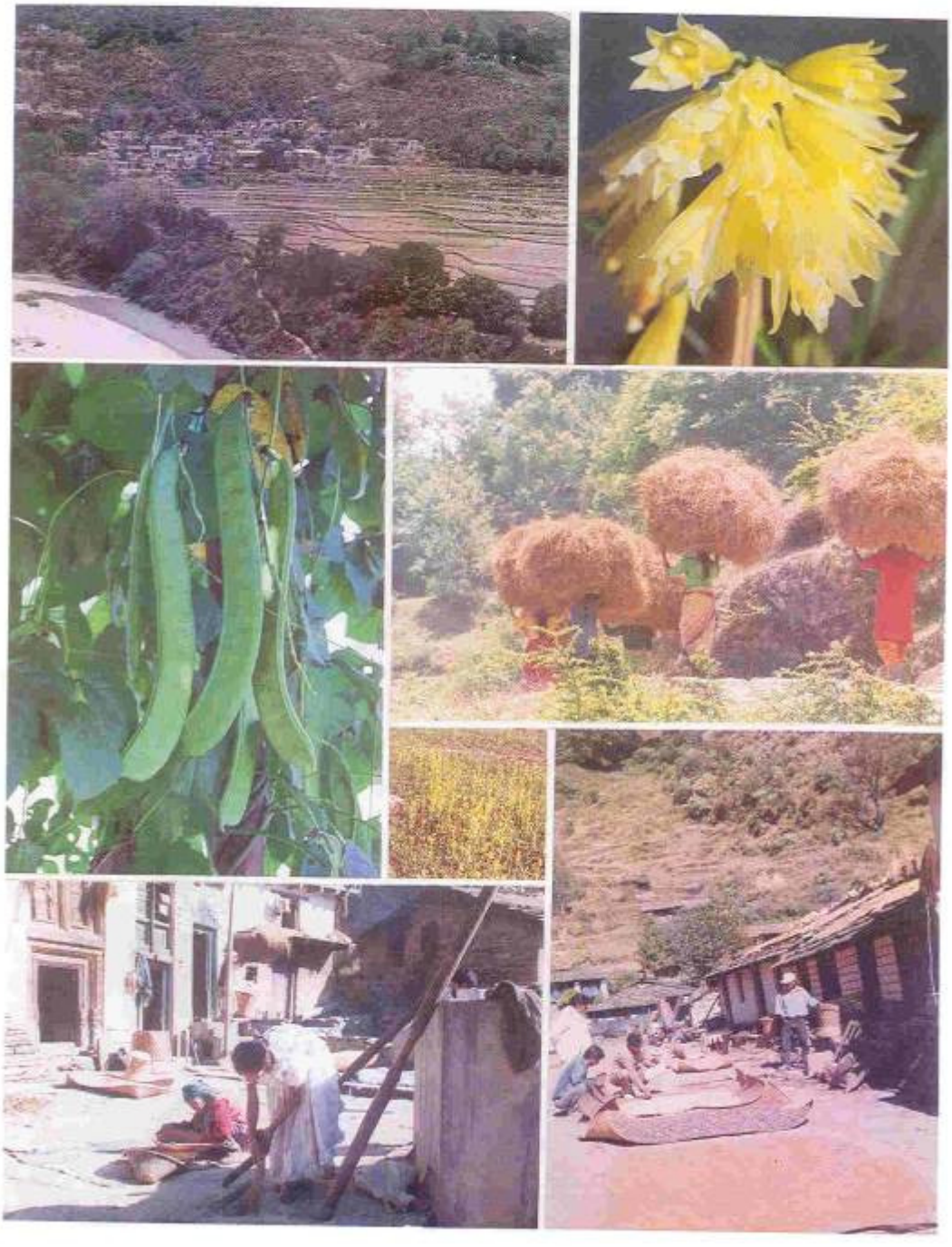


ABBREVIATIONS USED

BIOTECH	:	Department of Bio-technology
CSIR	:	Council of Scientific & Industrial Research
DOS- (DBT)	:	Department of Space (Department of Bio-technology)
DST	:	Department of Science & Technology
ENVIS	:	Environmental Information System
FAO	:	Food and Agricultural Organization
FARM	:	Farmer Cantered Agricultural Resource Management
ICAR	:	Indian Council of Agricultural Research
ICIMOD	:	International Centre for Integrated Mountain Development
IEG	:	Institute of Economic Growth
IERP	:	Integrated Eco Research Program
INHI	:	Institutional Networking and Human Investment
INSA	:	Indian National Science Academy
ISSMA	:	Institutional Strengthening for Sustainable Mountain Agriculture
MOE&F	:	Ministry of Environment and Forests
MRE	:	Mountain Risk Engineering
NDBR	:	Nanda Devi Biosphere Reserve
NEC	:	North Eastern Council
NWDPRA	:	National Watershed Development Project for Rainfed Areas
SALT	:	Sloping Agriculture Land Technology
TSBF	:	Tropical Soil Biology Fertility
UNDP	:	United Nations Development Programme
UNESCO	:	United Nations Educational Scientific and Cultural Organisation
UNICEF	:	United Nations Children Fund
WWF	:	World Wide Fund for Nature







हिन्दी को आप हिन्दी कहें या हिन्दुस्तानी,
मेरे लिए तो दोनों एक ही हैं।
हमारा कर्त्तव्य है कि हम
अपना राष्ट्रीय कार्य
हिन्दी भाषा
में करें।

—राष्ट्रपिता महात्मा गाँधी

है भव्य भारत ही हमारी मातृ भूमि हरी भरी,
हिन्दी हमारी राष्ट्र भाषा और लिपि है नागरी।

—राष्ट्रकवि मैथिलीशरण गुप्त

INSTITUTIONAL PUBLICATIONS

1991

* Agricultural Economy of Himalayan Region, Vol. I - Kumaun
  (Himavikas Pub. No. 1)

1992

* Himalayan Environment and Development : Problems and Perspectives.
  (Himavikas Occasional Pub. No.1)
* Integrated Watershed Management : A Case Study of Sikkim Himalaya.
  (Himavikas Pub. No.2)
* Action Plan for Himalaya.
  (Himavikas Occasional Pub. No.2)

1993

* Agricultural Economy of Himalayan Region, Vol. II - Garhwal
  (Himavikas Pub. No.5)
* Himalayan Biodiversity : Conservation Strategies.
  (Himavikas Pub. No.3)
* Tropical Soil Biology and Fertility Research : South Asian Context.
  (Himavikas Pub. No.4)

1994

* Environmental Friendly Hill Development : An Approach for District Chamoli.
  (Himavikas Occasional Pub. No.4)
* Sustainable Rural Development Opportunities and Constraints.
  (Himavikas Pub. No.6)
* Myrica esculenta Box Myrtle (Kaiphal) : A promising under-exploited tree crop of the Himalaya.
  (Himavikas Occasional Pub. No.3)
* Hydropower Management for Sustainable Rural Development in Remote Unelectrified Zones of Himalaya.
  (Himavikas Pub. No.7)
* Sustainable Development and Rehabilitation of Degraded Village Lands in Himalaya.
  (Himavikas Pub. No.8)
* Medicinal Plants of the Sikkim Himalaya : Status, Uses and Potential.
  (Himavikas Occasional Pub. No.5)

1995

* Fodder Trees and Shrubs of Central Himalaya
  (Himavikas Occasional Pub. No.6)
* Cultivation of Medicinal Plants and Orchids of Sikkim Himalaya.
  (Himavikas Occasional Pub. No.7)

1996

* Land Utilization in the Central Himalaya : Problems and Management Options.
  (Himavikas Occasional Pub. No.8)
* Tribal Development : Options.
  (Himavikas Occasional Pub. No.9)
* Water Management in Himalayan Ecosystem : A Study of Natural Springs of Almora.
  (Himavikas Pub. No.9)

1997

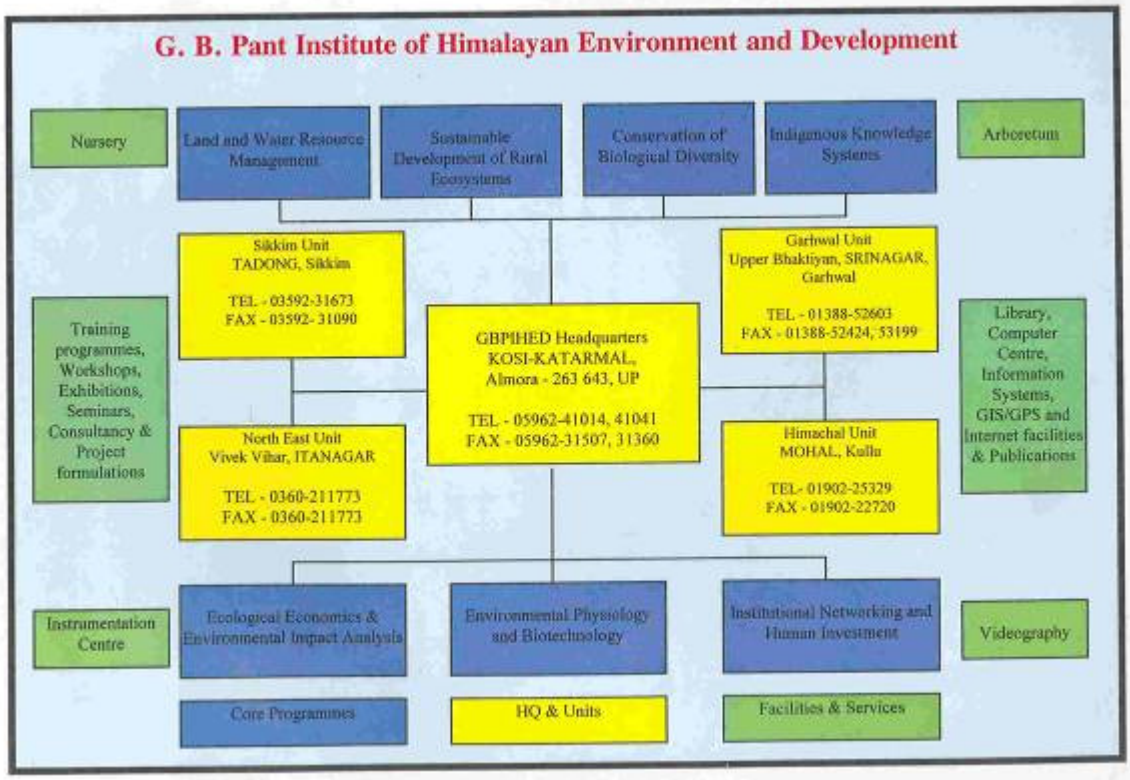
* Himalayan Biodiversity : Action Plan.
  (Himavikas Pub. No.10)
* Development Dilemma : Indian Scenario and Rural Himalaya – A Central Himalayan Perspective
  (Himavikas Pub. No. 11)
* Perspectives of Mountain Risk Engineering in the Himalayan Region.
  (Himavikas Occasional Pub.No.10)

1998

* Research for Mountain Development : Some Initiatives & Accomplishments.
  (Himavikas Pub. No.12)
* Medicinal Plants of Indian Himalaya : Diversity, Distribution, Potential Values.
  (Himavikas Pub. No.13)
* Perspectives of Planning & Development in North-East India.
  (Himavikas Occasional Pub. No.11)
* Biosphere Reserves & Management in India.
  (Himavikas Occasional Pub. No.12)

1999

* Guidelines for Protection, Maintenance, Research and Development in the Biosphere Reserves in India.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