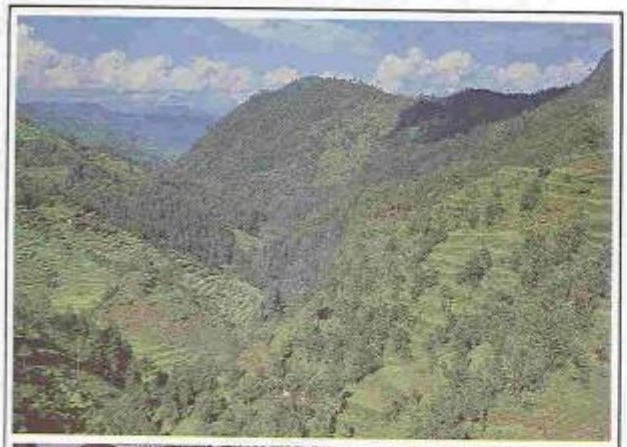

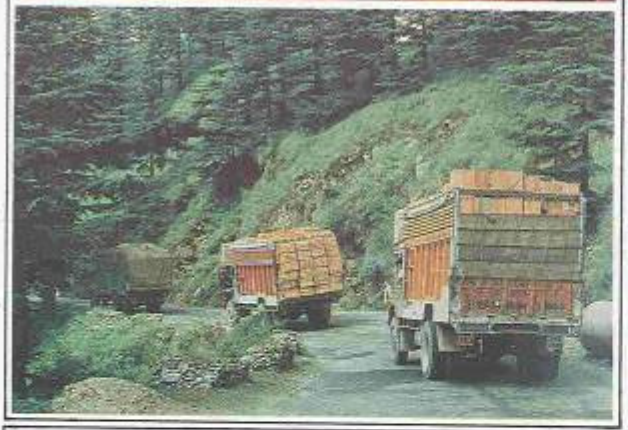

ANNUAL REPORT 1993 - 94

G.B. Pant Institute of Himalayan Environment and Development
(An Autonomous Institute of Ministry of Environment & Forests, Govt. of India)
Kosi, Almora-263643
INDIA

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Environment and Development
Kosi, Almora

ANNUAL REPORT
1993-94

G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT AND DEVELOPMENT

(An Autonomous Institute of Ministry of Environment & Forests, Govt. of India)
Kosi, Almora 263 643
INDIA

CONTENTS

THE YEAR 1993 - 94 : AN OVERVIEW

The need of this Institution, its mandate and niche were clearly spelled out by the Union Ministry of Environment and Forests at the time of its establishment in 1988. However, difficult as it may be, the Institute has an obligation to explain its progress to the public. Unlike many of grown up and well established Institutes located far away from the Himalaya and trying to interpret, simplify, generalise, and popularise hot issues of Himalayan environment, this Institute has placed priorities for logical understanding of ground realities, developing and demonstrating appropriate technologies for environmentally sound development, together with influencing the decision making processes at all levels. It is more like a "loyal partner" to many other Institutions working for Himalaya and its inhabitants rather than as a "competitive partner". As with any other growing Institution, often expectations from the Institute are more than the realities it is faced with. It is located in relatively non-accessible area and, therefore, is known more to those who live in these areas. Its main niche is the area where conventional science has not only to deliver goods to the people but has also to gain substantially from local knowledge. The Institute's horizontal and vertical development depends on the available man power and funding; both of these are sure to build-up in the years to come.

We are moving from descriptions to prescriptions and demonstrations. Some of the major achievements during the year include designing, development and installation of adaptive mini- micro hydel in a remote area; development of method of vegetative propagation of common Yew - a Himalayan asset under threat; development of simple technology for transforming weed biomass to organic manure; identification and promotion of value additions to wild edibles as a source of off-farm income to the villagers; and bringing people from different walks of life together to join hands in restoration of Badrivan. A technology package for regeneration of degraded lands in hills under the mane of Sloping Watershed Environmental Engineering Technology (SWEET) is at final stage of testing and will be available to the users by next year. Small scale trials for the introduction of Bulgarian rose (Mamlay watershed, Sikkim and Kosi) and hops (Kosi) have been initiated and the early indications are quite promising.

The milestone events, mentioned subsequently in this report, are indicative of the fact that the Institute is gradually becoming apparent. It has gone a step ahead in strengthening its national and international collaborations by signing MOUs with RRL, Jammu for scientific collaboration on some perennial cash crops and with the University of Yale, USA for resource management. Our collaboration with NORAGRIC and ICIMOD continues to give encouraging outputs. Funding of two major projects by the Department of Biotechnology, Govt. of India is indicative of the increasing scientific capabilities of the Institute.

Our Networking with NGOs and the educational Institutions is getting strengthened day by day. The improved residential facilities in the coming years is sure to increase further interactions by way of training courses, workshops and seminars.

During the past five years major part of our core funds had to be spent on building the infrastructural and laboratory facilities. However, the improved financial situation by next year will be a turning point in facilitating further strengthening and spreading research and development activities.

A. N. PUROHIT
Director

1. INTRODUCTION

The reporting year 1993-94 is the fifth financial year of research and developmental activities being carried out by the Institute at different locations in Himalaya, intune with regional issues, and endeavouring to seek practical and workable solutions to specific problems. Presently the activities are centred around six designated Core Programmes. A total of seven programmes were successfully concluded during the year; summaries of each of these projects appear at appropriate places in the text. Detailed reports would also be published in due course and made available to the users. The progress made during the year 1993-94 on ongoing and newly initiated projects, and a brief account of academic and other activities is placed in this report. Suggestions for improvement and indication of our shortcomings by anybody interested in the well being of the Himalaya would be gratefully received.

2. MILESTONE EVENTS

* The foundation stone for the building complex of Himachal Pradesh Unit of the Institute was laid by Shri Kamal Nath, Honourable Union Minister of Environment & Forests on June 12, 1993 at Mohal Village of Kullu district

* The Institute celebrated its third Annual Day on September 14, 1993 at Garhwal Unit, Srinagar, Garhwal. The highlight of this event was the III G.B. Pant Memorial Lecture delivered by Shri V. Rajagopalan, Vice-President, the World Bank and Chairman, Consultative Group of International Agricultural Research (CGIAR). In his lecture, Shri V. Rajagopalan dwelt on a number of issues and problems of Himalaya focusing on the need for participatory development. He also stressed upon identifying priority issues and dealing with them through effective partnership among planners, researchers, and the people.

Three publications of the Institute namely Agricultural Economy of Garhwal Himalaya, ENVIS Bulletin and Himalayan Biodiversity: Conservation Strategies were released on the Annual Day.

Shri Rajagopalan donated a sum of Rs. 5,000/- towards endowment fund of the Institute.

* Badrivan restoration programme in Badrinath through participation of local inhabitants, forest department, pilgrims, saints, army personnels, NGOs, and members of Badrish Panda Panchayat was inaugurated on September 16, 1994 by Shri R. Rajamani, Chairman, Governing Body of the Institute and Secretary, Ministry of Environment & Forests, Government of India.

* A regional training Seminar on Conservation and Management of Biological Resources in the Himalaya sponsored by United Nations Educational, Scientific and Cultural Organisation was organised by the Institute from Sept. 21-30, 1993 at Srinagar, Garhwal. Fifty participants including representatives from Afghanistan, Iran, Iraq, Bangladesh, Myanmar, Nepal, Sri Lanka participated in the workshop.

* First project monitoring workshop under Integrated Ecodevelopment Programme of the Institute followed by third meeting of Project Evaluation committee was held on June 22 and 23, 1993 at Tadong (Gangtok).

* A workshop on "The Role of NGOs in Environmentally Sound Development of Himalayan Region" was organised by the Institute at Srinagar, Garhwal on September 20, 1993. Twenty four NGOs from Central Himalaya attended the workshop presided over by Shri Sunder Lal Bahuguna.

* The first meeting of high powered Coordination Committee of Uttranchal Research and Development was held in the Institute on November 8, 1993. Over 40 participants including the Secretary Uttranchal Development Department attended the meeting to discuss and decide the priorities.

* The Institute participated in an exhibition organised by ICIMOD at Kathmandu, Nepal from November 20 to December 6, 1993. The theme of the exhibition was "Mountain Environment and Development-Constrains and Opportunities".

* First Project Presentation cum Evaluation Workshop on Biodiversity/ Biotechnology theme was organised by the Institute at Kosi, Almora on December 29-30, 1993. Fifteen prospective PIs of Indian Himalayan region presented their proposals during the workshop.

* The Institute under its mandate of developing and demonstrating people oriented developmental project designed a mini-microhydel. The model developed involves simplified design and safeguards ensuring its maintenance by the local people. It was installed in January, 1994 in Pranmati Watershed, the area which does not have electricity at present. A multipurpose cooperative with energy as a major concern has been initiated in the watershed to manage the resources at village level.

* A regional meeting of NGOs from North-East was organised on February 17-18, 1994 at Guwahati to identify initiatives for sustainable development in the area. The meeting was inaugurated by His Excellency Shri Lok Nath Misra, Governor of Assam; Shri R. Rajamani, Secretary, Ministry of Environment & Forests, Govt. of India delivered the keynote address.

* The Institute signed a Memorandum of Understanding with Yale University School of Forestry and Environmental Studies, New Haven, U.S.A. for research and information exchange concerning rural resource management and rural development programme. Similarly, a MOU was also signed with the Regional Research Laboratory, Jammu for collaborative research with particular reference to medicinal plants, and introduction of high value crops, e.g., hops and saffron, etc.

3. RESEARCH AND DEVELOPMENT PROGRAMMES

All research and developmental activities of the Institute are essentially multi-disciplinary in nature, and based on a conscious effort to interlink natural and social sciences to promote sustainable development of the Indian

Himalaya, preserving the fragile ecosystems, indigenous knowledge and customs, and in complete harmony with the perceptions of the local inhabitants. As in previous years, the present efforts revolve around core programmes now six in number, 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 last two programmes having come into formal operation from this reporting year. The project sites are selected carefully, keeping in mind the heterogeneous heritage of the Himalaya along with its specific needs. The thrust of research and development efforts is to provide solutions to location specific problems through time-bound projects; the research is essentially need based and all field activities are well supported by laboratory based "basic" efforts, whenever required. Rigorous data collection and demonstration of science and technology inputs, including packages developed by the Institute, are underlying elements of all project activities. A number of projects (7) were completed this year, majority are now in the second or third year of operation and a few projects were initiated during the reporting year. Highlights of the progress made during the year 1993-94, alongwith a conceptual background, specific objectives and major achievements are summarized for individual projects.

3.1 LAND AND WATER RESOURCE MANAGEMENT

3.1.1 Integrated Watershed Management : A Case Study in Sikkim Himalaya

Background

The first phase of the project has been completed this year which covered: (i) climate and geomorphology, (ii) structural and functional analysis of different land-uses viz. forests, agriculture, agroforestry etc., (iii) landman relationship, (iv) understanding of linkages between different components (livestock, cropland, agroforestry, forests, farm-family, market etc.) of upland farming system, (v) socio-economic and ethno- cultural pattern and (vi) identification of gap areas for action in view of model development at farm level for demonstration. The summary of the results obtained in the first phase are as follows:

1. Area under different land-use/land cover categories of the Mamlay watershed was estimated using IRS-IA.IB, LISS-II, band 2,3 and 4 geocoded false color composite (FCCs) for November 1992 and 1988. About 2.12% area (same for both the years) was under built-up land, 24% and 16% under agricultural usage, 67% and 76% under forest, and 6% and 5% under waste land categories in 1992 and 1988, respectively. Change in land-use/land cover area using multidate imagery showed an increase in rainfed area (8.06%), and orange orchard (0.13%).

2. A decrease in dense mixed forest (by 5.94%), open mixed forest (by 5.25%) and sal forest (by 0.13%), while

an increase in degraded forest (by 0.70%), scrub land (by 1.76%), forest blanks (by 0.07%), rock out crops (by 0.40%) and landslides (by 0.20%) was recorded between 1988 and 1992 This shows the pressure on forests by the surrounding inhabitants.

3. The land-use management options for the watershed were evaluated using ranking technique. Six factors were used in this comparison, viz., crop preferences, productivity, gross margins, resource requirements, soil quality and risk. Maize/ginger/pulses showed high ranking followed by large cardamom, maize/potato and maize/pulses. Paddy cultivation was found to be non profitable.

4. A total of 122 woody species were considered for phenological study, out of which 110 were trees and 12 shrubs. The species fell into 3 categories, i.e., evergreens (54 species), semi-evergreens (5 species) and deciduous (63 species). Peak leaffall period for most of the deciduous species was October to December while peak flushing was recorded between February to April. Maximum flowering coincided with leaf flushing. For most species the fruit maturation and dispersal is over by November; for deciduous species in fruit maturation takes place a little earlier than for evergreens. This phenological information can be utilized in tree harvesting, use of by-products etc., and may be made use of in forest management.

The second phase to be initiated from the forthcoming year envisages to map natural resources of the Mamlay watershed and all the watersheds of Sikkim using satellite digital data and geographical information system. At the Mamlay watershed a model for agroforestry will be developed and technology packages such as weed composting, use of symbiotic N_2-fixers and root associated diazoatrophs for crop improvement, introduction of cash crops are planned. Some of the results already recorded in the second phase indicate that:

1. Out of 141 wild edible species in the Sikkim Himalaya, 77 were trees, 22 herbs, 25 shrubs, 14 climbers and 2 epiphytes. These are being evaluated for their nutritional value, marketing and regeneration potential. A general screening revealed 38 species to have medicinal value. Environmental consequences with regard to their extraction from nature have been enumerated.

2. Pulses are among the most potential crops for rainfed agriculture in the Himalaya. In Sikkim, pulses account for 11% of the total cropped area, and show high diversity. Pulses contain high protein (up to 40% in bhatmas), and the input is 3 to 10 times less in pulses as compared to maize and ginger, respectively, in terms of human labour; 40-130 times less than potato and ginger in terms of seed input per hectare. Nitrogen, phosphorus and protein content of 9 pulse varieties of the watershed have been estimated.

3. Weed composting technique has been evolved to increase/ maintain fertility levels of the soil in the upland farming system in the watershed. Crop field weeds and *Eupatorium adenophorum* have been efficiently composted in 6 weeks. Traditional cow-dung composting requires 8-10 months and is not sufficient. Farmers without livestock

can also make compost using this technology. Traditional winter-weed burning practice in upland farms is detrimental; 90% of ash-nutrients are lost during the first few rains. In contrast, weed composting is efficient with less than 10% nutrient loss. As with cow-dung compost, it also increases soil porosity, reduces surface run-off/erosion and enhances infiltration. Increase in soil organic matter in upland farms also helps in conservation of moisture and nutrients.

Based on the research findings as well as farmers' priorities, an agroforestry model has been devised for two different villages (one each in the sub-tropical and temperate zones) of the watershed. The main focus of the model, is to: (i) check soil erosion from farm fields, (ii) maintain soil fertility, (iii) increase crop productivity to an optimum level, (iv) strengthen cash crop, fodder and fruit component in the farms, and (vi) harvest rain water for the lean period.

3.1.2 Soil and Water Conservation, Landuse and Planning and Integrated Watershed Management : A Case Study in Garhwal Himalaya.

Background

Erosion is the greatest destroyer of land resource in the Himalayan region. Estimation of soil loss is, therefore, a valuable design, extension and planning tool. Its most immediate advantage is that a well-defined conservation objective can be formulated, namely, to reduce soil losses to acceptable levels. The satellite remote sensing and geographic information system (GIS) can play a very important role for the purpose of evolving an integrated approach for the management of land and water resource at a larger scale in the Himalaya. Resource mapping through these techniques will help identify the areas suitable for agriculture, horticulture, forest development, fisheries, surface and ground water development, soil and water conservation, food and fodder development and mining, etc. Watershed management requires all above information as well as study of various socio-economic factors operating in the watershed. On the lines similar to the study undertaken in Mamlay watershed in Sikkim, work was initiated in Dugar Gad catchment in Garhwal with following objectives :

Objectives

1. Socio-economic and environmental studies on representative watersheds in the Himalaya.

2. Identification of factors leading to land abandonment, and to assess future landuse trends and alternative land management systems.

3. Integrated resource management and development using digital data techniques : to demonstrate the use of satellite remote sensing and GIS (i) in assessing the potential of land and water resource in the region, and (ii) to identify the areas under degraded/ waste lands and to find out the suitability and environmental soundness of the present landuse practices.

4. Monitoring soil loss and water yield under representative landuse practices /currently operating in the region, on a long term basis.

5. Monitoring soil fertility levels, soil and nutrient loss and water uses in traditional as well as in proposed model farm systems and development of a fertility management strategy to maintain and improve land productivity.

6. Application of computer technology for simplifying terrace grading design.

7. Performance evaluation of vegetative measures for conservation of land and water resource.

Results and Achievements

1. Hydrological data monitoring (mainly run-off and silt load) in two small watersheds (Dugar Gad 306 ha, Dobh-Srikot 286 ha) was done using stage level recorder with flume arrangement.

2. Analysis of year round data for Dugar Gad watershed indicated a run-off coefficient of 0.18, infiltration coefficient of 0.82 and silt load of 1.05 t/ha.

3. Watershed retention is very high which may be attributed to the treatment measures taken earlier e.g. bench terracing, check dams, gully plugging, contour trenching, contour plantation of trees/hedge and utilization of water for raising paddy in the catchment.

4. A multislot divisor has been installed to evaluate the agroforestry system, initially at Banswara, in terms of its effect in reducing the soil erosion and run-off over the years and with various crop combinations.

5. A computer software Lotus for land grading designs has been customised to work out the appropriate land grading designs including reshaping of old terraces; these can be quickly computed as per the location specific needs, ensuring economy of the earthwork in excavation and filling.

6. Covering an area of 306 ha, Dugar Gad catchment (Fig. 1) has four villages with a population of 958 persons residing in 186 families. People own a total of 115 ha land, distributed in 10,707 terraces, a total of 1,926 animal units per ha cultivated land and a total of 1,098 fodder/firewood trees, 539 fruit trees and 5,807 wild trees, representing a mixture of both temperate and subtropical species.

Fig. 1 : Map of Dugar Gad Catchment

7. Differences in livestock composition were found across the villages despite similar livestock size, emphasizing that this is an outcome of resource availability, bullock labour required and economic returns envisaged.

8. Based on 179 households sampled,

it was found that land abandonment has reached an alarming level to almost 60%; land : man ratio has gone up by 2.5 times, both due to increase in population and land abandonment; dependence on market for imported foodgrain has thus increased many-fold.

9. Strong positive correlation between land holding and abandoned land indicates that households having large holdings appear to be able to afford to abandon a greater fraction of their land. In All, a lower degree of land abandonment and strong positive correlations between cultivated land and food grain yield, ground fodder collected and money paid to agricultural labourers and between household size and livestock size emphasize that dependence upon agriculture is still greater in this village.

10. A significant difference in land abandonment between households having an income source (47.9%) and those without a regular income source (41.5%) support our contention that the forces of perceived economic development promote the process of land abandonment. And, if this trend continues possibility of offering such land for alternative land management is high.

11. A net increase of 37.5% in irrigated area over the past few years indicates the need of water and warrants attention to use this resource fully.

3.1.3 Development of Agroforestry Model in Garhwal Himalaya

This is an ongoing project, please see previous Annual Reports for details.

The major achievements in the reporting year are as follows:

1. The survival percentage after 30 months of plantation in the agroforestry site remained same as it was after six months. Whereas, the average survival percentage declined from 78% to 76% in the restoration site. Minimum survival was recorded for *Aesculus indica* (18%) and *Boehmeria rugulosa* (36%).

2. The growth of main axis and diameter at collar height, 30 months after plantation in both the sites were maximum for *Alnus nepalensis*, *Ficus glomerata*, *Albizzia stipulata*, and *Dalbergia sissoo*.

3. It has been observed that cardamom can be cultivated successfully, as a cash crop under the shade of multipurpose trees in rain-fed terraces of Garhwal between 1000-1600 m amsl; cardamom started bearing fruit after two years of plantation and yielded about 250 $gm/m^2/yr.$ on dry weight basis.

4. Soil under the agroforestry site was found to be rich in nutrients than that of restoration site. In general, soil nutrient status at different depths on both the sites showed increasing trend.

5. A low-input technique, based on mulching, was designed on the restoration site to improve the growth and survival percentage of newly planted seedlings. Six months after plantation, maximum survival and growth was recorded for all species under treatments where partially decomposed mulch was applied.

6. All species planted at the agroforestry site exhibited significantly higher photochemical efficiency and leaf area as compared to those growing in the restoration site.

3.1.4 Biological Mechanisms in the Maintenance of Soil Fertility under Various Land Use Practices in Kumaun Himalaya.

(Summary of completed project; please see last annual report for details)

The project has attempted to answer three specific questions: what are the key factors and processes regulating soil fertility and their manifestations in terms of crop yields? To what extent has soil fertility declined and what are the reasons thereof? What are the possible options for maintaining/improving soil fertility levels, specifically the avenues for improved utilization of locally available resources? Among a multitude of factors and processes regulating soil fertility, the ones found, most crucial to Kumaon hills include: (i) a shift in emphasis from coarse grains to fine grains (wheat and paddy); (ii) expansion of canal based irrigation under the control of Government; (iii) reduction in forest area and forest based resources accessible to farmers and (iv) soil fertility problems are more serious in the mid hill region than in high elevation remote areas. Wheat and paddy, in terms of crop yields, responded more to low levels of soil moisture and nutrients when compared with millets, pseudomillets and other coarse food crops. Soil organic carbon and nitrogen pools were found to be much less variable than the inorganic pools. In many instances, significant relationships between organic carbon and nitrogen levels in the soil during the crop growth were not found indicating the need of amendments which synchronize release of nutrients from the organic residues/soil organic matter with the crop demand.

This project was sponsored by the Dept. of Science and Technology, Govt. of India.

3.1.5 Irrigation Systems Management, Hydrology and Rural Water Supply and Sanitation.

Background

Water, being the basic input for any developmental activity, has a great impact on the agriculture of an area. Irrigation changes low-priced grazing–land into expensive cropland. New crops can be grown, and much of the risk taken out of growing established crops, even in humid mountainous region. In most cases, irrigation schedules are not designed to match the physiological demands of the crops. This is mainly because of inadequate attention paid to the characterization of soil, water, plant environment and farmer interactions. On-farm management of precious irrigation water for its optimal utilization and also development of cost-effective techniques for organising irrigation water need very special attention in the Himalayan region. Drinking water is becoming a scarce commodity in the mountains. Needless to emphasize that safe drinking water- supplies and environmental sanitation are vital for protecting the environment, improving health and alleviating poverty.

Objectives

1. Field evaluation of existing irrigation systems and possible enhancement in their efficiency.

2. Development of demonstration models for water harvesting, storage and irrigation scheduling, including consumptive use estimation for the proposed as well as traditionally grown crops.

3. Studies on drinking water supply and sanitation including hydrological aspects of springs.

4. Investigations on hydrology and water balance in selected watersheds under various landuse, and employing vegetative manipulations.

Results and Achievements

1. Irrigation status in Pauri-Garhwal was studied; out of the five available types in the region, kuhl/canal system covered the maximum area, i.e. about 67 per cent of the culturable command area (CCA).

2. Evaluation studies of some of the important canal systems indicated that the area under irrigation has marginally increased. This increase may be attributed to the levelling of land/terraces and use of culturable wasteland for crop cultivation.

3. Studies showed heavy seepage losses in unlined kuhl and in damaged sections of the lined kuhls. Kuhls were seen to be facing landslide and subsidence problems. The existing diversion structures were poor and purely temporary. No regular operational schedule was followed.

4. Appropriate lining and more free board alongwith suitable drop structures, at critical points need to be provided. Additional escape structures are required at middle and tail ends of the canals to enable safe releasing of excessive flow of water during heavy rainfall. Crop water requirement and the irrigation schedule need to be worked out for the crops grown in the command area. And, accordingly a regular operational schedule need to be followed.

5. A community tap system has been developed with the provision of an automatic on/off valve on the stand post. The device is envisaged to check wastage of precious drinking water and also hazards due to pounding water around the stand post.

3.2 SUSTAINABLE DEVELOPMENT OF RURAL ECOSYSTEMS

3.2.1 Designing Ecologically Sound Natural Resource Management Strategies for Sustainable Rural Development in Kapkot Block (District Almora) in Central Himalaya.

(Summary of completed project; please see last annual report for details)

Over-emphasis on economic growth has been a major drawback in administered development planning. Economic growth, apart from being inequitable in the past, has not resolved many social issues. The prejudice against and the inferior status of women in society, religious persecution in both subtle and overt ways figure among serious social issues. Many is-

sues are of more recent origin, especially the perceived degradation of the environment, both as a result of improvident cutting down of forests and some of the development policies. Social, political and professional institutions are getting eroded. The present lifestyle of some sections of people is unsustainable. Thus the social tensions that are now beginning to appear, cannot be contained unless we move towards a more egalitarian society. Scope of this project was limited to high altitude villages in Kapkot block of Almora District where basic amenities such as motorable transport and electrification have not yet reached. Temperate bamboos (locally called as Ringal) constitute the basis of non-farm sector economic activities. Sustainable resource management strategies with focus on bamboos were designed and tested. Project activities included enrichment plantation of temperate bamboos mixed with suitable tree species, cultivation of medicinal plants, improvement in local skill of bamboo cottage industries/ handicrafts, promoting cooperation among villagers and enhancement of local knowledge pertaining to natural resource management with appropriate science and technology inputs.

3.2.2. Jhum and Sustainable Development of a Village Cluster in Nagaland.

Background

This project was taken up in collaboration with the Nagaland Gandhi Ashram, Chuchuyimlang in 1989-90 with the following objectives:

1. To find out ways and means of hastening the process of soil fertility recovery in jhum cultivation.

2. To explore the possibilities of introducing new crops and to identify fast growing native tree species valued by the tribals and to standardize their cultural techniques.

3. To develop and demonstrate low cost water harvesting technology, ensuring availability of water during the lean season.

4. To create awareness on the consequences of forest degradation, exploitation and conservation measures through involvement of local people in the project activities.

The first phase of the project is near completion. The results are summarised below. However, it needs to be continued in the second phase as a demonstration.

Results and Achievements

1. Over 5000 saplings of *Alnus* were distributed to the villagers, to be planted in jhum plots and fallows.

2. Although no new water harvesting tank was constructed, a locally modified version of the low-cost tank constructed by our field assistant was put to use for the nursery. The tank has a capacity of approximately 200 l; constructed out of bamboo rings and polythene/plastic sheets, this tank is ideal for households for storage of water, especially for irrigation in home gardens.

3. Monitoring of ongoing experiments in the agro-forestry model developed on the Nagaland Gandhi Ashram's agricultural farm continued. (A) Simultaneous monitoring of the growth performance of two varieties of *Alnus*, Nagaland and Sikkim varieties, did not show any difference. Both varieties showed similar growth characteristics in terms of biomass accumulation, leaf and branch recruitment and average number of leaves. (B) Monitoring of hydrological parameters and soil losses indicated an interesting trend. (C) The effect of *Alnus* introduction on productivity of paddy indicated that grain yield on a unit area basis as well as grain yield per plant increased in plots having *Alnus*. Plant biomass (minus grains) also increased but the grain number per plant was much lower in plots with *Alnus*. (D) A survey of plants with potential economic use indicated two such species to which the local people are familiar. *Hogsonia* sp., used by the locals, has potential as a source of edible fat. Passion fruit grows profusely in the area and the ripe fruits yield a delicious drink. This drink, as well as fresh fruit, has potential for marketing outside the region. The leaves of the plant are believed to have medicinal value.

4. A survey carried out in and around Chuchuyimlang revealed twelve varieties (land races) of paddy. Another six were collected from a neighbouring village. The preliminary survey suggested a rich traditional knowledge about the different land races, their suitability for cultivation in different/particular soil and topography and their growth characteristics. Some varieties are highly priced, but rare; while others are grown widely because they are the 'poor man's rice'. Productivity of these varieties varies from 2 tons/ha. to 7 tons/ha. Considering that the paddy is grown in jhum fields, with minimum of inputs in terms of fertilizers, a high crop-weed competition and reduced available manpower, the productivity is considerable.

3.2.3 An Empirical Study of Development of Tribal Communities from Ecocultural Perspectives: A Study in the Central Himalayan Region of India.

Background

Tribals constitute a very significant part of our heritage and the backward classes have been the focus of attention, particularly since independence. Though a number of development models have been suggested, a viable one interlinking ecology, economy and culture, and conducive to them is yet to evolve.

This project aims to evolve a model for development which is acceptable, through a study of two tribal communities, the Bhotia and the Jaunsari in UP Hills. The study has so far been confined to 5 villages, predominantly inhabited by the Bhotia tribe, in Kapkot block of Almora District in Central Himalaya. Bio-physical and eco-cultural diversities were accorded prior consideration while selecting the sample villages. The investigation is expected to identify markers of sustainability and constraints of peoples' participation in the development process.

Objectives

1. To study the integrated nature of

tribal culture and its influences on resource use and management.

2. To understand the concept of development from tribals perception.

3. To study the interlinkages between ecology, economy and culture and their influence on development.

4. To identify markers responsible for sustainable development and nature of variation of these markers in different tribal communities.

5. To quantify the degree of diffusion of development interventions and their impact on social structure and community culture.

Results and Achievements

1. The Bhotia tribe could be divided into two distinct sects (Joharia and Harkotia) based on their way of life (Table 1) which influences resource use and consequently development efforts. Both the sects inhabit separate villages, mostly multi-ethnic in composition, with considerable interdependence of one community on the other. Development stress has, so far, been mostly on infrastructural growth and agriculture, though agriculture is not practiced by the Joharia sect. Further, the introduced interventions, like HYV of crops, were found to be of little use to the other sect, since they were unsuitable for the ecology and could not withstand drought, hailstorm and snowfall. The seeds are sold at high cost and are incompatible to their cultural habits. Development apathy is well reflected in the process of distribution of HYV seeds as only 6 Agricultural Centres manned by 3 persons cater to 212 villages of the block.

2. In keeping with the eco-cultural conditioning, 48.4% of the sampled Joharia families have made use of Government loans in contrast to 8.3 % of Harkotia families. Around 27.7 % of the married couple among Joharias adopted family planning against 7.4 % among Harkotias. Higher percentage of literacy (47.2) and service class (21.3) among Joharias appear to give them more socio-economic security than the Harkotias, with lower literacy (26.6) and service class (10.1).

3. The study suggests a different approach to development for the Bhotia tribe than other ethnic groups of the hills, and even different approaches for its two different sects, with existing cultural variations within the same eco-system. For Joharia Bhotias, the interventions should focus on trade and cottage industry, and for the Harkotia Bhotias on agriculture and cottage industry.

Table 1: Distinctions Between Joharia & Harkotia Bhotias

	Joharia Bhotia	Harkotia Bhotia
1.	Traders and pastoralists, neither cultivate nor plough and land by themselves.	Agriculturists who cultivate and plough their land by them- selves.
2.	Do not domesticate bullocks and buffaloes.	Domesticate bullocks and buffaloes.
3.	Rear sheep and goats for commercial use of wool and wool products.	Rear sheep and goat for domestic use of wool products.
4.	Occupy a higher position in social hierarchy.	Occupy a lower position in soci-al hierarchy.
5.	Women have a higher status in society and a easy life.	Women have a lower status and a hard life.
6.	Educationally advanced and economically forward.	Both educationally and economically backward.
7.	Have taken advantage of the constitutional privileges.	Have failed to take advantage of the consitutional privileges.

3.2.4 Resource Management Strategies in Himachal Pradesh and Uttar Pradesh Hills.

Background

It has been argued that many unsustainable practices, in the hills, could be avoided if resource management strategies and development programmes are based on watershed as a planning unit. Integrated watershed management approach has been tried in a few segments of Himalaya in the recent past (please see 3.1.1 and 3.1.2). These efforts have undoubtedly played a catalytic role in promoting environmental orientation to conventional sector centred economic development approaches. However, the outcome also indicates need for further refinements in design as well as in execution. This project is a collaborative venture between the Institute and Norwegian Centre for International Agricultural Development under a bilateral cooperation programme between the Governments of India and Norway, supported through Norwegian Agency for Development Cooperation.

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 the socio-economic conditions prevailing 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.

4. To evaluate the concept of cover approach in the agroforestry system for land management and its effect on the reduction of soil erosion and run-off.

5. To identify land management options capable of raising the overall productivity of the land and economic condition of the farmers.

6. To evaluate the impact of small dams on production systems.

7. To develop and demonstrate models of agroforestry systems through farmer's participation.

8. To explore the possibilities for development policy reorientation for ecologically sound development of rural areas in the hills.

Results and Achievements

1. Micro-level analysis of the problems and prospects of managing natural resources for socio-economic development of the people was undertaken in two watersheds viz., Pranmati in Uttar Pradesh and Chandkinal in Himachal Pradesh. Conventional schedule based survey and informal discussions with a range of people formed the basis of prioritization of the problems and feasibility of implementing available options.

2. Crop and animal husbandry are the primary occupation of the majority of rural population. However, a change from traditional subsistence farming

to economic, growth targeted farming is advancing. Therefore, interventions are needed not only for raising the crop yields but also for influencing market forces so that farmers could adequately realise the monetary benefits. Local village level cooperative institutions need to be strengthened.

3. Soil and water parameters including soil loss, hydrological processes and nutrient pools are being analysed under different land use practices in the selected watersheds.

4. Water is the most abundant but also the most neglected resource in the area. Appropriate science, technology and institutional inputs were planned for management of water resource and hydropower, integrated with soil and water conservation, farming, forestry and horticulture sectors.

5. With people's participation, innovative microhydel technology was developed and tested in a remote village, Pai in Pranmati watershed, an area devoid of electrification and motorable transport. The technology was simplified so that farmers lacking any technical education can operate and maintain the plant after some training.

6. Through education, training and institution building, productive end uses of hydroelectricity and other sources of hydropower are being promoted (Fig. 2). Use of electricity in the mountain villages has been confined to lighting purpose. There is enormous scope of value addition to locally available/ produced resources using hydropower.

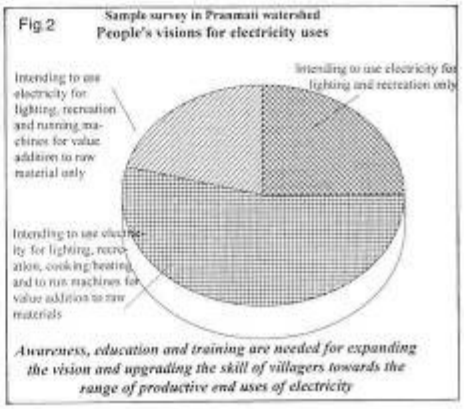

Fig. 2 : Sample survey in Pranmati watershed.

7. Data on ecological and economic efficiency of different land/resource use practices in the selected area are being collected. and effective framework for soil/land classification and mapping at large scale in the Himalaya are being evolved.

8. Geographic information system capability is being developed for analysing resource dynamics and resource modelling objectives; scope of cable ways in the remote areas lacking motorable roads is being explored. To start with, demonstration of the technological potential has been planned for movement of goods at one location.

3.2.5 Restoration of Degraded Land and Sustainable Rural Development at Katarmal, Kumaon Himalaya.

(Summary of completed project; please see Annual Report for 1991-92 for details)

Restoration of degraded natural resources has emerged as an issue which requires feasible management options to ensure improvement in the

quality of physical, biological and human environment in an integrated manner. To establish a balance between harvesting of natural resources and fulfilment of basic needs of the inhabitants, in a manner conducive to the environment, is the long term aim, in addition to short term goal of bringing the land back into use. Technology demonstration and its transfer at the field level is important to ensure long term benefits to the inhabitants of this region.

Keeping the above in view, this project was undertaken to develop and to demonstrate an ecologically stable and economically viable restoration model at Katarmal, Kumaon Himalaya. Appropriate utilisation of indigenous resources and simple technologies to amend soil and water harvesting have been used to improve soil fertility. Due consideration was given to establish practical linkages between resource availability, basic needs and utilisation of resources.

Since the restoration of degraded land is a long term process and requires atleast 20 years, the report containing details of methodology applied, approach and results on the basis of studies made during last 5 years will soon be published. General recommendation for restoration work in a degraded land are as follows:

Degraded area should be protected against grazing, other biotic interferences, fire and land slides. Development of vegetational cover should be done by plantation of indigenous plant species on ecological principles and on the concept of community organization and utility value, as recognised by the local inhabitants. Inputs in the form of FYM and water are essential to improve fertility status of the soil. Some elementary engineering works to protect the land against erosion and soil amendments are required during early stages of restoration. Careful and long term scientific studies to monitor changes in soil, water, vegetation, microbial communities, meteorological and socio- economic aspects are required to reach any conclusion.

3.2.6 Rehabilitation of Degraded Land in Mountain Ecosystems: Indian Central Himalaya

Background

As a direct consequence of the success of the rehabilitation experiment in Katarmal, there was a demand that this success story should be repeated in the community land. In this connection even ICIMOD got interested in its replication and approved funding under a coordinated project on rehabilitation of degraded land in Hindukush Himalaya including China, Nepal and Pakistan. The community land in Garur, distt. Almora was identified for the purpose.

Objectives

1. Improvement of productivity of degraded land.

2. Studies on socio-economic aspects with special reference to dependency of the villagers on forest and agricultural land.

3. Introduction of water harvesting technology in the area.

4. Promotion of environmental awareness among the villagers, through their direct involvement in project activities.

Results and Achievements

1. General characteristics of the study site have been studied. Primary information on socio-economic aspects, livestock statistics and related issues have been collected by using detailed questionnaire for individual household. Soil physical and chemical properties, soil microbial population are being analysed following standard methods. Soil texture is loam to sandy loam with an average moisture content of 12.7 percent alongwith 0.98 percent organic carbon. The soil is of low fertility status, and thus needs amendment by way of external inputs in the form of organic manure, fertilizers and biological means.

2. Following careful selection of tree species in consultation with the villagers and on the basis of ecological as well as socio-economic utility, large scale plantation has been carried out with over 95% survival. Surface and seepage water harvesting technology has been introduced in the 8.5 ha site. The work site has been fenced with stone walls and two low cost, polythene lined tanks of over 50,000l capacity have been made and the entire plantation in the area can now be watered at regular intervals.

3. A nursery has been raised on the site; perennial grasses including *Thysanolaena* have been introduced and the villagers have already harvested much more grass from the site in the first eight months of the project than in the previous years.

4. Phytosociological studies of the ground vegetation showed that the species having highest IVI (*Imperata cylindrica*, 128.5; *Euphorbia prolifera*, 11.2; *Chrysopogon serrulatus*, 21.3; *Erianthus rufipilus*, 19.1 etc.) are those characteristic of ecosystems that are low in fertility. The site is dominated by C_4 plants like *Imperata cylindrica*, *E. rufipilus*, *C. serrulatus* etc. Also, the presence of *Drosera peltata* is an indication of low fertility status of the soil because it generally grows in acid bogs where nitrogen is in short supply. Carnivory, therefore, appears to be an alternative strategy for obtaining nutrients that are in short supply.

3.3 CONSERVATION OF BIOLOGICAL DIVERSITY

3.3.1 Mechanisms of the maintenance of biological diversity and their role in ecosystem organization and function in conservation areas.

Background

The biological mechanisms maintaining a diverse community are not as clearly known as the variation in diversity in space and time. The project aims to assess and analyse community/ecosystems and landscape level diversity in Binsar Wildlife Sanctuary. Preparation of Thematic mapping, studies on population dynamics of tree species, identification of forest communities and the pattern of biomass accumulation in representative areas. The effect of forest fire envisaged in the plan were studied in the previous years. Efforts in the current year were concentrated on the following objec-

tives:

Objectives:

1. To analyse phenophases of major tree species and impact of climate on functioning of ecosystems.

2. Establishment of a computerized database for sanctuary by using Geographical Information System Technology.

Results and achievements:

1. An Automatic Weather Station was installed at an altitude of 2300 m in Binsar Wildlife Sanctuary to monitor weather parameters.

2. Different phenophases in major tree species (*Quercus leucotrichophora, Q. floribunda, Pinus roxburghii, Rhododendron aroboreum* and *Lyonia ovalifolia*) were recorded and are being correlated with climatic factors.

3. The computerized database for different outputs (thematic mapping, forest cover and types, population structure of tree species and biomass, effect of forest fire and regeneration) studied in the previous years were established by using ARC/INFO (a GIS software developed by ESRI Inc., California).

4. The dataset were categorised using (i) Core zone and buffer zone, (ii) Elevational zones, (iii) Micro-watershed, (iv) Habitat representation. Preliminary analysis revealed the following : The diversity, physiographic as well as vegetative, is well represented in the buffer zone. A shift in dominant forest type was observed along the elevational gradient; Spatial patterns indicate that pine forests are dominant; With an increase in elevation forest biomass was found to be increasing.

3.3.2 Exploration of Lesser Known Crops of Garhwal Himalayan as Food Source.

Background

Humans have used about five thousand plant species as food, but only 100 or so have entered world commerce and less than twenty provide most of the world's food. Just three crops (wheat, rice and maize) account for roughly 60 per cent of the calories and 56 per cent of the protein that humans consume directly from plants. Hence, in spite of a rich flora, we seem to depend on only a very small fraction of global plant wealth. With ever increasing population pressure and fast depletion of natural resources, it is necessary that we explore the possibilities of using underutilized traditional crop resources. In this direction Garhwal Himalaya serves as a reservoir for a large number of traditional, under-utilized crop species which are yet to be exploited and utilized properly for the benefit of mankind.

Objectives

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

2. To study the contribution of lesser-known crops in meeting the food requirements of traditional societies.

3. To compare the nutritional attributes of the lesser-known crops with those of common food crops.

4. To analyse the land management cultural practices and eco-physiological requirements of lesser-known crops and their comparison with common crop agro-ecosystems.

5. To identify strategies for conservation of the lesser-known crops.

Results and Achievements

1. While conducting the survey regarding the extent of cultivation of traditional crops, it was found that majority of the villages and families particularly at higher altitudes are giving emphasis on these traditional under-utilized crops as compared to the villages located at middle and lower altitudes.

2. Majority of the traditional crops, i.e. pulses, pseudocereals and millets/minor grains are rich in nutrition and mineral than common food crops (rice, wheat, barley).

3. In general, the per capita annual food consumption in terms of energy and protein equivalents, is maximum by the people of higher Himalayan villages. Among the traditional crops consumed, millets/minor grains contribute more in the local diet than pseudocereals and pulses across three different altitudes with maximum consumption at higher altitudes.

4. The role of traditional crops in the seasonal per capita food consumption pattern varied with higher consumption during winter; it declined during rains and summer season.

5. The annual per capita cash earned from these crops was approximately Rs. 1120. The economy of the locals inhabiting the higher Himalayan villages is largely dependent upon crops like *Amaranthus,* Rajma and Potato. It was observed that the locals of this region are exploited by the middlemen traders with more than 50% benefit from this business.

6. Farmers of higher Himalayan villages prefer to exchange these traditional crops with common food items like rice, gur, salt and the quantity depends upon the items they need for their own consumption all through the year.

7. Data on photosynthesis for *Hordeum himalayens, H. vulgare* (generally grown at lower elevation) for the light response curve of flag leaf of both the species, at 20°C, was measured. It was found that the light saturation of photosynthesis occurred around one-third of full sunlight. Significantly higher stomatal conductances for water and CO_2 were recorded in *H. vulgare,* yet there was no significant difference in net photosynthesis between the two species.

8. *H. himalayens* invariably showed higher respiration rate. There was an apparent reduction in photosynthesis in *H. himalayens* with increase in temperature, whereas *H. vulgare* was found insensitive to temperature. Morpho-physiological characteristics of *H. himalayens* indicate that this species can perform equally well even at lower elevation.

3.3.3 Studies on Biodiversity, Fragmentation and Conservation of ecologically sensitive habitats of the Himalaya.

Background:

In the Himalaya the scenario of habitat heterogeneity and species diversity is changing at a fast pace. The identification and characterisation of the habitats of the Himalaya, especially those supporting sensitive biota are of paramount importance for identifying the disruptions and magnitude of pressures leading to extirpation of important species. The consequences of habitat fragmentation are multiple. Therefore, the whole process has a negative effect on the population size, extinction rates and dispersal capacity. Index of change in a system can effectively be monitored and corrective conservation measures adopted when habitat, instead of single species are taken as study units. The project envisages to initially study the habitat diversity in protected areas of Kumaun Himalaya, and the present investigations are confined to Askot Wildlife Sanctuary.

Objectives:

1. Identification, classification and mapping of fragmented habitats; Identifying natural and anthropogenic pressures leading to fragmentation.

2. Predicting future potential habitats, and identifying habitats which support important taxa; Evolving conservation strategy for preserving fragile and vulnerable habitats.

3. Narrowing gulf between in-situ and ex-situ conservation, and developing products of potentially economic plants to support village economy.

Results and Achievements:

1. Resource Use Pattern of the Inhabitants: Along the vertical gradient (Baram 1000m, Chopta 1400m, Maitli 1800m) the most preferred fodder species were *Arundinaria falcata* (20.6%), *Castanopsis tribuloides* (13.11%), *Mallotus philippinensis* (9.8%) at lower elevation, *Vitis capriola* (30.8%), *C.tribuloides* (20.5%), *Trachelospermum lucidum* (15.4%) at mid elevation and *Quercus lanuginosa* (100%) at higher elevation. Along the horizontal axis (East-West), *Arundinaria falcata* (20.6%), *Castanopsis tribuloides* (13.11%) and *Mallotus philippinensis* (9.8%) at *Baram* (East); *Woodfordia fruticosa* (28.4%), *Bridelia montana* (19.7%), *Bischoffia javanica* (13.1%) at Mori (Mid): *Boehmeria rugulosa* (25.8%), *Meliosma pungens* (16.3%), *Bauhinia variegata* (9.8%) at Lumti (West) were highly preferred species. Of the preferred species *Castanopsis tribuloides* (Sensitivity Index(SI)=6), *Boehmeria rugulosa* (SI=7); *Meliosma pungens* (SI=5), *Quercus lanuginosa* (SI=5) are notable due to their high sensitivity index in the area.

2. Identification of Critical Habitats : i. Degraded Forest Site: Low average IVI of *Q. leucotrichophora* (86.8) was observed as compared to average IVI (165) recorded for this species in other undisturbed forests of Kumaun. The total tree basal area (28.9 m^{-2} ha^{-1}) was also low as compared to 44.6 m^{-2} ha^{-1} in natural (undisturbed) forests of Kumaun. Regeneration (38.9%; see-

dling + saplings) of this dominant species (*Q.leucotrichophora*) was low, while two undercanopy stress tolerant species i.e. *Rhododendron arboreum* (seedling + saplings = 77.8%) and *Lyonia ovalifolia* (seedling + saplings = 69.7%) showed better regeneration. Both species exhibited expanding population. Proliferation of alien taxa in the herb layer was seen. Of the identified (30) species only 7 (23.3%) were of Himalayan origin; most of the dominant taxa were alien and the Himalayan species exhibited low dominance (Table 2). ii) Semi Modified Habitat (Field borders/ marginal lands): Along an altitudinal range (800-2200m) a total of 44 species were present (36 trees, 6 shrubs, 2 climbers); all the species were of high fodder value and most of these (58.1%) were evergreen. iii) Modified Habitats (e.g. Agriculture lands): 1. A total of 19 crops, 26 vegetables and 16 fruit trees were observed in the area. 2. Among crops, wheat, paddy, and maize exhibited high genetic diversity; for example, wheat alone had 9 varieties (i.e. Kalyan, Malaysia, Roksona, Mongaria, Dabti, Vikas, Jhusia, Geruwa, Sonhera).

3. The newly introduced high yielding wheat varieties were mostly cultivated in irregared, lowlying valleys. In such areas cultivation of traditional varieties, e.g., Dabti, Geruwa, Mongaria was less. These varieties, however, were widely cultivated towards higher elevational villages (e.g. Maitli).

4. Of the 19 varieties of Paddy under cultivation, Taichun, China, RR-21, Kaljaria, Danabasmati and Jumali appeared promising. Towards the higher elevations cultivation of relatively newer varieties (e.g. Kaljaria, Taichun, and Ratna) has started, thus affecting cultivation of old varieties (i.e. Nandhani, Jharua).

5. Information obtained from the locals indicated cultivation of several traditional (lesser known) crops, e.g., Maduwa (*Eleusine coracana*), Rajma (*Phaseolus vulgaris*), Koni (*Setaria italica*), Ghurush (*Vigna umbellata*), Lobia, Rians (*Vigna unguiculata*). Til (*Sisamum orientale*) and Bajra (*Pennisetum typhoides*); this has decreased in recent years. In most of the villages cultivation of Koni, Rajma, China, Ghurush, Rians and Til is now not in practice.

6. Among vegetables, *Allium cepa* (Piaj), *Hibiscus esculenta* (Bhindi), *Brassica oleracea* (Gobhi) and *Colocasia esculenta* (Gaderi) are new introductions for the area.

Table 2. Performance of Important Herb layer species at a degraded forest site

Species	Frequency (%)	Density ($indi.\ m^{-2}$)
Himalayan species:		
Elsholzia strobilifera	6.9	2.9
Scrophularia calycina	13.3	0.8
Festuca modesta	26.7	3.7
Ainsliaea aptera	6.7	0.3
Anaphalis contorta	13.3	0.5
A. triplinervis	13.3	0.5
Important Alien Species		
Arundinella pumila	46.7	29.3
Arthraxon nudus	46.7	14.1
Eragrostis ciliata	60.0	18.1
Bothriochloa pertusa	60.0	26.1

Total species: 30, Himalayan: 7 (23.3%), others: 23 (76.7%).

This project has been extended to the protected and ecologically sensitive areas of Himachal Pradesh from 1994.

3.3.4 Establishment and Maintenance of a functional arboretum (Surya Kunj) at Kosi-Katarmal.

The work on establishment of a functional arboretum in Kosi-Katarmal to serve as a germplasm bank of the Himalayan species, and a model for training and research activities was started in 1992. During the current reporting period infrastructural facilities such as nursery development, pathways preparation, glass house and net house were developed. Seeds of 60 species (rare-endangered, ethnobiological and other values) were collected from different parts of Kumaun Himalaya. These were sown in polythene bags and nursery beds and their germination monitored. Cuttings of nine species were raised. Three species namely *Salix tetrasperma, Ginkgo biloba* and *Forsythia viridissima* showed 100% sprouting.

Considering the landscape, selected tree species were planted and their survival monitored. *Erythrina arborescens* showed maximum survival rate (71.01%) followed by *Terminalia chebula* (69.23%), *Fraxinus micrantha* (45.83%), and *Semecarpus anacardium* (13.33%).

Biotic disturbances (porcupine and rhesus monkey) destroyed some species whereas growth of about 60% of total planted individuals was effected by frost.

3.3.5 Conservation of Biological Diversity of Ecologically and Economically important plants of Central Himalaya.

Background:

Among the ecologically and economically important plants, wild edibles constitute an important source as a supplement and substitute, especially in times of scarcity. Due to limited cultivable land, hill people cannot afford optimum agricultural inputs. Therefore, they largely rely on a number of unconventional crop plants such as buckwheat, chenopodium etc. Different parts of wild edibles such as roots, tubers, rhizomes, leaves, inflorescence, flowers, fruits and seeds, etc. are consumed either raw, roasted, fried, cooked, boiled or in the form of oil, spice, seasoning material, jams, pickles etc. Presently their use is limited to certain rural and remote areas inspite of their potential value as income generating resource and for promoting diversity of plant resources for human consumption. It is envisaged to study the population biology of thes species, so that conservation strategies are developed for potential species on priority.

Objectives:

1. Inventory and identification of economically viable species.

2. Categorisation and classification of wild edible species with regard to rarity, endemism and other attributes.

3. Population biology of potential species.

4. Development of products and dissemination to locals.

Results and achievements:

1. Of the 334 species, 95 (28.44%) are

trees. The phenological observations revealed that 62 species (65.26%) are deciduous, 30 species (31.58%) evergreen and 3 species (3.16%) are semi-deciduous.

2. The analysis of the species showed that 104 (31.14%) are native to Himalaya, 62 (5.56%) Indian oriental, 28 (8.38%) Tropical Asia, 21 (6.29%) European, 18 (5.39%) Himalayan with extension and 101 (30.24%) are native to other regions of the globe.

3. Germination and survival of some of the edibles was analysed. *Semecarpus anacardium* showed highest germination (48%), followed by *Terminalia chebula* (25%) and *Zanthoxylum armatum* (12.73%).

3.3.6 Bio-Resource Inventory of the Himalaya.

Background

The field related studies in conservation biology is largely dependent on an adequate base line data of the bioresources of the region. It is, therefore, imperative to assess and develop a computerised data base of existing bioresources of the Himalaya. To ensure the strengthening of existing information, studies on the preparation of inventory of bioresources (family wise, rare-endangered, ethnobiological, endemics) has been initiated.

Objectives:

1. Develop a computerised data base of all the species and their habitats and to identify gaps therein.

2. Draw information about various attributes of specific habitats/species and its effective dissemination.

3. Prioritization of activities related to conservation.

Results and Achievements:

1. Of the 334 wild edible plants of West Himalaya, 4 species (i.e. *Allium strachey, Angelica glauca, Lonicera parvifolia* and *Pyrus vestita*) are endemic to Indian Himalaya and 50 species (14.9%) are near endemics.

2. Of the ten families analysed, four (Dilleniaceae, Tetracentraceae, Circaeasteraceae and Menispermaceae) are not represented by endemics in Indian Himalaya. The extent of endemism in the remaining six families is presented in Table 3.

3. Except Berberis (Berberidaceae) with specific endemism reading of 34% in Trans/Northwest Himalaya, others show endemic diversity in East or Central Himalaya. Thus, the endemism distribution in families (including Ranunculaceae and Paeoniaceae) identifies two centres of endemic diversity: i) Trans/North West Himalaya (Ranunculaceae and Berberidaceae) and ii) East Himalaya (Magnoliaceae, Schisandraceae, Annonaceae, Lardizabalaceae and Podophyllaceae).

4. The variation in extent of endemism due to subspecific taxa is seen only in the family Berberidaceae (37.0%) and is comparable to Ranunculaceae (31.5%).

5. Families, in majority (except Annonaceae) are represented by only one life form.

6. Except Schisandraceae, endemics in tropical families are mostly confined to lower reaches (<1500m). In temperate families (except Lardizabalaceae), endemics are mostly represented in the zone 1501-3000 m (Berberidaceae 85.7%, Podophyllaceae 100%).

7. Family Circaeasteraceae and Tetracentraceae (Endemic to East Asia) with narrow genetic base, and Berberidaceae and Podophyllaceae with high anthropogenic pressure are among the most sensitive families in the Indian Himalaya.

Table 3. Species composition and representation of endemic taxa in Indian Himalaya

Family	Total taxa	Endemics (%)	T/NW	W	C	E	Others
Magnoliaceae	20	5 (25.0)	–	–	–	4	1 (C,E)
Schisandraceae	06	2 (33.3)	–	1	1	–	
Annonaceae	19	2 (10.6)	–	–	1	1	–
Lardizabalaceae	05	1 (20.0)	–	–	–	1	
Berberidaceae	76	27 (35.5)	8	5	3	5	6
Podophyllaceae	05	1 (20.0)	–	–	–	1	–

(T/NW = Trans/North West; W = West; C = Central; E = East)

3.3.7 Timber Line and Snow Line Vegetation of Kumaun in Central Himalaya: Aspects of Composition, Diversity and Conservation.

Background:

Inspite of its recognition as a biological indicator of environmental change, both timber line and snow line habitats in the Himalaya remain least explored. Present study has been initiated focusing on extensive survey and inventorization of vegetation of such habitats of Kumaun Himalaya with an aim to provide a baseline information on existing biodiversity at timber line and snow line.

Objectives

1. To study and collect information on specific diversity, phenology of important species, and regeneration status and population structure of tree species.

2. To identify endangered/threatened species and microhabitats supporting ecologically sensitive species, for prioritization of species/microhabitats to be conserved in the future.

3. To identify ehtnobotanically important species and their habitat preference in natural conditions so as to determine their specificity.

Results and achievements:

1. The altitude of Kumaun Himalayan timberline varies between 3000-3500m, which is comparatively low as expected from other adjacent latitudinal (25-35° N) counterparts (e.g. West Sichuan and Yunnan: 3800 to 4500 m; Tibet: 4000-43000 m; East Himalayan: 3800-4000m).

2. Extensive inventorying has resulted in identification of over 480 species of angiosperms and gymnosperms and their analysis for spatial pattern of distribution and abundance is in progress.

3. Asteraceae (44 spp.), Poaceae (42 spp.), Rosaceae (38 spp.), Ranun-

culaceae (23 spp.), Brassicaceae, Caryophyllaceae and Scrophulariaceae (22 spp. each) are the dominant angiosperm families.

4. Floristic diversity among 6 distinct habitats (i.e. forest sites, forest edges, moist rocks and crevices, moraines, and human disturbed sites) have been analysed.

5. A total of 18 forest stands were analysed and the information is summarised (Table 4).

6. The data obtained on diameter-density-distribution are being computed/analysed for the preparation of population structure in the forest stands.

7. From the identified sites/individuals, seasonal information on following attributes is being collected: Phenology, Regeneration, Ground flora, and Identification of problems.

Table 4. Analytical Features of Timberline Stands

	Density (indi. ha^{-1})	Diversity Index	Basal Area M^2ha^{-1}
Trees	200-910	1.23 - 3.31	3.9-57.1
Seedlings	40-630	0.00 - 1.52	–
Saplings	70-480	0.00 - 2.41	–
Shrubs	770-36,500	0.14 - 3.10	–

3.4 ECOLOGICAL ECONOMICS AND ENVIRONMENTAL IMPACT ANALYSIS

3.4.1 Transhumance in Central Himalaya and its Impacts on the Himalayan Environment.

(Summary of completed project; please see last annual report for details)

Transhumance is a historical phenomenon evolved as an adaptation to extremities of physical environment in remote and high Himalayan mountains. Transhumance encompasses essentially varying degrees of dependence on agriculture and pastoralism. The very existence of this life support system alongwith intact social and cultural values for centuries offers opportunities for understanding the element of sustainability harmonising the social, cultural, economic and environmental facets of development.

The Bhotiyas of Dharchula (District Pithoragarh) practicing transhumance in of Darma and Byans valleys constitute the focus of this study. The target group consists of tribals settled in 13 villages of Darma valley and 7 villages of Byans valley settled across an altitudinal range of 2300 m to 4100 m amsl. The extreme cold in higher reaches imposes constraints on intensive agriculture. People depended more on trade as a profession to support their livelihood. The termination of trade with China in 1962 necessitated diversion of attention from trade to agriculture. Palthi or ogal (*Fagopyrum esculentum*), Phapher (*F. tataricum*) and potato (*Solanum tuberosum*) are the major crops grown in the area. Vegetables grown for domestic consumption include cabbage, turnip, peas and radish. Animal husbandry is well developed. Collection of plant products from the wild is another occupation tied up with crop husbandry. The studies highlight the scientific principles of resource conservation and management, particularly livestock management and local knowledge system. Tribal societies in these extremely marginalized areas

characterised by climatic extremities too, offer several lessons for how to respond to abrupt changes in marketing and trade by capitalising upon the local knowledge, skill and resources. Livestock and minor forest produce, are concluded to be the key resources for sustainable development in the area.

3.4.2 Environmental Impact Analysis of Multipurpose River Valley Projects - Tehri Dam.

(Summary of completed project; please see last annual report for details)

Recent advancements in remote sensing technology complemented with automated data processing offer immense scope for enhancing the element of objectivity in development project appraisals. This project initiated in collaboration with Space Application Centre, Ahmedabad examines the applicability/utility of thematic information derived from earth resources satellite data, integrated with other information, for environmental appraisal of multipurpose river valley projects, selecting Tehri dam as a test case. Land cover/use and geological features of the effective area was mapped using satellite data supplemented with ancillary information. Conventional socioeconomic data on population growth, sex ratio, literacy, land holdings and agriculture were transformed to spatial information considering village as the mapping/classification unit. Detailed studies were undertaken in fifteen villages representing different combinations of environmental and socio-economic features in the catchment area. Changes induced following the multipurpose river valley project have been analysed. Integration of spatial and non-spatial information using computer based techniques has been attempted.

3.4.3 Impact of Domestic Sewage Disposal on Natural Water Springs of Almora Town

This project was started three years ago. Based on this study, a detailed report has already been given to the State Government for follow up. The major findings and recommendations are as below:

1. The present system of sewage disposal in Almora town was studied in details and it is found that substantial part of sewage might be percolating through soil strata and it could be a reason for sub-soil water pollution.

2. Study of spring water chemistry in three different seasons indicated marginal seasonal variations in water quality.

3. High concentration of nitrates (ranging from 60 to 68.4 ppm) was observed in springs located near thickly populated areas like Thapalya and Rajpura. However, noticeable reduction in nitrates was found in springs located at higher altitudes. This clearly indicates possibility of seepage of sewage from the town which has certainly affected the groundwater quality.

4. Organic pollutants found in water and presence of coliform bacteria in the protected spring water confirmed the percolation of sewage which resulted in the sub–soil water contamination. It is therefore necessary to treat water before use.

5. A comparison of water quality of two springs (Thapalya Dhara and Rajpura Dhara) located nearly at the same altitude but on either side of the hill was made. The results indicated occurrence of same spring-line across the bill with the same base rock composition.

Recommendations for Spring Water Management

Springs of Almora are a source of fresh water and can provide an alternative solution to the problem of water shortage to some extent. However, the study reveals that proper management is the need of the hour for protection of springs. Following protection measures are recommended for better management of spring water.

1. The concentration of water is one of the important requirements of hill towns. Waste minimisation can be achieved by applying proper checks in the supply line. Mass public awareness programme can be initiated to educate the local inhabitants about importance of the springs during water crises. Use of rain water should be given more emphasis through rain water harvesting technology.

2. Wastewater transportation through lined drains and sewage should be practiced within town boundary to prevent percolation of sewage.

3. It is suggested to have two separate trunk sewer lines on both sides of the hill with separate aerated lagoons for treatment of sewage at low cost.

4. The treated sewage water is recommended to be used for irrigation for reclamation of the degraded land available on the northern and southern side of the town for woodland development.

5. All unprotected springs need to be covered with regulated outlets and continuous monitoring of water quality is recommended to prevent outbreak of epidemics in future. This aspect should be taken up through public participation.

3.4.4 Development of Roads and Its Socio-Economical Impact: An Analysis of the Kapkot Block, Kumaon Himalaya

Background

Road network is commonly considered as a prime index of development as it plays a vital role in economic and infrastructural development of a region. Expansion of roads, in length and in breadth often becomes a contentious issue in environmental and socio-economic appraisal of development activities in the mountains. In a fragile landscape like Himalaya, environmental problems such as hydrological imbalances and soil erosion are considered to be undesirable consequences of motorable road development. On the other hand, motorable transport is considered to be the most felt need for socio- economic development in the remote and inaccessible areas in the mountains cut off from the mainstream. The present study is aimed at evaluating and quantifying the socio-economic and ecological impacts of road construction in Kapkot block of Almora district. The block is the most remote and backward in the district and its altitude ranges

from 1000 m to 7000 m.

Objectives

1. To derive a true picture of the transport system, i.e. accessibility, connectivity, length and density, traffic flow, etc.

2. To highlight the role of road network in changing the landuse, occupation, expansion of human settlement, building material and shape and size of houses.

3. To quantify the degree of enhanced socio-economic services and infrastructural growth articulated in different areas, i.e, near and far from the road.

Results and Achievements:

1. In order to achieve the objectives of the study, the villages in the block were categorised into 3 different zones on the criterion of their location from a road. The three zones are: villages located on the road or within 2 kms. from the road, villages located 2 to 5 kms, and villages located at a distance of more than 5 kms from a road. To compare and quantify the impacts of road on these three zones, 7 villages (table 5) were selected representating variability in altitude, forest cover, landuse, irrigation, and cropping pattern in the block. The bench mark year for impact analysis was 1960-61. Changes in each of seven selected village during 1960-1993 are being analyzed.

2. There was no significant difference in arithmetic density among the selected villages but agricultural and physiological densities differed considerably. In general, villages on or adjacent to road network were more developed in terms of infrastructural facilities and education.

Table 5: Geo-Demographic Particulars of Sampled Villages, 1993

Villages	Area (Ha)	Altitude (mts.)	Slope Aspect	Distance from Bus Point (km)	Population	No. of Household
Ason	134.8	1075-1240	W	0.0	772	165
Poling	99.1	1040-1260	E	5.0	276	56
Munar	110.2	1460-1600	E	5.0	96	15
Sama	439.9	1600-2400	SE	0.0	1089	156
Bhantola	85.4	1550-1750	SW	7.0	391	58
Darsing	48.3	1400-1540	W	6.0	187	40
Kiroli	116.0	1600-1900	SE	0.0	142	25

Table 6: Aspects of Impact Studies

Demographic Structure	Economic Activities	Quality of life (Infra-Structure)
Distribution	Landuse	Educat. Institutions
Growth	Forest	Health Institutions
Density	Barren & Unculturable	Drinking Water
Arithmetic	Culturable waste	Electrification
Agricultural	Area not available	Bank
Physiological	for cultivation	Post Office
Family Size	Net sown area	Telegraph Office
Age & Sex	Fallow land	Telephone
Literacy	Horticulture	Transportation
Occupation	Grazing land	Public Distribution
Migration	Irrigation	System (PDS).
Agriculture & Cropping pattern		
Per Capita land		
Size of land holding		
Livestock		

3. Further villages in the valleys connected by road were characterized by degraded forest, smaller land holdings, less per capita cultivated land, more

use of chemical fertilizers, high yield varieties of crops, and more irrigated land when compared with other villages.

4. Each household had livestock but sheep and goats were more in remote hill slope villages.

3.4.5 Ecology and Socio-Economy of Transhumance Communities of Central Himalaya

Background

Bhotiya is a Transhumant community of the Garhwal Himalaya inhabiting in northern most mountainous border areas of Chamoli and Uttarkashi Districts. The community comprises of three small sub-communities viz. Marchha, Tochha and Jadh. These communities have two dwellings, and practice transhumanic life every year from higher Himalayan zone (2000-3600 amsl) to lower Himalaya (400-1400 amsl) during winter and again back to higher Himalaya during summer. Each Bhotiya sub-community has its own culture, tradition and religious beliefs. Recently due to increased human and bovine population, which has not only posed heavy pressure on the alpine pasture and forest of Shiwalik and Bhabar track but also threatened their age old practice which helped maintain these societies at a subsistence level and took care of most of the needs of the people. Therefore, the aim of the present study is to compare and analyse in-depth the inter linkages between agriculture, animal husbandry, handicraft/trade dependence on forest and domestic sector of these communities under varied ecologic, socio-economic and cultural backgrounds and ultimately aims to come up with an integrated development plan that could help these communities and the environment.

(Sponsored by DST for the period of two years.)

Objectives

1. To study the structural and functional aspects of these transhumant communities at their winter and summer dwellings under varied ecologic, socio-economic and socio-cultural background.

2. To study the production consumption balance of subsistence needs viz. food, fuel, fodder and other domesticated goods.

3. Exchange/trade of commercial goods and their economic impact individually and interactive.

Results and Achievements

1. In-depth survey and identification of Bhotiyas transhumant communities of Garhwal viz. Marchhas, Tolchhas and Jadh inhabiting at higher and lower Himalayan zones has been completed.

2. A total number of 25 villages of these communities located in summer and winter dwellings have been surveyed and considerable information related to population, population density, literacy, sex ratio, employment, livestock, land holding, migration and natural resource utilization pattern have been collected.

3.4.6 Study of Biogeochemical Cycles in the Himalayan Eco-systems

Background

The atmosphere is an integral component of planetary life supporting system. Atmospheric processes are complex in nature and require multidisciplinary studies of physical, chemical and biological cycles to anticipate the impact on earth ecosystem of natural and anthropogenic changes in the chemistry of lower atmosphere. There is an intimate interaction among the cycling of chemical elements through soil, water, air and biomass. Changes in natural and man made ecosystems also influence the climate of earth. Study of different biogeochemical cycles and their interaction is important for assessment of short and long term climate changes. Biosphere serves as a source of trace gases which affect the atmospheric chemistry. The fragile Himalayan ecosystem was selected as an ideal area to study changes in atmospheric chemistry, due to its influence on local climate, diverse altitudinal and vegetation patterns. The project was conceptualized in collaboration with Indian Institute of Tropical Meteorology, Pune to study interaction in biogeochemical cycles in Himalayan ecosystem and its impact on climate change.

Objectives

To organise field observation programme at Kosi (5000 ft.) and Tungnath (13,000 ft.) for the following:

1. Assessment of background concentrations of air pollutants

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

Results and Achievements

During the field observational programme at Kosi the following measurements were carried out:

Trace gases (SO_2, NO_2, NH_3, & O_3); atmospheric aerosols and their mass size distribution; Aitken nuclei; rain water sampling and its chemical analysis; meteorological parameters (wind speed, direction, wet bulb, dry bulb, maximum and minimum temperatures and pressure); dew water sampling and its chemical analysis.

The preliminary results of the analysis of trace gases, aerosols and rain water composition suggest the following:

1. The concentration of trace gases (SO_2, NO_2, & NH_3) was within the range of world background levels.

2. The average mass concentration of atmospheric aerosols, also called Total Suspended Particulates (TSP), was 45 $\mu g/m^{-3}$, whereas, the minimum and maximum concentrations were 24 and 63 $\mu g/m^{-3}$ respectively. This is substantially lower than in 10 large cities in India (2000-600 $\mu g/m^{-3}$). The mass size distribution of aerosols showed bimodal distribution. The coarse particles contributed 70% and sub-micron particles 30% of the total mass of aerosols. This distribution suggests that the natural sources, mainly soil, dominated the anthropogenic sources.

3. Average pH of rain water at Kosi

is 5.82 and the individual value varied between 4.9 to 7.1. Average pH of rain water at Tungnath is 5.68 which is around CO_2 equilibrated value (pH=5.65) suggesting that the rain water is not acidic at both the places. Also, the pH of dew water varied form 6.78 to 6.11 with an average of 6.35.

4. The average concentration of Aitken nuclei was 2282 cm^{-3}, whereas the average minimum and maximum concentrations were 1000 and 5070 cm^{-3}, respectively.

The low concentration of TSP at Kosi is attributed not only to the absence of anthropogenic sources in the area but also to the elevation of the station which is 1.7 km above mean sea level. During 1994-95, it is proposed to carry out detailed sampling at Tungnath in Garhwal Himalaya. The programme is also likely to be extended to other locations in the Himalaya.

3.4.7 Carrying Capacity Assessment of Kullu-Manali Complex: A Study of Tourism Sector

A study of tourist carrying capacity of Kullu-Manali complex was carried out. In the study an assessment of accommodation and transport facilities etc. were attempted. The study has covered a number of aspects for Kullu town and some work has been carried out at Manali also.

Objectives

1. Ascertaining existing tourist flow and accommodation carrying capacity.

2. Assessment of transportation carrying capacity.

3. Assessment of other infrastructural facilities such as water and electricity supply, solid wastes and sanitation.

Results and Achievements

1. The total annual tourist arrivals were tentatively derived to be 11.4 lakh at Kullu-Manali Complex. It is further estimated that nearly 2.58 lakh tourist (22.5%) halted at Kullu.

2. The tourist arrivals showed two distinct peaks. Once during summer and once in October during Dussehra festival at Kullu. Whereas, the summer season accounted for nearly 36% of all tourist flow; the Dussehra period accounted for nearly 21% flow.

3. The accommodation occupancy for various types of hotels at Kullu and Manali for winter and summer seasons was assessed. While in Kullu occupancy peaked during Dussehra, in Manali summer was the peak occupancy time. The near total saturation was noticed in star category hotels during peak seasons at Kullu as well as at Manali. However, other types of hotels also recorded >75% occupancy during peak season. The winter occupancy was <20% at Kullu and <40% at Manali for all categories of accommodations. The hotel ownership analysis indicated largely local ownership. The outside ownership for star hotels was nearly one-fourth and for other categories it was <15%.

4. The bus services accounted for nearly two-thirds of all tourist arrivals. Additionally, while the car/taxis accounted for nearly one-third arrivals: the air transport brought in only ~1%

tourists. The HRTC bus occupancy during peak season in 1993 was observed to be ~84%.

3.5 ENVIRONMENTAL PHYSIOLOGY AND BIOTECHNOLOGY

3.5.1 Microbial inoculants for improved plant performance in the Himalaya.

Background:

A variety of microorganisms are used for inoculation of plant species for better establishment in the soil. Using basic knowledge, development of beneficial associations by inoculation of seeds, seedlings or growing plants, with selected microorganisms can be used for effective plant-microbe association leading to increased productivity. Major groups of these associations are: *Rhizobium*-legumes; free living microorganisms-plants; *Frankia*-actinorrhizal plants, and mycorrhizae-host plant. Rhizosphere provides an opportunity for the isolation of microorganisms that can be used for biotechnological applications. Most studies on the rhizosphere have, however, 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 different types of microorganisms. This study includes isolation and purification of microbes from the rhizosphere soil. These isolates are being studied for their biological properties. The selected beneficial isolates can then be used for inoculation of seed, cutting/tissue culture raised plants. The microorganisms support plant growth in several ways: (1) By fixing atmospheric nitrogen (2) By producing antimicrobial metabolites (3) By synthesising and secreting the phytohormones, vitamins and siderophores (4) By solubilising the rock phosphates, thus making it available to plants.

Objectives:

1. To study plant-microbe and microbe-microbe interactions in tree rhizosphere. This includes three microbial communities-bacteria, actinomycetes and fungi.

2. In vitro screening of isolated microorganisms for biotechnological applications.

3. Selection of efficient root colonisers from isolated strains.

4. Developing inoculants of promising isolates for improved establishment of plant species.

5. Maintenance of these isolates.

6. Inoculation of cereals, particularly maize seeds with free- living N_2 -fixing bacteria.

Results and achievements:

1. Isolations of bacteria, actinomycetes and fungi are being carried out from rhizospheres of *Cedrus, Pinus, Taxus* and tea.

2. A number of antagonistic bacteria and actinomycetes have been selected on the basis of their antifungal activity against rhizosphere fungi. These iso-

lates are regularly subcultured.

3. Bacterisation (Bacterial inoculation) of *Taxus* seeds: Five isolates were selected for inoculation of *Taxus* seeds. The criteria for selection of these strains were — production of antimicrobial metabolites and nitrogen fixing ability (Table 7).

Table 7

Isolate	Criteria for selection	Population in rhizosphere soil (cfu/g soil)	Medium
T_1	antibacterial activity	4×10^5	Nutrient agar
T_2	antibacterial activity	6×10^3	Nutrient agar
T_3	antibacterial activity	3×10^4	Nutrient agar
C_1	antifungal activity	3×10^3	Nutrient agar
T_4	Nitrogen fixing ability	8×10^5	Jensen agar (Nitrogen agar)

T and C represent isolations from *Taxus* and *Cedrus* rhizosphere soil.

4. Maize Experiments: Establishment of *Azotobacter chroococcum* on maize roots - Three cultures of *Azotobacter chroococcum* viz. C_2, M_4 and W_5 (carrier based) were used for the seed inoculation of local maize. After two months of sowing the rhizosphere and rhizoplane samples were analysed to observe the colonisation of inoculated strains. Roots were found to be heavily colonised with bacterial strains from the inoculated plots. The roots collected from control plot were not colonised with bacteria and after few days of inoculation, got contaminated with a black fungus.

A detailed experiment has been set at three different elevations in Sikkim. Seed of local maize variety (for all the three elevations) were inoculated with five cultures of free-living bacteria. These bacteria included 3 strains of *Azotobacter chroococcum* (A_{41}, W_5 and M_4) and 2 strains of *Azospirillum brasilense* (gynl and SP_7). The sites and elevation of three selected locations are: Jaubari, 1900m; Chhamgaon, 1600m; and Kamrang, 1200m.

5. Studies on tea rhizosphere: It has been found that an established tea rhizosphere is a very good source for the isolation of antagonistic strains. Soil samples have been collected from different sites of U.P. hills and Temi Tea Estate, Sikkim. These samples are being analysed for isolation of microbial strains for studying their biotechnological properties.

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

3. To develop and demonstrate the use of low cost polyhouses.

Results and achievements:

1. In order to obtain sufficient material for planting locally and economically important tree species, an attempt has been made to develop simple techniques for clonal propagation with the use of chemicals. Amongst various treatments tried, auxins particularly indole-3-butyric acid (IBA) and napthalene acetic acid (NAA), are known to be quite effective. We have attempted to induce rooting in some locally important plant species (*Grewia optiva, Juglans regia, Malus* spp., *Rosa* spp. and *Punica granatum*) by treatment with auxins, phenolics and a systemic fungicide, Bavistin. The treated cuttings, planted in the month of December in the Nursery (under a shade) at Kosi, have shown excellent sprouting.

2. In view of the problem of dormancy in seeds of many forest and alpine species, we are trying to understand this phenomenon. Regeneration of *Taxus baccata* L. under natural conditions is quite poor and reports indicate that seeds do not germinate until the second year. Experiments have been initiated under different conditions to ascertain/optimize germination. Seeds have been sown in experimental plots at Kosi following various chemical treatments. Seeds have also been sown in Katarmal soil, and in soil collected from *Pinus, Taxus* and *Cedrus* growing areas. Moreover, soilrite, an inert germination medium with good porosity, is also being tried. Seeds have also been sown under the natural habitat, i.e. below *Taxus* trees at Jageshwar, and under aseptic conditions, in flasks containing Murashige & Skoog's medium.

In addition, seed germination studies of the alpine herb *Podophyllum hexandrum* (a rich source of podophyllotoxin) are underway in the soil as well as in culture.

3. As a step towards germplasm conservation, cuttings of some important forest tree species (e.g. *Taxodium mucronatum, Acer cappadocicum, Populus nigra,* and *Salix alba*), collected from various locations (Nainital, Sariatal, Ramgarh-Gagar), have been successfully rooted following a simple dip treatment for 24h with 0.5 mm IBA. At spring, percent sprouting has been found to be highly effective (*Taxodium mucronatum* 73%; *Acer cappadocicum* 20%; *Populus nigra* 93% and *Salix alba*, 98%) with profuse shoot growth in *Populus nigra* and *Salix alba.*

4. In view of the tremendous importance of *Taxus baccata* as a source of the anticancerous drug, taxol (Rs. 18

lakhs/g) and due to its excessive and reckless exploitation from the Himalayan region, an attempt has been made to undertake clonal propagation of this extremely slow growing gymnosperm. A systematic experimentation was initiated in a polyhouse at Kosi using cuttings derived from both male and female trees (collected from Jageshwar area, 1840 m amsl, Almora district). Amongst the various treatments tried, a dip treatment based on plant growth substance of the auxin group (namely indole-3-butyric acid or napthalene acetic acid) has been found to induce rooting in young (1 yr growth) shoots with over ninety percent success (Fig. 3). Young shoots (1 yr growth) were found to have better rooting ability than older shoots (2 yr growth). This finding will pave the way for substantially augmenting natural regeneration through "seed", which is reportedly very poor; in addition this has the advantage of clonal or "true - to- type" propagation of elite trees.In addition, experiments have also been carried out to examine the seasonal variation in rooting of *Taxus baccata*

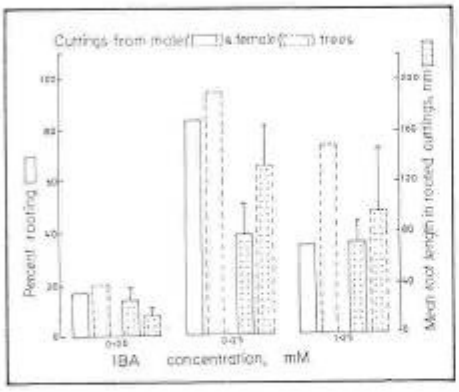

Fig. 3 : Cutting from Male & female trees.

cuttings, and the rooting potential of cuttings obtained from other regions like Tungnath (3400 m amsl) and Pindari (2650 m amsl) has been examined.

5. Inexpensive polytunnels can be used at times to supplement or in place of expensive glasshouses for conducting studies relating to seed germination and clonal propagation, and to save plants from harsh environmental stresses. At the Institute nursery a polytunnel of 8.5 m length x 2.5 m width and 1.8 m height in the middle has been constructed at an approx. cost of Rs. 5000/- . By making a two tiered arrangement, available space for around 4000 polysleeves (16 cm height, 8 cm diameter) is possible. Clonal propagation of *Taxus baccata* has been successfully carried out in such a polyhouse.

3.5.3 Evaluation, Propagation and Utilization of Selected Multipurpose Trees for the Waste and Marginal Lands of Central Sub Himalayan Hills.

Rapid depletion of tree resource, a major concern of today, has resulted in acute shortage of fodder, timber and other by products (oil, tannins, medicine etc.) directly affecting the Himalayan environment and it's people. In order to ameliorate this problem, plantation of selected multipurpose trees remains a viable alternative. The project envisages the importance of initiating plantations of economically viable selected tree species of the region by developing simple nursery and in-vitro packages, which will be eventually made available to the local populace. This can serve the dual purpose of meeting the optimum demands for

renewable energy resources and also to uplift the economic status of the local inhabitants.

(Project sponsored by the Department of Biotechnology)

Objectives

1. Identification and quantification of the resource availability.

2. Monitoring intraspecific morphogenetic variability of the selected species and identifying temporal and edaphic constraints in nursery technique.

3. Initiating in-vitro techniques and establishment of cultures.

4. Monitoring biological and edaphic adaptation of the seedlings raised through tissue culture.

5. Developing propagation packages both for nursery and in-vitro methods.

Results and achievements:

1. Extensive surveys were made to identify the area/habitats of the selected species at different altitudes of the Kumaon Himalayan region and the following sites were identified for details study. *Diploknema*: Chaurmania, (1320m.); Biskholi, (1290m.); Egyardevi, (1350m.); Panar, (1175m). *Bauhinia:* Jeolikote, (1130m.); Sat Tal, (1360m.); Khairna, (850m.); Dogaon, (950m.). *Sapium*: Matela, (1200m.); Hawalbag, (1250m.); Bhimtal, (1300m.).

2. A detailed inventory for each species was developed on the following: i) By products of the species ii) Utilization potential of *Diploknema* Ghee and *Bauhinia* leaves. The survey of Pithoragarh district revealed that the average household involved in ghee preparation ranged between 60%-100% with an average production of 8-30 kg/household/season.

3. Extent of availability of *Diploknema, Bauhinia* and *Sapium* population resources were identified in the region. Seeds were collected from selected populations for germination trials.

4. A well equipped tissue culture lab was set up in the Institute and standardization of in-vitro protocols for identified species is in progress. Encouraging results have been achieved in case of *Sapium* explant establishment and the attempts are being made to sort out suitable explant sterilization procedures for *Bauhinia* and *Diploknema*.

5. On the basis of population variability studies Chaurmania population for *Diploknema* with maximum leaf yield (165354 leaves/tree), fruit yield (613783 fruits/tree), weight (10.4 gm.), seed size (3.12 cm.) weight, (2.0 gm.) and Jeolikote population for *Bauhinia* with maximum leaf yield (43105 leaves/climber) and leaf size (584 cm) have been identified as morphological elites.

6. In order to strengthen the studies on morphological variability within populations of *Diploknema butyracea*. isozyme patterns were studies by subjecting the seedling leaves to polyacrylamide gel electrophoresis.

3.5.4 Symbiotic Nitrogen Fixation and Maintenance of Soil Fertility in the Eastern Himalaya.

Background

Biological nitrogen fixation is one of the key processes in building up the soil fertility. Symbiotic N_2-fixation contributes significantly to the nitrogen economy of agricultural and natural ecosystems. Angiospermic plants have two distinct groups of symbiotic associations: (a) *Rhizobium* symbiosis-restricted to the family leguminosae; and (b) *Frankia* symbiosis - distributed in eight families of angiosperms other than leguminosae. In Sikkim Himalaya; about 80 species belonging to family Leguminosae (including 65 species of sub-family Papilionoideae, 10 species of sub-family Mimosoideae and 5 species of sub-family Caesalpinioideae) and many species of actinorrhizal plants, belonging to four genera viz., *Alnus, Coriaria, Elaeagnus* and *Hippophae* have been identified. After the initial survey, two major systems have been identified in Sikkim for detailed study on N_2-fixation efficiency and N-accretion, and on their role on the maintenance of soil fertility; *Albizzia-Rhizobium* combination in mandarin orange-based agroforestry system in sub-tropical conditions, and *Alnus-Frankia* combination in the large cardamom- based agroforestry system in temperate conditions.

Objectives:

1. Extensive investigation for sorting out the symbiotic N_2- fixing species and their association in the Eastern Himalaya.

2. To test the effectiveness of symbiotic association on N_2- fixation.

3. To estimate the N_2-fixation efficiency and nitrogen accretion in some important associations.

4. To evaluate the role of some of these species on the maintenance of soil fertility.

Results and achievements:

1. Soil pH is slightly acidic to neutral in mix spp+cropland and *Albizzia*-mix spp + cropland system, while it is acidic in *Alnus*+cardamom and natural forest +cardamom systems. Overall soil moisture was higher in temperate sites than in sub-tropical sites. Soil organic carbon was highest in natural forest+cardamom (3.54% to 8.60%) followed by *Alnus*+cardamon (2.93% to 5.50%) and *Albizzia*-mix spp+cropland (0.88% to 2.67%) stands. There has been drastic decrease in the soil organic carbon with the change in land-use, from natural forest to cropland. However, incorporation of N_2-fixing *Alnus* and *Albizzia* was found to help in maintaining soil organic carbon levels to a considerable extent.

2. Per cent total nitrogen in the soil was highest in natural forest+cardamom (0.33% to 0.91%) in all seasons, followed by *Alnus*+cardamom (0.24% to 0.47%), *Albizzia*–mix spp+cropland (0.11% to 0.50%) and mix spp + cropland (0.12% to 0.37%). As much as 2.5 times less total nitrogen was recorded in mix spp+cropland as compared to natural forest+cardamom in autumn. Nitrate concentration in soil varied significantly between sub- tropi-

cal and temperate sites both in spring and rainy season. Pooled NO_3-N concentration in the spring was 4.243 mg/100 g soil in mix spp+cropland, followed by 0.985 mg/100 g soil in *Albizzia*-mix spp+cropland and 0.614 mg/100 g soil in *Alnus*+cardamom. Ammonium nitrogen (NH_4-N) when pooled for each stand showed highest value of 0.90 mg/100g soil in natural forest +cardamom followed by 0.75/100g soil in *Alnus*+cardamom and 0.63 mg/100g in mix spp+cropland.

3. Data for total–phosphorus and mineral-phosphorus were pooled for each stand in each season. Total-P values were higher in autumn and spring while lower values were recorded in winter and rainy seasons. In spring at mix spp+cropland site, both total-P and mineral-P were higher and 69% of total-P was contributed by mineral-P. This was attributed to burning of weeds and non-palatable crop residues at this site. Total-P and mineral-P relationships clearly indicated that the bulk of phosphorus is organically bound in natural forest +cardamom and *Alnus* + cardamom stands. Phosphorus fractionation for secondary phosphates such as Ca-PO_4, Fe-PO_4 and Al-PO_4 and insoluble phosphorus such as occluded Fe-PO_4 and occluded Al-PO_4 was also carried out in all the stands. Secondary phosphates were highest in *Alnus* + cardamom stand.

4. Biomass and net primary productivity of the *Alnus*+cardamom stand exceeded by about 28% and 54% respectively, to that of the natural forest+cardamom. Large cardamom agronomic yield was more than twice under *Alnus*. Nutrient concentrations of different plant components of *Alnus* were higher than for mix tree species. Back translocation of nutrients from leaf, before abscission in *Alnus* was lower than mix tree species, because of higher availability and uptake of these elements in *Alnus*+cardamom stand. This indicated poor nutrient conservation in *Alnus*. Nutrient use efficiency decreased under *Alnus*; this pattern is consistent with the expectation that efficiency should decrease with increasing rates of uptake. Large cardamom based agroforestry system under *Alnus* was more productive having accelerated nitrogen and phosphorus cycling, and seemed sustainable.

5. Biomass and net primary productivity of the *Albizzia*-mix spp+cropland stand exceeded by about 24% and 13%, respectively to that of the mix spp+ cropland stand. Agronomic yield of crops was nearly the same in both the stands. Madarin orange fruit production was 1.2 times higher under the influence of *Albizzia*. Nutrient concentrations of different plant components of *Albizzia* were higher than in mix tree species. Back translocation of nutrients from leaf before abscission in *Albizzia* was lower than for mix tree species because of higher availability and uptake of these elements. Nutrient use efficiency increased under *Albizzia*, whereas it decreased under *Alnus* in temperate site. The mandarin orange-based agroforestry is a highly nutrient exhaustive system, as compared to large cardamom-based agroforestry system. Mandarin orange-based agroforestry system under *Albizzia* was more productive having accelerated nitrogen and phosphorus cycling, and could be made sustainable by maintaining *Albizzia* in higher density.

3.5.5 Impact of Possible Climate Change on Growth Performance of Plants

Background

The elements of climate (radiation, temperature, wind and moisture) determine to a large extent the type of vegetation of a region. A substantial body of evidence indicates that human activity is altering the earth's climate and this effect will become more pronounced over the next decades. The predictions are that over the next several decades the climate will change in ways not experienced in the recent history.

A continuous rising of atmospheric CO_2 concentration which is expected to double by the mid-to end of 21st century, is now regarded as a major environmental problem. It is yet not known how increases in atmospheric CO_2 will influence photosynthetic and general ecosystem behaviour and how such behaviour will interact with the earths' climate. It is also speculated that species which are much in use may not be suitable species for the future. Therefore, a knowledge of plant responses to increased CO_2 concentration may be useful to predict the ecological consequences of rise in atmospheric CO_2 concentration for growth, composition and structure of general ecosystem.

Objectives

1. Short and long-term effect of rising CO_2 concentration on morphological, anatomical and physiological attributes of plants.

2. Combined effect of rising CO_2 and other environmental factors on growth performance of plants.

3. Identification of useful physiological criteria selection of better adapted genotypes.

Results and Achievements

1. A short-term increase in CO_2 concentration resulted in slight increase in net photosynthesis but significant decrease in transpiration rate (Fig. 4a & 4b).

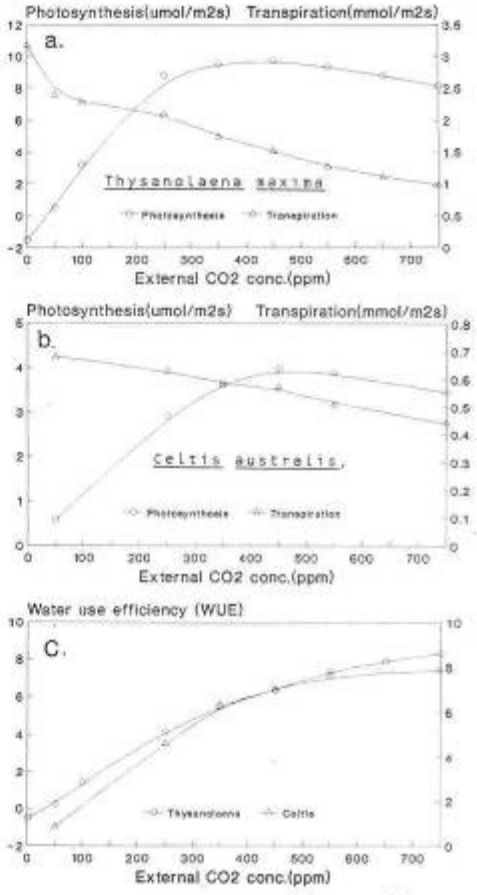

Fig. 4 : (a) Photosynthesis (umol/m^2s) (b) Photosynthesis (umol/m^2s) Transpiration (mmol/m^2s) (c) Water use efficiency (WUE)

2. With increase in CO_2, a corresponding decrease in conductances for water and CO_2 were found.

3. The water use efficiency of plants did show improvement upon exposure to elevated concentration of CO_2 (Fig. 4c).

3.5.6a Biomass of Woody Debris and other Detrital Pools in Different Forest Types of Binsar Wild Life Sanctuary

Background

Woody debris in the form of snags, logs, large branches and small twigs, and other detrital pools forms major structural feature with many crucial ecological functions as habitat for the organisms, in energy flow and nutrient cycling, thus influencing soil and sediment transport and storage in a forest system. The present study was undertaken in chir pine (*Pinus roxburghii*) at 1600 m amsl, and mixed (*Quercus leucotrichophora, Rhododendron arboreum and Lyonia ovalifolia*), banj oak (*Q. leucotrichophora*) and tilonj oak (*Q. floribunda*) forests each at 2500 m amsl.

Objectives

1. To quantify woody debris of different size classes.

2. To quantify the amount of other detrital pool

3. To quantify woody debris in different decay classes

4. To analyse distribution pattern of wood pieces of different species

Results and Achievements

1. The fresh leaf litter of dominant species across the forest types was higher in summer when most of the litter fall takes place and lower in winter season. Across the forest types, it ranged from 10.4 - 118.0 g/m^2 in summer, 4.4 - 22.4 g/m^2 in rainy and 1.2 - 13.2 g/m^2 in winter. Miscellaneous leaf litter was generally higher in summer (2.0 - 26.4 g/m^2), followed by winter (1.o - 17.2 g/m^2) and rainy (2.0 - 14.0 g/m^2) seasons. Miscellaneous litter viz., reproductive parts, bark etc. ranging from 8.4 - 72.0 g/m^2 was also higher in summer season.

2. Partially and more decomposed litter was highest in summer (116.4 - 1298.4 g/m^2), followed by rainy (55.6 - 1112.0 g/m^2) and winter (114.0 - 907.6 g/m^2) months. Wood litter of 5 mm diameter was recorded to be highest in summer (44.4 - 102.5 g/m^2) and lowest in winter (40.1 - 48.0 g/m^2) except mixed forest where it was lower in rainy season (11.2 g/m^2). Wood litter of 5 mm diameter but 20 cm length ranged from 16.0 - 62.0 g/m^2 in summer to 5.6 - 12.4 g/m^2 in winter. In rainy season values were in the range of 2.0 - 34.8 g/m.

3. Woody debris of 5-20 mm diameter varied from 30.65 in mixed forest to 59.21 g/m^2 in bank oak forest, of which 56-92% was due to dominant species. Woody debris of 21-100 mm was in the range of 82.61 (chir pine forest) to 208.37 g/m^2 (banj oak forest), of which 68-100% was contributed by dominant species. Amount of logs and snags of 101 mm diameter, recorded only from chir pine forest were 987.52 g/m^2, respectively.

4. Most of the wood pieces for different species of 5-20 mm diameter were randomly distributed (61.5%), followed by regular (23.1%) and contagious (15.4%) distributions. 50% of wood pieces for different species of 21-100 mm diameter were contiguously distributed, followed by random and regular distribution. Logs and snags of 101 mm diameter were distributed regularly.

(This project is supported by Council of Scientific and Industrial Research, New Delhi).

3.5.6b Physico-Chemical Properties of Soil along an Elevational Gradient in Binsar Wild Life Sanctuary

Background

Soil is an important component of the forest system because it acts as a medium for the plant growth. Nutrients are taken up by the plant from soil and returned to the soil through litter fall for re-use. Soil nutrient concentrations are influenced by the type of vegetation. Therefore, for ecological studies, management decisions, conservation practices and sustainable use of resources, information on soil properties of various forest types of any region is a pre-requisite. Keeping this in view, a study on soil properties of two depths (0-15 and 15-30 cm) has been carried out for chir pine (*Pinus roxburghii*) at 1600m amsl, chir pine-banj oak (*Quercus leucotrichophora*) at 2100 m amsl, and banj oak coppiced, mixed (*Q. leucotrichophora, Rhododendron arboreum* and *Lyonia ovalifolia*) and tilonj oak (*Q. floribunda*) at 2500 m amsl in Binsar Wild Life Sanctuary.

Objectives

1. Analysis of physical and chemical properties

2. Analysis of total nutrients

3. Study of the influence of vegetation on soil nutrients

Results and Achievements

1. The soil was found to be residual and shallow; light yellowish brown to yellow in color in lower elevation forests and brown to brownish yellow or dark greyish brown in color in higher elevation forests.

2. With few exceptions, water holding capacity was found to be in the range of 76-115% and 87-135% for lower and upper depths, respectively.

3. The soil moisture of samples from two depths was not much different and ranged from 15.2% (chir pine forest) to 32.7% (tilonj oak forest).

4. The pH which has an effect on soil structure, weathering, humification processes, mobilization of nutrients and exchange of ions was slightly lower for the lower depth samples. pH values ranged from 5.72 to 6.66 at upper depth and 5.64 to 6.57 at lower depth.

5. Organic matter (7.74-18.8% for upper depth and 2.17-14.49& for lower depth), organic carbon (4.10-9.79% for upper depth and 2.17-7.60% for lower depth) and nitrogen (0.174-0.473% and 0.154-0.310%, respectively for upper and lower depths) were recorded to be higher for upper depth compared to

lower depth.

6. Carbon/nitrogen ratio which indicates the net rate of mineralization was 17.5-33.1 for upper depth and 13.8-24.5 for lower depth samples.

7. Water holding capacity, soil moisture, organic matter and carbon, nitrogen, and potassium increased with increasing elevation while the reverse was true for phosphorus, sodium and calcium.

3.6 QUICK APPRAISAL STUDIES

3.6.1 Study of the Diversity and Status of Plants in Nanda Devi biosphere Reserve.

Background

Dr. S.S. Samant, a scientist of the Institute, participated in the Scientific and Ecological Expedition to Nanda Devi biosphere reserve. The expedition was organised by the Corps of Engineers. The quick appraisal study of the area was taken up by the scientist with following objectives:

1. Inventory of vascular plants (Angiosperms, Gymnosperms and Pteridophytes).

2. Assessment on habitat diversity and floristic diversity.

3. Natural resource utilization pattern of villagers within Nanda Devi Biosphere Reserve.

4. Identification of status of plants and prioritization for conservation.

Observations Recorded:

1. A total of 620 species of vascular plants were recorded from NDBR and 308 species were added to the previous list.

2. The altitudinal distribution of the flora shows that the maximum number of species (464) occur between 2800-3800m, followed by 325 species between 2000-3800 m, 313 species between 3800-4800 m and the lowest number of species (2) between 4800-5800 m.

3. 15 types of habitats (i.e. forests, exposed places, shady moist places, riverine, water courses, rocks/boulder, rock crevices/under boulders, marsh/wet, alpine pastures/slopes, moraines, shrubberies, waysides/roadsides, epiphytic, saprophytic, parasitic) were identified.

4. 76 species exhibited restricted habitats, small population size and narrow range of distribution and are rare-endangered.

5. 8 species (i.e. *Allium stracheyi, Cypripedium elegans, C. himalaicum, Dioscorea deltoidea, Nardostachys grandiflora, Picrorhiza kurrooa, Acer caesium and Saussurea costus*) listed in the Red Data Book (RDB) of India were noticed in NDBR.

6. 97 species are being utilized by the villagers in different forms (i.e. 17 as medicine, 55 edible/food, 15 fodder, 16 fuel, 5 cultivated tools, 8 house buildings, 11 religious purposes and 6 with miscellaneous uses).

7. 13 species of crops and 12 species

of vegetables are cultivated by the villagers. 7 fruit plants occur in the villages. Of these, *Juglans regia* (Akhruwa) and *Prunus persica* (Khirola) also grow in the wild.

3.6.2. Impact of Rain and Landslides on Almora Town: An Assessment

Background

During the month of September, 1993, Almora town received unprecedented rainfall. The rainfall recorded during the first fifteen days of the month was in excess of 300 mm; whereas the total average annual rainfall for Almora is 1000 mm. This led to large scale damage to houses and prolonged blockage of roads, leaving Almora in an state of practical isolation for nearly three weeks. A quick study was undertaken by the scientists of the Institute with following objectives:

1. To survey damage to movable and immovable property and identify possible causes.

2. To assess hardships faced by the residents, and also to assess general preparedness of people and the official machinery for such events

Observations Recorded

A rapid assessment resulted in the following:

1. Damage varying from minor to major was recorded in over ninety houses; high to almost total damage was recorded in about thirty houses; nearly three fourths of badly damaged houses were in Khatiyari, the new residential colony of Almora.

2. Except for isolated cases, nearly all houses with high or near total damage were constructed within the last five years; and most within the last two years.

3. The damage was largely confined to immovable property and generally enough time was available to shift from houses reported damaged. This fortunately avoided loss of life and injuries.

4. The leading causes of damage were: Lack of proper surface and subsurface drainage, leading to landslides and subsidence; improper disposal of loose soil and construction debris; improper foundations and heavy building structures.

5. On hardship count, a good deal of support from neighbours etc. was available to people having to move out of houses; Electricity supply was largely normal; Supplies were available in the market. No hoarding tendency was noticed amongst traders. The goods in stock were displayed prominently in the shops. The prices of vegetable produce tended to be slightly high; however, people in the outer fringes of town were less affected as they were closer to local produce areas. Water shortages were experienced by a number of localities for upto two weeks. However, people depending on springs were unaffected. People in general were found to be psychologically unprepared for such an event as it was not anticipated. Most households had sufficient stocks of essential supplies as the stocks had been replenished at the beginning of the month.

6. Water Supply Department (Jal Nigam) was found ill equipped to handle such eventuality. Most of the pumps had mechanical failure and problem of silt in the Kosi-river uptake points. A major pipe break near Sanwal Cottage led to not only total disruption of water supply in a number of colonies, but also a leading cause of extensive slippage of a public pathway there.

7. The town's stock position of essentials was found to be adequate for three weeks, the duration of road block. The position of petrol, diesel, kerosene was however affected badly. After nearly a week of blockage the above items were on reserve.

8. The Public Works Department was found to be over whelmed by multiple landslides and extensive settlement of roads.

Based on the above observations, some recommendations are as follows;

1. City needs strict control over construction activity. The following measures are proposed: All plans of construction be examined for suitability of construction site. Constructions in known "unstable" areas or where construction can lead to substantive alteration of surface and subsurface drainage patterns should not be undertaken. Attempts should also focus on working out percentage area which can safely be constructed upon in a given locality. In building plans, specific attention should be paid to earth and debris borrow and disposal areas. Special attention should be paid to design of foundations to ensure that it reaches all the way down to the rock. Heavy structures should be avoided especially in unstable areas.

2. The area starting from cantonment and extending down below to Khatyari Colony needs extensive examination. At the upper end, the area is nearly 300 mt. wide extending from Sitapur Eye Hospital to Vivekananda Laboratory. At the lower end, this area is approximately 1000 mts. wide extending from newly constructed campus for law and commerce faculties of Kumaon University Campus to Base Hospital.

3. Pumping and piping network of Water Department needs upgrading and renovation.

4. The supply stocks were sufficient during present situation. However, attempt should be to have stocks which will suffice for 6-8 weeks as opposed to about 3 weeks.

4. INSTITUTIONAL NETWORKING AND HUMAN INVESTMENT

For environmental management of the vast Himalayan region, net working of the existing Institutional infrastructure is critical to optimize the use of available scientific talent. This is proposed to be achieved through interactive workshops and seminars organized on specific themes or on regional problems. Pooling the scientific capability within and outside the Himalayan region and strengthening this is the prime objective of this activity.

4.1 Integrated Eco-Development Research Programme in the Himalayan Region

Integrated ecodevelopment research programme, transferred from the Ministry of Environment and Forests, Govt. of India to the Institute in 1992-93, has enabled Institutional Networking for comprehensive action oriented research during the year. The main objective of this programme is to promote socio-economic development of the hill people, in harmony with the environment, and striving to improve the well being and quality of life of the people in the Himalayan region. Under two broad thrust areas, namely Technology Development and Research for Integrated Eco-development and Technology Demonstration and Extension, 15 new projects (09 to Universities, 02 to Autonomous Organisations and 04 to NGOs) were processed for funding during the year.

In addition to newly sanctioned projects, financial commitments of 14 projects sanctioned earlier were fulfilled. 8 projects have been successfully completed during the year. Furthermore, the follow-up action on the recommendations of completed projects have been taken up, and the same were also sent to the concerned departments of State/Central Govt. for follow up action at their end.

Following workshops/meetings were organised during the year

- First Project Monitoring Workshop (June 22, 1993, Tadong, Sikkim).

- Third Project Evaluation Committee (PEC) meeting (June 23, 1993, Tadong, Sikkim).

- First Project Presentation-cum-Evaluation Workshop (Dec. 28- 29, 1993, Kosi, Almora).

- Fourth Project Evaluation Committee (PEC) meeting (Jan. 20, 1994, Dehradun, U.P.).

4.2 Human Investment

Peoples' perception of environment and development are important for their involvement in effective management of natural resources. The objective is not only to build direct links with the people through regional centres, but also to strengthen links through NGOs by organizing a series of training and interactive workshops.

First workshop on "The Role of NGOs in Environment and environmentally Sound Development of Himalayan Region" was organised at High Altitude Plant Physiology Research Centre, Srinagar (Garhwal) on September 20, 1993. Twenty four NGOs from Himalayan region, especially from Garhwal and Kumaun, attended the workshop.

Second workshop on " The Role of NGOs to identify initiatives for sustainable development of North East India" was organised at Guwahati on 17-18th Feb., 1994. Thirty two officials from NGOs of the North East region attended this workshop.

Badrivan Restoration at Badrinath

After testing restoration methodology for degraded lands, it was considered important to demonstrate

it in the area which needs immediate restoration and will be seen by all sectors of the society. Badrinath valley was, therefore, selected for setting a demonstration of restoration of degraded land.

The programme was inaugurated on September 16, 1993 by Shri R. Rajamani (Secretary, Ministry of Environment & Forests, Govt. of India) and presided over by Shri R.S. Tolia (Secretary, Hill Development, Govt. of Uttar Pradesh). The event marked the beginning of a long-term project which envisages to involve pilgrims, saints, army personnel, NGOs, members of Badrish Panda Panchayat, school children and local people.

A large number of seedlings of *Betula utilis, Hippophae tibetena* and *Populus ciliata* have been raised at different locations in Garhwal Himalaya. Negotiations have been made with the officials of District administration (Chamoli, Garhwal), State Forest Departments, Badrinath-Kedarnath Temple Committee, Badrish Panda Panchayat and Army personnel of 9 Independent Mount Brigade. Afforestation drive in and around Badrinath area will again be launched soon after the shrine opens.

4.3 Institutional Collaboration and Publications

4.3.1 Institutional Strengthening of Sustainable Mountain Agriculture: ICIMOD-GBPIHED Collaboration

The broad objectives of this collaboration are to promote joint efforts for (i) undertaking research and development activities directly relevant to the problems and issues of mountain farming in a regional perspective (ii) exchange of knowledge, and improvement therein, between different countries for environmentally sound development in the Himalaya (iii) enhancement of expertise and institutions through training/ workshops/reorientation capsule courses using pre-existing knowledge and output from activities in (i) and (ii).

Thematic activities planned relate to (a) biodiversity management for socio-economic rural development (b) creating a data base and agroecological zoning by setting up Geographic Information System facilities through Mountain Resource Information System (MENRIS) programme of ICIMOD (c) dissemination of knowledge on options of sustainable resource management through audiovisuals in local languages and demonstration of Sloping Land Agricultural Technology (SALT) adapted to Indian conditions. This programme has taken off by entering an agreement by the collaborating Institutions in March, 1994.

4.3.2 Tropical Soil Biology and Fertility (TSBF) Programme

A coordination centre for researches related to soil fertility management component of agriculture started operating during the current year. The objective of the centre sponsored by International Development Research Council (IDRC) as an extension of International TSBF programme is to promote sustainable agriculture in South Asian countries. Core theme addressed in the programme pertains to identification of ways and means of synchronising the nutrient release

processes driven by soil organic matter and organisms with crop demands and to test the efficacy of identified interventions in terms of environmental, social and economic parameters. A major project proposal focusing on small and marginal farmers in uplands in the Himalaya is being negotiated for funding. A workshop for crystallizing multidisciplinary approaches linking agronomy, ecology and soil science for enhancing the sustainability component in mountain farming has been tentatively planned for October, 1994.

4.3.3 Environmental Information System (ENVIS) Centre

The ENVIS Centre at the institute was established in Sept. 1992. During 1992-93, computer systems etc. were procured and a biannual periodical - ENVIS Bulletin, on Himalayan Ecology and Development was planned. In keeping with above, ENVIS Bulletin was published and circulated. The ENVIS Bulletin Vol.2, No 1 has also been brought out. The format for bulletin has been revised. A conscious attempt has been made to present primary data as well as compiled secondary information. It is also proposed to strengthen secondary information compilation further. Additional publications containing suitable compilations will be brought out as and when necessary during 1994-95.

During the year, proposals for Information Archival and Retrieval System along with a Documentation Centre were submitted to Ministry of Environment & Forests (MEF). The proposals aim at creating modern facilities for quick storage and retrieval of information; in addition to creating state of the art document creation facilities. MEF has part funded one of the proposal and accordingly equipment are being procured. Subject to availability of funds, it is proposed to make both facilities operational during 1994-95. Additionally, in ENVIS Advisory group meeting at MEF in Feb 94, a presentation was made highlighting requirement of networking between regional units of the institute.

4.3.4 Tropical Soil Biology and Fertility Research: South Asian Context

This volume results from the proceedings of the workshop sessions in the "Inaugural Tropical Soil Biology and Fertility (TSBF) Programme-Indian Network Workshop" held in Kausani, Uttar Pradesh in April, 1992, sponsored/organised jointly by TSBF Headquarters, Nairobi, Department of Science and Technology, Government of India, School of Environmental Sciences, Jawaharlal Nehru University, New Delhi, Indian National Science Academy, New Delhi and the Institute. The volume aims to help those intending to carry forward research following TSBF principles.

The book is divided into two sections. The first section focuses upon the TSBF philosophy where in examples of designs for experiments nested within the SYNCHRONY, SOIL FAUNA, and SOIL ORGANIC MATTER research themes are given. The second section deals with two Indian case studies, one which is field based and another based on preliminary laboratory experiments. Linking together intensive field based studies with detailed process oriented field and

laboratory experiments is crucial for application of research results. The publication brings out an effective link-up between soil fertility related processes and social processes which is crucial for people's involvement in the sustainable management of soil fertility.

4.3.5 Sustainable Rural Development: Opportunity and Constraints. (A micro-level analysis of Pranmati watershed in Uttar Pradesh Himalaya)

The problems of the Himalaya in a regional perspective are now well known, though assessments on their nature and magnitude differ. A major concern of all those involved in thinking about the region is how best the economic goals of development could be approached without compromising on the environmental and natural resource values of the region and social goals of development. The actions needed to achieve multiple goals of development are being commonly put forward as approaches for sustainable development. This publication documents the opportunities and constraints for sustainable rural development in Pranmati watershed, an area lacking motorable transport and electrification in Uttar Pradesh Himalaya.

4.3.6 Publication of the Book on 'Planning and Development in Himalaya: An Approach for District Chamoli'.

A report on environmental status of district Chamoli was prepared by Society for Himalayan Environment Rehabilitation and Peoples' Action (SHERPA). The Institute, in collaboration with this NGO undertook the task of publishing this report as a Hima-Vikas Occasional Publication. The book deals in-depth about the geo-physical, ecological and eco-cultural aspects in addition to the problems and prospects in resource use, management and development. It is hoped that the book will help to work out a balance in programmes and activities that would build Chamoli as a model district where the twin goals of conservation and development can be achieved in a constructive harmony.

5. MISCELLANEOUS ITEMS

5.1 Additions to Laboratory and Library

A suitable equipped plant tissue culture laboratory with laminar flow cabinets, autoclaving room and constant temperature and humidity control room for maintaining cultures have been developed in the Institute. A similar facility is also being developed in the Srinagar Unit.

Several major equipments have been procured. These include high performance liquid chromatography (HPLC) System, UV-Visible Spectrophotometer (both from Kontron Instruments), Electrophoresis with densitometer Phast System (Pharmacia) and Quantum Radiometer (Licor). A walk-in cold room has also been installed.

Addition of 537 books this year raised the number of titles to a total of 4665 in the library. A total of 69 international and national periodicals are being subscribed by the library.

5.2 Prominent Visitors

1. Mr. Ronald Kemp and Mr. Steve Jones from Overseas Development Agencies (UK) visited the Institute in April, 1993 during their Forest Identification Mission to Kumaon

2. Dr. R.S. Kapil, Director Regional Research Laboratory, Jammu-Tawi, visited the Institute on June 6-9,1993 and signed a MOU for collaborative work on cash crops for U.P. Hills.

3. Drs. Rolf Sorensen, Per Kraft and Kjell Esser from NORAGRIC were in the Institute to work on soil and water resources in U.P. and Himachal Pradesh in collaboration with the scientists of the Institute during September, 1993

5.3 Awards and Honors

Prof. A.N. Purohit was honoured with SICO sponsored National Academy of Sciences (NASI) award for the year 1992 for his outstanding contribution in the field of environment

5.4 Membership of Specialised Committees

Dr. K.S. Rao was granted engratis membership of the Ecological Society of America for a period of three years from 1994.

E. Sharma, Scientist 'C' of the Institute has been elected as "Fellow of National Institute of Ecology" in 1993. Dr. B.P. Kothyari, has been working as Member Evaluation Committee, Somagra Saksharta - Dwarahat Block from Jan. 1993.

Dr. L.M.S. Palni organised Brain Storming Session on Plant Senescence for DST, and acted as Chairman - helped younger scientists from various parts of the country in preparing focused research proposals (CIMAP, Lucknow).

5.6 Publications of the Faculty

Arya, A.S., **V. Joshi**, T.V.R. Murthy, A. Narayana, **K.G., Saxena**, J. K. Garg and A. Narain (1993). Geoenvironmental study of landslides using remotely sensed and ancillary data in Tehri reservoir rim : a case study. In: Proceedings of National Symposium on Remote Sensing Applications for Resource Management with special emphasis on North-East region. pp. 23-30.

Badola, H.K., M.N. Jha, M.K. Gupta and B.M. Dhimri (1994). A traverse through a highland pastures. Himalaya Today 5(2): 28-31.

Bhatt, Y.K., E. Sharma and R.C. Sundriyal (1993). Runoff, erosion and nutrient conservation under different crop/vegetation covers in a catchment in Sikkim Himalaya. Journal of Hill Research 6 (1): 21-25.

Dhar, U. and S.S. Samant, (1993). Endemic plant diversity in the Indian Himalaya-I. Renunculaceae and Paeoniaceae. J. Biogeography 20: 659-668

Dhar, U., Vir Jee and P. Kachroo (1994). Ladakr.. An update on Natural Resources. In Y.P.S. Pangtey & R.S. Rawal (eds.): High Altitudes of the Himalaya (Biogeography, Ecology & Conservation), Gyanodaya Prakashan, Nainital. pp. 102-114.

Dhyani, P.P. and M.P Khali (1993). Rooting response of branch cuttings of two multipurpose Ficus tree crops. The Int. Tree Crops Jour. 7: 239-245.

Dhyani, P.P. and M.P. Khali (1993). Fruit-yield and economics of jelly and jam production from fruits of some promising Ficus (Fig) tree crops. Ecology of Food and Nutrition 30: 169- 178.

Joshi, S.C., A. Mukhopadhayaya and Renu Khanna-Chopra (1992). Proline accumulation in wheat leaves of tetraploid and hexaploid wheat species grown at different levels of water availability. Plant Physiol and Biochem 19: 65-68.

Kothyari, B.P.; R.D. Joshi and G.C. Joshi (1993). Prevention of virus infection and multiplication by extracts of some high altitude medicinal plants of Western Himalaya. Glimpses in Plant Research Vol. XI (1993): 519-525.

Joshi, V. (1993). Garhwal Himalaya Ke Prakritic Talon Ka Arthic Upyog Avam Sanrakashan Niti. Himalayan Geology 14: 171-176.

Joshi, V. and C. Prasad (1993). Significance of stromatolitic laminations in Lower Krol Carbonates near Dogadda, Garhwal Himalaya, U.P. Geoscience Journal 14: 149-153.

Maikhuri, R.K. (1993). Mithun (Bos frontalis) a threatened semi-domesticated cattle of the north-east India. International Journal of Ecology and Environmental Sciences 19: 39-43.

Maikhuri, R.K. and A.K. Gangwar (1994). Ethnobiological notes on the Khasi and Garo Tribes of Meghalaya, Northeast India. Eco. Bot. 47(4): 345-357.

Negi, G.C.S., B.S. Rana, Y.D. Bhatt and **H.C. Rikhari** (1992). Survival and growth of tree seedlings in certain village lands of Nainital, Kumaun Himalaya. J. of Tree Sciences 11(2): 131-134.

Negi, G.C.S., H.C. Rikhari and S.P. Singh (1993). Plant regrowth following selective horse and sheep grazing and clipping in an Indian Central Himalayan alpine meadow. Arctic and Alpine Res. 25(3): 211-215.

Palni, L.M.S. (1993). Conservation of Plant Genetic Resources: The Role of biotechnology. In: Himalayan Biodiversity-Conservation Strategies (ed. U. Dhar). Gyanodaya Prakashan, Nainital. pp. 481-496.

Pangtey, Y.P.S., **S.S. Samant and R.S. Rawal** (1993). Enumeration of ferns of Pindari, Sarju and East Ramganga valleys of Kumaun (Western Himalaya). Higher plants of Indian Subcontinent (Additional series of Indian Journal of Forestry No. 7) 4: 119-152.

Purohit, A.N. (1993). Himalayan eco-system and some universal eco-hotspots. Proc. Nat. Acad. Sci. 63(B) 37-45.

Purohit, A.N. (1993). Agroforestry movement in central Himalaya-some prerequisites. In: Himalaya: A regional perspective, resources, environment and development (ed. M.S.S. Rawat), Daya Publ. House, Delhi. pp. 151-154.

Rai, S.C. (1993). Energetics of cropping systems: A case study from Central Himalaya. International Journal of Ecology and Environmental Sciences 19: 25-33.

Ramakrishnan, P.S., **K.G. Saxena, and K.S. Rao** (1993). Agro- ecological approaches for soil fertility management. In: Tropical Soil Biology and Fertility Research: South Asian Context (Eds.) P.S. Ramakrishnan, K.G. Saxena, M.J. Swift and P.D. Seward. Himavikas Publication No. 4 Oriental Enterprises, Dehradun. pp. 77-126.

Rana, B.S. and **H.C. Rikhari** (1994). Biomass and Productivity of different forest grazing lands in Central Himalaya. Proc. Indian Nat. Sci. Acad. B60 (2): 129-135.

Rawat, D.S. and B.P. Kothyari (1994). Kumaoni Naree Ka Karyatimak Jeevan Evam Gramine Paristhitiki Tantra: Ek Sampshit Adhyan. In: C.M. Agarwal (ed.), Bharati Naree: Vibhid Ayam, Vol 1, Shree Almora Book Depot, Almora, pp. 150-163.

Rikhari, H.C., G.C.S. Negi and S.P. Singh (1993). Species and community diversity patterns in an alpine meadow of Central Himalaya. Himalayan Biodiversity: Conservation Strategies, (ed. U. Dhar). pp. 205-218.

Samant, S.S., R.S. Rawal and U. Dhar (1993). Botanical Hot spots of Kumaun: Conservation Perspectives for the Himalaya. In: Himalayan Biodiversity : Conservation Strategies. (ed.) U.Dhar, Gyanodaya Prakashan, Nainital. pp. 377-400.

Samant, S.S. (1994). An Assessment on the Diversity and Status of Alpine Plants of Indian Himalaya. (eds.) Y.P.S. Pangtey and R.S. Rawal . High Altitudes of the Himalaya. Gyanodaya Prakashan, Nainital. pp. 115-127.

Saxena, K.G., K.S. Rao and A.N. Purohit. (1993). Sustainable Forestry - Prospects in India. J. Sustainable Forestey 1(2) 69-95.

Saxena, K.G. and Purohit, A.N. (1993). Greenhouse effect and Himalayan Ecosystems. In: Proceedings First Agricultural Science Congress - 1992. (ed.) Prem Narain, National Academy of Agricultural Sciences, Indian Agricultural Research Institute, New Delhi. pp 83-93.

Saxena, K.G., Woomer, P.L. and Seward, P.D. (1993). Potential application of TSBF research in South Asian Regional network. In: Tropical Soil Biology and Fertility Research: South Asian Context. (eds.) P.S. Ramakrishnan, K.G. Saxena, M.J. Swift and P.D. Seward. Himavikas Publication No. 4. Oriental Enterprises, Dehradun. pp. 61-73.

Sharma, E. (1993). Nutrient dynamics in Himalayan alder plantations. Annals of Botany, 72: 329-336.

Sharma, M., A. Sood, and **L.M.S. Palni** (1993). In vitro methods for multiplication and conservation of Himalayan orchids. In: Himalayan Biodiversity-Conservation Strategies (ed. U. Dhar), Gyanodaya Prakashan, Nainital. pp. 479-512.

Sharma, S. and E. Sharma (1993). Energy budget and efficiency of some multiple cropping systems in Sikkim Himalaya. Journal of Sustainable Agriculture. 3: 85-94.

Sharma, V.P. and **P.P. Dhyani** (1993). Convection heat loss correlates with anatomical parameters in leaves of Ficus hispida and F. lacor. Int. Jour. Ecol. & Env. Sci. 19: 49-56.

Singh, R.D., **S. K. Sohani**, Brajinder Singh and D.N. Chakrabarty (1993). Influence of long term mulching on yield of young tea and weeds. Proc. International Symposium on Weed Science, Hisar, Vol. III (Suppl.) pp. 34-36.

Sohani, S.K. (1994). Development of a portable solar warmer-cum-nursery plant protector for high altitude areas. Indian J. Forestry. 17(1):91-96.

Sood, A., **L.M.S. Palni**, M. Sharma and O.P. Sharma. (1994). Improved methods of propagation of Maggar bamboo (Dendrocalamus hamiltonii Nees Et. Arn. Ex Munro). In: Biotechnology in India (ed. B.K. Dwivedi), Bioved Res. Soc., Allahabad. pp. 199-212.

Sundriyal, R.C. (1994). Vegetation dynamics and animal behaviours in an alpine pasture of the Garhwal Himalaya. In: Pangtey, (ed.) Y.P.S. & Rawal, R.S., High Altitudes of the Himalaya, Gyanodaya Prakashan, Nainital, pp. 179-192.

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Sundriyal, R.C. E. Sharma, and S.S. Negi, (1993). Effect of cutting height and frequency on the aboveground biomass in a Central Himalayan grassland in India. Tropical Grasslands, 27: 37-42.

Swarup, R., P.K. Samal and N.A. Farooquee (1994). Land holding scenario in the Himalaya. In: (eds.) Himalaya past and presented M.P. Joshi, A.C. Franger and C.W. Brown). Vol-III 1991-93, pp. 335-354.

Tay S.A.B., J.K. Macleod, and **L.M.S. Palni,** (1993). Quantification of intact cytokinin glucosides in Datura innoxia crown gall tissue by DCI. J. Plant Biochem. and Biotech 2:105-109.

5.7 Participation in Symposium/ Conferences

Plant Growth Substances: Fact or Fiction. National Symposium on Physiological and Biochemical Aspects of Crop Improvement. 23-25 March, 1993. Lucknow (L.M.S. Palni).

Physiological basis of winter dormancy and its effect on yield in tea. 23-25 March, 1993.

Ibid. (L.M.S. Palni and S.K. Nandi).

Possible involvement of alternative resp. pathway in regulating senescence of Gladiolus florets, 23-25 March, 1993. ibid. (S. Kumar and L.M.S. Palni; Recd. best paper award).

A cup that cheers: some contributions to tea research. Special talk organized by the Sikkim Science Society, Tadong, Gangtok. June 15, 1993 (L.M.S. Palni).

Integrated Waste Management. 19th WEDC Conference, 6-10 Sept. 1993, Aura, Ghana (A.P. Jain, D.R. Prasada Raju and S. Setty).

New Technology for Sustainable Development in the hills. Uttrakhand Shodh Sansthan, 10 Oct, 1993. Nainital (L.M.S. Palni and S.K. Sohani).

Hormonal Aspects of Plant Senescence. DST sponsored BSS on Plant Senescence. 18-19 Oct 1993, CIMAP, Lucknow (L.M.S. Palni and S.K. Nandi).

Regional meeting on Watershed Management and Hydrology organized by UNESCO, ICIMOD and IDRC, Nov. 1993, New Delhi (K.G. Saxena).

ICIMOD 10th Anniversary Symposium on "Mountain Environment and Development: Opportunities and Constrains", Dec. 1-2, 1993, Kathmandu, Nepal (P.P. Dhyani and R.G. Singh).

Antifungal activity of bacterial strains isolated from tea soils. 1-3 Dec. 1993, Indo–German conference on impact of Modern Agriculture on Environment, H.A.U., Hisar (Anita Pandey, N. Coulomb and L.M.S. Palni; Recd. best poster award).

Plant Biotechnology: Opportunities and Limitations. National Symposium on Recent Advances in Vet. Sc. & Animal Production, 2-3 Dec. 1993, Mukteshwar (L.M.S. Palni and N.A. Farooquee).

National Seminar on Newer Challenges in Agriculture, Horticulture and Industry : The Role of Physiologist and Biochemist, 11-13 January, 1994, Bangalore (S.C. Joshi and L.M.S. Palni).

Seminar on "Environment and Economics" organised by Centre for Science & Environment at New Delhi, between 27-29 Jan. 1994 (Y.K. Rai).

Seminar on Forestry Sector Review by World Bank, April 1994, New Delhi. (A.N. Purohit and K.G. Saxena).

Group Monitoring Workshop for D.S.T. Young Scientists held at Santiniketan (W.B.) April 28-29, 1994. (R.S. Rawal).

5.8 Training Courses/Workshops

Completed correspondence course entitled Designing Effective Research Proposals organised by Multipurpose Tree Species Research, Netaiok Bangkok, Thailand USAID-WINROCK Cooperative Agreement (Feb. 1 to May 31, 1992) (B.P. Kothyari).

Samagra Swakshyarta meeting, June 15, 1993 at District Planning Office, Almora. (D.S. Rawat)

Regular course on remote sensing with special emphasis on digital analysis at National Remote Sensing Agency, Hyderabad, from April 19 to June 26, 1993. (S.C. Rai).

Professional Training on Geographic Information System at International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal from 2 to 28 August, 1993. (D.S. Rawat, S.C. Rai, R.K. Maikhuri, Anita Pande and K.G. Saxena).

Fourth Regional Co-ordination Committee meeting of Regional Centre, NIH Jammu on August 3, 1993 at Shimla (S.K. Sohani).

1st National Meeting on the Biosphere Reserves on 26 August, 1993 at New Delhi. (S.S. Samant)

Glaciology Training Course organised by Geological Survey of India, Lucknow from 5 to 26 September, 1993 was attended. (Kireet Kumar)

Training on "Geographic Information Systems for the Management of Natural Resour-

ces and Environment" at ICIMOD, Kathmandu from 6th September 1993 to 1st October 1993. (S. Sharma, R.C. Prasad, U. Rana, K.K. Sen and A.P. Krishna)

Workshop on "The Role of NGOs in Environment and Environmentally sound Development of Himalayan Region" at Srinagar, Garhwal on 20 Sept. 1993 (E. Sharma and R.C. Sundriyal)

UNESCO Regional Training Seminar on "Conservation and Management of Biological Resources in the Himalaya" organised by the Institute at HAPPRC, Srinagar, Garhwal, U.P., Sept. 21-30, 1993 (P.P. Dhyani, S.S. Samant and R.K. Maikhuri).

National Workshop on farmer's participation in management of irrigation system, Oct. 12-14, 1993, Roorkee (S.K. Sohani).

The significance of Nanda Devi Biosphere Reserve on the conservation and development of remote U.P. hills, Oct. 16–17, 1993, Joshimath/Reni (S.S. Samant).

Regional level consultation on biodiversity, Jan. 19–20, 1994, Lucknow (U. Dhar).

Development of methodology for inventorying, monitoring and conserving biodiversity, March 9–11, 1994, Bangalore (U. Dhar).

6. Statement of Accounts *

HARISH C. KAPOOR & CO.
CHARTERED ACCOUNTANTS

22, Paltan Bazar
(Above Frontier Jewellers)
Dehra Dun-248 001
Tel: 0135-24941, 28255, 25368
Tlx.: 0585 - 280 - DDBC IN
Fax: 0135-25152, 22727

To

The Director
G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT
Kosi, Almora - Pin 263 643

Dear Sir,

We have examined the balance sheet of **G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT**, as at 31st March 1994 and the Income and Expenditure account for the year ended on that date which are in agreement with the books of account maintained by the said institution.

We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purpose of the audit. In our opinion, proper books of account have been kept by the head office and the units of the above named institution so far as appears from our examination of the books, and proper returns adequate for the purposes of audit have been received from units.

In our opinion and to the best of our information, and according to information given to us, subject to the notes on accounts annexed the said accounts give a true and fair view-

(i) in the case of the Balance Sheet, of the state of affairs of the above named institution as on March 31, 1994 and

(ii) in the case of Income and Expenditure account, of the income of its accounting year ending on March 31, 1994.

(iii) in the case of Receipt and Payment Account, of the receipts & payments during the accounting year ending on March 31, 1994.

For **M/S HARISH C. KAPOOR & CO.**
Chartered Accountants

sd/-
(HARISH C. KAPOOR)
F.C.A

Dated: July 12, 1994
Place: Dehra Dun.

* Detailed annexures. " A to W " are available for inspection at the institute.

HARISH C. KAPOOR & CO.
CHARTERED ACCOUNTANTS

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NOTES FORMING PART OF THE STATEMENT OF ACCOUNTS FOR THE YEAR ENDING ON MARCH 31,1994 AND ANNEXED TO THE BALANCE SHEET OF EVEN DATE

* The books of accounts have been maintained on cash basis.
* In consideration of accepted accounting principles, Format/presentation of the Statement of Accounts as on March 31, 1994 has been changed as compared to previous years for proper disclosure, true & fair view of accounts and for sufficient analysis of figures.
* Depreciation on Fixed assets has been provided in the accounts to show fair realisable value of assets held by the Institute.
* All purchase of consumables, laboratory expenses, chemicals, glassware, stores & stationery have been charged to Income & Expenditure Account at the time of purchase.
* Interest on Fixed Deposits has been provided on accrual basis.
* Full form of Short names reflected in the statement of accounts is as under:

  NORAD: Norwegian Agency for Development Corporation.
  ICIMOD: International Centre for Integrated Mountain Development
  TSBF: Tropical Soil Biology and Fertility.
  IERP: Integrated Eco Research Programme.
  ENVIS: Environmental Information System.
  DST: Department of Science & Technology.
  CSIR: Council of Scientific and Industrial research.
  DST (RWH): Department of Science & Technology (Rain Water Harvesting)
  DST (SF): Department of Science & Technology (Soil Fertility)
  INSA: Indian National Science Academy.
  BIOTECH: Department of Biotechnology.

* Stock registers of assets have been maintained by the institution for movement of assets, stores, vehicles and other consumables, which have been physically verified at regular intervals.
* Annexure 'A' to 'W' are integral part of Statements of accounts prepared for the year.

For M/S HARISH C. KAPOOR & CO
Chartered Accountants
Sd/-
(HARISH C. KAPOOR)

Dated: July 12, 1994
Place: Dehra Dun

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

Balance Sheet as on March 31, 1994

PARTICULARS	ANN	AMOUNT	AMOUNT	AMOUNT
SOURCE OF FUNDS:				
* General Fund:				
Last Balance:			1,118,641.24	
Add: Additions For the Year:			817,200.57	1,935,841.81
* Fixed Assets Fund:				
Last Balance:		23,599,093.00		
Add: Additions for the year:		9,577,086.39	33,176,179.39	
Less Accumulated Dep.:			4,639,403.69	28,536,775.70
* Construction Fund - CCU:				
Last Balance:		27,404,377.00		
Add: Additions for the year:		26,800,000.00	54,204,377.00	
Less: Transf. during the yr:			0.00	54,204,377.00
* Project Fund:	'A'			
Research & Development Fund:			2,299,166.18	
Construction Fund:			80,580.00	
Action Plan Fund:			0.00	
IERP Project Fund:			10.08	
ENVIS Project Fund:			94,573.00	
DST (RWH) Project Fund:			0.00	
DST (SF) Project Fund:			0.00	
DST (RSR) Project Fund:			25,734.00	
DST (ES) Project Fund:			0.00	
DST (RKM) Project Fund:			34,632.00	
CSIR Project Fund:			4,165.00	
BIOTECH (I) Project Fund:			1,405,360.00	
BIOTECH (II) Project Fund:			4,544,256.00	
BIOTECH (III) Project Fund:			4,581,650.00	
UNESCO Project Fund:			0.00	
INSA Project Fund:			125,000.00	
NORAD Project Fund:			730,153.21	
ICIMOD Project Fund:			31,923.05	
TSBF Project Fund:			181,374.00	
TSBF Workshop Fund:			0.00	14,138,576.52
Balance Carried Forward:				98,815,571.03

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

Balance Sheet as on March 31, 1994

PARTICULARS	ANN	AMOUNT	AMOUNT	AMOUNT
Balance Brought Forward:				98,815,571.03
* Other Liabilities:				
Security Deposit:			40,952.00	
Group Saving Link Insurance:			200.15	
CPF Payable:			1,885.00	43,037.15
TOTAL Rs..				98,858,608.18
APPLICATION OF FUNDS:				
* Fixed Assets:	'W'			28,536,775.70
* Deposits with:				
CCU for Construction			54,204,377.00	
SP. LAO for Land:			80,000.00	54,284,377.00
* Security Deposits				7,870.00
* Closing Balances:	'V'			16,029,585.48
TOTAL Rs....				98,858,608.18

Sd/-
(Accounts Officer)
Sd/-
(Drawing & Disbursing Officer)
Sd/-
(Officer Incharge)
Sd/-
(Director)

Dated: July 12, 1994
Place: Dehra Dun

As per our separate report of even date.
For **M/S HARISH C. KAPOOR & CO.**
Chartered Accountants
Sd/-
(HARISH C. KAPOOR)

HARISH C. KAPOOR & CO.
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G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT, KOSI, ALMORA

Income & Expenditure Accounts for the Year Ending on March 31, 1994.

PARTICULARS	ANN	AMOUNT	AMOUNT	AMOUNT
Grants in Aid:				
Designated Project Grants:				
* Research, Development & Other Expenses		14,500,000.00		
* Construction Work:		25,000,000.00		
* Action Plan:		0.00		
* NORAD:		0.00		
* ICIMOD:		621,730.00		
* TSBF:		279,955.00		
* IERP:		3,607,334.58		
* ENVIS:		0.00		
* DST (RWH):		0.00		
* DST (SF):		25,000.00		
* DST (RSR):		0.00		
* DST (ES):		40,000.00		
* DST (RKM)		50,000.00		
* CSIR:		19,520.00		
* BIOTECH (I):		2,179,000.00		
* BIOTECH (II):		4,605,000.00		
* BIOTECH (III):		4,591,000.00		
* UNESCO:		327,600.00		
* INSA:		125,000.00		
* TSBF Workshop:		0.00	55,971,139.58	
Less: Trf. to Designated Funds:				
* Research, Development & Other Expenses:		14,500,000.00		
* Construction Work:		25,000,000.00		
* Action Plan:		0.00		
* NORAD:		0.00		
* ICIMOD:		621,730.00		
* TSBF:		279,955.00		
* IERP:		3,607,334.58		
* ENVIS:		0.00		
* DST (RWH):		0.00		
* DST (SF):		25,000.00		
* DST (RSR):		0.00		
* DST (ES):		40,000.00		
* DST (RKM):		50,000.00		
* CSIR:		19,520.00		
* BIOTECH (I)		2,179,000.00		
Balance Carried Forward :		46,322,539.58	55,971,139.58	

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

Income & Expenditure Account for the Year Ending on March 31, 1994.

PARTICULARS	ANN	AMOUNT	AMOUNT	AMOUNT
Balance Brought Forward:			55,971,139.58	
Trf. to Designated Funds Contd.:		46,322,539.58		
* BIOTECH (II):		4,605,000.00		
* BIOTECH (III):		4,591,000.00		
* UNESCO:		327,600.00		
* INSA:		125,000.00		
* TSBF (Workshop):		0.00	55,971,139.58	0.00
				0.00
Interest From Banks:				719,742.17
Other Incomes:				
* License Fee:			9,267.00	
* Hostel Charges:			116.00	
* Lodging Charges:			766.00	
* Water Testing Fee:			3,960.00	
* Tender Form Sale:			400.00	
* Car Recoveries (For Personal Use):			1,598.00	
* Fine and Penalty:			7,635.00	
* Nursery Sale:			6,550.00	
* Sale of Publications:			280.00	
* Miscellaneous:			2,125.00	
* Rounding off Difference:			0.59	32,697.59
Designated Grants Utilised:				
* Research, Development & Other Expenses:			12,818,897.20	
* Construction Work:			27,715,776.00	
* Action Plan:			102,286.00	
* NORAD:			3,134,820.36	
* ICIMOD:			589,806.95	
* TSBF:			98,581.00	
* IERP:			3,607,456.50	
* ENVIS:			16,814.00	
* DST (RWH):			20,934.55	
Balance Carried Forward:			48,105,372.56	752,439.76

HARISH C. KAPOOR & CO.
CHARTERED ACCOUNTANTS

22, Paltan Bazar
(Above Frontier Jewellers)
Dehra Dun-248 001
Tel: 0135-24941, 28255, 25368
Tlx.: 0585 - 280 - DDBC IN
Fax: 0135-25152, 22727

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

Income & Expenditure Account for the Year Ending on March 31, 1994

PARTICULARS	ANN	AMOUNT	AMOUNT	AMOUNT
Balance Brought Forward				752,439.76
Desig. Grants Utilised Conted:			48,105,372.56	
* DST (SF):			38,110.26	
* DST (RSR):			69,689.00	
* DST (ES):			40,030.00	
* DST (RKM):			15,368.00	
* CSIR:			19,520.00	
* BIOTECH (I):			773,640.00	
* BIOTECH (II):			60,744.00	
* BIOTECH (III):			9,350.00	
* UNESCO:			327,600.00	
* INSA:			0.00	
* TSBF (Workshop):			426.00	
				49,459,849.82
TOTAL INCOME (A)				50,212,289.58
EXPENDITURE:				
Project Expenditures:				
* Research, Development & Other Expenses:	'B'		6,726,699.76	
* Construction Work:	'C'		0.00	
* Action Plan:	'D'		102,286.00	
* NORAD:	'E'		1,446,829.36	
* ICIMOD:	'F'		356,217.00	
* TSBF:	'G'		98,581.00	
* IERP:	'H'		3,607,456.50	
* ENVIS:	'I'		16,814.00	
* DST (RWH)	'J'		11,586.00	
* DST (SF):	'K'		11,852.00	
* DST (RSR):	'L'		62,274.00	
* DST (ES):	'M'		40,030.00	
* DST (RKM):	'N'		15,368.00	
* CSIR:	'O'		19,520.00	
* BIOTECH (I):	'P'		159,940.00	
* BIOTECH (II):	'Q'		34,327.00	
* BIOTECH (III):	'R'		9,350.00	
* UNESCO:	'S'		298,872.00	
* INSA:	'T'		0.00	
				13,018,002.62
Balance Carried Forward:				13,018,002.62

HARISH C. KAPOOR & CO.
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G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT, KOSI, ALMORA

Income & Expenditure Account for the Year Ending on March 31, 1994

PARTICULARS	ANN	AMOUNT	AMOUNT	AMOUNT
Balance Brought Forward:				13,018,002.62
Capital Expenditure:				
* Research & Development:				
Library:		2,268,565.50		
R & D Equipments:		3,458,721.19		
Office Equipments:		19,642.35		
Furniture:		345,268.40	6,092,197.44	
* Construction Exp.:				
Capital Exp. Trf to CCU:		26,800,000.00		
Glass/Net House:		915,776.00	27,715,776.00	
* NORAD Project:			1,687,991.00	
* ICIMOD Project:			233,589.95	
* TSBF Project:			0.00	
* DST (RSR):			7,415.00	
* BIOTECH (I):			613,700.00	
* BIOTECH (II):			26,417.00	36,377,086.39
TOTAL EXPENDITURE (B):				49,395,089.01
EXCESS OF INCOME OVER EXPENDITURE [(A) - (B)]:				817,200.57

Sd/-
(Accounts Officer)
Sd/-
(Drawing & Disbursing Officer)
Sd/-
(Officer Incharge)
Sd/-
(Director)

As per our separate report of even date.
For **M/S HARISH C. KAPOOR & Co.**
Chartered Accountants
Sd/-
(HARISH C. KAPOOR)

Dated: July 12, 1994
Place: Dehra Dun

HARISH C. KAPOOR & CO.
CHARTERED ACCOUNTANTS

22, Paltan Bazar
(Above Frontier Jewellers)
Dehra Dun-248 001
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G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT, KOSI, ALMORA

Receipt & Payment Account for the Year Ending on March 31, 1994.

PARTICULARS	ANN	AMOUNT	AMOUNT	AMOUNT
RECEIPTS:				
Opening Balance:	U			4,749,932.02
Grants in Aid:				
* Research, Development & Other Expenses:			14,500,000.00	
* Construction Work:			25,000,000.00	
* Action Plan:			0.00	
* IERP:			3,607,334.58	
* ENVIS:			0.00	
* DST (RWH):			0.00	
* DST (SF):			25,000.00	
* DST (RSR):			0.00	
* DST (ES):			40,000.00	
* DST (RKM):			50,000.00	
* CSIR:			19,520.00	
* BIOTECH (I):			2,179,000.00	
* BIOTECH (II):			4,605,000.00	
* BIOTECH (III):			4,591,000.00	
* UNESCO:			327,600.00	
* INSA:			125,000.00	55,069,454.58
Interest from Bank				554,925.17
Other Receipts:				
* Earnest Money:			9,800.00	
* Security Deposit:			43,378.00	
* Group Savings Link Ins.:			248.00	
* Licence Fee:			9,267.00	
* Hostel Charges:			116.00	
* Lodging Charges:			766.00	
* Water Testing Fee:			3,960.00	
* Tender Form Sale:			400.00	
* Car Recoveries For Personal Use:			1,598.00	
* Fine & Penalty:			7,635.00	
* Nursery Sale:			6,550.00	
* Sale of Publications:			280.00	
* Miscellaneous:			2,125.00	
* Rounding Off Difference:			0.00	86,123.00
TOTAL RECEIPTS Rs.				60,460,434.77

HARISH C. KAPOOR & CO.
CHARTERED ACCOUNTANTS

22, Paltan Bazar
(Above Frontier Jewellers)
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G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT, KOSI, ALMORA

Receipt & Payment Account for the Year Ending on March 31, 1994.

PARTICULARS	ANN	AMOUNT	AMOUNT	AMOUNT
PAYMENTS:				
Project Payments:				
* Research, Development & Other Expenses:	'B'		6,754,803.76	
* Construction Work:	'C'		26,800,000.00	
* Action Plan:	'D'		102,286.00	
* IERP:	'H'		3,607,456.50	
* ENVIS:	'I'		16,814.00	
* DST (RWH):	'J'		11,586.00	
* DST (SF):	'K'		11,852.00	
* DST (RSR):	'L'		62,274.00	
* DST (ES):	'M'		40,030.00	
* DST (RKM):	'N'		15,368.00	
* CSIR:	'O'		19,520.00	
* BIOTECH (I):	'P'		579,878.00	
* BIOTECH (II):	'Q'		281,059.00	
* BIOTECH (III):	'R'		9,350.00	
* UNESCO:	'S'		298,872.00	
* INSA:	'T'		0.00	38,611,149.26
Capital Expenditure:				
* Glass/Net House:			915,776.00	
* Library:			2,268,565.50	
* R & D Equipments:				
RESEARCH & DEVELOPMENT:		3,458,721.19		
DST (RSR):		7,415.00		
BIOTECH (I)		613,700.00		
BIOTECH (II):		26,417.00	4,106,253.19	
* Office Equipments:			19,642.35	
* Furniture:			345,268.40	7,655,505.44
Foreign contribution Inter A/C:				43,256.00
Balance Carried Forward:				46,309,910.70

HARISH C. KAPOOR & CO.
CHARTERED ACCOUNTANTS

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G.B. PANT INSTITUTE OF HIMALAYAN ENVIRONMENT & DEVELOPMENT, KOSI, ALMORA
Receipt & Payment Account for the Year Ending on March 31, 1994.

PARTICULARS	ANN	AMOUNT	AMOUNT	AMOUNT
Balance Brought Forward:				46,309,910.70
Closing Balance:				
* Cash & Bank Balance:				
Cash in Hand (IC A/C):				
Almora:		40,371.51		
Srinagar:		7,044.39		
Sikkim:		30.93		
Kullu:		5,835.01	53,281.84	
Cash at Bank (IC A/C):				
CBI Kosi A/C No. CD-14:		1,226,094.11		
SBI Almora A/C No. 22752:		7,617,688.53		
SBI Tadong A/C No. CA/4/65:		113,953.54		
SBI Kullu A/C No. 50201/7:		35,506.97		
SBI Srinagar A/C No. 3/615:		319,400.82		
SBI Chuchuyimlang A/C No. CA-51:		54.61	9,312,698.58	
* Stamps on Hand:			2,240.00	
* Fixed Deposits:				
SBI Almora:		851,954.00		
CBI Kosi:		93,824.06	945,778.06	
* Fixed Deposits (Short Term):				
SBI Almora:		2,620,638.00		
CBI Kosi:		1,039,363.69	3,660,001.69	
* Advances:				
House Building Advance:			66,524.00	
Units of Institute:				
Srinagar:		32,229.00		
Sikkim:		11,157.55		
Kullu:		(8,976.00)	34,410.55	
Balance Carried Forward:			14,074,934.72	46,309,910.70

HARISH C. KAPOOR & CO.
CHARTERED ACCOUNTANTS

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

Receipt & Payment Account for the Year Ending on March 31, 1994.

PARTICULARS	ANN	AMOUNT	AMOUNT	AMOUNT
Balance Brought Forward:				46,309,910.70
Closing Balance Conitinued:				
* Advances Brought Forward:			14,074,934.72	
Due - Staff/Others (IC A/C):				
C.S. Negi (CSIR):		2,000.00		
Harish Chandge:		1,662.00		
S.K. Gurani:		3.00		
A.O. Area Business				
Message Network, Noida:		5,000.00		
Pan Singh:		385.00		
A.S. Parihar:		4,000.00		
Harish Kumar:		5,290.00		
Director - IARI:		26.50		
Klenzaids Con. Controls Pvt. Ltd.:		57,175.00		
Group Sav. Link Ins.:		47.85	75,589.35	14,150,524.07
TOTAL Rs....				60,460,434.77

Sd/-
(Accounts Officer)

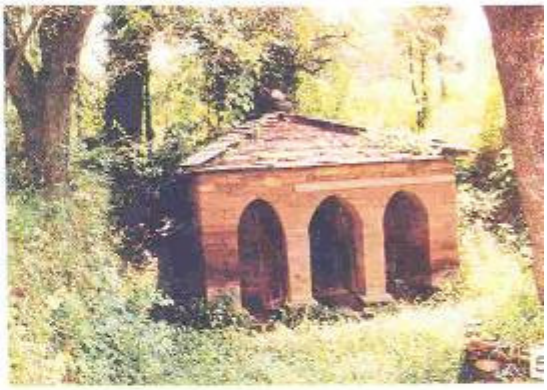
Sd/-
(Drawing & Disbursing Officer)

Sd/-
(Officer Incharge)

Sd/-
(Director)

As per our separate report of even date.
For M/S HARISH C. KAPOOR & CO.
Chartered Accountants
Sd/-
(HARISH C. KAPOOR)

Dated: July 12, 1994
Place: Dehra Dun



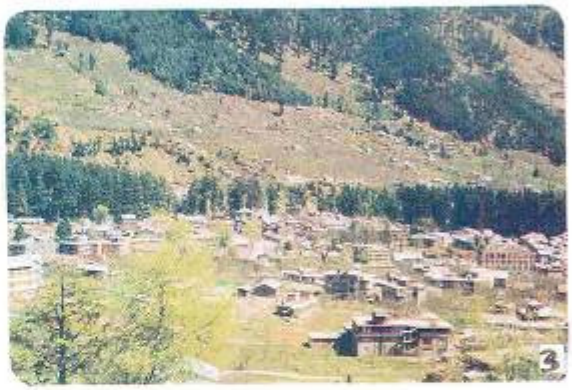
1. Canopy measurement using a portable analyser.

2. Lush growth of hops in the nursery at Kosi.

3. A community tap system with an automatic on/off valve on the stand post.

4. Air study using an automated device.

5. A traditional naula in Almora, a perennial (?) source of drinking water.

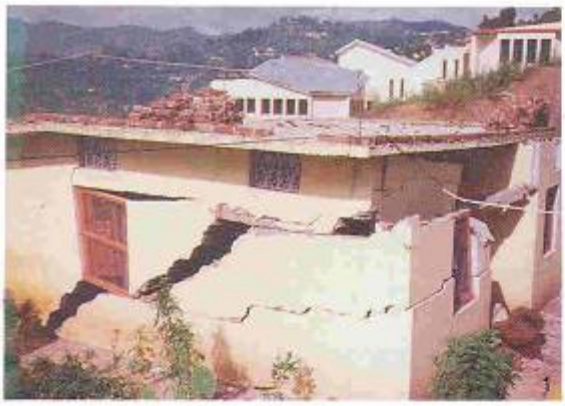


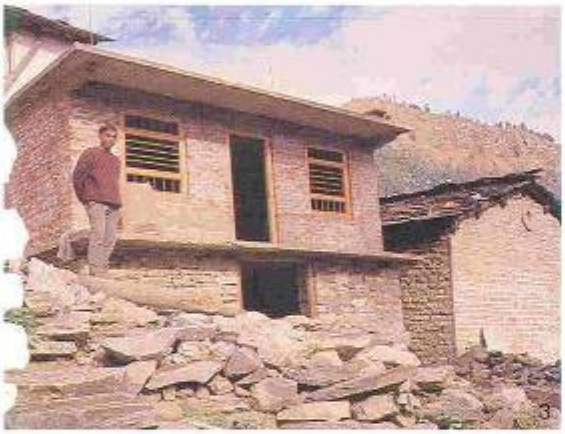
1. Installation of Automatic Weather Station at a sub-alpine site, Kyangnosla (3200 m amsl) in Sikkim

2. Use of a multislot divisor to record soil erosion and run-off at Banswara, Garhwal.

3. Carrying capacity of Kullu-Manali Complex

4. Data generation on silt and run-off in a watershed using a stage-level-recorder with flume arrangement at Dugar Gad, Pauri.





Impact of rain and landslides on Almora town : largescale damage to houses and roads (1 and 2).

Impact of road access and improved purchase power in a remote Himalayan location (Kapkot) : changing housing pattern and use of high yielding varieties (3 and 4).