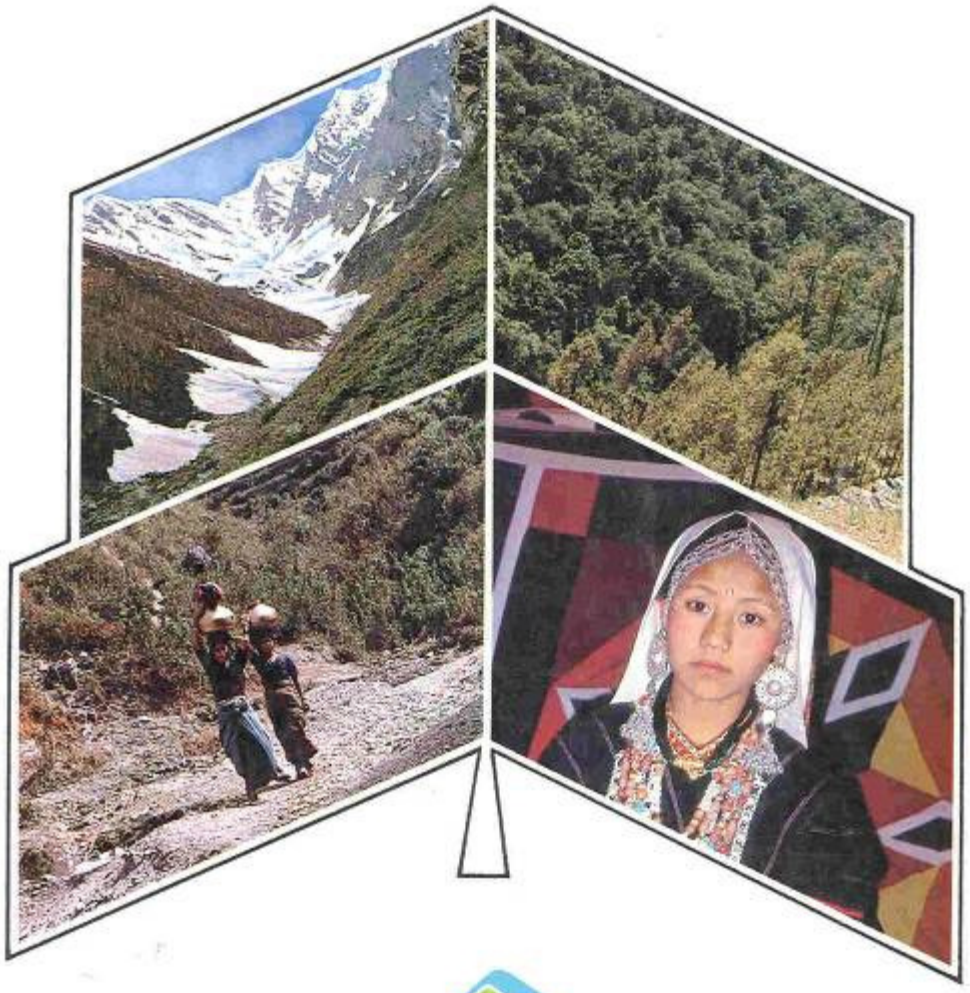
ANNUAL REPORT

1991-92



G.B. Pant Institute of Himalayan Environment & Development

(An Autonomous Institute of Ministry of Environment & Forests, Government of India)

Kosi - Almora 263643

INDIA

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CONTENTS

THE YEAR 1991-92: AN OVERVIEW

Laying of the Foundation Stone of the Institute's Building Complex at Katarmal, Almora, First Meeting of the G.B. Pant Society of Himalayan Environment & Development and a number of academic activities on the occasion of First Annual Day of the Institute were the notable events of the year 1991-92. The Institute could advance its visibility through significant research and development outputs as well as by creating laboratory and library facilities open to all concerned with Himalayan environment and development.

The year was the third financial year of 12 research and development projects launched in different parts of the Himalaya and focused on location specific issues concerning four core themes viz., Land and Water Resource Management, Sustainable Development of Rural Ecosystems, Conservation of Biological Diversity, and Ecological Economics & Environmental Impact Assessment. Though there was no increase in scientific/technical staff strength, it was possible to initiate 7 projects through networking with a few other organisations. Some of the efforts which remained incipient in the past became apparent. Publications *viz.* 'Agricultural Economy of Himalayan Region: With special reference to Kumaon' and 'Himalayan Environment and Development : Problems and Perspectives' got out of press. The research and development output was partly published in 14 publications in the name of the scientists of the Institute in national and international journals/ other publications. Detailed documents on a number of projects are in considerably advanced stage and likely to be released as Institute's publications in the following year. The scientific recognition was seen from participation of Institute's scientists in international fora on invitation at times. The research and development output could attract a couple of agencies for organizing international workshops at the Institute. Planning for organizing two such events was done during the year. Significant progress could be made towards developing major action oriented research programmes through international cooperation. These efforts though could not materialize during the year, are significant from the point of future developments at the Institute. Transfer of Himalayan Eco-development Programme as an extra-mural funding mechanism from the Institute to strengthen networking was an additional task to be executed from the following year.

This report is a summarized document on the achievements of the Institute during the year 1991-92. The contents do not claim extraordinary output but do reflect a significant contribution towards a better understanding of problems linked to Himalayan environment and development.

A.N. PUROHIT
DIRECTOR

1. INTRODUCTION

Although the basic character of the Institute remained fundamentally the same, as defined in its charter, there were changes in the multitude and magnitude of the activities during the year. There was emphasis on developing the Institute's national and international roles. The Institute was assigned the tasks of formulating an Action Plan for Environmentally Sound Development of Himalaya and initiating scientific collaboration with Norwegian Center for International Agricultural Development of the Agricultural University of Norway (NORAGRIC) through Norwegian Agency for Development Cooperation (NORAD). It was also identified as the nodal agency for International Centre for Integrated Mountain Development (ICIMOD) programmes in India. The Institute's interest in encouraging synthesis of knowledge regarding the scale of complexity in relation to sustainability and biodiversity in Indian Himalaya grew to a considerable extent during the year. Following pages of this report give a brief account of the various projects in hand and other academic activities.

2. MILESTONE EVENTS

Honourable Minister of Environment and Forests, Govt. of India, Shri Kamal Nath laid the Foundation Stone of the Institute's Buildings at Katarmal, Almora on January 13, 1992. The Honourable Minister visited the technology development and demonstration plots, and discussed the various issues with the public on this occasion.

A tradition of celebrating the Annual Day of the Institute by organising academic activities to mark the birth anniversary of Pandit Govind Ballabh Pant was set in. The eminent scholar Dr. M.S. Swaminathan, F.R.S. delivered First Pandit Govind Ballabh Pant Memorial Lecture as the focal activity of Annual Day Function on September 14, 1991.

Excerpts from Pt. G.B. Pant Memorial Lecture - Dr. M.S. Swaminathan

— The ecological security of the Himalayas is not only vital for the welfare of the hill people and their children but also for the food security of India. The future of agriculture in the Indo-gangetic plains, a major foodbasket region of India and of the world, will be determined by what we do or do not do in the Himalaya today.

— The neglect of traditional food crops like amaranth, chenopodium and buckwheat has not only weakened the household nutrition security system of the hill people, but also prevented the Himalaya becoming the home of the health foods of the future. These traditional food crops still afford an opportunity for building a dynamic eco-food industry.

— The growth of tourism in the Himalaya has, instead of strengthening the livelihood security of the local people, often tended to erode their capacity to earn their daily bread.

— The Eastern Himalayan region and North-east India are important repositories of genetic variability in citrus, cotton, rice and other plants as

well as in animals like Mithun and Yak. Shifting cultivation and invasion of cleared lands by non-edible weeds like *Eupatorium, Mikenia* and *Lantana* have resulted in a considerable damage to natural ecosystems and rendered the region a "hot spot" location with reference to the loss of biological diversity.

— The destiny of nearly 40% of our population inhabiting the Gangetic plains depends on the management of the Himalayan hydrologic estate. One of the urgent tasks facing us is the conservation and wise use of this extensive hydrologic estate, spread over an area of about 6,50,000 sq. km.

— The G.B. Pant Institute of Himalayan Environment and Development should spearhead the concept "Think Himalayan but analyse and act locally". My first plea on this occasion is the fostering of participatory research designed to promote a new paradigm of development based on the integration of the principles of ecological sustainability, economic efficiency and social equity.

— An integrated strategy involving *in situ* and *ex situ* methods of conservation will have to be developed taking into account the incidence of biological diversity at different altitudes. Special efforts will have to be made to involve local communities, particularly women, in the conservation work and to make them feel full partners in the efforts to conserve the biological wealth of Himalaya.

— Thus, the G.B. Pant Institute should become a repository not only of gene pools but also of the pool of knowledge required to convert natural endowments into economic wealth based on sound ecological and social groundrules.

G.B. Pant Society of Himalayan Environment and Development, the apex decision making body of the Institute met on March 12, 1992. The Society under the Chairmanship of Honourable Minister of Environment and Forests, Govt. of India, Shri Kamal Nath reviewed the developments at the Institute in the past and took several crucial decisions for furthering the objects of Himalayan environment and development. Governing Body met thrice and Science Advisory Committee once during the year.

3. RESEARCH AND DEVELOPMENT PROGRAMMES

Multidisciplinary approaches linking natural and social sciences for environmentally sound development in the Himalaya are the research and development thrusts of the Institute. Four core programmes *viz.*, Land and Water Resource Management, Sustainable Development of Rural Ecosystems, Conservation of Biological Diversity, and Ecological Economics & Environmental Impact Analysis have been identified. As the problems differ, depending upon the area under consideration in the ecologically as well as socially heterogeneous Himalaya, the project sites are located at different places. Location specific problems and their likely solutions are addressed through time-bound research projects. Rigorous data collection and analysis coupled with development and demonstration of science and technology inputs for an alround betterment constitute essential project work elements. Most of the projects entered second or third year of the envisaged plan during the reporting year. A few

were initiated during the year 1991-92. Highlights of the work done in 1991-92 alongwith a contextual background and specific objectives are summarized below for each project separately.

3.1. Projects Funded by the Institute

3.1.1. Projects initiated in 1989-90 and continued

3.1.1a. Restoration of Degraded Land and Sustainable Rural Development at Katarmal, Almora in Kumaon Himalaya

Background

Degradation of forests, soil erosion, hydrological imbalances, low crop production and out-migration of able-bodied males are the major problems of the Indian central Himalaya. The problems are realized in qualitative terms but their likely consequences remain to be precisely quantified. The need of integrated resource management targeting a problem not in isolation but in conjunction with the other problems, in a long term rather than short term perspective is invariably felt. While there are many gaps in the existing science and technology base to offer solutions to the problem complex, the scope of applying the existing knowledge in retarding or arresting the ongoing trends of environmental degradation is not altogether lacking. Stimulation of vegetation regeneration in a large chunk of degraded or culturable wasteland by ways which also meet the essential needs of the people through their direct involvement has been emphasized for environmental amelioration and socio-economic development of the area. Increasing the utility value of land through integrated management though discussed and argued time and again, has rarely been demonstrated and evaluated for the associated ecological and environmental costs and benefits in a long term perspective. This project initiated a couple of years back envisaged developing and demonstrating the potential of existing science and technology knowledge base to enhance the utility potential of denuded dry slopes through appropriate management of locally available resources. Integrated strategy of resource management designed looking over the food-fodder-forest linkages, environmental constraints and opportunities and socio-economic problems of the area was applied over an area of 3 ha of denuded slopes. Treatment of the area included introduction of water harvesting and storage technology, plantation of tree species with a potential of meeting the local needs and also ecological regeneration of the area and mechanical preparation of land alongwith biological amendments to rejuvenate crop production. Action oriented treatment work was completed by the second year of project execution. Ecological and economic evaluation of the impacts of introduced interventions initiated in the preceding year were carried forward in the current year. Looking over the demand of fodder, fuelwood and multipurpose tree species from the government agencies and the people, a nursery was developed to cater the needs at nominal costs.

Objectives

1. To improve upon the productivity of degraded land by applying in-hand science and technology.

2. To undertake fundamental and applied researches for refining the existing science and technology of restoration/ rehabilitation of degraded land.

3. To create awareness towards environment related issues in the rural mass in order to enhance the participation of common man in environmental regeneration tasks.

Results and Achievements

1. Water harvesting and storage technology introduced two years back continue to be effective ensuring on site availability of 40 m^3 at least of water all through the year. The maintenance cost was negligible.

2. Restrictions on open grazing and surface watering once in fortnight during the dry spells enhanced the green fodder production through natural regeneration of herbaceous vegetation. Grass production which increased from 0.3 tonne/ ha in the first year of treatment to 3.5 tonne/ha during the second year was found to have further improved to the level of 5.95 tonne/ha during third year. It was found that at least two surface watering events during the dry summer season are essential for maintaining higher levels of palatable grass production. These findings suggest that restricting open grazing and managing water resource could mitigate the fodder crisis to a considerable extent.

3. Monitoring of growth in terms of shoot elongation of the introduced tree species was continued. All the species responded positively to organic inputs to the soil. The response in *Acacia dealbata, Grewia optiva, Prunus cerasoides* was most prominent. Species like *Toona ciliata, Quercus* spp. though responded during first year following the transplant were found to be comparatively less responsive by 2nd-3rd year. The data indicate that common fast growing tree species which also happen to be the early successional ones are more responsive to soil moisture and nutrient stresses than the slow growing species dominating late successional habitats (Table 1 & 2).

4. Frost induced damages were observed in *Toona ciliata* and *Grewia optiva. Alnus nepalensis, Alnus nitida, Acacia dealbata, Prunus cerasoides* and *Dalbergia sissoo* were found to be fast growing hardy species.

5. Economic output: input ratio improved from 0.62 in the first year of treatment through 1.41 in the second year to 1.9 in the third year. The inputs applied in rejuvenating abandoned terraces were labour, water and locally available organic manure at the rate of 12 tonne/ha. The management of indigenous resources thus can improve crop production without expanding the agricultural land.

6. Three tree species *viz., Diploknema butyracea, Sapium sebiferum* and *Prinsepia utilis* were identified as potential oil yielding species. The utility value of these species are known to the people but they are not popular in the current restoration programmes. Seeds of these species were collected and techniques for raising them in nursery were developed. Over 5000 saplings of

Table 1. Percentage survival of species planted in degraded land at Katarmal, Almora District

Plant Species	Control[a]			Amended soil[b]		
	6	12	18	6	12	18
Alnus nepalensis	86	80	80	89	84	84
Alnus nepalensis (naked roots)	15	15	15	15	15	15
Alnus nitida	78	78	74	82	80	80
Acacia dealbata	64	60	56	93	90	82
Bauhinia malabarica	62	55	-	78	70	-
Bauhinia variegata	-	-	-	70	65	-
Cedrus deodora	62	62	60	78	76	74
Celtis australis	57	56	40	86	86	84
Cupressus torulosa	60	50	45	76	70	66
Dendrocalamus hamiltonii	-	-	-	40	30	30
Dalbergia sissoo	90	86	-	95	95	-
Grewia optiva	46	45	38	80	80	73
Grevillea robusta	68	66	66	75	75	72
Melia azedarach	68	66	66	84	84	80
Myrica esculenta	-	-	-	50	50	50
Pinus roxburghii	80	80	80	-	-	-
Prunus cerasoides	64	60	60	88	88	86
Pyrus pashia	35	20	20	60	56	51
Quercus leucotrichophora	28	26	20	72	70	62
Q. glauca	41	34	30	76	70	70
Toona ciliata	60	56	48	85	75	71

a, transplants in pits of 0.2m × 0.2m × 0.2m size with no addition of organic manure

b, transplants in pits of 0.6m × 0.6m × 0.6m size filled with soil devoid of boulders and mixed with organic manure

Table 2. A comparative account of shoot elongation (30 months following transplantation) of important tree species.

Plant species	Growth of main axis (cm)		
	Control[a]	Semi-amended[b]	Amended[c]
Alnus nepalensis	395.2	465.5	-
Alnus nitida	384.2	477.1	-
Acacia dealbata	231.3	443.2	685.5
Celtis australis	135.5	167.1	431.5
Dalbergia sissoo	198.0	171.2	-
Grewia optiva	95.5	154.8	292.0]
Grevillea robusta	167.0	221.5	446.2
Melia azedarach	116.7	181.1	659.5
Prunus cerasoides	123.0	179.4	411.5
Quercus glauca	104.5	117.4	-
Q. leucotrichophora	103.3	123.4	161.5
Toona ciliata	103.1	98.7	-
Cedrus deodara	86.0	116.1	-

a, – transplanted in pits of 0.2 m X 0.2 m X 0.2 m size with no additional organic manure and soil preparation.

b, – transplanted in pits of 0.6 m X 0.6 m X 0.6 m size filled with soil devoid of boulders and mixed with 3 kg (approx.) organic manure.

c, – transplanted in terraced land and pit size and other preparation were similar to 'b'.

these species have been raised and plan to propagate them is finalised.

7. Over 40,000 saplings of a total of 22 species were raised, and supplied to government agencies and the local people on demand. Styloform seedling trays were designed to economize the cost of nursery development and to ensure safe transport of seedlings/saplings in the undulating hilly terrain. Revenue earned through the nursery output during the year was about Rs. 10,000/-.

3.1.1b. Integrated Watershed Management- A Case Study in Sikkim Himalaya

Background

Watershed has been recognised as an appropriate unit of analyzing development linked resource problems, designing appropriate solutions of the identified problems and eventually testing the efficacy of the prescribed solutions in the mountains. Watershed approach helps in tackling the ecological and socio-economic problems in an integrated perspective. In view of limited information on the watersheds of Himalaya in general and those of eastern Himalaya in particular, this project was undertaken as a multidisciplinary effort with the goal of facilitating integrated management for improving the ecology and economy in the Mamley watershed located in South district of Sikkim. The watershed is spread over an area of 3009 ha at an altitudinal range of 300-2500 m and falls in the upper catchment of Rangit river. Preliminary structural characterization of the watershed was completed in the previous year. The current year efforts were concerned with the collection of data/information (primary as well as secondary) in order to have an in-depth understanding of structure, function and problems in the watershed to serve the needs of designing appropriate management strategies for ecologically sound economic development of the region.

Objectives

1. Structural analysis of the watershed - studies on vegetation, soil, geology, socio-economics and their integration.

2. Intensive studies on the dominant land use systems.

3. Analysis of interactions of dominant land use systems.

4. Identification of integrated resource management models and their on site testing.

Results and Achievements

1. A "tectonic window" and Sikkip and Tendong thrust zones are the conspicuous geological features of the area. The parent rocks are represented by sandstones, shales, coal seams, slates, phyllites, dolomites and conglomerates. Dolomite and coal offer economic potential for development in the watershed area.

2. Out of the nine first order streams draining the watershed, four are perennial. However all streams exhibited vigorous flows during the rainy season.

The discharge rate during the study period varied from 164 l/sec in Rinjhi Khola to 0.013 l/sec in Rangrang Khola. The seasonal streams were found to be sub-surface flow systems.

3. Measurement of rainfall at a number of sites representing variability in altitude and aspect within the watershed showed range of 1800 mm to 2600 mm annual rainfall. In general upper slopes receive larger quantities of rainfall than the lower ones. Significant differences in rainfall over a small geographical area warrant caution in deducing conclusions on hydrological processes based on one point measurement or large area averages.

4. Run-off and surface soil loss decreased with increasing dominance of perennial crops. Losses in terms of physical soil, organic carbon and nitrogen were maximum in barren land followed by annual crop fields, agroforestry systems with perennial cash crops and natural forests (Table 3).

5. Land use dynamics in the watershed was interpreted from the topographical map of Survey of India (1951/52) supported with other ancillary information and the survey of area made during the present year. The agricultural land use was found to have expanded during the last 40 years. The increase of 12.74 % in the area of croplands was found to have been accomplished by diversion of 7.61 % of culturable wastelands, 1.93 % of barren land, 0.68 % of pasture land and 2.49 % of reserve forest land. Agricultural land use on steep slopes (more than 30°) were found to be in critical phase and need restorative/ameliorative treatments. Population growth coupled with household fragmentation were found to be the underlying factors for the expansion of agricultural land use.

6. Land capability classification following the procedure developed by United States Department of Agriculture showed that hardly 25 % of the watershed area falls in capability class I and II suitable for conventional annual crops. Most of the land is of class III category which is not suitable for cultivation. Further these are the socio-economically privileged people who own most of the good quality class I and class II land. This has enforced the weaker people to practise agriculture on marginal/poor quality land.

Table 3. Run-off and erosion under different crop/vegetation cover in the Mamley Watershed

Crop/vegetation cover	Run-off (l/ha)	Soil loss (kg/ha)	Organic carbon loss (kg/ha)	Total Nitrogen loss (kg/ha)
Agricultural field (Maize crop)	6426.97	121.83	0.27	0.09
Agroforestry system (Cardamom crop)	6989.28	65.54	0.08	0.03
Natural forest	5581.43	12.11	0.03	0.01
Barren land	8097.24	165.65	0.30	0.19

7. Animal husbandry is an integral component of farming systems in the area. Each household on an average possesses four heads of livestock (excluding poultry birds). Open grazing is rarely practised. Animals are stall-fed.

8. Most of the agricultural land is rainfed. Maize is the main staple cereal while ginger, cardamom and orange constitute the chief cash crops. Crop composition consists of maize and at least one cash crop in a farmer's field. Crop yields in the watershed are comparable to the state averages. Soils are generally acidic having organic carbon in the range of 0.59 - 1.15%, total nitrogen in the range of 0.09 - 0.16% and available phosphorus in the range of 0.01 - 0.07% depending upon crop grown and altitude.

9. Three types of agroforestry systems were practised in the watershed - annual food crops mixed with fodder and timber trees, annual food crops mixed with fruit trees such as oranges, perennial cash crops *viz.*, large cardamom mixed with various tree species.

10. Among eighteen fodder tree species traditionally known to the people, *Litsea polyantha, Ficus hookerii, Ficus nemoralis* and *Saurauia napalensis* meet a substantial requirement at present. Based upon the chemical analysis of fodder leaves, *Ficus hookerii* was found to be the source of best quality fodder followed by *Bauhinia purpurea, Ficus nemoralis and Litsea polyantha*. Cellulose and lignin contents varied from 5 - 23% while that of protein varied from 15 - 20% in the palatable constituent of fodder trees analyzed for their fodder quality.

11. Only 12% of watershed area was covered under reserve forest category represented by two forest types *viz.*, sub-tropical and temperate forest. Regeneration in both the types was good as inferred through vegetational analysis. It is the restriction on open grazing by the people which accounts for a fair level of regeneration in the forest. *Castanopsis indica, Shorea robusta* and *Schima wallichii* are the dominant tree constituents of sub-tropical forest type. The temperate forest type was dominated by *Quercus lamellosa, Alnus nepalensis, Castanopsis tribuloides* and *Eurya acuminata*. The emergent trees formed a more closed canopy cover in temperate forest than in the tropical ones. The sub-tropical forests showed substantially lower tree biomass (362 Mg/ha) than the temperate forest (764 Mg/ha). Wood biomass extraction estimated on the basis of whole tree removal was higher in sub-tropical type (4.5 Mg/ha) compared to the temperate forest (3 Mg/ha) indicating the former facing a more severe extraction pressure than the later. Total litterfall was estimated as 2703 Kg/ha in sub- tropical forest and 2326 Kg/ha in temperate forest. The two forest types did not differ significantly in respect of forest floor litter ...ass.

12. Organic carbon and nitrogen decreased while pH and available phosphorus increased down the depth in forest soils studied for one meter of the profile. Nitrogen content was highest under *Alnus nepalensis* dominated temperate forest stands (1549 kg/ha of humus nitrogen content) which is attributed to symbiotic association of nitrogen fixing *Frankia* and *Alnus*.

13. About 80% of annual household income is spent on the purchase of food items particularly rice. Lack of irrigational facilities account for absence of paddy cropping in the watershed.

14. Nearest neighbourhood analysis showed that human settlements are randomly distributed (Rn=1.19). New settlements were found to be concentrated on the road sides. Gastro intestinal disorders were detected as the major cause of infant mortality. Prevalence of grade II and grade III goitre in the age group of 5-44 years indicates iodine deficiency of the drinking water. Literacy level worked out in the blocks covered by the watershed was far below the state or national average.

15. Namchi town is the central marketing place for the people of the watershed. Monetary flows and marketing forces are being analyzed.

16. A low cost water harvesting technology was introduced in a degraded site in the watershed. Efforts are being made to improve upon the crop production and its economic value.

3.1.1c. Designing Ecologically Sound Natural Resource Management Strategies for Sustainable Rural Development in Kapkot Block (District Almora) in Central Himalaya

Background

The conventional approach defining resources involves identification of material or energy components which are useful or potentially useful to the society in the sense that they can be exploited. Exploitability confers a connotation not only to mere existence of a given resource but also the technological and economic potential rendering monetary profits. Rendering sustainability to the development process involves a change in the approach of getting developed. Exploitation of natural resources should be designed with parallel and equally effective efforts on their replenishment. In case of biological production systems, recovery in the factors influencing production rates (land resource base) depleted as a result of harvest must be ensured for achieving sustainability. The sustenance of life and development of human beings depend upon the biological production and use systems which vary depending upon the environmental opportunities and constraints. This project aimed to analyze the natural resource and development linked problems and their likely solutions in high elevation areas with difficult accessibility. While a general account of environment and development issues of one block is being prepared utilizing secondary data supported with primary surveys, three villages differing with respect to elevation/accessibility, were selected for detailed studies and experimental demonstrations of science and technology inputs to improve the production of critical resources as an instrument of sustainable rural development. The project has the components of both analytical research and applications of existing knowledge on restoration of degraded land with people's participation. Improvement in ringal (temperate bamboo) based cottage industries by enhancing the production and

thereby availability of raw material coupled with strengthening the direct economic benefits to the people is the focal point of the project and has been linked with other production and use systems.

Objectives

1. To analyze the current problems and consequences of ringal based cottage industry.

2. To identify appropriate land management practices and resource uses so as to mitigate the current problems.

3. To define integrated resource management on a geographical unit vis-a-vis administrative unit.

Results and Achievements

1. Time sequence analysis is required to identify the resource dynamics and the pace of development of the area and people. The data on the various attributes published in district census report from 1951 to 1981 were compiled and analyzed. Variability in the definitions of the parameters and inconsistent methodologies adopted for enumeration/measurement/estimation constrained derivation of meaningful and reliable temporal trends. Analysis of census information followed by field survey led to arrive at following conclusions : (a) women folk constitutes the major work force in production process but is not accounted in realistic terms, (b) increase in forest area reported for a number of villages is not due to increase in tree cover but on account of transfer of land in the category of culturable wastes to the the category of forest land, (c) repeated afforestation of a number of sites indicates serious drawbacks in the technology applied and non-cooperation of the local inhabitants, (d) area of irrigated crop land decreased following intervention by the government agencies charged with providing irrigational facilities suggesting that a careful planning is required before the traditional systems are targeted for replacement by the new ones, (e) development interventions have diverted the attention of people from strengthening the indigenous traditional instruments of development to alien mechanisms, (f) while the males emphasize over cash fetching ways of resource exploitation and market economy, the females are more concerned for improving the availablity of domestic needs through local production.

2. Ringal cottage industry as at present provides negligible economic benefits to the producers. The benefits reach to the middle men (Table 4). Institutional mechanisms need to be strengthened for realising benefits of this cottage industry.

3. Similar to the ringal cottage industry, valuable crops are produced in the high elevation areas but the present marketing system hampers monetary benefits reaching the local people (Table 5).

Table 4. Monetary analysis of ringal based cottage industry in Khaljhuni (2300 m) monetary input-output values calculated for the most common item - mat of size 4.5m x 3.5 m.

Activities	Cost (Rs.)
Getting permit for harvesting raw material from the forest	5.0
Collection, harvesting, transporting and preparation of raw material (2 man day)	46.5
Weaving (1 skilled man day)	46.5
Monetary cost of inputs	98.0
Selling price in and around village	100.0
Selling price in the urban market	150.0

Khaljhuni is a remote village located at a distance of 12 km from the road head and connected by a briddle path in Kapkot block in District Almora.

4. Restriction on open grazing following plantation of tree species mixed with ringal in a highly degraded piece of land was found to alleviate the crisis of fodder availability and also improved the protective vegetal cover. The restoration plot yielded 40 tonne/ha (air dry weight) of green fodder during the year, the yield being evenly shared by all the households. There was no significant mortality of planted individuals which survived the initial one year period following the transplant. New culms were produced in over 80% of the ringal transplants. This experience in the village Khaljhuni is a success story of the project demonstrating that regeneration of degraded land is possible provided the management is focused on the priority needs of the people and linked with their development.

5. Cultivation of medicinal plants was also tested as an option for diversifying the existing biological production systems linked to providing economic benefits to the people. People own a rich repository of traditional knowledge on the distribution and uses of medicinal plants but have not tried to cultivate them. The knowledgeable people were induced to

Table 5. Trade economy of farm output in village Khaljhuni

Crops	Selling price in village (Rs per kg)	Commodity[a] exchanged with in village (per kg)	Selling[b] price in nearest urban centre (Rs per kg)
Hordeum vulgare	1.0	1 kg wheat	5.0
Soyabean	3.5	1 kg rice	16.0
Macrotyloma uniflorum	3.5	1 kg rice	8.0
Amaranthus	3.5	1 kg rice	20.0
Rajma	9.4	2 kg rice	20.0
Potato	0.5	-	3.0
Fagopyrum esculentum	-	-	24.0

a. Adjacent village is located at a distance of 4 km
b. Nearest urban centre is at a distance of 52 km

test cultivation of species of *Aconitum*, *Rheum*, and *Mentha*.

3.1.1d. Development of Agroforestry Model in Garhwal Himalaya

Background

Agroforestry is argued to be a sound land management option meeting both environmental and developmental imperatives in the hills, particularly on the hill slopes. Agriculture, forests and animal husbandry are interlinked sectors all across the Himalaya. The nature and magnitude of these linkages do vary. Agriculture in the Himalaya continues to be of subsistence type and productive potential of cropland depends upon the organic inputs derived directly from the forest in the form of litter or indirectly through animal dung. The Himalayan dwellers still depend heavily upon fuelwood to meet their energy needs. In central Himalaya food crop cultivation on terraced slopes, often as steep as 40-45°, is a major threat for aggravating the environmental degradation. Introduction of trees which provide a perennial canopy cover, meet multiple needs (food, fodder, fuel), add to the fertility of soil is likely to accompany the dual benefits of maintaining productive potential of land and increasing protective cover. The traditional land use in central Himalaya reflects a practice of maintaining trees on the slopy cropland. However under the present pressure of high population densities and many other influences, the traditional agroforestry systems are getting weakened. There is a need of evaluating the costs and benefits of introducing trees in cropland, identifying potential species, standardizing the propagation and cultivation techniques of the identified species and rejuvenating the traditional agroforestry systems with appropriate science and technology inputs. This project aims to answer questions like which species should be introduced, what should be the scientific criteria for species selection, what are the socio-economic reasons behind diminishing trends of tree crop mixture. The experiences of a pilot project completed last year in Garhwal indicated a need of diversifying the agricultural systems not only by means of introducing trees but also by altering the traditional cropping pattern in ways which render benefits over short terms to the poor farmers. It was also realised that development and demonstrations of land management technology should be undertaken as a fairly long term collaborative programme with High Altitude Plant Physiology Research Centre of H.N.B. Garhwal University and taking people of the target area in confidence before the project is executed. Interaction of scientists and the people led to transfer of a piece of 5.5 hectares of barren land by Jalai Village Panchayat near Banswara (about 16 km from Rudraprayag on way to Kedarnath in District Chamoli) on lease to the Institute for a period of 10 years.

Objectives

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

2. To evaluate the acceptability of the identified management practice/use systems to the people.

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

Results and Achievements

1. The experimental land was fenced. An understanding with the local institutions was developed that a model of land redevelopment would be framed by the Institute with no interference in the land proprietary rights and the people would extend all possible cooperation in the project execution.

2. About 2 hectares of the site consisted of abandoned and damaged terraces while the remaining land had never been put to agriculture use earlier and was currently devoid of even a sparse vegetal cover. It was planned to develop an agroforestry model in the abandoned agricultural land and stimulate natural vegetation regeneration in the barren land.

3. Damaged terraces were repaired and carefully ploughed adding sufficient organic manure.

4. Indigenous tree species having multiple uses coupled with a high photochemical efficiency were screened. Chlorophyll-a fluorescence measured from plant efficiency analyzer was used as an indicator of photochemical efficiency. 38 tree species were analyzed (Table 6) and 15 multipurpose tree species were selected for field trials.

5. Variable combinations of nitrogen fixing leguminous and non-leguminous, and species

Table 6. Photochemical efficiency (Fv/Fm) of plants grown in botanic garden at Srinagar (550 m)

Plant Species	Photochemical efficiency
Acer oblongum	0.79
Aesculus indica	0.80
Albizzia lebbeck	0.80
Alnus nepalensis	0.76
Diploknema butyracea	0.75
Bauhinia retusa	0.82
B. variegata	0.81
Boehmeria rugulosa	0.79
Bombax ceiba	0.81
Toona serrata	0.80
T. ciliata	0.81
Celtis australis	0.80
Cornus capitata	0.76
C. macrophylla	0.80
Dalbergia sissoo	0.81
Eugenia	0.79
Ficus auriculata	0.83
F. clavata	0.78
F. cunia	0.82
F. glomerata	0.81
F. hispida	0.81
F. palmata	0.82
F. religiosa	0.75
Fraxinus micrantha	0.81
Grewia optiva	0.81
Kydia calycina	0.80
Litsea lanuginosa	0.75
Myrica esculenta	0.78
Olea glandulifera	0.73
Ougeina dalbergiodes	
Normal	0.80
Variant	0.78
Populus ciliata	0.82
Prunus cerasoides	0.81
Quercus floribunda	0.82
Q. glauca	0.79
Q. lececotrichophora	0.79
Sapium sebiferum	0.82
Terminalia bellirica	0.79

lacking nitrogen fixing microbial associations were created as treatments in the agroforestry plots. Six - twelve months old saplings were transplanted in pits of 0.6m x 0.6m x 0.6m size dug out at an interval of 3m on the margin of terraces. Soil in each pit was amended with 2 kg of organic manure at the time of transplanting in July/August 1991. In case of non agricultural barren land interplant distance was kept as one meter.

6. Survival as observed after six months from the date of transplant was better in terraced land in comparison with the barren land. *Ficus glomerata, Ficus rumphii, Ficus auriculata* and *Prunus cerasoides* showed 100% survival on terraces. *Alnus nepalensis, Prunus cerasoides, Quercus glauca* and *Grewia optiva* were most successful in the barren land (Table 7 & 8).

Table 7. Survival percentage of multipurpose tree species (after six months of transplantation) planted on barren land.

Tree species	Survival percentage
Aesculus indica	77.5
Albizzia lebbeck	74.4
Alnus nepalensis	87.4
Boehmeria rugulosa	78.0
Celtis australis	75.2
Toona ciliata	55.5
Dalbergia sissoo	72.0
Ficus glomerata	68.1
Grewia optiva	79.0
Melia azedarach	66.8
Prunus cerasoides	85.7
Quercus glauca	80.0
Sapium sebiferum	68.2
Sapindus mukorossi	59.2

Table 8. Survival percentage of multipurpose tree species (after six months of transplantation) planted in agroforestry demonstration model at Bansvara.

Tree species	Survival percentage
Albizzia lebbeck	75.0
Alnus nepalensis	85.6
Bauhinia variegata	33.3
Boehmeria rugulosa	94.5
Celtis australis	87.7
Dalbergia sissoo	88.2
Ficus glomerata	100.0
F. rumphi i	100.0
F. auriculata	96.8
Grewia optiva	100.0
Prunus cerasoides	90.5
Sapium sebiferum	85.4

7. Stresses were more in soil of barren land compared to the agricultural land. A comparison of photochemical efficiency of transplant at two sites was made to assess the stress tolerance of important species. Except for *Sapium sebiferum* all species tested showed lower efficiency in more stressful environment. *Boehmeria rugulosa, Alnus nepalensis* and *Celtis australis* were more responsive than others.

8. Adaptive behaviour of the planted trees was also studied looking over the biochemical attributes *viz.*, proline, total amino acids and soluble sugars in the photosynthetic tissues. Variable species

responses were observed. Proline and total amino acid contents were higher in the barren land compared to the levels in agricultural land in all species, *Dalbergia sissoo* being the only exception. Efforts are continued to look into the details of biochemical and physiological responses to stresses.

9. *Alnus nepalensis*, *Ficus glomerata* and *Celtis australis* exhibited highest rate of shoot elongation among the species tested on both the sites.

10. Water stress was found to be a severe constraint in land redevelopment plan. Water harvesting and storage technology was introduced. Construction of a water tank to store surface run-off and diversion of water from perennial sources to the tank through gravitational force could ensure on-site availability of 40 m^3 stored water per day all through the year.

11. With the introduction of water harvesting technology it was possible to raise off-season vegetables, cereals, pulses and other cash crops mixed with trees. Labour and farmyard manure constituted the major inputs. Economic output/input ratio during the first year of treatment was found to be 1.8. Quite a few medicinal plants including *Aconitum heterophyllum*, *Aconitum balfourii*, *Rheum emodi*, *Rheum moorcroftianum*, *Podophyllum hexandrum*, *Picrorhiza kurrooa*, *Nardostachys jatamansi*, *Saussurea obvallata* are being tested for their efficacy in providing quick returns.

12. The results obtained so far indicate that it is possible to restore the degraded land with participation of people provided the recommended interventions involved both short term economic and long term ecological gains.

3.1.1e. Jhum and Sustainable Development of a Village Cluster in Nagaland

Background

Shifting cultivation locally referred to as Jhum, is the predominant subsistence farming system in the tribal belts of north eastern Himalayan ranges. Low crop yields on one hand are insufficient to meet the nutritional needs of the tribal population, on the other hand repeated cultivation of a site at short intervals causes severe environmental degradation in terms of both soil fertility and vegetation cover under the present situation of high population pressure and socio-economic influences. While the drawbacks of this age old farming practice have been realised long back, the alternative options recommended have failed to make any visible impacts. However, the jhum in a traditional form has been found to be superior to many modern cropping systems when looked from the point of ecological costs and benefits associated with crop harvests. Unfortunately the drawbacks in the system induced in the recent times (shortening of fallow phase particularly and concomitant degradation of forests) have led to the neglect of positive aspects of jhum. Conservative attitudes of the tribal communities and appreciation for shifting cultivation not merely as a land use practice but as an integral component of tribal culture impart resistance to the solutions envisaging replacement of shifting cultivation by completely new systems. This project initiated two years back was planned to identify technological interventions which arrest and/or revert the ongoing trends of environmental

degradation originating from the distortions in the traditional jhum, keeping in view the social, economic and cultural specificities of the tribals and environmental management imperatives in mountains. The target area of the project included three villages *viz.*, Yaongyimsen, Salulmang and Chuchuyimlang in district Mokokchung of Nagaland. The approach involved interaction with people, NGO (Nagaland Gandhi Ashram) and undertaking participatory research and development. Activities such as introduction of ameliorative tree species in the jhum system, diversification of traditional cropping pattern by introducing new crops, introduction of water harvesting technology to support cash crop cultivation in good quality land and scientific evaluation of the introduced interventions comparing with the traditional system initiated last year were carried forward during the reporting year.

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 .
3. To identify potential fast growing native tree species valued by the tribals and to standardize their cultural techniques.
4. To develop and demonstrate low cost water harvesting technology ensuring availability of water during the lean period.
5. To create awareness on the consequences of forest degradation, exploitation and conservative measures through involvement of local people in the project activities.

Results and Achievements

1. Comparison of cropping pattern and yields under different lengths of slash-burn cycle in three villages differing with respect to population size and remoteness from the urban centres revealed some interesting variations. While mixed cropping with paddy and tapioca as the chief constituents was common in all situations, cash fetching vegetable crops were found only in the village Chuchuyimlang subject to urban influences. Crop yield in case of paddy was found to be more responsive to the length of cultivation cycle as compared to tapioca indicating differential nutrient requirements of rhizome and seed borne crops. Long cultivation cycles of 20 years were rare and practised only in the remote village Yaongyimsen. The common length of cultivation cycle was found to be 8 years (Table 9).

2. *Alnus* trees were introduced in the cropped fields and fallow fields covering an area of two hectares as an intervention for hastening the recovery process in the traditional jhum system. About 80 % of the bag-transplants survived after a period of one year. Direct seed sowing or transplant of naked root individual turned to be absolute failures. The growth was found to occur at a biomass accumulation rate of around 10 kg/tree in the cropped fields and 2.5 kg/tree in the fallow fields over a period of 18 months indicating sensitivity of growth to light intensity in this species (Table 10). The introduced tree was found to be acceptable to the farmers. Having observed the introduction of *Alnus* trees in the experimental plots, a number of farmers voluntarily came forward

Table 9. Crop yields (Q/ha) under different jhum cycles in district Mokokchung, Nagaland

Crops	Jhum Cycles and village						
	8-years (Chuchuyimlang)		11-years (Salulamang)		8-years (Yaongyimsen)		22-years (Yaongyimsen)
	1st year of cropping	2nd year of cropping	1st year of cropping	2nd year of cropping	1st year of cropping	2nd year of cropping	1st year of cropping
Rice	28.18	24.51	35.21	26.79	27.38	23.00	42.50
Maize	0.50	0.29	0.43	0.30	0.35	0.23	0.57
Taro	1.95	2.75	1.68	3.50	1.38	2.93	1.95
Tapioca	1.15	-	1.57	1.16	1.28	0.98	1.70
Ash gourd	0.19	-	0.75	-	0.60	-	0.80
Cucumber	0.85	-	0.81	-	0.63	-	0.85
Ginger	0.25	-	0.19	-	0.15	-	0.80
Garlic	0.03	-	0.02	-	-	-	-
Beans	0.25	-	0.19	-	0.15	-	0.21
Brinjal	0.15	-	0.12	-	0.10	-	0.17
Bitter gourd	0.05	-	-	-	-	-	-
Chilly	0.50	-	0.48	-	0.40	-	0.57
Foxtail	0.45	-	-	-	-	-	-
Lady finger	0.50	-	-	-	-	-	-
Mung	1.75	-	-	-	-	-	-
Sweet melon	0.15	-	-	-	-	-	-
Sweet potato	0.25	-	-	-	-	-	-
Tomato	0.95	-	-	-	-	-	-
Labiatae	0.27	-	-	-	-	-	-

to get saplings during the current year. An area of about one hectare of jhum land was planted by the people getting saplings free of cost from the Institute's nursery.

3. Introduction of *Alnus* saplings in the first year of cropping was not found to accompany any significant changes in run-off, percolation and soil erosion. However similar treatment of one year old fallow fields showed reduction in run-off and soil erosion. These findings suggest that *Alnus* may not be effective in conserving resources during the cropping phase but would be effective in doing so during the fallow phase. Monitoring of soil and water flows is continued to quantify the ameliorative effects of introduced trees (Table 11).

Table 10. Growth of alder (*Alnus nepalensis*) introduced in cropped and fallow fields in village Chuchuyimlang

Growth parameters	Cropped field	Fallow field
DBH (cm^2/year)	13.5	6.94
Shoot elongation (cm/year)	261.8	200.75
Branch recruitment (nos./year)	21.5	19.35
Biomass (gm/plant/year)	6124.7	1941.8

Table 11. Run-off, percolation (% of total rainfall) and sediments (t/ha) losses from traditional Jhum (1st year of cropping), alder saplings introduced in jhum (1st year of cropping), 1 year old fallow field developed after cropping and alder saplings introduced in 1 year old fallow field developed after cropping (data of early part of the rainy season at village Chuchuyimlang in district Mokokchung in Nagaland).

Losses	Field Types			
	Jhum		1 year old fallow field	
	Traditional	Alder introduced	Traditional	Alder introduced
Run-off	13.05	13.02	4.46	2.86
Percolation	8.28	8.29	28.52	36.55
Sediments	3.57	3.55	1.51	1.31

4. Saplings of native Species of *Terminalia*, *Albizzia* and *Melia* were raised and distributed to the farmers for introduction in jhum and fallow land. A positive response by the farmers owning land but negative response by the landless people getting cultivation rights from the village council for short terms was observed. Since a large chunk of land is community owned, afforestation/reforestation depends upon the village institutions. Afforestation work over an area of 1 ha in a school campus in Chuchuyimlang was undertaken jointly with local institutions. Fourteen tree species occurring locally were planted with an object of creating awareness towards environmental management in the students.

5. Saplings of perennial cash crop cardamom were raised and planted in the farmer's fields and also regenerating fallow fields. The growth of crop introduced in an area of one hactare distributed in the three villages is being monitored.

6. Efforts are being made to standardize the propagation techniques of cane (*Calamus* spp.) which could be a potential raw material for household industries in the area.

7. A low cost water harvesting/storage technology was introduced in the village Chuchuyimlang suffering with water crisis even with respect to the needs of daily life. A water storage tank with a capacity of 9 m^3 was constructed and full level of the tank is being maintained by diverting the water from a perennial source through bamboo channels. The appreciation of people towards this component of the project is evident from voluntary labour inputs from ten families of the target village in the construction work. The impact of the technology introduced stimulated a local institution to approach the Institute for construction of large size (53 m^3) tank to cultivate crops like sweat pea and mustard which are not grown in the jhum system. Data are being collected to analyze the ecological and economic impacts of the introduced technology.

8. An inventory of non-conventional nutritional, medicinal and other valuable crops is being prepared making use of the vast traditional knowledge of the Nagas. So far 53 plant and 25 animal species with diverse utility values have been identified.

3.1.1f. Mechanisms of the Maintenance of Biological Diversity and Their Role in Ecosystem Organisation 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. Diversity is an attribute apparent at variable levels starting from individual to population, community/ecosystem and landscape. This project aimed to concentrate on community/ecosystem and landscape level diversity in Binsar sanctuary. Objectives of thematic mapping and population dynamics of tree species in representative areas envisaged in the plan were accomplished in the previous years. Efforts in the current year were concentrated on biomass accumulation pattern in different forest types.

Objectives

1. To prepare thematic maps of the study area
2. To study population dynamics of tree species.
3. To study growth and regeneration pattern of individual tree species.
4. Data analysis and synthesis to identify mechanisms maintaining biological diversity and associated attributes.

Results and Achievements

1. Forest tree biomass was found to increase with increase in elevation. Higher biomass accumulation was partly due to variation in species composition and partly due to lower disturbance regimes (Table 12).*Quercus floribunda* forest at an elevation of 2300 m had accumulated over 6-8 fold biomass estimated in *Pinus roxburghii* forest in the elevation range of 1800-1950 m.

Table 12. Tree biomass in different forest types in Binsar Sanctuary.

Forest Type/ Dominant species	Elevation (m)	Aspect	Biomass (t/ha)
Pine Forest			
Pinus roxburghii	1800	SW	97.57
	1850	S	70.74
	1950	SE	81.85
Mixed Forest			
Pinus roxburghii	2100	W	296.27
Quercus leucotrichophora	2200	S	575.05
Banj oak Forest			
Quercus leucotrichophora	2200	N	499.08
	2300	SE	401.74
Tilonj oak Forest			
Quercus floribunda	2300	NW	641.47
	2500	NW	443.25

2. Proportional allocation of accumulated biomass to bole was highest in *Pinus*. The data show that the broad leaved species emphasize more on radial growth of the canopy as compared to the coniferous species.

3. Community dominance was more marked in *Pinus* dominated forests than in the *Quercus* dominated forests.

4. Firewood and fodder supply potential of important tree species was estimated (Table 13).

Table 13. Biomass available for fuelwood and fodder (branch, twigs and leaf) from different forest tree species.

Species	Utilizable biomass as fraction of total tree biomass in percentage
Top canopy species:	
Quercus leucotrichophora	42.15
Quercus floribunda	49.30
Pinus roxburghii	18.64
Common associated species:	
Litsea umbrosa	43.95
Rhododendron arboreum	34.60
Ilex dipyrena	43.50
Viburnum cotonifolium	44.80
Machilus duthiei	45.00
Lyonia ovalifolia	44.12

3.1.1g. Documentary Publications on Agricultural Economy of Himalayan Region

The Institute has planned to bring out a series of comprehensive publications on the agricultural economy of the region. Looking over the diversity in agricultural systems and their linkages with the social and cultural systems, apart from vastness of the region, this task is being accomplished in phased manner. The object is not only to compile the isolated published/unpublished data, but also to evaluate the quality and reliability of the data, to identify data gaps, and treatment of data for discerning economic development trends in conjunction with the environmental specificities of the region. First publication in the series "Agricultural Economy of Himalayan Region:with special reference to Kumaon" published by Gyanodaya Prakashan, Nainital was released on the First Annual Day (September 14, 1991) of the Institute. Efforts have already been initiated to produce similar documentations on Garhwal. Needed information on land use, land holdings, livestock, farm implements and machinery have been collected and processed. Hopefully the publication is given a final shape by the end of the following year.

3.1.1h. Edited Publication - Himalayan Environment and Development: Problems and Perspectives

The above edited title comprising ten articles written by eminent personalities on critical issues of Himalayan environment and development published by Gyanodaya Prakashan, Nainital was released by the Honorable Minister of Environment and Forests, Govt. of India, on January 13, 1992.

3.1.1i. Documentary Publication on Fodder Trees and Shrubs of the Central Himalaya

It has been planned to comprehensively document the systematics, geography, nutritional, and common ecological, physiological and socio-economic features of fodder resources of central Himalaya, seeking help from an outside expert. The draft manuscript is being given the final shape and is likely to be out in the following year.

3.1.2 Projects initiated in 1990-91 and continued

3.1.2a Exploration of Lesser Known Crops of Garhwal Himalaya as Food Source

Background

The current trends in the demand and supply of food have made it abundantly clear that developments in production technology alone cannot ensure food security for the future generations. Current levels of yields of common staples are progressing towards maximum possible yields under the high input cultural practices. Sustainability of high input systems itself has become questionable in the developing and underdeveloped world. Diversification of food base as an option to food requirements of the future has not received as much recognition as the technological improvements increasing the yield levels of common food crops. Peasant agriculture in the mountains provide ample scope for diversifying the food base. Food requirements in the mountains, particularly in the high elevation areas, were traditionally met from a variety of cultivated crops and many of these crops escaped the attention of scientists for their food potential and thereby remained 'lesser known' in the scientific world. An illusory distinction of coarse and fine grains by the western modern civilization and selective emphasis on increasing the yields of fine grains have relegated negligence to many crops traditionally grown in the hills. A detailed survey of the biodiversity of cultivated food crops, their productive potential and the quantitative trends in their acreage and yields are altogether lacking. This project aimed to fill up the gaps in knowledge documented on the food crop biodiversity in Garhwal Himalaya. Studies were concentrated in district Chamoli and Tehri. These were remote villages located in high elevation zones which were intensively surveyed.

Objectives

1. To survey plant species of potential food value domesticated by the traditional societies.

2. To study the contribution of 'lesser known' crops in meeting the food requirements of the traditional societies and temporal trends in their acreage and yields.

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

4. To analyze the land management, cultural practices and ecophysiological requirements

of 'lesser known' crops and their comparison with common crop agroecosystems.

5. To identify strategic actions for conservation of 'lesser known' crops and its long term implications.

Results and Achievements

1. Survey of the area including Niti, Mana, Urgam, Mandakini, Mandal, Birhi, Alaknanda, Pindar, Bangar valleys led to identification and collection of 25 under utilised traditional crops. The propagules of different species/varieties were collected for detailed analytical studies.

2. Data on area cropped under the important species during last two decades were collected. A drastic reduction in the acreage of these crops was apparent in all the three elevation zones (500-1300, 1400-1900, 2000-3500 m) studied (Table 14). Species like *Panicum milliaceum, Hordeum himalayens, Secale cereale* showed a more prominent decline in the acreage than the others.

Table 14. Changes in acreages (ha) of important traditional crops during 1970-1990 in villages located in elevation zone of 500 -1300 m of Garhwal Himalaya.

Village	1970-80			1990		
	A	B	C	A	B	C
Langasu	40	40	40	40	-	40
Panai	15	15	15	15	-	15
Nagrasu	15	15	15	15	-	15
Gholtir	3	3	3	3	-	3
Punar	18	18	18	19	-	18
Sewai	12	12	12	12	-	12
Girsa	10	10	10	10	-	10
Dhunglawali	3	3	3	3	-	3
Girgawn(Khanda)	2	2	2	2	-	2
Saikot	22	22	22	22	-	22
Manso	18	18	18	18	2	18
Malatha	31	31	31	31	15	31
Bagwan	12	12	12	12	6	12
Bharpur	15	15	15	15	0.5	15
Dungripanth	11	11	11	11	4	11
Farasu	9	9	9	9	2	9

A = Wheat - mustard combination
B = *Panicum milliaceum*
C = Paddy
(-) = no cultivation

3. Mixed cropping is a common cultural practice in traditional crop cultivation. However a trend of departure from mixed to mono cropping was noted. Crop yield data under different cropping patterns across an elevation gradient for dominant crops have been collected. The data collected so far indicate higher yields in the mixed crop systems.

4. Based upon the energy input and output budgeting, mixed crop systems were in general found to be more efficient than the pure single crop system in a given elevation zone.

5. Monetary returns in the high elevation zones were found to be maximum with crops *Fagopyrum esculentum* - potato combination followed by *Amaranthus -Phaseolus* combination. These agro-ecosystems though required higher level of monetary inputs, were found to be monetarily most efficient (Table 15).

6. Measurement of environmental costs in terms of soil erosion and nutrient depletion were planned for the following year.

3.1.2b. An Analysis of Transhumanic Repository of Knowledge in the Central Himalaya

Background

Transhumance is an age old practice in the societies inhabiting remote and rigorous terrains of high elevation areas. These societies are in general considered to be primitive and their livestock as agents of vegetation degradation in the hills. These imaginary generalizations have suppressed the positive elements of the traditional tribal societies and associated life support systems. Successful existence preserving social coherence, cultural

Table 15. Monetary (Rs/ha) output/input pattern for some important under-utilized crops growing in pure and mixed stands at higher altitude of Garhwal Himalaya.

Crops	Input	Output	Net return	Output/ input ratio
Secale cereale	800	3392	2592	4.2
Secale cereale + *Amaranthus* spp.	1560	7164	5604	4.6
Hordeum himalayens	2300	5100	2800	2.2
H. vulgare	2479	4623	2145	1.9
Fagopyrum esculentum	2875	8820	5949	3.1
F. tataricum	1698	3037	1339	1.8
F. esculentum + Potato	5440	28232	22792	5.2
Amaranthus sp. + *Phaseolus* sp.	2430	21140	18710	8.7

integrity despite of alien distortive influences testify the wisdom of tribals to adapt themselves with the changing conditions. This study aims to analyze the social, economic and ecological attributes of three transhumant ethnic races *viz.*, Bhotia, Mercha and Jadh restricted to Pithoragarh, Chamoli and Uttarkashi districts, in the context of sustainable/ unsustainable development trends in the Himalaya. Bhotia tribe inhabiting Darma and Byans Valleys (Dharchula tehsil of Pithoragarh district) in an elevation range of 2300 m - 4000 m was the study target for the year.

Objectives

1. To compile and analyze the historical accounts of social, cultural and economic set-up of pastoral transhumant ethnic races in central Himalaya.

2. To analyze spatial patterns and temporal trends of the basic needs of the societies.

3. To estimate the efficiency of resource use in terms of both economic and ecological costs in transhumant systems in representative areas.

4. To analyze the current problems in migration vis-a-vis kind and level of interaction with sedentary population during the course of movement.

5. To identify appropriate institutional and managerial inputs for sustainable development of the tribal societies.

Results and Achievements

1. Sample household survey of 13 villages in Darma valley and 7 villages in Byans valley was undertaken to parameterise the socio-economic attributes of the people. Complete household survey in 4 villages *viz.*, Sela, Dantu, Boondi and Naabi different with respect to remoteness was made for detailed data analysis and to get a realistic understanding of peoples' percepiions on environment and development.

2. Each family owned two settlements, one in high elevation area (3500 - 4000 m) and another at lower range (2000 - 1100 m). Migration of the entire village community from low settlement to the higher one in summers, and from high to low in the winters is an age old practice. Before Zamindari Act was executed in the year 1966, people used to practise agriculture at both the settlements. However subsequently in majority of cases land ownership rights are lost restricting agriculture in the high elevation zone. The yield level of common crops are not too low.

3. Trade of woolen products, medicinal herbs and pastoralism are the chief occupations of the people. Indigenous agricultural production also enters in the market exchange. Although the average land holding is substantially bigger than elsewhere in the hills, quantum of agricultural production is low as only a segment of individual holding is cropped in a year. Exchanging locally produced Chua (*Amaranthus*), Phaphar (*Fagopyrum tataricum*), Ogal (*Fagopyrum esculentum*), and potato with rice and wheat is a change crept in with the introduction of Public Distribution System.

4. The monetary gains are fairly high through marketing of woolen items made from indigenous resources and skills.

3.1.3. New projects initiated in 1991-92

3.1.3a Ecosystem Studies on Sensitive Habitats of Himalaya

Background

Conservation of natural resources has now been well recognised development imperative for alround improvement of the Himalayan region. The trends of spatio-temporal dynamics of natural resources during the last few decades have made it clear that exclusive emphasis on exploiting the resource base to meet the subsistence and economic development needs can not be sustained in the fragile Himalayan landscape. Floristic and faunal richness in the wild have been the focus of attention in conservation planning and management and man induced disturbances are invariably argued to be the fundamental reasons of loss in biodiversity. Human settlements in the Himalaya are historic/ prehistoric. Interferences with natural features and processes by man to meet his subsistence and development needs result in reduction in habitat diversity, area of a given habitat type, disjunction of habitats. Quantitative information on these key conservation issues are lacking. This project aims to address the issue of species conservation in a human ecosystem perspective in central Himalaya.

Objectives

1. Habitat classification and large scale habitat mapping of protected areas in central Himalaya.
2. Assessment of biotic pressures causing habitat fragmentation.
3. Identification and demarcation of critical/ sensitive habitats/species.
4. Identification and testing of management options approaching a balance in actions of meeting the present and future needs of biological resources.

Results and Achievements

1. Literature on conservation problems and management strategies in the area have been studied and the knowledge gaps have been identified.

2. Reconnaissance survey of three wildlife sanctuaries *viz.*, Binsar, Dudhatoli and Askot were completed.

3. Sites in each sanctuary have been selected for undertaking intensive studies.

3.1.3b. Establishment of a Functional Arboretum at Kosi-Katarmal, Almora

Background

Most of our efforts on protecting species from extinction are through *in situ* conservation measures specifically by expanding the area under Wildlife Sanctuaries, National Parks and Biosphere Reserves. It is believed that protection of forests/ natural vegetation from human interferences entails

protection of species through natural processes. While such a realization cannot be denied, a long gestation period seems essential for regeneration of particularly long lived tree species to viable population densities. Arboriculture is an alternate option for conserving the eroding genepool which has not received any significant attention so far. The land transferred to the Institute at Kosi-Katarmal has been subjected to severe anthropogenic disturbances in the past. The existing land cover consists of thin herbaceous cover with sparse distribution of pine trees. It has been planned to develop an arboretum of ecologically and economically valuable tree species, over an area of 20 ha in the first phase. In addition to tree species, critical herbaceous and shrub species would also be introduced. The broad goal of this long term project is to improve upon the ecology with a thrust on the objects of conservation of biodiversity. The site would also serve the purpose of creating an effective awareness towards ecological and economic gains associated with maintaining a diverse vegetal cover through both formal and informal education.

Objectives

1. To create a functional arboretum and to facilitate conservation of ecologically and economically important species in the mid hill zone of the central Himalaya .
2. To undertake long term fundamental studies on the biology of critical species as relevant to the research needs of conservation management.
3. To strengthen formal and informal educational institutions in order to popularize conservation imperatives in the Himalaya.

Results and Achievements

1. Physiography of the target area has been mapped at 1: 5000 scale.

2. Vegetation of the area has been analyzed in terms of species distribution, abundance and associations.

3. Over 50 species of limited distribution and presently exposed to severe constraints towards maintenance of their viable population size have been identified based on the field surveys. Individuals of the identified species have been collected and are being acclimatized.

4. Planning for constructing a glasshouse was done.

5. Preplanting land preparation is completed over an area of 5 ha.

3.1.3c. Bioresource Inventory of Himalaya

Background

Climatic and topographic diversity have led to evolution of a rich flora and fauna in the Himalaya. Diversity in bioresources of the region though well recognised, comprehensive systematic investigations are limited. Divergent approaches and concerns have returned in fragmented documentation of existing knowledge. There is a need of not only to cover the unexplored areas but also to pool up the available information and its easy retrieval. Recent advancement in computer technology offer immense scope for compiling, categorizing and quick access to the existing

information according to the specialist specific needs.

Objectives

1. To develop a centralised database on biology, ecology, economic uses and spatial distribution of flora/fauna.

2. To infer habitat diversity, critical/sensitive habitats/species for immediate conservation measures.

3. To develop institutional mechanism for effective dissemination and use of information.

Results and Achievements

1. Information on biogeographic distribution pattern, economic utility, general rarity, red data book rarity, endemism with respect to over 1000 species have been entered in database.

2. Efforts are continued to develop a users' friendly software.

3.1.3d. Environmental Impact Analysis of Multipurpose River Valley Projects - Tehri Dam

Background

Multipurpose hydroelectric projects were conceived initially as potential instruments for harnessing the abundant water resource in the Himalaya for large scale and immediate economic benefits. Environmental problems likely to accompany large scale transformation in the fragile Himalayan ecosystem with unique social and cultural set-ups which escaped the attention of planners in the initial phase of planned development, are now strongly realized. Possibility of ecological changes following execution of such projects can not be ruled out but advance corrective actions can be ensured provided decision making mechanism is objective. Objectivity in decision making process demands availability of strong analytical inputs on the likely environmental, social and economic consequences accompanying/ following a particular action and alternative options. Data compilation, collection, analysis often fail to reach decision makers in time leading to irrational decisions, apart from many other factors. Remote sensing technology offers an immense scope for large area survey, mapping and monitoring of various natural resources in an integrated manner. The structure and processing of satellite data render integration of spatial and non-spatial data/ information in much less cost and time when compared with the conventional methods. This project, a collaborative venture of Space Application Centre, Ahmedabad and the Institute was formulated to assess the potential of remote sensing technology and computer based data processing techniques in providing inputs required for ecological impact assessment of multipurpose river valley projects selecting Tehri dam as the test site.

Objectives

1. To review the present mechanisms of preparing environmental impact assessment document and management plan in the context of multipurpose river valley project.

2. To carry out a time sequence resource analysis in Tehri Dam catchment area for the period 1972-1990 using remotely sensed data .

3. To undertake socio-economic analysis in the catchment area and to integrate non spatial, data/information for inferring the ecological and economic trends.

4. To identify specifications for methodology to be adopted for impact assessment analysis and preparation of environmental management plan and their monitoring.

Results and Achievements

1. Satellite (IRS and Landsat TM) data were acquired and screened for resource mapping at 1:50000 scale for the catchment area of Tehri dam.

2. Reconnaissance survey of the area was done and land cover classification scheme was finalized.

3. Preliminary visual interpretation for land cover mapping using false color composite data was done and interpreted details were checked. Necessary corrections in interpretation are being incorporated.

4. A sample area of around 30 km^2 was planned for processing through digital land cover classification procedures in order to compare the quality of information extractable from digital and visual image analysis techniques.

5. The non spatial information available from both secondary and primary sources are being collected and organized.

3.1.3e. Impact of Domestic Sewage Disposal on Natural Water Springs of Almora Town

Background

Although water is abundantly present in the Himalayan region, availability of adequate quantity of desirable quality is a challenging problem in many areas. In central Himalaya these are the sub-surface and surface natural flows being tapped for domestic needs. Degradation of forest cover leads to reduction in recharge capacity manifested as poor spring flows initially and eventually drying up of the springs. Rapid rate of urban sprawl and reckless disposal of organic wastes in the city centres is likely to accompany pollution. Such risks are more likely in case of shallow springs in the hill areas. Around 50% of human population meet domestic water needs from natural springs and have so far failed to get treated municipal water. This project aimed to collect and analyze data on the impacts of domestic sewage disposal on natural water springs of Almora town.

Objectives

1. To map the spring lines and their recharge areas in and around Almora town and to infer their dynamics in the recent times.

2. To monitor quantity and quality of water and impact assessment of present system of sewage disposal on sub-surface water flows currently in use.

3. To suggest appropriate mitigation measures in order to contain qualitative and quantitative problems pertaining to domestic water in the town.

Results and Achievements

1. Based upon the Survey of India topographical sheets augmented with other ancillary information, a map depicting urban growth during the last couple of decades and natural springs in the area was prepared. Survey was made to locate the major drains used as open sewers.

2. Fourteen springs differing with respect to quantum of flows/capacity and nature of flows (conventional open type locally referred as 'Naula' and well defined tapped sources locally referred as 'Dhara') were selected for monitoring. Spatial configuration, morphology and flow directions of springs of the town are indicative of a common recharge zone.

3. Nitrate-nitrogen concentration was found to be higher than the permissible limit of 45 mg/litre in a number of sampling sites.

4. Studies are continued for water quality and quantity monitoring all through the year.

3.1.3f. Development Dilemma: National Context and Rural Scenario in the Himalaya

Background

Social, economic and political transformations have accompanied both positive and negative trends of development all through the country. Even the positive trends are often suspected to turn to negative ones, in many areas at present and likely in future in case of others. The development problems are more complex in the Himalaya on account of conflicting interests pertaining to preservation of ecology of region on one hand and aspirations for economic development of the local inhabitants on the other. Development policies and programmes need to be formulated by integrating the ecological and economic needs in ways which are appreciated by the people. Improvement in future could be possible only when the trends in development are elucidated based upon a precise location specific data in the diverse Himalayan region rather than generalized picture emerging from mere experiences or large area averages. This study aimed to analyze development changes during the past few years based largely on primary data in three villages *viz.* Adhuria, Seel and Natadol differing with respect to their resource potential in Kumaon.

Objectives

1. To compile information and data relevant to development linked issues for the past and to undertake detailed survey to document the present scenario.

2. To quantify development changes in the recent past - an ecological appraisal of development trends.

3. To identify feasible and effective development approaches for sustainable rural development in the central Himalaya.

Results and Achievements

1. Data on a number of development attributes collected through limited sample household survey in 1981 in three villages *viz.*, Adhuria, Seel and Natadol (all in Almora District) available in an Institutional publication were compared with data collected on the same attributes in the year 1991. While Seel was a totally rainfed village, Adhuria had irrigational facilities. Natadol differed from these two for having adopted horticultural development too.

2. There was a decline in output in food grain production in all the villages. The decrease in food grain production within the village was due to both decrease in yield and also the area put to food crop cultivation during the recent past. An increasing preference to annual cash crops and fruit crops was observed.

3. Income from agriculture/horticulture was observed in the irrigated Adhuria and Natadol but not in rainfed village Seel. There was only a marginal increase in annual income through agricultural crops in Adhuria where horticultural crops are not grown. On the other hand in Natadol where horticulture has also progressed well showed significant improvement in income derived from annual cash crops like potato as well.

4. Distribution of households by size of land holdings remained unchanged in the rainfed village Seel during the last 10 years. Proportion of large land holdings sharply declined in Adhuria in contrast to Natadol where an increase was observed.

5. Serious drawbacks in the precision of data pertaining to the markers of development have been noted which warrant a careful approach in concluding the temporal trends.

6. Positive trends of development in agricultural and horticultural sectors are apparent in the villages excluding the rainfed one but changes in values and lifestyle have infused an aspiration for development in secondary and tertiary sectors.

7. The data interpretation part is yet to be completed.

3.1.3g. Institution Building at Community Level: Understanding the Constraints from a Micro-analysis

Background

Monitoring of the development programmes though as important as the programme identification and implementation, is often not given due consideration. Weak monitoring mechanisms result in perpetual continuance of development activities without any improvement in the delivery of goods and services. Often enormous wastage of resources is realised but the programmes continue claiming achievement of physical and financial targets. Central Himalayan Environment

Association (CHEA), a non-government organisation executed an ecodevelopment project in Khulgad micro watershed in catchment of Kosi river. Watershed management approach was adopted to enable villagers participation in the development process through group action capabilities. Strengthening the activities of already existing institutions and supplementing/bypassing the existing institutions by the new ones were considered as the alternative options. The newly constituted institutions were Gram Sansadhan Prabandh Samiti (Village Resource Management Committee), Mahila Mangal Dal (Women Welfare Committee) and Pani Panchayat (Water Council). This project was a response to the request from the Central Himalayan Environment Association to the Institute for undertaking a quick assessment of the efficacy of the watershed management approach tried by the organisation.

Objectives

1. To assess the functions of various institutions involved in watershed management.

2. To understand the interlinks of community resources, culture, socio-economics, environmental needs with the institutions' role performance.

3. To identify the missing links and corrective actions for institution building in order to enhance the effectiveness of ecodevelopment actions.

Results and Achievements

1. The institutions created following project execution promoted the economy specifically through elevating the agricultural output level and also created awareness towards environmental economics in the villages studied.

2. Creation of new Institutions received a more positive response in prosperous villages. Conscious or unconscious ignorance of economic necessities was found to be the primary cause of non cooperation particularly that of women.

3. Food insecurity due to low levels of crop production and lack of secured income were the critical causes of improper functioning of the institutions in the later phase of the project (Table 16).

Table 16. Potential of agricultural productivity in meeting the subsistence needs estimated as periods (in months), when food demand is met from farm production.

Village	Cereals	Pulses
Deolikhan	5.7	5.8
Salla Rautela	5.8	3.7
Dhari	3.0	2.4
Latwal	10.0	7.8

4. Increase in literacy did not accompany any significant improvement in involvement of rural people in the service sector.

5. Significant improvement in fodder value of community land was achieved but the accrued benefits were not evenly distributed, specially in multicaste villages. Low caste populace has no access to the community land. Institutions were more successful in discharging their responsibilities

in villages where the traditional dependence of low caste populace on the high caste ones was maintained as compared to those where the tradition has disintegrated.

6. Creation and growth of infrastructural facilities and education were the prime concern of development in the perception of rural mass. With the introduction of infrastructural facilities, benefits accumulate with the wealthy and influential high caste people and this has further widened the gap between the rich and poor.

7. Multiplicity of institutions targeting a common object and lack of coordination are the serious constraints in furthering the objects of development.

8. Conscious or unconscious involvement in ecodevelopment activities with political motives and village functionalism, in the absence of strong leadership deteriorates the functioning of the institutions.

3.1.4. Projects planned for 1992-93

Baseline information were collected to formulate detailed project proposals on following themes:

- Conservation of biological diversity of ecologically and economically important plants of Kumaon Himalaya.

- Development of roads and its socio-economic impact in Kapkot Block, Almora District in Kumaon Himalaya.

- An empirical study of development of tribal communities from eco-cultural perspectives in central Himalaya.

3.2. PROJECTS SPONSORED BY OTHER FUNDING AGENCIES

3.2a. Introduction of Water Harvesting Technology for Sustainable Rural Development in the Himalaya

Background

Water constitutes a problem as well as with proper management offers solutions to many problems in the Himalaya. Deforestation in the past has accompanied a drastic reduction in availability of water at time and place when and/or where it is needed. There is no perceptible increase in irrigated cropland enforcing expansion of agricultural practices in marginal land and poor agricultural production and low economic returns. Contrary to this, surface run-off has dramatically increased eroding the hill slopes and siltation of streams and rivers to alarming levels. Water stress alongwith other factors hastens the degradational process and conversely impedes vegetation regeneration. Slopes and slope gradient in the mountain terrain facilitate harvesting the surface run-off from perennial discharge points and run-off component of the rainwater. A cost effective technology of water storage coupled with establishing linkages with resource production system in degraded land is likely to accompany both ecological and economic gains. This project involving collaboration of Jawaharlal Nehru University, New Delhi and financed by the Department of Science and Technology, Government of India, passed through the second year following its execution.

Objectives

1. To survey the existing water harvesting techniques in the region.

2. To design and construct water harvesting tank as suited to location specific requirements and environmental conditions of the area.

3. To assess the performance and impact of introduced technology and to incorporate the needed refinements.

Results and Achievements

1. Technology developed and introduced in Kumaon and Garhwal regions, during the preceding year was extended to project sites in Chuchuyimlang in Nagaland and Namchi in Sikkim.

2. With the introduction of technology it was possible to put degraded land to multiple uses by increasing the biological production potential.

3. Survival and growth of a number of multipurpose tree species introduced in degraded land were dramatically enhanced by alleviating the water stress augmented with organic input to the soil (Table 17).

Table 17. Growth and survival percentage of multipurpose trees after six months of plantation using water harvest system at Banswara, Chamoli, Garhwal.

Plant species	Plantation integrated with water harvesting system		Plantation without water harvesting system	
	Height increment (cm)	Survival percentage	Height increment (cm)	Survival percentage
Albizzia lebbeck	37.7	75.0	10.0	74.4
Alnus nepalensis	56.6	85.6	33.7	87.4
Boehmeria regulosa	16.4	94.5	11.7	78.0
Celtis australis	58.0	87.7	13.1	75.2
Dalbergia sissoo	23.5	88.2	15.9	72.0
Ficus glomerata	36.0	100.0	25.7	68.1
Grewia optiva	17.0	96.8	4.7	79.0
Prunus cerasoides	18.8	100.0	7.0	85.7
Pyrus pashia	17.0	90.5	7.1	71.4
Sapium sebiferum	5.7	85.4	4.9	68.2

4. It was also possible to support cash crops in land which was otherwise not cropped even with hardy crops. Monetary output : input ratio was found to be 1.8 with annual returns amounting Rs. 8,500/- per hectare per year (Table 18). The returns were higher when the technology was introduced in farmers' own land compared to a situation where the technology was introduced in community land and was shared by a group of farmers. Often problems were faced in the maintenance of water input sources and flows design for the storage tanks.

Table 18. Cost-benefit analysis (Rs/yr) of cash crop cultivation following introduction of water harvesting and storage technology in abandoned land at Banswara, Chamoli

Production measures	Monetary equivalent (Rs/ha/yr)
Input	
Labour	10375.0
Seed	375.0
Organic manure	250.0
Output	
Leafy vegetable	2600.0
Fruit vegetable	6887.5
Roots and tubers	2500.0
Cucurbits	937.5
Oil seeds	3850.0
Pulses	2375.0
Net return	8149.5
Output/Input ratio	1.8

3.2b. Biological Mechanisms in the Maintenance of Soil Fertility under Varied Land Use Practices in Kumaon Himalaya

Background

Agricultural systems in central Himalaya are characterized by massive organic inputs consisting of animal dung and tree/ shrubs leaves in varying proportion. With depletion of forest cover and restriction on the rights to forest resources, quantum of these inputs is expected to have declined. This could be one of the reasons behind negative trends in agricultural production. However such conclusions generalized for the region have a weak supporting data. The dependence on forests for maintaining soil fertility in agricultural land could be reduced by interventions which facilitate fast decomposition and release of nutrients from good quality inputs. This project financed by Department of Science and Technology, Government of India and executed during the current year aimed to diagnose the specificities of problems concerning soil fertility and crop yields and to identify alternative management options in Kumaon.

Objectives

1. To quantify nutrients/water demand and supply in managed, degraded and protected ecosystems in Kumaon hills.

2. To analyze the biological mechanisms of maintenance of soil fertility already existing or which have a possible scope in the region.

3. To study the impact of different land use/ cultural practices on soil fertility processes and identification of appropriate biological amendments.

Results and Achievements

1. Efforts were initially concentrated on diagnosing the specificities of soil fertility problem and its expression in terms of crop yields across an elevation gradient of 800 - 2400 m and covering

the local variations in agricultural systems.

2. Data on wheat crop under rainfed conditions and exclusive organic input systems practised traditionally showed highest yield (much higher than the national average) at elevation around 1,500 m. Such findings indicate the potential of organic management to sustain high yield levels.

3. Variation in composition and quantum of organic input was found to have significant impact on productivity and yield but not on proportional allocation to fruits/grains in case of paddy. Crop growth was better in soil amended with Oak forest litter in comparison to that amended with Pine forest litter. Coarse grain crops were in general found to be more tolerant towards moisture and nutrient stresses than the fine grain ones.

4. Nutrient analysis part is continued alongwith crop yield, input-output analysis of crops to complete a full crop calendar.

3.2c. Symbiotic Nitrogen Fixation and Maintenance of Soil Fertility in the Eastern Himalaya

Background

The maintenance of soil fertility in natural and derived ecosystems through biological processes have been hard felt recently. 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 association: (i) *Rhizobium* symbiosis - restricted to the family Legumiosae; and (ii) *Frankia* symbiosis - distributed in eight families of angiosperms other than Leguminosae. There is no proper listing of such species in the eastern Himalaya. The project aims to screen out N_2– fixing symbiotic association, to estimate their effectiveness of N_2– fixation and to evaluate their contribution in the maintenance of soil fertility.

Objectives

1. Extensive inventory investigation for sorting out symbiotic N_2-fixing species and 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. N_2– fixing associations were identified in 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. Four species of actinorhizal plants all belonging to different genera, *viz.*, *Alnus*, *Coriaria*, *Elaeagnus* and *Hippophae*, have been identified.

2. Two major systems have been identified in Sikkim for detailed study on maintenance of soil fertility. *Albizzia-Rhizobium* combination in agroforestry system in subtropical conditions and *Alnus-Frankia* combination in the cardamom-based agroforestry system in temperate conditions.

3. Nitrogen mineralization under in situ moisture levels of soil incubated at 26±2°C temperature revealed highest rate under natural forest + cardamom (54 µg N g soil 14 day^{-1}) system followed by *Alnus* + cardamom (35 µg N g^{-1}soil 14 day^{-1}), *Albizzia* + cropland (19 µg N g^{-1}soil 14 day^{-1}) and lowest (8 µg N g^{-1}soil 14 day^{-1}) in cropland with no N-fixing *Albizzia*. The data on N mineralization rate strongly depended on moisture level and organic matter content of the soil.

3.3. Environmental Management Information System for the Himalayan Region

Environmental management information system for the Indian Himalaya is planned to be established at the Institute as a central facility to serve the information needs of all those concerned with environment and development of the region. Software pertaining to database creation, statistical data analysis, resource dynamics modeling, technical processing of literature developed elsewhere and some computer programs to meet specific requirements for the research and development needs developed in the Institute were tested. Efforts were made to get infrastructural support for strengthening, expanding and providing access to the users. Ministry of Environment and Forests formalized a proposal of setting up an ENVIS centre catering the needs of Himalayan region in the Institute.

3.4. Institutional Networking

The overall goal of environmentally sound economic development in the vast and diverse Himalaya demands optimization of human and finance resources. A number of steps were taken to establish linkages with other relevant organisations, expert individuals and over and above the common man. Memorandum of understanding for cooperative and complementary research and development were signed with Himachal Pradesh Agricultural University, Palampur, Y.S. Parmar University of Horticulture and Forestry, Solan and Department of Geology, Kumaon University, Nainital. Considerable advancement could be made in establishing rapport with International Organisations including Norwegian Development Agency, Oslo; Tropical Soil Biology and Fertility Programme, Nairobi and International Centre for Integrated Mountain Development, Kathmandu. Formalities for the execution of Himalayan Eco-development Programme for extra-mural funding from the Institute were completed. Several opportunities were created/exploited to facilitate exchange of information between scientists of the Institute, resource managers, administrators and the decision makers.

Continuity in the publication of a newsletter HIMA-PARYAVARAN from the Institute twice in a year as a vehicle of information exchange and dissemination was maintained.

3.5. Workshops/Symposia

3.5.1. Workshop on Environmental Impact Analysis of Multipurpose River Valley Projects

The Institute organised a workshop on 'Environmental Impact Analysis of Multipurpose River Valley Projects' on September 14-15, 1991 at Kosi-Katarmal, Almora. A wide array of participants representing the Ministry of Environment and Forests, River Valley Project Authorities, Irrigation Department, Forest Department, Agriculture Department, Environment experts from different sectors of the Himalaya presented their studies and experiences. Irrespective of their expertise or their organizational priorities all concurred to work towards minimization of ecological damage while executing development projects. Many of the current problems are due to the fact that project formulation and even execution, often precede assessment of likely environmental impacts. The adverse impacts projected after the project execution often become difficult to mitigate, not only because of financial constraints, but also because of lack of appropriate packages to redress these impacts. It was suggested that the existing mechanism of impact assessment should be further refined so as to avoid subjectivity in problem evaluation. Action for imparting training in environmentally sound management of natural resources in order to put the existing knowledge in practice in such development projects were recommended to be taken up by the Himalayan Institute.

4. LABORATORY AND LIBRARY

Laboratory and Library are the most crucial assets on which the quality of research and development outcome depends. Equipping the laboratory with adequate facilities and enriching the library were taken on priority. Facing the constraints of making such facilities available at remote areas with difficult accessibility where Institute is located, considerable progress could be made. The major equipments procured by the Institute are Atomic Absorption Spectrophotometer, Infrared AG Multimeter with Computerized Data Recording, Colony Counter, Infrared Soil Moisture Balance and Bomb Calorimeter.

Addition of 1889 books this year raised the number of titles to a total of 3167 in the library. Some of the titles were gifts from Food and Agricultural Organisation, Winrock International and in house scientists. The library subscribed 53 periodicals including 32 from overseas. A number of newsletters from Indian and foreign organisations are being received in library. Computer programs developed at the Institute were made operational and library databases were updated.

5. SCIENTIST-PEOPLE INTERACTION AND ENVIRONMENTAL AWARENESS

Peoples' participation forms an integral component of the action oriented research and development projects launched by the institute. In addition to interaction through these projects, several opportunities were created or exploited to

understand the problems and priorities for environmentally sound development in the Himalaya as perceived by the people of the region. On several occasions scientists of the Institute participated in the meetings/workshops organised by local institutions addressing the environmental, economic, social and cultural problems of the region.

Institute organised functions to stimulate interest for environment in the school children on the World Environment Day. These efforts were visible in the form of frequent visits of students and teachers to the Institute in different parts of region. A few graduate students studying outside the Himalaya even preferred to undertake their dissertation tasks on the problems of Himalayan Ecology.

Scientists of the Institute were deputed to deliver lectures in Refresher Courses organised by the State Government from time to time at Almora.

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Singh, A.K. and D.S. Rawat. 1992. A note on women and work in Kumaon Himalaya. In: C.M. Agarwal (ed.) *Dimension of Indian Womanhood*. (in press).

7. PARTICIPATION OF SCIENTISTS IN SYMPOSIA/ WORKSHOPS/ CONFERENCES/TRAINING COURSES

Scientists of the Institute participated in the following:

Birth Anniversary Celebration of Late Sarla Behn. Parvateeya Paryavaran Sanrakshan Samiti, Dharamgarh, Pithoragarh, U.P., April 5, 1991.

Cultural Function organized by Mahila Mangal Dal of village Baugarh, Pithoragarh, U.P., April 6, 1991.

National Seminar of Young Scientists on Environmental Plant Physiology. High Altitude Plant Physiology Research Centre, H.N.B. Garhwal University, Srinagar, U.P., May 27-29, 1991.

Workshop on Project Management. National Productivity Council, Jaipur. Mt. Abu., June 26-30, 1991.

Training Course on Remote Sensing Applications in Resources Studies. National Remote Sensing Agency, Hyderabad. July-September, 1991.

Training Course on Mini Compact Photosynthesis System at Heinz Walz GmbH, Effeltrich, Nuremberg, West Germany. September 9-18, 1991.

Workshop on Energy and Environment Issues in Mountain Development. Shimla, September 24-25, 1991.

Workshop on Orcharding, Animal Husbandry, Agriculture and Environment. Kurmanchal Paryavaran and Audhyogik Vikas Parishad. Bhikyasain, November 27-29, 1992.

International Workshop on Mountain Off- farm Employment. International Centre for Integrated Mountain Development, Kathmandu, Nepal, February 17-20, 1992.

National Seminar on Communication Strategy for Environmental Awareness for a Common Man. Kota Open University, Kota, March 14-16, 1992.

Course on Sloping Agriculture Land Technology (SALT). Philippines. March 15-24, 1992.

8. GOVIND BALLABH PANT SOCIETY OF HIMALAYAN ENVIRONMENT & DEVELOPMENT

Minister-in-charge Union Cabinet, Ministry of Environment & Forests, Government of India, New Delhi	President
Minister of State in-charge Union Cabinet,	Vice-president

Ministry of Environment & Forests, Government of India, New Delhi		Minister-in-charge Environment, Government of Tripura	Member
Two Members of Parliament Nominated by Govt. of India		*Two Members of Legislative Assembly, Uttar Pradesh Nominated by Govt. of India*	
Shri Venkatesh Naik Lok Sabha	Member	Shri Matwar Singh Bhandari Tehri Garhwal	Member
Shri Bekal Utsahi Rajya Sabha	Member	Shri Lakhan Singh Khatima	Member
Minister-in-charge Environment, Government of Jammu & Kashmir	Member	*Five non-officials (nominated by the Government of India)*	
Minister-in-charge Environment, Government of Sikkim	Member	Prof. S.P. Nautiyal 376 Phase II, Vasant Vihar, Dehra Dun	Member
Minister-in-charge Environment, Government of Himachal Pradesh	Member		
Minister-in-charge Environment, Government of Uttar Pradesh	Member	Prof. Mahatim Singh Director Potash Research Institute of India, Gurgaon	Member
Minister-in-charge Environment, Government of West Bengal	Member		
Minister-in-charge Environment, Government of Assam	Member	Prof. Mrinal Miri North-Eastern Hill University, Shillong	Member
Minister-in-charge Environment, Government of Arunachal Pradesh	Member	Shri Chandi Prasad Bhatt Desholigram Swarajya Mandal, Gopeshwar (Chamoli)	Member
Minister-in-charge Environment, Government of Mizoram	Member	Shri Natwar Thakkar Nagaland Gandhi Ashram, P.O. Chuchu Yimlang, District Mokokchung, Nagaland	Member
Minister-in-charge Environment, Government of Manipur	Member		
Minister-in-charge Environment, Government of Meghalaya	Member	A representative from Indian Institute of Forest Management, Bhopal	Member
Minister-in-charge Environment, Government of Nagaland	Member	Secretary Ministry of Environment & Forests, New Delhi	Member

Secretary Department of Science & Technology, New Delhi	Member
Secretary Department of Scientific & Industrial Research New Delhi	Member
Secretary Ministry of Human Resource Development, Department of Education, New Delhi	Member
Secretary Ministry of Rural Development, New Delhi	Member
Secretary Department of Urban Development, New Delhi	Member
Secretary Expenditure, Ministry of Finance, New Delhi	Member
Secretary Department of Non- Conventional Energy Sources, New Delhi	Member
Secretary Department of Steel & Mines, New Delhi	Member
Secretary Department of Water Resources, New Delhi	Member
Secretary Department of Agricultural Research & Education, New Delhi	Member
Secretary Planning Commission, New Delhi	Member
Chief Secretary Government of Uttar Pradesh, Lucknow	Member
Director General Indian Council of Forestry Research & Education, Dehra Dun	Member
Inspector General of Forest, New Delhi	Member
Director Botanical Survey of India, Calcutta	Member
Chairman Indian Council of Social Science research, New Delhi	Member
Director Wildlife Institute of India, Dehra Dun	Member
Director Govind Ballabh Pant Himalaya Paryavaran Evam Vikas Sansthan, Almora	Member-Secretary

9. GOVERNING BODY

Secretary Ministry of Environment & Forests, Paryavaran Bhawan, C.G.O. Complex, Lodi Road, New Delhi 110 003	Chairman
Secretary Department of Biotechnology C.G.O. Complex, Lodi Road, New Delhi 110 003	Member
Chief Secretary Government of Uttar Pradesh, Lucknow	Member
Inspector General of Forests Ministry of Environment & Forests, Paryavaran Bhawan, C.G.O. Complex, Lodi Road, New Delhi 110 003	Member

Joint Secretary & Financial Adviser Ministry of Environment & Forests, Paryavaran Bhawan, C.G.O. Complex, Lodi Road, New Delhi 110003	Member
Prof. A.K. Sharma Department of Botany, University of Calcutta, 35, Ballygunge Circular Road, Calcutta - 700 019	Member
Prof. T.N. Khoshoo Tata Energy Research Institute, 7 Jor Bagh, New Delhi-110 003	Member
Prof. S.K. Sinha Director Indian Agricultural Research Institute, New Delhi	Member
Prof. K.S. Valdiya Department of Geology, Kumaon University, Nainital	Member
Director G.B. Pant Institute of Himalayan Environment and Development, Kosi, Almora - 263 643	Member–Secretary

10. SCIENCE ADVISORY COMMITTEE

Prof. S.K. Sinha Director Indian Agricultural Research Institute, New Delhi	Chairman
Prof. K.S. Valdiya Department of Geology, Kumaon University, Nainital	Member
Dr. C.L. Acharya Department of Soil Science, Himachal Pradesh Agriculture University, Palampur, Himachal Pradesh	Member
Prof. J.S. Singh Department of Botany, Banaras Hindu University, Varanasi - 221 005	Member
Dr. P.V. Sane Director National Botanical Research Institute, Lucknow	Member
Dr. R.C. Guha Institute of Economic Growth, University of Delhi, Delhi 110 007	Member
Dr. Baldev Sahai Group Director Remote Sensing Area, Space Application Centre, Ahmedabad	Member
Dr. Manju Sharma Adviser Department of Biotechnology, B-Block, C.G.O. Complex, Lodi Road, New Delhi 110 003	Member
Dr. P.G. Lavakare Adviser Department of Science & Technology, Technology Bhawan, New Mehrauli Road, New Delhi	Member
Dr. G.D. Sootha Adviser Department of Non-Conventional Energy Sources, Paryavaran Bhawan, C.G.O. Complex, Lodi Road, New Delhi - 110 003	Member
Director G.B. Pant Institute of Himalayan Environment and Development, Kosi, Almora - 263 643	Convenor

G.B. Pant Institute of Himalayan Environment and Development
Kosi-Katarmal, Almora -263 643 (U.P.)
Receipts and Payments Accounts for the year ending 31st March 1992

Receipts			Rs.	Payments			Rs.
Opening Balance				Salary to Staff			17,41,199.05
				Institute's Cont. to CPF			12,051.00
(A) Cash and Bank Balance				Traveling Expenses (Officials)			1,38,741.15
(i) Cash in hand		7,955.66		Traveling expenses (Non-official)			60,487.25
(ii) SBI (including Rs. 35,03,640 for L/Cs and Margin Money)		35,24,919.83		Wages			70,630.45
				Postage expenses			31,367.75
(iii) Central Bank of India				Stationery expenses			49,681.82
- Institute's funds	1,319.85			Petrol/Fuel expenses			2,14,567.70
- DST (RW)	30,783.76			Telephone expenses			20,030.75
- DST (SF)	1,18,395.00			Electricity & Water expenses			37,938.15
- CSIR	2,900.00	1,52,798.61	36,85,674.10	Repair & Maintenance Vehicle			1,93,877.11
				Hospitality expenses			35,817.21
				Repair & Maintenance Building			51,959.75
(B) Advances				Rent			25,925.00
(i) to staff		6,334.40		Advertisement expenses			52,038.00
(ii) DST (RW)		32,000.00		Other Office contingencies			1,20,561.94
(iii) DST (SF)		75,000.00		Research and Development expenses			7,16,361.61
(iv) CSIR		3,882.00		Workshop & Seminars			13,638.00
(v) Deposit with CCU for construction		6,00,000.00	7,17,216.40	Printing charges			1,73,093.30
				Repair and Maint. office equipment			21,048.00
Grant-in-aid received				Periodicals and Newspapers			10,369.95
- From ME&F (i) for R&D & other expenses		9000000		Bank Charges			816.00
(ii) for construction work		9589000	1,85,88,000.00	Audit fee			4,000.00
- DST (WS)			6,997.00	Leveries expenses			3,246.00
- DST (RW)			40,000.00	Office equipments			46,723.40
				Library			14,96,186.02
Interest received from Banks			92,640.91	Research and Development (capital)			51,09,531.50
Earnest Money received			48,700.00	Furniture and fixture			31,746.00
				Vehicle (capital)			1,64,128.00
				Security deposit made			6,570.00
Miscellaneous receipts on account of:				Deposit with CCU for construction of office/residential complex			72,15,377.00
- Licence fee for residential accommodation		7304.00		Expenses DST (WS)			2,725.30
- Sale of nursery items		8483.30		DST (RW)			60,617.33
- Personal use of staff car		4834.00		DST (SF)			1,04,287.00
-Sale of tender forms		1300.00		CSIR			6,182.00
- Lodging charges of transit hostel		272.00		Cash and bank balances:			
- Other receipts (DST)		166.00	22,359.30	(a) Cash in hand		13,684.79	
				State Bank of India Almora (includes Rs. 29,72,623.00 for construction and Rs. 15,15,000.00 for LCs & Margin Money)		45,32,016.23	
				Central Bank of India Kosi (includes funds receive for DST (RW) Rs. 40,562.43 & DST (SF) Rs. 28,743.65		79,138.07	
				State Bank of India Tadong		11,421.11	
				State Bank of India Chuchuyimlang		500.51	46,36,760.71
				(b) Advances to:			
				M/s Swaraj Mazda Limited			4,51,516.00
				Staff and Units of institute			19,686.51
				DST (RW)			1,604.00
				DST (SF)			48,500.00
Total			2,32,01,587.71	Total			2,32,01,587.71

Sd/-
(N.K. Jain)
For Rattan Lal & Associates, Chartered Accountants

Sd/-	Sd/-	Sd/-	Sd/-
(HARISH CHANDRA)	(ANIL JOSHI)	(K.G. SAXENA)	(A.N. PUROHIT)
Drawing & Disbursing Officer	Administrative Officer	Scientist & Officer Incharge	Director

Note: 1. All items of receipts and payments are accounted for on cash basis.
2. Figures have been regrouped and rearranged wherever felt necessary.

G.B. Pant Institute of Himalayan Environment & Development
Kosi-Katarmal, Almora - 263643 (U.P.)
Income & Expenditure Account for the year ended 31st March 1992

Expenditure	*Rs.*	*Income*	*Rs.*
Salary	17,41,199.05	Miscellaneous receipts	22,359.30
Institute's Cont. to CPF	12,051.00	Interest received from banks	92,640.91
Travelling Expenses Official	1,38,741.15		
Travelling Expenses Non-official	60,487.25	Excess of expenditure	38,58,258.36
Wages	70,630.45	Over income	
Postage Expenses	31,367.75		
Stationery Expenses	49,681.82		
Petrol/Fuel Expenses	2,14,567.70		
Telephone expenses	20,030.75		
Electricity & water expenses	37,938.15		
Repair & Maintenance Vehicle	1,93,877.11		
Hospitality Expenses	35,817.21		
Repair & Maintenance Building	51,959.75		
Rent	25,925.00		
Advertisement Expenses	52,038.00		
Other office contingencies	1,20,561.94		
Research and Development Expenses	7,16,361.61		
Workshop and Seminar	13,638.00		
Printing expenses	1,73,093.30		
Repair & Maint. office equipments	21,048.00		
Bank charges	816.00		
Audit fee	4,000.00		
Liveries expenses	3,246.00		
Periodicals & Newspapers	10,369.95		
Expenses:			
DST (WS)	2,725.30		
DST (SF)	1,04,287.00		
DST (RW)	60,617.33		
CSIR	6,182.00		
Total	39,73,258.57		39,73,258.57

Sd/-
(N.K. Jain)
For Rattan Lal & Associates, Chartered Accountants

Sd/-	Sd/-	Sd/-	Sd/-
(HARISH CHANDRA)	**(ANIL JOSHI)**	**(K.G. SAXENA)**	**(A.N. PUROHIT)**
Drawing & Disbursing Officer	Administrative Officer	Scientist & Officer Incharge	Director

Note: 1. All items of income and expenditure are accounted for on cash basis.
2. Figures have been regrouped and rearranged wherever felt necessary.

G.B. Pant Institute of Himalayan Environment and Development
Kosi-Katarmal, Almora-263643, (U.P.)

Balance Sheet as on 31st March 1992

Liabilities	As on 31.3.91 Rs.	Received during 1991-92	As on 31.3.92 Rs.	Assets	As on 31.3.91 Rs.	Additions during 1991-92	As on 31.3.92 Rs.
Balance as per last Balance Sheet	1,24,01,256.74	-	1,24,01,256.74	Office Equipments	5,88,855.08	46,723.40	6,35,578.48
				Furniture & Fixture	9,98,486.62	31,746.00	10,30,232.62
				Vehicle	6,49,186.78	1,64,128.00	8,13,314.78
				Library	11,04,321.26	14,96,186.02	26,00,507.28
Received during the year				Building	27,13,848.10	-	27,13,848.10
- From ME & F							
i. for R & D and other expenses		90,00,000.00					
ii. for construction work		95,88,000.00	1,85,88,000.00	Laboratory and Scientific Equip.	18,48,518.40	51,09,531.50	69,58,049.90
- From DST			46,997.00	Deposit with CCU for Construction	6,00,000.00	66,15,377.00	72,15,377.00
				Deposit with Sp. LAO for Land	80,000.00	-	80,000.00
Earnest Money received			48,700.00	Acquisition			
				Security deposit	15,150.00	6,570.00	21,720.00
				Advances			5,21,306.51
Less: Excess of expenditure over income			38,58,258.36	Cash at Banks			46,23,075.92
				Cash in hand			13,684.79
Total			2,72,26,695.38				2,72,26,695.38

Sd/-
(N.K. Jain)
For Rattan Lal & Associates, Chartered Accountants

Sd/-	Sd/-	Sd/-	Sd/-
(HARISH CHANDRA)	(ANIL JOSHI)	(K.G. SAXENA)	(A.N. PUROHIT)
Drawing & Disbursing Officer	Administrative Officer	Scientist & Officer Incharge	Director

Note: 1. All items of income and expenditure are accounted for on cash basis.
2. Figures have been regrouped and rearranged wherever felt necessary.

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