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WATERSHED MANAGEMENT EXPERIENCES IN THE HINDU KUSH-HIMALAYAN REGION

Summaries of Review Country Studies

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PREFACE

From the time of its inception, improved management of mountain watersheds has been one of the major areas of concern for ICIMOD. One of the first activities of ICIMOD was the organisation of an international workshop on this theme in Chengdu, China. Integrated management of watersheds remains one of the principal focal programmes of the Mountain Environmental Management Division of ICIMOD which is primarily engaged in developing, mobilising, and disseminating alternative strategies and techniques for sustainable economic and ecologic development of mountain environments and the people living therein, with a primary focus on the Hindu Kush-Himalayas.

This paper was prepared for, and presented at, the International Workshop on Watershed Management Experiences in the Hindu Kush-Himalayan Region, held in Chengdu, China, 14-19 October 1985, in collaboration with the Commission for the Integrated Survey of Natural Resources (CISNAR) of the Chinese Academy of Sciences, China.

This discussion paper covers the summaries of review papers on country experiences from Bangladesh, Bhutan, India, Nepal and Pakistan. The papers on country experiences from China have allready been published jointly by ICIMOD and CISNAR in 1986.

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WATERSHED MANAGEMENT AND SOIL CONSERVATION IN THE HILLY AREAS OF BANGLADESH

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Introduction

Bangladesh has a large population (95 million) spread over a habitable area of just over 110,000km^2.) The rest of the total area of Bangladesh (143,700km^2 consists of major rivers and estuaries, mountains and highland forests, tidal mangrove forests, and general tree cover. The majority of Bangladesh lies within the flood plains of three great river systems, the Ganges, the Brahmaputra, and the Meghna. The monsoon accounts for 80 per cent of the total annual rainfall between May and October, and is used chiefly to the production of rice and jute. During the dry season a variety of other crops are grown, including wheat and oilseeds. In all, the hills account for about 12 per cent of the total land surface area of the country and are largely in the Chittagong and Sylhet regions.

In Bangladesh, priority has so far been given to construction of dams, irrigation development, and to flood protection in the plains. The Bangladesh Water Development Board has been given the supervising authority. But in the hilly areas, where there is not a single institution to manage the problems relating to soil conservation and watershed management, active soil erosion and land degradation are taking place at an alarming rate.

Problems in Watershed Management

These are caused by a variety of factors:

In Sylhet, the cultivation of unsuitable crops such as pineapples are causing massive erosion because they are grown in rows oriented vertically down the slopes and the inter-row spaces are highly vulnerable to sheet and rill erosion. Another factor is the burning of sun-grass stubble at the end of the dry season to stimulate regrowth. As a consequence; the following heavy monsoon rain causes the denuded hillsides to erode. Both cause the deposition of sand into the low land paddy fields and into the rivers, which rise and cause river bank erosions and eventually major flooding. During 1981, two road bridges were washed away. Previously, the Forest Department could raft logs and bamboos down these rivers for six months of the year, but now due to flooding this is only possible for two and a half months.

In the Chittagong Hill Tracts, soil erosion is mainly caused by shifting cultivation. The people who practise this are known as *jhumias*, and they used to plant the hillside without really cultivating the soil. The seeds were planted near the surface and harvested progressively throughout the year. When the area showed signs of declining fertility it was allowed to revert back to the forests for 8 to 10 years, thus gradually rebuilding its fertility and soil structure. Population pressure and reduced availability of agricultural land due to the construction of the Kaptai Hydroelectric Dam have sharply reduced the timespan that the land is left to rejuvenate. It is now down to about 4 to 5 years. Another reason, for land degradation in this area is the planting of rubber trees on bench terraces cut out of steep slopes of sandy soil, with little or no ground cover.

The Government is now taking steps to improve the situation. The multi-sectoral Chittagong Hill Tracts' Development Project (funded by the Asian Development Bank and UNDP) is resettling the tribal people on individual 2 to 3 hectare plots in three catchment areas (Myani, Changi, and Kasalong). One-third of the population of the valleys are being resettled in villages of 50 to 100 families, with rural development facilities such as schools, access roads, and health services. The Bangladesh Agricultural Development Corporation (BADC) is providing seeds and fertilisers to the forest dwellers.

The Forest Department and the Department of Agricultural Extension (DAE) are also resettling *jhumias*. The DAE does so on an individual basis, giving credit for clearing, cultivating, and preparing the land, repayable over 10 years with a 3 year moratorium. The planting material is given free of charge and consists of mixed orchards that take 8 to 10 years to mature.

The Forest Department also works with groups of families, combining afforestation with resettlement. The plantations consist of long rotation high-value timber species and short rotation pulpwood species. During 1985 to 1990, it was planned to carry out forest plantation on 40,000 ha. Under a scheme that was initiated in 1962, land that had eroded has been identified and is now classified as Protected Forest. With this afforestation scheme, there is also provision to rehabilitate 3,400 landless shifting cultivators in the operational areas of afforestation. The rehabilitation includes land allotment and financial assistance for the construction of houses and the supply of agricultural and horticultural inputs for the development of the land.

Despite all these measures, further research and training needs to be carried out. In 1964 Soil Conservation and Research Station was established at Ramgarh and is now called the Chittagong Hill Tracts' Agricultural Research Station. Specifically the station researches into soil use and conservation, combining the production of different kinds of arable crop with the plantation of fruit trees and timber without losing the fertility of the topsoil. Training is also provided to the extension staff and interested farmers, in the technology that is available on soil conservation and hill farming. Although experiments have been done on infiltration rates of different soil types, and the basic data on rainfall intensity maintained, results have not been distributed widely enough.

Before a cohesive policy can be devised, data must be gathered on the entire range of conditions relating to soil, geology, climate, natural vegetation, and land use. The urgent need, however, is for an operational type of research that will produce measurable trends in gross hydrological behaviour in various land use patterns, such as natural forests, plantation forests, horticultural forests (tree planting), and *jhum* cycles. The correct combinations of soil conservation measures, cropping patterns, crop variety, and fertiliser application for optimum production on a long-term basis while keeping soil losses within reasonable limits, need to be ascertained through research and experiment.

Watershed management will reduce the siltation of river beds including the Kaptai Hydel reservoir, through the control of erosion, and the improvement and maintenance of the productive capacity of the soil. Subsequently, flood hazards in the piedmont plains will be reduced and efforts could be made to increase hydro-power production. The major problems in relation to the eastern hills are (a) uneven distribution of rainfall, (b) shifting cultivation by the tribal forest dwellers, (c) a high deforestation rate, and (d) increased population pressure in the hilly areas due to migration from the plains.

Problems in Planning and Coordination

There is no overall plan to tackle the problem and no single department/organisation within the Government, with the manpower or required expertise, to formulate and implement integrated policies. In the Chittagong Hill Tracts various agencies are involved in the resettlement of displaced families but lack of planning leads to settlement often being on very steep slopes, without being made the provision for the supply of water or fuelwood, or adequate plots of land. At the present growth rate, the population of Bangladesh might rise to 140 million by the year 2000. To feed the people will require a drastic increase in production from the existing land under cultivation or an increase in the area under production. The present cropland is already being extensively cultivated and the possibility of further expansion of cultivation lies in hilly areas only. At present, the hilly areas in general though often cultivated with cereals, vegetables, fruits, as well as forests are not being properly used. This should not continue.

In 1982, the Government formed a task force to investigate, report, and advise on soil degradation problems. It recommended that, the Government should form a Division of Watershed Management and Soil Conservation and approach an international funding agency for assistance in training and the provision of expert services; that legislation should be drafted for the control of erosion; that immediate action should be taken to control the deteriorating situation on the rubber estates; and that the Task Force should remain operational until such time when an effective anti-erosion capability had been achieved. The Task Force also prepared a project document for a Soil Conservation, Training, Research, and Extension Project for increased agricultural production.

After a lapse of two years, the Ministry of Agriculture reconstituted a multidisciplinary Task Force to review the earlier report and the proposed document on Soil Conservation. It was recommended that an independent organisation be created under the name of the Department of Hill Agriculture, Soil Conservation, and Watershed Management (HASCWM), under the Ministry of Agriculture; that legislation be framed in connection with the control of soil erosion, particularly on two major issues: (a) to give HASCWM the power to close an over-cultivated area or stop bad land use practices, and (b) to define the soil conservation practices needed in each area; that a National Coordination Board be set up drawing members from all concerned agencies; and that the proposed Board undertake the considerable research needed to find the correct combination of soil conservation and cropping practices, and that trained staff be thereby forming a nucleus for the Department. The recommendations to take immediate action on the rubber estates and to explore the possibilities of getting both technical and financial assistance from any donor agency, were reiterated.

Conclusions

The conditions prevailing in the Chittagong Hill Tracts, increased land abuse, and the consequent stagnation of agricultural output render economic and social betterment a challenging task. There is an urgent need to develop the productivity of the area and thereby achieve a greater commercial interchange and equity of economic and social benefits.

In view of the limited scope for expansion of arable lands in the hilly areas and uncertainties in improving irrigation facilities, the development and application of improved technology is immediately required to increase the productivity of hill farming areas. Practices that have evolved over the years should be reassessed and adapted to present needs and should include the various components of the farming systems.

It should be emphasised that in order to tackle the problems of soil erosion and land degradation on a natural basis, and because of the multidisciplinary expertise required, there is a need for the proposed, separate Department of Soil Conservation and Watershed Management, with its headquarters in Chittagong. Because of the interdisciplinary and inter-institutional complexity of the problem, such a department could provide the coordination and integration that leads to successful management on a national scale.

WATERSHED MANAGEMENT IN BHUTAN

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Introduction

The patterns, intensities, and modes of resource utilisation in Bhutan may be examined in terms of human interventions, such as the traditional subsistence sector activities, modern commercial/economic activities, and infrastructure-building activities. Data on household natural resource interactions is scarce and the more readily available macro-level data leads to generalised conclusions. This constraint has led to the analysis of typical farming systems, that have been arbitrarily chosen to represent a continuously changing spectrum of practices ranging widely between plant and animal breeding, rather than a specific watershed case study.

The pastoral system is prevalent at high altitudes, called the yak-zone, and is based on raising yak and sheep. The yak herders lead a semi-nomadic life moving from one habitation to another, dictated by the availability of fodder. In each place they cultivate a small amount of land for barley, millet, and buckwheat. Growth rates for yak population were higher than expected during the period 1976 to 1980 because a family needs the support of more animals as their individual productivity falls due to decreased fodder availability. This, of course, creates a vicious circle. Also, where in the past diseases periodically decimated a herd, the popularisation of veterinary medicine and vaccines have upset this regulatory mechanism and the population may well exceed the carrying capacity of the pasture, even in the yak-zone. The higher pastures lack nutritive grasses but at a slightly lower altitude, where animals are grazed in the winter, there is the potential for productivity improvement.

Outstanding Issues

The provision of winter fodder is a problem in almost all of Bhutan, and is caused primarily by land overuse. Grazing rights have to be obtained from the Government on a perpetual year-to-year payment basis but some winter pastures have become common property, open to grazing by all. Soil fertility and climate indicate a good potential for productivity improvement but until the pasture grazing can be better regulated, this will not be realised. It calls for a rejuvenation of the local traditional institutions to monitor pasture grazing.

The agro-pastoral system combines animal husbandry with cropping activities. Land use emphasis is on pasture. It is practised mainly at the middle altitude level, known as the wheat-barley zone, but overlaps into the rice cultivation zone.

The animals, predominantly cattle, goats, and sheep, are grazed from one forest to another to exploit the complementary forest fodders. There is as yet no assessment of carrying capacity but the forests that are used all year round appear to be losing their regenerative ability. This can cause more deforestation in the long run than fuelwood or timber extraction. The situation is not improved by pasture and forest burning as less and less time is being allowed between each consecutive burning because of the population pressure on the land. Winter fodder availability may improve if farmers use irrigated fields in between cropping, to grow their own.

Maize is the major crop grown in the dry lands and rice is grown lower down on the wet, irrigated valley terraces. Shifting cultivation, or *Tsheri*, is common and although the tendency has been to expand the cleared area, government discouragement and household labour constraints have put pressure on the people to simply reduce the duration of the rotational cycle. Productivity of the soil is progressively reduced through over-cultivation and also through bad terracing methods which lead to topsoil and nutrient loss in the monsoon period.

A possible solution to this decreasing productivity lies in improved irrigation, although gravity canals are already constructed with extraordinary skill, and also through the careful use of fertilisers. It would be possible to develop small reservoirs and combine them with lift irrigation, but cattle dung, being an obvious fertiliser, cannot easily be utilised because cattle are grazed in the open and are often moved, making the collection of their dung a difficult task.

Finally, productivity levels could be raised with the use of more modern farming tools but it should be stressed that the present rudimentary, wooden ones do have the advantage of not digging deep thereby preventing wind erosion of the deeper soil that is richer in organic nutrients. Deeper cultivation techniques would be unwise without the attainment of better irrigation, manure, and soil cover, during the windy seasons. The main handicap in all these suggestions for improvement is labour scarcity.

At lower altitudes, an agricultural system is practised where rice paddy cultivation is predominant. The climate is also suitable for winter wheat and horticulture. The area is known as the rice zone and suffers from deforestation and a lack of irrigation which eventually implies a severe reduction in the availability of fuelwood and animal fodder. Cropping intensities vary over Bhutan and are dependent, primarily, on labour availability. In some areas, the maximum crop yield is maintained throughout the year, and in others, lack of manpower has led to paddy being established over a six month period, and harvesting being drawn out, often precluding winter wheat.

Although there has already been some progress, more improvements in terracing, irrigation, and the use of fertilisers, could still be made in the rice zone . The Government is focussing on the intensification of land use rather than its extension. This would entail improvements such as wider terracing and contour building, with the support of strengthened farmer organisation to maintain and operate irrigation schemes. A serious effort is being made to form compost and litter into effective fertilisers.

Livestock in this area are grazed, where possible, in pasture and forests. But where these have become degraded beyond use, crop residues, particularly straw, are used. Fodder scarcity is a nationwide problem. The approach should be to use traditional regulatory institutions and arrangements and community participation, so that forest grazing can be made less harmful to the tress, for example, through rotational use.

Despite heavy use of forests and pastures, and the generally fair to poor quality of the vegetation, particularly in pastoral areas, there is very little evidence as yet of severe erosion in Bhutan. Erosion is most pronounced in areas of winter pasture, where excessive grazing and fuelwood extraction, combined with a dry, windy climate, has led to the loss of the fine topsoil that has been loosened by animals' hooves. However, the loss of production from pastures due to the practice of pasture burning, combined with the climatic conditions, has weakened the vitality and vigour of trees in surrounding areas, and this implies long-term damage. Deforestation also takes place higher up in the yak zone, but here heavily used pastures have been taken over by more tenacious bamboo bushes which provide an effective shield against erosion.

Tsheri cultivation can have a direct and indirect effect on the watershed; although *Tsheri* patches are often surrounded by trees which provide a certain degree of shelter, the wind can move fine particles of soil and ash quite a long distance. Where the pasture is burned, organic plant nutrients are converted into inorganic, soluble salts that are carried away by streams during the rainy season and the nutrient loss is high. Indirectly, *Tsheri* effects the hydrological regime in terms of runoff and water yields, but these do not attain significance until the land under *Tsheri* becomes a large part of the total area of the watershed. They depend upon factors such as soil and ground porosity and the geology of the area, and there is a lack of data on this.

Severe erosion is often caused by sloped land cultivation, but in Bhutan, particularly in the south, the terraces are usually level. This, however, makes them prone to saturation during the high intensity rains, resulting in damage that requires the work of many people to repair.

Commercial use of watershed land seems to have had a limited detrimental effect so far. The main cash crop has been potatoes, and orchards have been developed; both of which are generally harmless to the watershed, but in southern Bhutan the development of orange orchards and cardamom fields has been accompanied by a land encroachment process that could cause landslides and erosion.

Although the Government earns 9 per cent of its total receipts from royalties and taxes on forest, commercial logging was restricted so that some formal management could be set-up to ensure that only particular species of trees are extracted and only from designated areas. The government wants to maintain 60 per cent of the land under forest but although inaccessibility protects overaged trees in northern Bhutan, logging extraction in southern and eastern Bhutan has denuded many hills that are now susceptible to landslides and erosion. A veneer and sawmill complex at Gedu, that was set up by the Government with assistance from UNDP, requires quality logs, most of which, they cannot get from the stipulated logging areas of forests. Moving further afield and increasing the scope of the logging area would entail certain environmental damage, and would also increase the level of investment needed in infrastructure.

Lemon grass oil has a good market and there is a small distillery plant in the Mongar District, to extract the oil from the grass. Mature grass which is not relished by animals for grazing is used, but it does provide the needed ground cover in light of the dry climate and the fragililty of the ecosystem where it grows. The stills also use a substantial amount of fuelwood, so the extraction of both raw materials must be regulated and monitored.

There is a real danger related to the pine resin-tapping that occurs mainly in eastern Bhutan. Excessive resin-tapping can weaken the trees and make them even more prone than they already are to disease and fire. Consequently, the deforestation that results would leave the land open to erosion.

The presently adopted pasture improvement strategy consists of identification of suitable pockets for pasture development, through fertility management and pasture-seeding. However, the most significant pasture-improving activity would be grazing management, as well as seeding and the introduction of *Rhizobium* innoculated clover seeds.

Hydropower development has been taking place in two complementary directions, the development of small plants distributed near population centres and large single projects, of which the Chukha Project is the largest with an investment of Nu 2,000 million (Bhutanese currency) and a peak power output of 336 MW. The project is a runoff river scheme with tunnel and power house built completely underground. The tunnel provides a 465m drop between Chimakothi and Chukha and the water is delivered through two intake shafts. The project is

designed with an elaborate desilting chamber, so apart from the high dam, the project construction does not create any surface disturbance, minimising erosion and landslide hazards.

Road building in Bhutan has progressed rapidly. The process of construction itself does not appear to have disturbed the environment too much, although a minimum amount of surface damage is unavoidable. In a few exceptional instances, landslips have taken place on the road and some culverts have created erosion down stream, but the effects are very localised. Black-topping activities induce a certain amount of tree-felling due to the fuelwood requirement for heating and melting the bitumen. This is normally not very significant because road construction through forested areas of Bhutan entails felling trees on the alignment, that can be used as fuel. At present, fuelwood demand for black-topping is nominal but this factor can have significance in the future when more tarred roads are constructed.

Programmes and Policies

There is a high degree of concern for the conservation of the natural environment in Bhutan, illustrated by many explicitly stated policies with regard to forest, land, or pasture conservation. A move to completely prohibit commercial tree felling in 1979, was partly on account of the need to maintain ecological stability through adequate forest cover and partly to ensure a good economic value for forest wood and timber. Similarly, explicit policies were adopted regarding land and pasture resources, arising out of the realisation that human and animal population pressures are rising rapidly, and that if over-exploitation is allowed to continue soil fertility will decline and there will be significant danger of erosion. However, there is no clear coordination between these sectoral policies. Therefore, what is needed is a mechanism for coordinating all resource conservation policies within a national policy. Such a mechanism could be provided within a multidisciplinary planning framework, based on the principles of watershed management.

National policies for agricultural development are handicapped by lack of accurate and reliable data, particularly on land capability. Classification of the latter would make it possible to adopt the optional land use policy commensurate with the respective carrying capacities of good, average, and marginal land. Thus areas most suitable for afforestation, pasture development, and intensive cultivation, could be determined. The lack of resource data means that an integrated framework of policy analysis can not be made effective.

The other important policy gap relates to the identification of areas which, although small, erode noteworthy amount of soil/silt into existing rivers. These hot spots can be comparatively easy to control provided that accurate information on them is obtained. In Bhutan, where the majority of the area in the watershed is relatively trouble free, extra effort can be focussed on selected areas. This management "by exception" would not only mean reduced outlay in watershed conservation activities but could also provide benefits through prevention of greater damage that may accrue if the hot spots are left unattended. Policies dictating preventative measures appear to be most appropriate in Bhutan as the present overall conditions of the watershed do not create any alarm.

There has not been a project that can be considered an integrated watershed management scheme in Bhutan. There are proposed schemes; such as the Intensive Area Development Project, that are testimonies to the existing awareness of the need to have integrated schemes, but so far the control of the watershed has been through a series of seemingly unconnected measures in the fields of land development, resettlement, irrigation, animal husbandry, pasture development, and forestry.

In land development, soil erosion has been reduced through terracing, contour building, drainage channel construction, and also the promotion of compost and fertiliser application to maintain the quality of the soil. However there is still a lack of supply of complementary farming inputs and arrangements made for marketing the outputs.

The resettlement programme was launched with the aims of reducing population pressure on land, and locating people in areas with easier access to rural services. Implementation of the programme may have suffered on account of data and information gaps on land capability and soil productivity. This reinforces the need for adequate project planning and evaluation data, and scientific research at the project level.

The Small Farm Development and Irrigation Rehabilitation Project has renovated and constructed irrigation systems with training built into the programme. Other existing schemes include the Taklai Irrigation Scheme assisted by UNDP and the Gaylegphug Area Development Project assisted by the Government of India. Watershed management components have been included and prospects look good, but problems have arisen because of inadequately performed soil surveys and analysis.

The focus in the animal husbandry sector has been on scientific breeding and the introduction of improved husbandry practices. Very little has been allocated to develop pasture resources, and this may need to be increased and grazing rights defined, so that the most effective use can be made of the pasture available through rotational grazing.

The main objectives of the present forestry schemes are to fill data and information gaps to prepare for conservation and management plans and to set-up industrial and production plans designed to increase the value of wood and wood products currently being exported from Bhutan. Filling data gaps has been quite successful so far, due primarily to the Pre-investment Survey (1974-79) carried out with Indian assistance, and has been considered adequate for the preparation of broader conservation and management planning and strategy. The location of industries has to be carefully planned because of the high cost of transportation of the timber. This demands detailed information on existing and potential forest resources, combined with data on external markets, so as to maximise the benefits to Bhutan. Thus, data gathering, market research, and product innovations, are all needed to fill the present gaps. However, the most critical gap appears to be the absence of the work standards that have to be followed in all activities related to logging operations in the fragile environments of Bhutan, so that problems can be prevented from the start.

Conclusions

Watershed management efforts in Bhutan relate mostly to preventative measures augmented by the treatment of hot spots for the reduction of erosion, landslides, and nutrient loss. The need for coordination between the schemes will grow fast and it may become necessary to have a separate institution which will specialise on watershed management activities. There is also scope for improving the policy analysis and implementation capability of various central and line agency institutions. This requires data and information on land use, climate, household level resource use, human and animal population statistics, demographic parameters, and soil classification. The priority in agriculture is accorded to the development of land and soil conservation activities; linked to this should be a strong policy on afforestation and pasture improvement.

The institutional development as well as the potential impact of the various schemes proposed, needs to be examined. This is important, particularly in Bhutan, where resource use policies are based on sectoral concerns of line agencies. It will require a further understanding of the interaction between biological and physical processes; for example, research should be done on the extent to which *Tsheri* cultivation has an adverse effect on soil fertility. There should be applied research into the productivity of specific types of pasture and forest lands; the latter with regard for its use as winter grazing and as a source of timber

Records must be maintained relating to the production levels of the various crops, legumes, and fodder. Data is not available either on the productivity of livestock, particularly hybrids and crosses, under different feeding arrangements. Some areas of Bhutan suffer from strong winds and it is not clear to what degree topsoil loss is taking place. In these areas research on wind erosion should be a priority.

No specific training exists in watershed management at present. Such training would particularly benefit many lower level technical staff in departments such as agriculture, animal husbandry, and forestry There has been limited training in topics related to soil and water conservation at the Kunglung Training Institute and the Lame Gompa Forestry Training Centre has provided basic groundwork with an introduction to ecological principles. More emphasis should be put on practical community and social forestry. If farmers, who are trained at departmental farms, are taught watershed management techniques together with basic animal husbandry and agriculture, farming practices may improve substantially in the future, both from a productive and ecological point of view.

WATERSHED MANAGEMENT IN THE INDIAN HIMALAYAS

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Introduction

Of the Indian Himalayan Area, 53.2 per cent is classified as forest land and is under the control of the Forest Department. The actual area under forest varies from 8.3 per cent in Meghalaya to 91.3 per cent in Arunachal Pradesh. Large areas of land that are not under the control of the Forest Department may be assumed to be either devoid of forest, or supporting only very degraded cover. Even the land within their control is often inferior both for use as forest land and for cultivation. Only 58 per cent of it is economically exploitable.

The land in this area is grossly mismanaged. The condition of grazing land is fair to poor at all altitudes. Only irrigated land is properly bench terraced. Shifting cultivation is practised extensively in the North-eastern Himalayan Zone. At present, the fallow period is between five and seven years, which is insufficient to allow natural regeneration of the 16.8 per cent of land that is generally under cultivation at one time.

In recent times, the increasing pace of developmental activities such as mining, quarrying, road construction, and power transmission towers have contributed to the degradation of the watersheds. But the primary physical factors that have accelerated the degradation of the watersheds in the Indian Himalayas are misuse and mismanagement of land.

Among the secondary factors high pressure of human and livestock population may be included. Given these pressures, subsidiary factors, such as steepness and length of slope, geological features, and climate, intensively contribute to very high rates of erosion, runoff, and degradation.

Problems of erosion and land degradation received attention as early as the late 19th and early 20th centuries. After independence, when planning for development was initiated, soil and water conservation programmes and research and training activities were provided in the First Five Year Plan (1951-56). A close scrutiny of the agricultural development programmes reveals that emphasis was placed on watershed management only since 1974 with the start of the drought area development programme.

Forestry programmes were also initiated during the First Five Year Plan. Soil and water conservation programmes were taken up in the first plan and expanded in scope and activity with each successive plan, by the State departments of Agriculture, Forest, and Irrigation. Before the end of the Second Plan there was an urgent need to pay attention to the reduction of sedimentation rates of reservoirs. Catchment treatment programmes were therefore started from the Third Plan (1961-66). For centuries, India has developed and used tanks and ponds on an extensive scale to harvest water from watersheds and to store and recycle it for crop growth. Since the commencement of the Sixth Plan, not only the entire soil and water conservation programme but also agricultural development programmes have been firmly based on the concept of watershed management.

It was not until the Sixth Plan (1980-85) that a national policy was adopted to use watersheds as a unit of land and water resource development. During the Seventh Plan (1985-90) it is anticipated that the main thrust will be towards intensification of soil and land use surveys, continuing the ongoing programme of stabilisation of catchments of river valley projects and flood prone rivers, control of shifting cultivation, and initiation of large-scale restoration and development of waste-lands.

The Himalayan River Valley Project catchments have an area of 52,000km^2 of which 61 per cent have been covered. A pilot project for controlling shifting cultivation was initiated in 1977/78 in Andhra Pradesh, Assam, Meghalaya, Nagaland, Orissa, and Tripura. The programmes included developing and allocating 2 ha of land for subsequent allotment to each beneficiary family.

On non-agricultural land, tree plantation programmes are being undertaken. Attention has been paid to water resource development and conservation and sediment control, by programmes such as *nala* bunding, check dams, gully plugging, land shaping, percolation tanks, water harvesting, and water conveyance. Up to 1984/85, a total land area of 27.07 million ha has been treated. In addition 2.31 million ha was treated under the central sector.

Seven catchments of river valley projects were under treatment during the Sixth Plan. Although expenditures for each plan have been progressively increasing, regrettably, the cost per hectare of land treated has also been rising. To that extent the area treated has become proportionately reduced.

From 1951 to 1980, India has invested 128,690 million rupees in agriculture and allied programmes (34.1 % on agriculture and land reforms and 18.8 % on forestry). This reflects the level of priority given to the creation of an infrastructure for increasing food production. In the Sixth Plan a quantum jump was made in the investment in the forestry sector; 6,925 million rupees as compared to the investment of 4,839 million rupees in the preceding 20 years. The centrally sponsored scheme of SOILWATCH (Soil, Water, and Tree Conservation in the Himalayas) started during the Fifth Plan. In the Sixth Plan, 250 million rupees were provided for this sector.

Watershed management programmes, in catchments of river valley projects have a primary concern to increase the life of reservoirs. In Bhakra Reservoir and Ramganga Catchment, the observed rates of sedimentation in the reservoirs were 200 per cent more than the designed inflows, and, contrary to the belief that all sediment would be deposited in dead storage, the sediment has been deposited in both live as well as dead storage. The treatment of river valley catchments, after construction of the reservoir, is at best a remedial measure. There is a need for preventive measures to be taken before the reservoir is filled. This approach has perhaps more economic advantages as will be shown later.

India has been fortunate in terms of awareness of the problems of watershed degradation. At the government level, this is evident in extensive development, research, and training programmes initiated and implemented. At the people's level, the Chipko movement in the Himalayas is a classic example showing that they are also aware of the degradation of their production base and the disappearance of water. Regarding national land use policy, the Government of India constituted, in 1984, a National Land Board under the Chairmanship of the Minister of Planning and a National Land Resources Conservation and Development Commission. The former is the apex body and the latter has been entrusted with responsibility for the formulation of policy and for its implementation.

Programmes and Policies

Himalayan watersheds, in particular, have inherent biophysical and socioeconomic constraints which impinge on the pace, quality, and growth of development. Constraints identified are:

- o isolation of the area and poor infrastructural facilities;
- o lack of efficient management sustained production; the natural system being ecologically fragile and refined;
- o a wide variation in agro-ecological conditions within very short distances due to many permutations and combinations of altitude, slope, and aspect conditions; and
- o very limited good agricultural land available which places a natural barrier on increases in food production.

The strategies implemented include the following.

- o All States, parts of States, and Union territories, located in the Himalayas, have been recognised as "**BACKWARD HILL AREAS FOR SPECIAL CONSIDERATION**". Guidelines for dealing with backward hill area problems have been provided to States and Union Territories (Planning Commision 1981).
- o The Fourth Plan, suggested a multi-directional area development approach to accelerate development of backward areas - Himalayan hill areas included.
- o The Fourth Plan recognised that in hill areas investment is high and returns low. Therefore, more central assistance was allocated to meet specific needs and problems.

A chain of soil conservation research, demonstration, and training centres was established during the first and the early part of the Second Plan. Two centres were responsible for work in the Siwalik Hill Region (at Chandigarh) and the Himalayan watersheds (Dehradun). In addition, there is an extensive network of universities, central research institutes, and State research centres in the Indian Himalayan regions.

In the First Plan, 1951-60, training of labour power for the development programmes in soil and water conservation was provided due to continually expanding watershed management programmes. The lack of trained personnel has been recognised as a major constraint in starting, implementing, and reaping better fruits from soil and water conservation. Currently, the rate of degradation is higher than the rate of restoration/afforestation.

Legislative authority on land and water issues lies with individual States. In order to enthuse, encourage, and support the State Governments to enact such legislation, the Central Government formulated a "Model Conservation Bill" in 1955, and circulated it among the States. Sixteen States and union territories now have legislation relating to soil conservation (Jacob 1981). In some States the soil conservation measures have been implemented under earlier, existing statues, e.g., Madras Land Improvement Scheme Act (1949) and Bombay Land Improvement Act (1953).

The same is the case with the Forest Act. As a sequel to the recommendations of the National Commission on Agriculture (1976), a Central Forestry Commission was established to formulate a model bill of forests for eventual adoption by the States, since the subject of "forests" was also in the States' legislative jurisdiction. Amendments incorporated place the subject of "forests" in

the Concurrent List, confirming jurisdiction of the Central Government to also enact legislation. As a consequence, a new draft of the Forest Act has now been prepared for enactment by the Parliament.

Conclusions

With the changing socioeconomic conditions, programmes such as soil and water conservation, watershed management, afforestation, and social/community/farm forestry have an urgency. Hence there is need of new legislative approaches and initiatives. Policy initiatives regarding land use and forestry are anticipated and new legislation may be forthcoming in the near future.

Seventy per cent of land holdings are less than 1 ha and only 13 per cent are more than 2 ha, with as many as 13.5 locations per holding. The problem cannot be resolved within the present farming system. The solution may lie in development and growth of other sectors so the population is weaned away from the land.

Regarding forest land, about 50 per cent of the land in the Himalayas is under the control of the Government Forest Departments, but it is not necessarily forested land. Emphasis should be on increasing the pace of afforestation and developing a sence of a job well done.

It would appear that the situation of carrying capacity is very critical in the Uttar Pradesh Himalayas and not critical in Arunachal Pradesh. Other States fit at various levels between these two extremes. However, it is clear that in the entire region, wherever man has intervened, are pockets where the carrying capacity has been exceeded. To that extent, the entire Himalayan ecosystem in India, either extensively (as in UP) or locally is consequently subject to stress and strain. What are the options ? The only option is to optimise land use and increase productivity on a sustainable basis, in conjunction with population control.

A primary source of sediment generation, instability of hill slopes, cause of landslides, erosion, and gullying and forest degradation is road construction; yet, roads are the first prerequisite of development. The techniques and technologies of aligning and constructing roads on a scientific basis and stabilising the slopes are well-known. The issue is not technology but socioeconomics and politics. What is needed is action which ensures that, with given allocations for road construction, roads are aligned and safe based on scientific principles including provisions for drainage and slope stabilisation. This calls for managerial and political will. However, the best of roads can easily be damaged or destroyed by ecological disturbances if the surrounding forest land and grazing land is not properly used. Coordination and cooperation are the needs of the day.

WATERSHED MANAGEMENT IN NEPAL

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Introduction

Ecological degradation has been increasing in Nepal to the point where it has been estimated that over 240 million m^3 of topsoil is being eroded annually from the hills of Nepal to the Bay of Bengal. According to a nationwide inventory of watershed conditions, 13 per cent of Nepal's land area (18,300km^2) have deteriorated seriously and 10,000km^2 are devoid of sufficient vegetation and are in danger of desertification (Nelson et al. 1980).

There has been a decline both in quality and quantity of forest cover. For fuelwood alone, the estimated annual yield is 6.9 million m^3 while the annual demand is estimated at about 9.9 million m^3 (HMG 1984).

About 22 per cent of the total land area is being used for cultivation (ADB 1982). The cropped area has increased by 10.6 per cent during the period of 1971 to 1981, but yields have declined Compared to the per unit area of cultivable land, Nepal has the highest livestock population density in the world and this is putting added pressure on land use.

Because of the growing population and also the influx of tourists in the Mountains, there is a severe energy shortage and the forests near settlements are being depleted and are even disappearing, in the search for additional cultivable lands. Out of fifteen mountain districts, watershed conditions are very poor in one (Mustang); marginal in two; fairly good in five, and good in seven. Productivity of land is not subject to significant disturbances. Overall productivity of land is not impaired except in localised pockets near settlements. Soil breakage and movement indicate that meadows on glacial valley slopes in parts of the main Himalayan chain have been overgrazed.

In the Hill areas, 42 per cent is forest land (APROSC 1984) and although there has been no drastic reduction in the number of trees, the quality has declined. Out of 39 hill districts, watershed conditions in five are very poor; five are marginal; ten are fairly good; and two are good. Annual erosion rates are very high for grazed land, followed by scrub land and terraced land (Flemming 1978). The soil loss of overgrazed land can be as high as 34t/ha (Pereira 1980). This erosion has led to frequent downstream flooding and has also been exacerbated by lack of attention being paid to the fragile slopes in the construction of roads and other soil disturbing civil works.

The steep hills of Nepal support approximately 60 per cent of the country's livestock population, which is increasing year by year. This extreme pressure has led to the destruction of the fodder resource base, and therefore a reduction in the productivity of the animals. The hill area is dominated by small, fragmented farms with average land holdings of 0.5 ha, 60 per cent of which produce below their subsistence level. The need to expand will result in the cultivation of marginal land which is presently supplying other basic needs such as fodder and fuel.

With the control of malaria in the *Terai*, massive spontaneous migration from the hills has continued since the mid-1950's. About 100,000ha of good commercial forests have been lost to meet the ever increasing demand for agricultural land. The total area of the *Terai* forest is now estimated at 1.4 million ha. At the present rate of conversion, commercial and other accessible forests in the *Terai* may disappear within 25 years.

The shrinking of available fodder resources and increasing livestock population in the *Terai* is not as acute as in the Hills. Nevertheless, inadequate water management of irrigated land and the untrained diversion of water from the streams are causing erosion and loss of soil fertility.

Programmes and Policies

Planning and forest conservation and management only emerged in 1956, with the introduction of the First Five-Year Plan. The second plan, 1962-65, concentrated on scientific methods of data collection, inventory, and other information concerning existing natural resources. Emphasis was put on research in the agricultural sector.

Between 1965 and 1985, there have been four more five-year plans. The first of these fixed output for the production of food grains and cash crops. Forest management plans and the development of medicinal plant cultivation were also initiated.

Despite recognition of the importance of natural resources, no significant programmes for conservation as such, were included in these plans until 1974, when what is now the Department of Soil Conservation and Watershed Management, was established. The Institute of Forestry was also set up, in order to build up the required manpower for natural resource management and conservation.

The priority in the plan period 1975-80, was to create an awareness of the need for soil conservation and watershed management, both at the national and international levels. Programmes in this field were designed and implemented in several watershed areas of Nepal. The plan also conceived of the need to treat agriculture as the lead sector, to upgrade the socioeconomic condition of the local people, and to develop irrigation practices in all areas.

The Sixth Five-Year Plan (1980-85) gave top priority to environment protection. It provided off-farm employment opportunities to reduce the pressure on natural resources, and regulations were formulated to control the environmental degradation likely to be caused by the development of physical infrastructures. Conservation and development of forest resources by means of local community involvement was highlighted; at the same time, emphasis was put on making the people self-sufficient in food production, and on increasing the production of exportable commodities. The National Council for the Conservation of Renewable Natural Resources was established to coordinate the agencies responsible for the conservation of natural resources.

The main objectives of the Seventh Five-Year Plan (1985-90), are to upgrade water resources, to develop agricultural and forest produce, and to maintain a balanced environment through the conservation and improvement of natural resources. Community involvement in projects will be stressed.

Watershed management programmes in Nepal can be grouped into the following:

- projects being implemented within defined watershed boundaries, to ensure maximum supplies of good quality water, and to prevent and control erosion and sediment discharges;
- forest, soil conservation, and watershed management activities, a component of multifaceted Integrated Rural Development Projects;
- sectoral projects designed to address sectoral issues such as forestry management, agricultural development, and livestock management; and
- those initiated to support other programmes by generating data; land use information, extension techniques, and conservation education materials.

The ministries of Forest and Soil Conservation, Agriculture, and Water Resources, as well as various university units are involved in research related to environmental management. Under the ministry involved in research and training are the departments of Medicinal Plants, National Parks and Wildlife Conservation, and Watershed Management.

Conclusions

Research studies, trials, and experiments, adopted so far by the agencies responsible for conservation tasks, are mostly based on ad hoc assumptions and are largely limited to curative operations in fields such as agroforestry, planting techniques, seed production, soil and forest mapping, wildlife, ecology and land biomass, land capability studies, and pasture and range management. The studies are modest compared to the extent of ecological degradation. They should be focussed on conservation management and production aspects, and conclusions should be easily communicable, socially acceptable, and economically feasible.

Over the last three decades, several bilateral and international donor agencies have taken a keen interest in the management of natural resources in Nepal. Principal contributions include the establishment of long-range forest policies and legislation; reorganisation of relevant departments in the ministries of forest and agriculture; development of integrated watershed management practices and techniques; the training of technicians in related fields; determination of socioeconomic and institutional mechanisms to promote community participation; development of methods of land resource mapping, inventory, and surveys; and highlighting future research needs. International cooperation and assistance has played a positive role in the promotion of watershed management in Nepal.

Forestry and soil conservation as well as watershed management activities should be implemented in all the districts of Nepal. In the mountain regions, priorities include increasing the productivity of pasture, rangelands, and the community orchards, as well as implementing rehabilitation programmes in eroded areas. Landless and unemployed farmers need to be guided towards employment opportunities.

In the Hills, large-scale afforestation, trail improvement, road slope stabilisation, and terrace improvement are urgently needed. Activities should relate directly or indirectly to the need to increase food and fodder production, and to provide employment opportunities.

The activity recommended for the *Terai* are the planting of grasses or trees along river banks, canal banks, and roadsides, to protect them from erosion and flooding, and also for use as fuel and fodder.

WATERSHED MANAGEMENT IN PAKISTAN

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Introduction

Pakistan depends entirely on precipitation received on the mountain watersheds of the upper Indus and upper Jhelum rivers to sustain irrigated agriculture and to produce hydroelectric power, (Raeder-Roitzsch 1968). To make the maximum use of the water resources of the country, a dam has been constructed on the River Jhelum at Mangla (project started in 1959/60) and another on the River Indus at Tarbela. A watershed management programme for the country has been launched to reduce soil erosion from these watersheds, to maintain and improve their productive capacity, and to reduce the rate of siltation of the Mangla and Tarbela reservoirs.

The period of productivity of the Mangla and Tarbela reservoirs are estimated at 60 to 80 and 30 to 40 years, respectively. One important cause of such heavy silt loads is soil erosion which has been accelerated by mismanagement of the watersheds through deforestation of steep mountain slopes, their cultivation without effective soil and water conservation measures, and the destruction of vegetation cover on grazed lands due to livestock pressure far in excess of the grazing capacity of mountain rangelands.

Watershed management dates back to the Forest Policy of 1894, which stressed the need to preserve the forests on climatic and physical grounds. The Agricultural Enquiry Committee Report of 1975, suggested extensive fruit tree planting and the construction and improvement of terracing in the hills.

Current watershed management programmes, with World Food Programme (WFP) commodities as incentives, are progressing well. The major concerns are with their long-term perpetuation after such assistance ceases, their narrow scope (mainly tree planting), and the relatively small areas to which they are confined.

In the watershed of the River Indus, of which 30 per cent is unproductive, land is used for grazing, cultivation, and forestry. Mountain agriculture is generally poor; most valleys can barely produce half their food requirements. Out of the 36 per cent under agriculture, 33 per cent is subject to soil erosion - 9.5 per cent moderate, and 23.5 per cent severe. In the Jhelum watershed area, human and livestock pressures on the land are also high. Only about 9 per cent is forest; out of the 52.3 per cent that is under cultivation, about 36 per cent is subject to moderate or severe erosion. Watershed operations in this area are showing results and at the current pace of work, it should be possible to cover the remaining area (about half is already under forest) by the year 2000.

However, since participation in the programme is voluntary, not all land owners participate, which leads to scattered work sites where trees have been planted or soil conservation works have been carried out, separated by areas that are left untreated. Therefore, the term "watershed management" as applied to the operations in progress is in itself a misnomer because it leaves out important practices which are essential components of a watershed management programme.

Therefore, no permanent solution to the problem of watershed deterioration is possible unless the income of the mountain farmer is raised considerably or he is provided with an alternative way of making a living. Watershed management programmes have eased the situation a little by providing job opportunities and distributing WFP food commodities, but a massive campaign for intensive management of all mountain resources is needed. Such a programme would have to include controlled road construction, timber harvesting, and forest planting. It should also make permanent employment of a significant proportion of the local labour force possible in skilled jobs that offer fairly high wages. A start has been made in the Kaghan Valley of the North West Frontier Province.

Rapid intensification of forest management in the mountains is an important means of ensuring more successful watershed management. The human population will continue to rise, necessitating continuous adjustment of land use. Though the task of watershed improvement may be completed in a few decades, the task of watershed management will remain, and must evolve towards the establishment of permanent, effective, multidisciplinary organisations. The urgent need is to incorporate expertise in range management, soil and water conservation, animal husbandry, horticulture, agronomy, and social sciences to enable a comprehensive programme of watershed management instead of continuing with tree planting alone.

The indigenous concept of watershed management (more accurately, watershed rehabilitation) requires the rectification of land use to conform to land capability, which will confine cultivation to less steep slopes. Soil and water conservation measures on agricultural land also need to be taken, and forest trees planted on steep mountain slopes (fruit and nut trees, wherever possible, that would provide an income for the local people, making them less dependent on cultivation and grazing). These would be closed to grazing until the trees are above the limit of trampling and browsing damage.

The two main agencies that have been involved in executing the watershed management programmes in these areas are the Water and Power Development Authority (WAPDA) and the Forest Department. WAPDA has been concerned with reducing the rate of siltation of the Mangla Reservoir using engineering structures and the Forest Department has taken a more holistic approach: the improvement of socioeconomic conditions of the mountain farmer, the correction of the current defective land use of the mountain watersheds, and the adoption of soil and water conservation measures where necessary. The 1962 directive on watershed management required the formation of a multidisciplinary organisation to undertake programmes on privately owned land, entrusting the Forest Department with the responsibility of managing government owned forests.

Programmes and Policies

The objective of the National Agricultural Policy of 1980 was to increase and sustain the development of all products and services in the wildlands (for example, clean water from watersheds is an important product of wildlands and output must continue). It therefore called for effective motivation of the local people linking their involvement in production with their involvement in mass tree planting and nature conservation. This Policy is illustrative of a gradual shift from the compulsive to the motivational approach in watershed management that has taken place between 1955 and 1980. In fact the watershed management programme in Pakistan only really began to show positive results when the compulsive approach was abandoned and was replaced by the introduction of incentives, and the emphasis on motivation. The Provincial Government has been empowered since 1900, under the Punjab Land Preservation Act of that year, to temporarily regulate, restrict, or prohibit the felling of trees,

cultivation of land, or the grazing of livestock in any area that has become subject to erosion. However these legal provisions have seldom been used because any interference with the full proprietary rights of the land owners is an anathema to them and they would have nothing to do with any programme which uses compulsion in any form. Actually watershed management programmes in Pakistan did not emanate from formally stated policies; rather their recommendations included practices being adopted in various regions at the time of their formulation.

Before a major developmental activity can get underway in Pakistan, it is essential to provide for it in a five year plan. Watershed management as a separate item, appears for the first time in the Third Five Year Plan, 1965-70 which stated that a programme would be undertaken over an area of 200 square miles. The Fourth Five Year Plan, 1970-75, called for an evaluation and subsequently an extension of the programme. By the Fifth Plan, 1978-83, the watershed management programme covered a total net area of about 200,000ha, comprising of afforestation over 120,000ha, and soil conservation over 180,000ha, and the distribution of 3 million trees for planting. During the Sixth Plan (1984), a financial allocation of 297 million rupees has been made for the implementation of further watershed management schemes.

The current constraint is no longer a lack of financial resources, but an adequate infrastructure manned predominantly by foresters. Priority must now be given to the diversification of staffing so as to utilise all the funds provided in the most efficient and effective way. The organisations should include competent, innovative professionals from all related disciplines such as anthropology, agricultural engineering, soil conservation, horticulture, agronomy, range management, fodder production, and animal health nutrition.

Watershed management programmes in Pakistan are based on the assumption that accelerated soil erosion in the mountain watersheds and the resultant rapid siltation of water storage reservoirs is mainly caused by defective use of mountain land. The strategy is to create a new equilibrium between the productive capacity of the mountains and the people living on them: the mountain farmer is encouraged to discontinue cultivation on slopes steeper than 50 per cent, planting fruit and forest trees there instead. On less sloping land he is taught to protect his fields by adopting soil and water conservation measures, and to use improved methods of farming to increase his yield.

Until now, projects have been oriented towards the two main executive agencies. The forest departments have concentrated on forest and fruit tree planting. The trees are supplied free of charge and in addition, the farmers who plant them are given WFP food commodities and also a small cash payment. This has recently been introduced to tempt more able bodied workers to join watershed management works. WAPDA has concentrated on the construction of soil and water conservation structures, and, so far, all operations have been carried out without financial cost to the farmers, as far as tree planting is concerned. The projects include the protection of trees planted, for five years. The farmer only has to pay 30 per cent of the cost of terracing and other soil and water conservation measures on his agricultural land.

UN inter-agency evaluation and appraisal missions in 1982 and 1983 provided the following assessments:

- Progress is very good in afforestation, but slow in soil and water conservation on cultivated land. Range improvement has hardly been attempted.

- Work sites are widely scattered.

- Projects are mainly attempted by foresters, with little assistance from other relevant technical services.
- The socioeconomic aspects of the projects require immediate attention.

The employment of professionals from a wider cross-section of related fields is essential before the programme can achieve its objectives in a significant manner. The need is to increase the momentum of the programme and to make it more comprehensive, placing emphasis equally on all its components.

The Division of Watershed Management of the Pakistan Forest Institution conducts research and training and includes education in watershed management in MSc and BSc forestry courses. Research and education capability in this field was created by the FAO-assisted National Forestry Research and Training Programme, 1965-1969, which was followed, in 1983, by a UNDP- assisted project, "Development of Watershed Management and Research at the Pakistan Forest Institute". The Pakistan Forest Institute is under the Ministry of Agriculture of the Federal Government. Its research and education programmes are formulated in consultation with the Heads of the provincial forest departments. For education, the institute is affiliated to the University of Peshawar

Watershed management research was initiated in 1966, and investigations conducted during the FAO project included the evaluation of climatological and hydrological data, interception and stem flow studies in *Chir* pine, water consumption studies of some agricultural and forest crops, soil moisture observations, and a comparison of runoff and soil erosion from a catchment where soil and water conservation measures had been adopted with a similar untreated catchment Studies of the latter are still in progress, along with research on the effect of watershed management operations (mainly *Chir* pine planting) on runoff and sediment release in Hazara Civil Division, which began in 1979.

At present, watershed management is one of about 30 subjects being taught to students of MSc and BSc forestry courses, each of two year duration. A project was started in 1983 by the UNDP, at a cost of Rs 18.96 million, covering a period of 54 months, to develop watershed management education and research at the Pakistan Forest Institute. In 1984, a total of 35 forest officers were trained and work was also started on the establishment of an experimental work station at Faza Gat in Swat District.

There have been useful meetings for the exchange of information. The First West Pakistan Watershed Management Conference was held in November 1964, and was followed by a CENTO Seminar, held at the Pakistan Forest Institute, Peshawar, in 1977. Experts from Pakistan, Iran, Turkey, the UK, and the US were present.

Conclusions

Important steps that may be taken towards a solution to the problem are mainly based on continued development of research and training. Investigations need to be carried out into methods of harvesting timber, regenerating forests, and constructing roads, that would successfully conserve the watersheds. An integrated effort by professionals in all related fields, backed by coordinated institutions, will ensure effective implementation of flexible policies, followed by ongoing monitoring of the programmes.

A unit for planning and conducting research in all the socioeconomic, biological, and physical facets of watershed management should be established and the staff who implement the programmes should receive continued education and training in this subject. Priorities for research include the problems of maintaining the level of livestock productivity despite more limited grazing facilities, possibly through increased fodder production and the development of improved methods for its storage, and by refining the marketing of their products so as to maximise sales and therefore income for the farmers.

Finally, crucial to the success of the programmes is the education and deep involvement of the local people, so that the work becomes more meaningful to them.

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