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Soil Fertility and Water Management Challenges for Sustainable Mountain Agriculture

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Agriculture in the mountains, broadly defined to cover all land-based activities such as cropping, animal husbandry, horticulture, forestry, and their linkages and support systems, is a primary source of sustenance for most of the mountain population. The general symptoms of decline in the agricultural sustainability of the Hindu Kush-Himalayas (HKH) include:

i increased population and declining per capita availability of cultivated land,

ii. scarcity of farmland resources,

iii. declining productivity of farm and non-farm lands due to erosion and land degradation, and

iv. lack of diversification and resource regenerative farming practices.

Negative changes in mountain agriculture reveal that, barring a few exceptions of improvements, the conditions of mountain habitats and their people are steadily deteriorating.

Soil and Water Concerns

Land degradation is a quiet crisis that is unfolding gradually in the hilly and mountain areas. Within the HKH Region, soil erosion from agricultural activities on sloping lands has been, by and large, the major contributor to land degradation.

The loss of topsoil has affected the ability to grow food in two ways. First, it has reduced the inherent productivity of land, through both the loss of nutrients and the degradation of other elements in the physical structure of the soil. Second, it has also increased the cost of food production. Increasingly, farmers losing topsoil are trying to increase land productivity by applying chemical fertilizers.

Declining Crop Yields

The productivity of farmland in upland areas has been recording either a

* *Abridged version: the detailed paper is available with the Mountain Farming Systems' Division, ICIMOD*

steady decline or stagnation in crop yields. For instance, average crop yields declined within a range of from five to 30 per cent during the past few decades in a number of mountain watersheds in the Indian Himalayas, in Nepal, and in the Tibetan Autonomous Region of China.

In rainfed uplands, where maize and millet are dominant summer crops, soil fertility is maintained mainly by the application of compost or farmyard manure. There are indicators of weakening forestry-farming linkages blocking the flow of nutrient cycling from forest to farmland. The loss of fertile topsoil from limited cultivated lands has caused many farmers to abandon their traditionally cultivated land and to move on to other marginal lands.

Declining Food Security

Households have been experiencing food deficits in varying degrees. Food deficits for at least six months each year are quite common in many mountain areas. The related concerns of local food security and rapid agricultural growth are being pursued through the promotion of intensive cropping of both food and cash crops by using external inputs.

Weakening Forestry Farming Linkages

Some estimates point out that about three to four hectares of support land are required to maintain one hectare of cultivated land for normal production in the middle mountains of the central Himalayan region, notably in Nepal. The degradation of forests will affect farming in mountain areas as major sources of crop nutrients (leaf litter and animal dung) are adversely affected by loss of forests. In terms of foodgrains, the magnitude of loss is likely to be enormous.

Factors behind Soil and Water-related Concerns in the HKH

Population Pressure

Approximately 56 to 80 per cent of the working population of the region are engaged in agriculture. The

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Tibetan farming family tending their potato plants (cash cropping) and the future farmer looking on, Central Tibet
T. Partap

average size of per capita cultivated land in 1980/81, was 0.097 ha in the Chittagong Hill Tracts of Bangladesh and 0.272 ha in the State of Sikkim in India. In most areas, the per capita cultivated land declined by 30 to 45 per cent between 1960 to 1980.

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Breakdown of Traditional Systems of Soil and Water Management

Terracing has been a critical aspect of sloping farmland management, because of its ability to reduce erosion substantially. Project interventions that include improving bench terraces are unlikely to have a positive effect, unless the productivity and profitability of the overall farming system are improved at the same time. The construction of new terrace systems is rarely seen today. Thousands of hectares of abandoned terraces can be seen throughout the mountains. This abandonment is a direct result of decline in soil fertility.

Swidden Farming

Swidden farming is an agricultural system in which the area to be cultivated is cleared, usually by fire, and cultivated for a short period and then fallowed for a longer period over several years (10-15 years).

In Bhutan, a large proportion (32%) of cultivated land is still under shifting cultivation. In the north-eastern Indian Himalayas, shifting agriculture, or *jhuming*, is a predominant land-use system, supporting 1.6 million tribal people over an area of 426 million hectares. In its typical form of a 20 to 30 years' cycle, *jhum* was a highly bioproductive system, but increased populations and reduced acreage have reduced the *jhum* cycle to four to five years. In the Nagaland State of the N.E. Indian Himalayas, for example, as much as 42 per cent of the land is under shifting cultivation.

In the South Yunnan province of the Chinese Himalayas, swidden farming covered about 90 per cent of *Xishuangbanna* farmland, supporting 48 per cent of its population. However, in recent years, the pressure of increased population, the need for cash crops, and the establishment of conservation parks have prevented these swiddeners from gaining access to sufficient land, resulting in the reduction of fallow periods.

In Bangladesh, *jhuming* (shifting cultivation) is practised by 13 hill tribes living in the Chittagong Hill Tracts. Once, over 95 per cent of the area was covered with dense forests, but, today, apart from the 25 per cent reserve forests, all other areas have been converted into scrubland due to shifting cultivation.

In Myanmar, hill farmers in the States of Kachin, Kayah, Kayin, Chin, and Shan largely depend on swidden farming. Realising the problems associated with shifting cultivation in today's context, the Myanmar Agricultural Services - a government agency responsible for managing and providing agricultural services to the nation - has introduced a programme of sustainable hillside farming.

Regeneration of forests is crucial for the long-term productivity and

Tibetan pastoralists on the move with their yak herds
T. Partap

sustainability of swidden agro-ecosystems, and many swidden groups are no longer able to leave their fields fallow for the necessary period of time. This is not because the link between forests, soils, and productivity is no longer recognised by swiddeners, but because they are in a situation that makes the continuation of forest fallow impossible.

Agropastoral Farming

The agropastoral system is a response and adjustment to many factors of crop farming such as marginal lands, high degrees of slopes, and unfavourable ecological conditions for profitable crop cultivation, etc. In general, there has been an increase in the population of animals during the past decades. One also finds that the composition of animals has changed since 1958. The main increase has been in sheep. Barring a few exceptions, this system is also showing symptoms of decline in both resource conditions and carrying capacity.

Gaps in Technological Research

Sustainable land management would mean combining the technologies, policies, and activities to integrate socioeconomic principles with environmental concerns so as to simultaneously maintain or enhance production/services, reduce the level of production risks, protect the potential of natural resources, and prevent degradation of soil and water quality; and to be economically viable and socially acceptable.

The remedies offered by modern technology to mountain farming, involving a range of improved soil, water, and nutrient management methods, may be capable of producing sufficient yields. What is less certain is whether their use is known in these less favourable areas, whether the needed inputs are available, and whether their use is economic. The value of these technological options to remedy the

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problems of the mountain farmer has either not been wholly proved or is inadequately tested.

Information Gaps

One important issue is the lack of adequate and proper knowledge and information. It is difficult to accept that it is agriculture and the farmer.*per se* that are responsible for the alleged environmental crisis in the hills and mountain. All the soil erosion from the Himalayas is not man-made, and, in fact, a large part of it is natural. The scale of the Himalayas' natural mass wasting is enormous, and the fact is that this process has many other contributing factors besides deforestation, cultivation, and human activity.

Defining Integrated Soil and Water Management Research Priorities for Mountain Areas

The future research agenda for soil water and nutrient management must integrate socioeconomic issues and biophysical processes.

Reversing the above cycle will require an integrated research strategy involving new models, methods, and institutional arrangements significantly different from earlier production approaches. These shifts must incorporate natural resources, develop contingent values, identify ecosystem maintenance activities, include biodiversity management, and deal with complex issues of water recharge.

Natural resource management is complicated technically and managerially for both farmers and scientists. It involves developing systematic relationships in a highly interactive manner. The issue of linkages within sociopolitical hierarchies and the scales of intervention at different levels also cannot be overlooked. Sustainability raises new issues, such as time and spatial dimensions, social hierarchies, and societal vs. individual benefits, and therefore requires new approaches to these problems. Unlike the conventional focus on crop and livestock improvements only, there are increasingly complex social aspects that have to be considered in the context of sustainable development.

An approach to solving problems at the farming system or catchment levels must incorporate the factors of time, hierarchy, benefits, and costs. This implies a participatory research approach involving farmers, policy-makers, and NGOs, besides scientists. Feedback must be provided to the researcher and flow through the whole research chain from adaptive to basic research. The farmer back to farmer paradigm provides a basis for conducting research in this way.

Platforms of negotiation between scientific understanding and local folk knowledge (including that of women) of soil and water management must be constructed.

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Recognition of the importance of organic matter maintenance and the long-term and off-site effects related to sustainability has led to renewed interest in so-called alternative agricultural methods. Maintenance of soil productivity is sought from the use of organic material, the maximisation of biological nitrogen fixation, and the minimisation of nutrient losses - while limiting to a minimum the use of inorganic fertilizers and synthetic pesticides in absolutely necessary circumstances.

The most serious issue concerning soils in the hills and mountains is that many areas have low or very low inherent fertility. Traditional methods of fertility maintenance, which involved the use of trees or animals to allow nutrients to be concentrated on the cultivated areas, are mostly no longer viable, because of the increased demands being made on the land. While recycling of all available organic residues is important, this will not raise the productivity of soils of low inherent nutrient status and fertility. Recycling by itself may not be an avenue of escape from the poverty trap for mountain farmers. Integrated organic/ inorganic management methods will most likely be needed to raise productivity and ensure sustainability.

Much is known about the causes of soil degradation and the negative impacts of degraded systems. However, information on rates of degradation and the regenerative capacity of the system is less well established. This provides a new avenue for research in the quest for sustainability.

Technology alone has little impact at the farm level if the social, political, and institutional contexts of on-farm and off-farm activities are not considered. Applied soil, water, and nutrient management research that does not address issues of gender, social structure, indigenous knowledge, and the functioning of different local institutions is unlikely to have permanent application.

As a final word on research priority for soil and water management for the initial decades of the 21st century, technical research and development efforts in soil and water management will only have long-term impact if local community control of resources and the environment is promoted; income generation and reduction of risk is encouraged; intergenerational equity is sought; national policies do not conflict with sustainability efforts; the land-user has an integral role in the research and development effort; and appropriate attention is given to spatial and temporal issues of mountain watersheds and their communities.

Discussion

A wide range of issues and questions was raised following the presentation. It was noted that the data on soil erosion were based on studies on small plots. Scientifically this is very interesting and important, but, for a broader generalisation of results, more macro-level studies should be undertaken throughout the mountains. This will help to relate soil erosion with agro-ecological zones and other specific factors such as snowmelt, levels of organic matter, deforestation,

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cropping intensity, rainfall, and winds. Different opinions were expressed regarding the role of man and nature in soil erosion. While the authors hinted that man's role is quite limited in highly fragile and dynamic environments, others questioned this view suggesting that the natural process had been the same for ages and it was primarily man's activities that had changed, giving rise to increased soil erosion. The whole issue of population pressure had been overlooked and needed more careful scrutiny.

Another aspect discussed extensively was the role of the farmer in soil erosion. It was pointed out that the management of natural resources by farmers is influenced by many problems and developments in society. Consequently, farmers alone cannot be held responsible for soil erosion problems. The entire society must be responsible for problems of population growth, poverty, lack of institutional support and poor understanding of the changing conditions of natural resources. What needs to be changed are the livelihood conditions of poor farmers living in fragile environments — people need better education and income levels need to be improved through greater productivity. As one speaker put it, we need to improve the nutrition of both the body and the mind to bring about the sustainable development of mountain agriculture. Many other comments emphasised the fact that research on critical issues was only the beginning and in future all agricultural development agencies should devote more resources to developing a better database and understanding needed to cope with these problems.

A pair of bullocks, the backbone of most mountain farming facilities, Uttarakhand, India
Vir Singh