UNEP Environmental Management Guidelines

for

THE INTEGRATED MANAGEMENT OF MOUNTAIN ECOSYSTEMS

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FOREWORD

The purposes of these guidelines are first to provide general background information useful for integrated land/soil management in mountain ecosystems. Second, the guidelines detail key techniques for integrated management stressing protection, conservation and development as well as methods of planning. There is no attempt at a comprehensive treatment rather selected techniques aimed at solving the major problems of environmental and socio-economic degradation. The guidelines are intended to be applicable irrespective of global location and prevalent socio-economic situations and systems. In a sense the guidelines may be regarded as a kind of template in which individual users may locate the problems of their own regions and their concerns.

The main focus is on the integrated management techniques which strive to preserve mountain ecosystems from adverse interventions and abuses, or to rehabilitate degraded systems. There is an emphasis on developing country situations where poverty and environmental problems coexist. The guidelines consider what modes of protection are needed to preserve ecological stability and to promote sustainable development, with an emphasis on erosion prevention/ control and socio-economic measures. There is a section on appropriate methodologies to be used when planning and designing integrated or comprehensive land/soil management and rural and sustainable development projects. The conclusions are presented in a checklist of desirable actions which are logical derivations from the earlier discussions in the text. To make the guidelines more useful a list of relevant literature is appended together with addresses, for further information.

The guidelines are basically for those working on or studying problems of integrated land/soil management in mountain ecosystems including government agencies and officials at all levels from the international to the local, environmental protection services and agencies, social and political organizations concerned with environmental management, interested scientists and students and others. The guidelines may also be of interest to other than mountain ecology specialists who are looking for more appropriate models for environmental management generally. Mountains after all, cannot be divorced from lowlands with which they are in a complex physical and socio-economic interaction, nor can ecology be separated from other disciplines and sectors.

Finally, it is hoped that the local people living in the mountains may refer to this guideline, not least, because of the increasing recognition of the desirability of local participation and self-management.

One function of a document like this is to generate thought, debate and discussion. That process is now underway under Chapter 13 of Agenda 21 and should be encouraged because identifying adoptable methods for husbanding resources in montane areas and sloping lands generally is a major topic to be addressed more forcefully, especially in the context of popular participation. Implementation of Chapter 13 of Agenda 21 would require identification of priorities within montane areas, and more in depth treatment of some of the specific situations and geographical areas.

E Dowdeswell

Elizabeth Dowdeswell
Under Secretary General and
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PREFACE

These guidelines have been prepared as an introduction to the range of environmental factors that need to be taken into consideration when formulating proposals for the development and management of mountain ecosystems, particularly within a developing country situation. They have been written primarily for development planners and subject matter specialists (from government departments, NGOs and donor agencies) responsible for the preparation of natural resource based development proposals within mountain regions. However, it is believed that these guidelines should also be of benefit to those government decision makers with responsibility for formulating mountain development planning and environmental appraisal policies.

These guidelines have been rewritten by Malcolm Douglas, who prepared the original drafts, and have been peer reviewed by Francis Shaxson, Rodney Cheatle and Norman Hudson of the Association for Better Land Husbandry, a non-profit making NGO, registered as a charity in the UK, and with a small operational secretariat located in Nairobi, Kenya. Within UNEP, Mr. A. Ayoub, Chief, Soils and Agriculture Unit, besides being the Programme Officer responsible for the implementation of the UNEP project FP/6101-83-01 from which large part of these Guidelines were extracted, also bore the major brunt of assembling inputs, consultants, and reviewers. We acknowledge with gratitude the contributions received from Centre for International Projects, Moscow, Russia, N. Poushkarov Institute of Soil Science & Agroecology, Bulgaria, FAO, and the International Centre for Integrated Mountain Development, Kathmandu, Nepal, who spent considerable time and effort diligently reviewing and commenting on each draft.

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INTRODUCTION

As much as 10 percent of the world's population - and a much larger percentage of the world's poor - live in mountainous regions. In the global context mountain areas are an important source of water, hydro-electric energy and biological diversity. In addition, at the national level they may provide valuable minerals, forest and agricultural products, and recreation areas. However mountain ecosystems are ecologically fragile and highly vulnerable to human disturbance. Exploitation of mountain resources has led to accelerated soil erosion, landslides and rapid loss of habitat and genetic diversity.

The degradation of mountain ecosystems was one of the issues addressed under Agenda 21 of the United Nations Conference on Environment and Development, in Rio de Janeiro, June 1992. Chapter 13 of the conference report - *Managing Fragile Ecosystems: Sustainable Mountain Development* - put forward two priority programme areas to address the problems of developing fragile mountain ecosystems. These are:

- Generating and strengthening knowledge about the ecology and sustainable development of mountain ecosystems;
- Promoting integrated watershed development and alternative livelihood opportunities.

These guidelines contribute to both of these programmes. They are intended as general guidelines on the issues that need to be considered in order to take account of environmental concerns when designing, appraising, implementing and monitoring development projects and programmes within mountain ecosystems.

These guidelines have drawn extensively on the joint work of the United Nations Environment Programme and the International Centre for Projects of the former USSR and the Government of Bulgaria (FP/6101-83-01), and the International Centre For Integrated Mountain Development (ICIMOD), the World Association of Soil and Water Conservation (WASWC), the International Fund for Agricultural Development (IFAD), the Food and Agriculture Organisation of the United Nations (FAO) and the Overseas Development Administration of the United Kingdom (ODA).

KEY CHARACTERISTICS OF MOUNTAIN ECOSYSTEMS

When seeking to develop sustainable management proposals for mountain ecosystems it is important to recognise that no two mountain areas will have exactly similar bio-physical conditions. Likewise the combination of socio-economic circumstances facing individual mountain communities will be unique to their local area. What this means is that the detailed characteristics of mountain ecosystems, and the ways they are managed can be expected to vary greatly from place to place. As a result any proposals for the development of individual mountain ecosystems must be area specific. That said, it is possible to recognise some key features that would be broadly characteristic of conditions within mountain lands.

a) Mountain ecosystems have distinct bio-physical characteristics:

- **Topography**: Mountain landscapes are extremely variable, and for the most part steeply sloping. They comprise high ridges, plateaux and mountain peaks, separated by deep incised valleys. There is marked altitudinal variation over short horizontal distances.
- **Hydrology**: Mountain regions have high energy river systems with considerable ability to scour soil and transport coarse as well as fine sediment. Steep slopes lead to high rates of surface runoff and high velocity channel flows. Runoff is often seasonal in occurrence associated with the monsoons and/or the melting of winter snows.
- **Geology**: In many mountain areas tectonic uplift is still on-going, such areas being seismically active and prone to earthquakes and volcanic activity. Geological instability and the geomorphological processes involved in the development of mountain landforms can result in high rates of natural erosion and mass movement.
- **Climate**: Mountain environments exhibit a wide variety of micro-climates as both temperature and rainfall can vary significantly depending on altitude and aspect. There is a marked decrease in mean temperature with increasing altitude. High mountain ranges may progress from tropical climatic conditions in the foot slopes to arctic conditions at their peaks. Above certain altitudes the occurrence of regular frosts will limit crop production. The problems of cold may be exacerbated by strong winds. Rainfall usually increases with altitude particularly on the side of a mountain range facing the prevailing rain-bearing winds. On the leeward side rainfall may drop off markedly. Within a mountain ecosystem there may be localised and severe rain shadow effects. Within and across mountain ranges the climate may vary from very humid to desert conditions.

- **Soils:** Montane soils are highly variable. Stony and shallow soils may be common. Where formed from the same parent material the soil type will change in an altitudinal succession. Typically a humic A horizon will increase in thickness and organic matter content with altitude.
- **Vegetation:** In mountain ecosystems there is usually a well-established altitudinal succession of vegetation zones. In the high mountain ranges of tropical and subtropical latitudes, such as the Andes and Himalayas, the succession may progress as follows: woodland/forest ➔ moist/montane forest ➔ bamboo thicket/scrub ➔ montane grassland ➔ loose scree, bare rock and snow & ice.
- **Fauna and Flora:** Whereas the bio-diversity of mountain ecosystems may be limited in terms of the total number of plant and animal species, a high proportion of these will often be endemic to the mountain range and may be restricted to a particular altitudinal and ecological zone.

b) Those people that live in and/or directly make use of the natural resources of mountain ecosystems can be characterised according to their socio-economic circumstances:

- **Isolation:** Historically, due to the nature of the terrain, mountain communities have been comparatively isolated (both from each other and the lowlands) requiring them to be largely self-reliant.
- **Cultural:** Individual mountain communities often exhibit a strong social and cultural cohesion and organisational structure. Mountain regions are commonly home to ethnic minorities that have historically been displaced from the lowlands by more powerful ethnic groups.
- **Political:** Nationally, political and economic power usually lies in the hands of the urban dwellers and commercial farmers of the lowlands. Mountain communities typically suffer from political marginalisation.
- **Economic:** Mountain areas are usually the poorest and least developed regions of a country. Mountain communities are predominantly rural and dependant on agriculture, although forestry, mining and tourism may be locally important. Mountain regions may be regarded as marginal to the national economy as they may have a comparative advantage over the lowlands for only a limited range of agricultural commodities. Mountain agriculture has remained largely a subsistence activity with opportunities for increasing cash income restricted to a small number of commodities that keep well, have high value or are easily transported.
- **Farming systems:** Farming is undertaken by individual households on a small-scale basis. Farm holdings tend to be small and fragmented. Farming systems are largely geared to the production of subsistence food crops.

Individual households may have widely dispersed fields at different altitudes enabling them to exploit differences in growing conditions, not only to produce a wide range of crops but also to spread production over time. In many mountain communities livestock are important for transport and draft power, and for a range of products such as meat, milk, eggs, hides and wool. Mountain farmers generally have access to communal pastures, often on the higher slopes unsuited to crop production. The foothills of mountain areas are typically characterised by crop-dominated farming systems, the upper mountains by livestock-dominated systems, with horticulture and mixed systems dominating the areas in between.

- **Migration:** In recent years improved communications and increasing social mobility has encouraged the outward migration from mountain areas of the able bodied in search of alternative livelihood opportunities. Where this occurs traditional mountain terraces and irrigation systems may fall into disrepair due to a shortage of labour to maintain them. Alternatively, expanding mountain populations and inward migration of settlers from the over-populated lowlands has increased pressure on scarce land resources and subjected fragile ecosystems to the threat of degradation.

c) There is often a distinct policy and institutional environment that will affect the way in which mountain ecosystems are managed:

- **Land alienation:** National concerns with the protection of 'critical' catchments may lead to areas within mountain regions being declared unsuitable for cultivation and grazing and legally reclassified as watershed protection zones or state land. Likewise many countries have a national policy decreeing that all land over a certain percentage slope (e.g. 18%) is legally forest land. The effect of such land alienation policies is to restrict the legal use of mountain areas. The imposition of such policies may render traditional mountain communities illegal squatters in their ancestral lands, contributing to their political and economic marginalisation.
- **Limited institutional support services:** The extension, research and conservation support services for mountain agriculture are usually short of funds and manpower, as governments typically concentrate the bulk of the available resources on the development of agriculture within lowland regions.
- **Conflicting institutional mandates:** Organisational problems related to the integrated management of mountain ecosystems may stem from inappropriate, and often conflicting, mandates of the different development agencies operating in mountain areas. In particular there is often a conflict of interests and legal responsibility over land use within mountain regions between the departments of forestry and agriculture.

Mountain Specificities

From the foregoing review it is clear that there are a number of basic features of the resource base and production environment that can be considered as specific to mountain areas. These have been defined by ICIMOD, and others, as mountain specificities. Particularly important ones are inaccessibility, ecological vulnerability, political and economic marginality, bio-physical and land use diversity, and micro 'niche' opportunities. Traditional mountain communities have adapted their livelihood systems to such specificities. Development interventions or resource-use practices that fail to take account of the constraints and opportunities implied in these will not only be unsuccessful but can be expected to contribute to the processes of land degradation.

THE NATURE OF MOUNTAIN ECOSYSTEM DEGRADATION

Mountain ecosystems will naturally evolve and change over time as a result of such natural processes as leaching and erosion. In areas of undisturbed natural vegetation such changes, within a historical time frame, are generally slow. However, when exploited by man for agricultural, forestry and tourism purposes the natural processes may be accelerated thereby producing, often within only a few years, major adverse changes in the bio-physical properties of a natural mountain ecosystem.

The ability of a mountain ecosystem to support specific land uses is finite. Land mismanagement - whether for crop, livestock or tree production purposes - typically consists of removing too much, returning too little and cultivating, grazing or cutting too often. Such 'mining' of land beyond its limits (i.e. exceeding the regenerative capacity of its soils and vegetation) results in degradation with decreasing productivity, and is non sustainable. For any given mountain ecosystem there are limits on the types of land use that can be pursued on a sustainable basis.

Land Degradation

When a mountain ecosystem is degraded, the productivity of its natural resources is reduced and may continue to decline unless steps are taken to restore the lost productivity and prevent further losses.

The degradation of a mountain ecosystem can be defined as the reduction in the capacity of the land to produce benefits from a particular land use under a specified form of land management. Such a definition embraces not only the bio-physical factor of land capability, but also such socio-economic considerations as the way the land is used and the products wanted from the land (the benefits).

Components of Land Degradation

There are a number of interrelated land degradation components all of which may contribute to a decline in the productivity of a mountain ecosystem. The most important are:

Soil degradation - decline in the productive capacity of the soil as a result of changes in the hydrological, biological, chemical and physical properties of the soil and associated soil erosion.

Vegetation degradation - decline in the quantity and/or quality of the natural biomass, decrease in the vegetative ground cover and lowered capacities for self-regeneration.

Water degradation - decline in the quantity and/or quality of both surface and ground water resources, less infiltration of rain and more surface runoff results in an increased risk of flooding and lower dry season stream flows, and a decrease in groundwater recharge.

THE CAUSES OF DEGRADATION

Land degradation results primarily from inappropriate land use and poor land management - from land being used in a manner incompatible with its bio-physical capability. In mountain areas inappropriate land use and poor management has often, wrongly, been attributed to the laziness and environmental ignorance of the local land users. In reality the root cause will usually be found within the range of economic, social and political pressures, typically outside their control, that force rural households to use the land in the way they do. Rural households rarely deliberately degrade the land resources on which their livelihoods and welfare needs depend.

Natural Factors

The conventional wisdom has been that soil erosion, following the growing of crops and/or grazing of livestock in mountain areas, is the primary cause of high river sediment levels. However, there is a growing body of opinion that believes a considerable proportion of the eroded sediment found in mountain river systems can be attributed to natural causes such as mass wasting (e.g. landslides, mudflows), glacial lake outbursts and various on-going geomorphological processes associated with the shaping of mountain landscapes. Hence, when looking for the cause of degradation within mountain ecosystems, a key question that has to be asked is what proportion of the present erosion and river sediment levels is attributable to on-going natural processes, and what proportion is largely the result of 'accelerated erosion' because of inappropriate land use?

Many mountain areas are characterised by high annual rainfall much of which may fall within a limited portion of the year (the rainy season) and often as isolated heavy storm events. Even with excellent forest cover, mountain soils can become totally saturated during periods of heavy and prolonged rainfall. With high levels of natural runoff within mountain ecosystems, often concentrated into a single channel, flooding associated with high volume stream flows (with the ability to transport large quantities of sediment) is a natural phenomena that can be expected to occur on a periodic basis. It is worth remembering that the flood-plains of the Indo-Gangetic river systems were developed by inundation from forest-covered mountains long before watershed damage by man had become a significant factor.

The management of mountain ecosystems therefore has to recognise that various natural denudation processes are at work even in areas where there has been no human disturbance. Such processes have to be considered as natural hazards, and therefore fixed design constraints when seeking to develop land use management recommendations appropriate to individual mountain ecosystems.

Socio-economic Factors

The nature, extent and risk of land degradation, and the potential sustainable yield of individual crop, tree and livestock enterprises, will ultimately be determined by the bio-physical conditions that prevail within a specific mountain ecosystem. Decisions as to what their land holdings are actually used for, and the management practices to be followed, will however be influenced primarily by the socio-economic circumstances in which individual rural households operate. While current land use enterprises and management practices may accelerate land degradation, technical remedies will only succeed if they can function within, and address, local socio-economic constraints.

In the past too much emphasis has been given to assessing what is happening rather than why it is happening. Priority has wrongly been given to tackling the visual symptoms of land degradation (e.g. soil erosion control, gully plugging, reforestation etc.), whereas the first step should have been to analyze why undesirable land uses and poor management practices were being followed. Attention should be directed to identifying the ultimate cause, which in the case of accelerated (as opposed to natural) erosion, more often than not, will have a socio-economic origin.

Failure to consider the socio-economic dimension may result in the underlying causes of land degradation being overlooked and much time, effort and money spent in dealing with the symptoms of a problem rather than with the problem itself. The integrated management of mountain ecosystems therefore requires that the issue be looked at, not just from a bio-physical perspective, but also in terms of the economic, social and political environment of those directly affected.

Population Growth and Movement

In many mountain areas there is a steadily expanding population leading to increasing pressure on a finite, and often ecologically vulnerable, natural resource base. The problem is exacerbated where population growth is taking place at the same time as the natural resource base on which it depends is shrinking, i.e. where land degradation has already reduced the productivity of the arable, pasture and forest areas.

Demands from an expanding population for land on which to grow subsistence food crops has in many mountain areas resulted in the conversion of forest and pasture land to crop land. Much of the new land opened up for cultivation is on land that, because of steep slopes, shallow soils and high altitude (cold temperatures), is marginal for crop production. Loss of the natural ground cover, the inability of stunted crops to provide adequate cover, and inappropriate tillage practices on steep slopes all contribute to accelerated erosion when lack of alternative land forces individual households to cultivate marginal areas.

Land Tenure

It is clear that if a household does not own in 'perpetuity' the land it farms, but operates on the basis of a tenancy agreement (share cropping, leasehold, etc.), its members will be unwilling to incur short term costs (e.g. labour, foregone benefits) for the sake of benefits that may not be realised until after the terminal date of the agreement. The same holds for households whose legal claim to land is precarious. Recognising the risk of future dispossession, they will disregard conservation benefits that may only be realised after the passage of several years.

In mountain areas where variations in soil type, relief and climate provide different agro-ecological niches for different crops, plots may become highly fragmented on inheritance to ensure each son and/or daughter has access to the same range of agricultural opportunities. In areas of high population density fragmentation may proceed to the extent that individual holdings are no longer large enough to meet a household's basic needs. The need to exploit such small holdings continuously is a significant factor in soil productivity decline in densely populated mountain areas.

The conventional wisdom is that the use and management of communal resources is poor which leads inextricably to land degradation. Certainly in many mountain areas such resources are currently subject to unsustainable pressures, particularly overgrazing of communal montane pastures and excessive removal of timber, poles and fuelwood from communal forests and woodlands. The worst problems are associated with open access resources where any individual who considers practising conservation knows that any gains will be dissipated by increased exploitation by other resource users. Attempts to improve the resource, which may nominally be regarded as government property (public land), are unlikely to succeed without altering its open access status.

Poverty and Economic Disadvantage

Poverty is the underlying cause of much of the land degradation within mountain areas. In most countries the mountain regions are the poorest and least developed. In Peru for example, 40% of the population lives in the mountains but accounts for only 16% of GNP. In the High Atlas Mountains of Morocco, infant mortality is about 50% greater than the national average.

Mountain people in developing countries are predominantly rural. Lack of alternative income generating activities (off- and non-farm) mean that most of these rural households are dependent on small-scale farming and/or forestry activities for their livelihood. The indigenous and migrant population of the mountains are generally very poor and often have a struggle to meet their basic survival needs. As a result they can not afford to forego the chance of short term production (e.g. growing of annual food crops on steep slopes) even when clearly non-sustainable, for the sake of long term conservation benefits (e.g. planting tree crops which may not give any productive returns for several years).

While a range of soil and water conservation and agroforestry technologies have been developed for mountain areas, the implementation of many of these requires substantial investments in labour, time, money and material resources - items that many households do not have. Hence, even when aware of the need to adopt specific sustainable farming practices, socio-economic constraints within their household circumstances prevent them from being in a position to do so. Many current conservation recommendations (e.g. terracing, alley cropping, reforestation) have high initial investment costs when compared to current land uses and the incremental development costs are beyond what many households can absorb. There is generally a lack of spare cash within the household economy and access to low cost credit is generally very limited. Commercial banks, when present, are usually unwilling to lend money to those they perceive as having no collateral with which to secure a loan.

Deforestation

Of concern in many mountain ecosystems has been the loss of the natural protective forest cover (leaf litter, undergrowth, multi-storey canopy, etc). The present widespread deforestation can be attributed to a variety of factors. Many tropical and sub-tropical forests have been subjected to destructive logging (both legal and illegal) to provide timber for domestic consumption and export. Logging has contributed to the opening of new areas for settlement, through road creation (logging trails) and partial clearing of forests. Demands for increased crop production to feed an expanding population has resulted in the conversion of forest areas into farm land. Elsewhere increasing demands for fuelwood, fodder and other forest products has led to the over exploitation, and impoverishment of forest lands.

A major factor in the loss of forest cover and the widespread non-adoption of sustainable forest management practices has been the underpricing, by governments (and in some instances local communities), of the rights to harvest the 'public' forest. This has typically induced excessive logging, and discouraged interest in reforestation or plantation forestry. In addition, there has often been a failure on the part of the licensing authorities to police and enforce any conditions attached to timber licence agreements (such as selective felling and replanting).

Institutional Factors

Development activities within mountain ecosystems are commonly promoted on a narrow institutional and commodity basis. In particular, there is typically a lack of coordination of effort between those agencies involved in forest protection and reforestation activities and those concerned with agricultural development.

In many countries the lead agency with responsibility for the management of mountain areas is the forestry department. While being the right technical agency for dealing with forest management issues, forestry departments usually lack the necessary in-house expertise to provide support to mountain farming communities. On the other hand agricultural development agencies have generally neglected mountain areas in favour of the lowlands which have greater food production potential and are often more densely populated, richer and politically influential.

SECTORAL ENVIRONMENTAL CONCERNS

The following sections highlight the sectoral issues that are likely to be of environmental concern in relation to the present and future management of individual mountain ecosystems.

Mountain Agriculture

All agriculture entails altering the natural environment in order to grow crops for subsistence or commercial purposes. Environmental concerns over crop production in mountain areas may arise in the following cases:

- expansion of cultivation into marginal areas with steeper slopes and shallow soils;
- the migration of lowland farmers into mountain areas;
- the movement of the young and able bodied away from mountain agriculture in search of alternative livelihood opportunities;
- decrease in the fallow period due to increasing land scarcity as a result of population pressure;
- permanent farming displacing shifting cultivation;
- conversion of forests and montane grasslands into crop lands;
- expansion of cash crops at the expense of subsistence food crops;
- use of tractors and power-tillers instead of animal draft power and human labour for land preparation and tillage; and,
- use of high yielding crop varieties and the increased application of agrochemicals (fertiliser, pesticides, herbicides, etc.).

The main environmental impacts can be grouped as follows:

- **Change in ground cover**: Of particular concern is the loss of the natural protective vegetative cover when extensive areas of forest and montane grassland are cleared for cultivation. The growing of annual crops results in much bare soil being exposed at critical periods of the year to the risk of erosion from rain drop splash.
- **Change in soil nutrient status**: In high rainfall areas leaching of nutrients and the 'fixing' of soluble nutrients due to acidification can increase in soils opened up for cultivation. Selective removal, by sheet erosion, of the organic matter and finer soil particles from cultivated soils results in losses of soil nutrients from the topsoil. Significant quantities of nutrients are removed in the harvested products. Some crops may deplete soil nutrient reserves more quickly than others.
- **Change in soil physical condition**: Changes in topsoil structure and/or subsoil compaction following cultivation can reduce root penetration and erosion

resistance. It can also adversely affect soil porosity thereby reducing surface infiltration and increasing the percentage of rainwater that goes as surface runoff.

- **Crop diversification/intensification**: Mountain areas in the tropics have a comparative advantage over the lowlands for the production of temperate fruits and vegetables. These generally require far higher levels of pest control than traditional food crops. Intensification of food crop production involves increased use of agrochemicals. Pesticides, herbicides, chemical fertilizers, etc. which, while they have a positive impact on yields, pose potentially serious negative risks to health and the environment. The introduction of improved seeds or tubers may lead to a loss of genetic resources and diversity as they replace traditional crop varieties. Traditional mountain agriculture is characterised by high crop diversity (species and cultivars) enabling a multitude of elevation related ecological niches to be exploited, and to reduce risk of crop failure in the face of harsh and highly variable climatic conditions.
- **Alterations to natural drainage patterns:** Most farming systems will disrupt and change surface and groundwater flows. Runoff may increase in volume and velocity following the cultivation of sloping land. However, the installation of terraces and other cross slope barriers may increase infiltration and reduce surface flow velocity.
- **Socio-economic effects:** Farming will figure highly in the household economy of most mountain dwellers. Any change, even the introduction of a new crop or tillage practice, may have far reaching effects on farm incomes and division of labour within the household. At the community level existing social and cultural patterns may be significantly altered. Particular strains and stresses are likely where permanent farming replaces shifting cultivation, commercial cash cropping replaces subsistence food production, or a low external input system is converted into one dependent on high levels of purchased inputs.

Livestock

Livestock are important in many mountain areas and generally serve a multipurpose, rather than a commercial function. In particular they:

- are able to convert crop residues into useful outputs (draft power, manure, meat, milk, hides, progeny, etc.);
- can utilise marginal land areas that are unsuitable for sustained crop production e.g. high altitude montane grasslands;
- provide a perennial resource that can be sold or slaughtered on a need basis, in particular, they are a capital resource than cat be called upon in times of hardship; and,
- serve to meet a variety of social purposes and cultural obligations.

Certain livestock species and breeds are well adapted to mountain conditions. For instance, camelids, such as the llama and alpaca, graze in the Andes at altitudes of up to 5,000m, while the yak is widely distributed in mountain and high plateau areas of Tibet and surrounding countries. A variety of other livestock types are traditionally found in the mountains, although many would have originated in the lowlands. Whether they are camelids, equines, yak, cattle, buffalo, sheep, goats, pigs, poultry or other small farmyard animals (rabbits, guinea pigs, etc.) each will have a different effect on the environment depending on their husbandry requirements and grazing habits.

Typical husbandry regimes in the mountains would include:

- intensive stall-feeding on crop residues, cut and carry fodder and occasionally purchased feeds;
- communal free range grazing on an open access, or controlled basis;
- mixed arable/livestock farming - grazing on planted pastures and/or foraging in the crop lands after harvest; and,
- transhumance - movement of animals to exploit seasonally available pastures e.g. use of high altitude grasslands in the summer months.

The main environmental impacts associated with mountain livestock production can be grouped under the following headings:

- **vegetation impact**: Where consumption by livestock exceeds the natural growth of vegetation (i.e. when overgrazing occurs), grazing areas gradually become devoid of plant cover. Over time this imposes a natural check on herd size but at some cost to the environment. It also aggravates the effect of periodic droughts. The effect of over-grazing is selective with species not favoured by the animals progressively taking over. Browsers (e.g. goats) may do considerable damage to young trees. Some grazers (e.g. sheep) will crop pastures so short as to damage the grass roots and prevent regeneration. The burning of pastures, to remove coarse unpalatable material and encourage tender new growth, may result in short term production benefits but long term environmental problems (loss of nutrients, increased runoff, erosion).
- **soil impact**: Losses of vegetation through overgrazing or selective destruction of trees, etc. expose the soil to wind and water erosion, setting a vicious circle in motion leading to further losses in carrying capacity. The effects are particularly marked along mountain trails, where the destruction of vegetation is accompanied by compaction of the soil from the animals' hooves. Livestock manure may be a valuable source of nutrients and organic matter for sustaining crop production, unless a shortage of firewood means that it is burnt as a fuel.

- **socio-economic impact**: Because of their multi-purpose role in the household economy, animals have pride of place in many mountain communities. In some societies they are valued above all other possessions and their number may bestow prestige on their owners. Improved veterinary services may raise livestock numbers, by decreasing mortality rates, but may increase overgrazing. Destocking programmes can jeopardise traditional pastoral survival strategies and typically fail to provide socially and culturally acceptable alternatives that households can use to sustain their prestige, status and livelihoods.

Forestry

Any activity that involves the cutting or planting of forests is almost by definition environmentally sensitive since trees are part of the environment and essential components of many diverse mountain ecosystems. The environmental impact of forestry activities can be discussed under three headings: Deforestation, Afforestation/Reforestation, and Sustainable Management of natural forests. In the following discussion many of the points will be relevant to situations where forests give way to mixed stands of trees and scrub or bamboo thickets.

Deforestation

Loss of tree cover (deforestation) can affect the environment as follows:

- **Soil erosion**: Loss of ground cover (tree canopy and leaf litter) and lack of tree roots to bind the soil can lead to accelerated soil loss, decline in humus and deterioration in soil structure and nutrient status, especially when clear felling results in forest land being converted into crop and/or pasture lands. Where clearance is by burning, these processes may be greatly accelerated. In many tropical mountain areas deforestation followed by over-cultivation has converted forest lands into infertile low productivity *Imperata cylindrica* grasslands with a high erosion risk from uncontrolled fires and overgrazing.
- **Disruption of the hydrological cycle**: Loss of protective vegetative cover results in less rainwater infiltrating into the soil, as a result, runoff volume increases, stream-flows fluctuate between higher and lower extremes, flooding is more frequent and sedimentation increases.
- **Loss of wildlife habitat**: In the case of primary forest, this might mean the irretrievable loss of genetic material (germ plasm) of medicinal, industrial and agricultural value.
- **Climatic change**: In mountain ecosystems where frequent cloud cover occurs at upper elevations, forests can 'capture' moisture by condensation, thereby increasing effective rainfall and the water yield of individual catchments. Loss of forest cover may affect local rainfall, removal of shade may increase day time temperatures.

- **Socio-economic effects:** Local communities may lose a range of wood (timber, poles, charcoal, fuelwood) and non-wood (fruits, nuts, fungi, game, honey, fodder, medicines, etc.) forest products. Firewood gatherers - usually women - have further to travel. This not only affects their labour burden but can cause female malnutrition. For forest dwelling tribal communities, loss of the forest may destroy their traditional livelihood systems and can have profound social, cultural and even religious significance.

Afforestation and Reforestation

Compared with the destruction of forests, planting trees has many positive effects on the environment, but it can have the following adverse effects:

- **Soil erosion:** Tree canopy alone will not protect the soil against erosion, failure to develop and maintain a litter layer and understorey vegetation in woodlots and tree plantations can lead to considerable loss of soil from splash, sheet, rill and, on occasion, gully erosion. At harvest time clear felling, log extraction via skid lines and poorly constructed forest trails can lead to very high sedimentation rates.
- **Decreased water availability:** Planting trees may reduce year round stream flow as forests can intercept more rainfall and evapotranspire more water than other types of vegetation. Also tree roots can penetrate deeper in search of dry season moisture and as a consequence lower ground water levels. This can be a bonus in valley floor sites where fast growing exotic species, with a high water demand, can be used to 'dry out' waterlogged soils enabling them to be used for crop production and settlement.
- **Ecological imbalance:** The introduction of exotic tree species, or changing the balance between existing ones (selective enrichment planting) will alter the ecosystem. Fast growing exotic species with the ability to rapidly revegetate degraded areas may be invasive and suppress the germination and growth of indigenous species. Natural forests are often cut in order to establish uniform plantations at a severe cost to bio-diversity.
- **Loss of communal access rights:** Local communities and their animals may be debarred from land set aside for the development of commercial timber plantations, or have their rights of access severely restricted. Women may be particularly affected by such restrictions.
- **Loss of minor forest products:** Replacing natural forests with monocrop plantations can result in the loss of many minor forest products (rattan, fruit, nuts, fodder, etc.) of value to rural communities.

Sustainable Management of Natural Forests

If natural woodlands, forests and bamboo thickets were to be managed on a sustained yield basis, for the production of timber, fuelwood and poles, then the rate of exploitation of individual species would be in balance with the rate of regrowth. Sustainable management also requires that there be no impairment of any indirect or invisible benefits (catchment protection, bio-diversity, contribution to climatic stability). Likewise the harvesting of minor forest products should also be undertaken on a sustainable basis.

Water Resources

Water is just as much a valued product of the integrated management of mountain ecosystems as the output from crop, livestock and forestry enterprises. Water is important not just for the welfare and livelihood needs of the mountain communities but also many lowland dwellers are dependent on rivers whose main catchment areas lie within mountain regions. In terms of water resources a key environmental concern is whether existing or proposed activities within a mountain ecosystem may adversely affect the quantity and quality of water required to meet the present and future needs of both upstream and downstream consumers.

Environmental concerns over the development and exploitation of mountain water resources can be considered on the basis of the following:

- **Quantity**: inappropriate water use, which may be exacerbated by other degrading land uses, may lead to a decline in the annual water (ground or surface) yield of a catchment as well as seasonal availability.
- **Quality**: Rising use of fertilizers and pesticides can lead to a deterioration in water quality, contamination coming from a range of agrochemicals. There may also be bacterial and chemical contamination from industrial, urban and rural (humans and livestock) sources. Both will affect the quality of downstream irrigation and drinking water supplies. High river sediment levels, as a result of erosion within the catchment area, will also affect water quality.
- **Upstream v. downstream equity**: The over extraction of water at one point in a mountain river system, for agricultural, industrial or urban purposes, may have an adverse impact on the welfare and livelihood needs of downstream agricultural and fishing communities. Many catchment management programmes result in unacceptable costs being imposed on land users in the upper catchment area for the benefit of downstream users of irrigation water, hydro-electricity, etc.
- **Settlement patterns**: Water is one of the most potent locational factors in human settlements, and any alteration in the location or nature (quantity and

quality) of supplies will cause settlements to change and regroup. Hence, the location of a new water point, or a new water distribution network, should be assessed with an eye to the growth of new communities. Unless basic public services are provided, harmful environmental effects may ensue.

Infrastructure Development

The infrastructure developments that are most likely to have an environmental impact within mountain ecosystems are the construction of roads and dams.

Road construction

The construction or improvement of roads in mountain areas can have both direct environmental impacts as a result of construction, as well as secondary impacts as a result of improving access to previously less accessible areas. The former can be mitigated by good design practice. The secondary impacts (e.g. induced development) are more difficult to predict and often the most serious. A new road may accelerate deforestation and loss of wildlife habitat by providing loggers and settlers with direct access into unexploited forest areas. This requires that careful consideration be given to alternative alignments when seeking to provide a new or improved road link between existing mountain communities. However, by providing better access to markets new roads may stimulate a change from annual food crops to higher value (and more conservation-effective) perennial cash crops.

Dam construction

Dam projects are highly complex and can alter the environment in a manner and on a scale that few other construction projects can match. Of particular concern are the following potential environmental impacts:

- **Reduction in river flow downstream:** Retention of water in reservoirs may affect navigation, fishing, cultivation, and drinking water supply.
- **Sediment deposition:** Dams act as sediment traps. Not only may this reduce the dam's long term viability, but may adversely affect the fertility of downstream floodplain soils that formerly depended on the regular deposition of enriched silt.
- **Relocation pressures:** The dam and reservoir will alienate a large area of land. Those previously occupying and farming that land will need to be relocated. Not only may this lead to changes in the socio-economic circumstances of those relocated but could lead to the areas they are moved to being subject to land degradation. Soil erosion, overgrazing and deforestation may be the consequence of poorly planned and implemented relocation programmes.

Tourism

Tourism and the environment have a two-way relationship. Successful tourism capitalises on an attractive environment (e.g. spectacular mountain landscapes), while the environment can be enhanced in the interests of future tourists. Although it is the adverse impact of tourism that is normally highlighted, certain positive impacts should be recognised. The creation of a tourism industry creates a potential vested interest in environmental preservation and control, which in the right hands, enhances the resource that it feeds off.

The following are some of the key environmental concerns related to tourism development in mountain ecosystems:

- **Bio-physical impact**: Soil erosion and trampling of vegetation may occur along much used trekking trails and ski runs. The natural fauna and flora may be put at risk through the collection of plants, poaching and disturbance of animal breeding sites. Discarded cigarettes and camp fires may result in the destruction of vegetation through accidental bush fires. Deforestation may result from increased demand for firewood, building materials and wood for making curios.
- **Pollution**: Tourists may pollute trekking trails and mountain peaks with litter, the remains of camp fires and human waste.
- **Socio-cultural impact**: The impact of affluent tourists, not always on their best behaviour, on a society at a very different level of social and economic development might corrupt moral values, encourage materialism and erode local cultures. Local traditions and ceremonies could be cheapened and trivialised to 'entertain' the tourist.
- **Land alienation**: local people (particularly hunter gatherers, shifting cultivators, pastoralists) may see their livelihoods threatened as areas are reserved for national parks, and the recreational use of tourists. With an influx of lowland entrepreneurs wanting to control and exploit the tourist potential of mountain ecosystems local communities may find themselves, over time, eased off their own land.
- **Economic impact**: Tourism can provide local people with a variety of income generating opportunities e.g. as guides and porters for trekking parties, sales outlets for local handicrafts, and payment for board and lodging. Increased demand for fruit, vegetables and other foodstuffs may stimulate agricultural development. Loss of prime agricultural land to accommodate the expansion of tourist facilities, and higher returns to labour from working in the tourist sector, rather than practising mountain agriculture, could lead to a decline in agricultural production.

Bio-diversity

Bio-diversity in the context of mountain ecosystems refers to the variety and variability among living organisms and the ecological complexes in which they occur. The natural habitats that contain a significant portion of this diversity are rapidly disappearing, prompting international concern for its conservation. Bio-diversity is also represented in the genetic diversity of agricultural crop varieties and domestic livestock species, found in many mountain regions. Bio-diversity is being reduced as a consequence of the destruction of natural habitats resulting from the pursuit of forestry, agricultural, livestock, industrial and urban development activities. There has also been a loss of bio-diversity associated with the introduction of a limited range of high yielding 'green revolution' crop varieties and so-called improved livestock breeds into diverse traditional farming systems.

DEVELOPMENT APPROACHES

The last 20-30 years has seen considerable investment of financial and human resources into soil conservation programmes within mountain areas, usually in the form of watershed management or upland development programmes. The return on this investment has generally been poor.

Top-down Physical Planning

To date most soil conservation and catchment management projects and programmes have been prepared using a top down physical planning approach. Typically this involves outside experts classifying the different land units within a mountain ecosystem according to their bio-physical capability. Land use plans are then formulated using the information gathered on the prevailing land capability classes. Such plans detail what are considered to be the most suitable land uses, and land management practices, according to their technical potential to reduce and/ or control soil erosion. The end result has often been inflexible projects and programmes, with a heavy emphasis on engineering and reforestation solutions. Where mountain development programmes have an agricultural improvement component, typically farmers have been offered one conservation package (e.g. bench terracing, or alley cropping) rather than a choice of alternative conservation effective practices from which to choose those that match their particular needs and circumstances.

With top down planning the target beneficiaries are largely passive recipients of externally conceived development proposals. All too often, the end result is a lack of enthusiasm for project implementation by the intended beneficiaries, and poor establishment and maintenance of the physical structures, hedgerows and woodlots promoted. Participation where it has occurred, has typically been a case of the professionals gather data, analyze it, prepare plans, and then ask the local community if they agree, before requesting mobilization of local resources (notably labour) to implement these plans. Farmers, and other land users, have to date had limited opportunity to be actively involved in the development and decision-making processes inherent in the management of mountain ecosystems, and even less in policy formulation.

Farmer First Development Approach

An alternative development approach is needed for the management of mountain ecosystems in order to counter the mistakes inherent in 'top-down' development. Instead of starting with the knowledge, problems, analysis and priorities of the development specialists, the need is to start with the knowledge, problems, analysis and priorities of the mountain communities. One such approach that is gaining increasing attention in international development circles is that popularly known as the 'Farmer First' approach. The main objective of the farmer first approach has been described as "not to transfer known technology, but to empower farmers to learn adapt and do better; analysis is not by outsiders - scientists, extensionists, or NGO workers - on their own but by farmers assisted by outsiders; what is transferred by outsiders to farmers is not precepts but principles, not messages but methods, not a package of practices to be adopted but a basket of choices from which to select."

From Soil Conservation to Land Husbandry

The integrated management of mountain ecosystems also requires a change of development focus away from soil conservation per se to what has been termed land husbandry. The concept of husbandry is widely understood when applied to crops and animals. As a concept signifying understanding, management and improvement, it is equally applicable to land. To quote from *Land Husbandry, A Framework for Soil and Water Conservation* (Shaxson et al. 1989) the "primary objective of land management should be improved, sustainable production through good land husbandry. Control of soil erosion follows as a consequence. This is a reversal of the previous idea that it is necessary to conserve the soil in order to get better crops."

Land husbandry involves the following:

- understanding the characteristics, potentials and limitations of different types of plants (crop, tree and pasture species), animals and lands;
- predicting the likely positive or negative effects on their productive potentials resulting from a given change in management, or when exposed to stress (regular and predictable constraints) or perturbation (severe irregular adverse events);
- designing resilient and flexible land use systems that can overcome the negative effects of changing circumstances and critical events;
- adopting financially viable (cost effective) systems of management that maintain and enhance their productivity and usefulness over time; and,
- recognition of the active and central role of the land user (farmer, forester, shepherd, etc.) as steward and manager of the resource.

In mountain ecosystems, land husbandry is concerned not just with the care and management of the croplands, but also the forest and pasture areas. In croplands good land husbandry involves the development of conservation effective farming systems that conserve soil as a consequence of improved crop management (increasing ground cover), improved soil management (increasing organic matter levels and erosion resistance) and improved rainwater management (reducing erosivity, increasing infiltration and decreasing surface flow velocity). Soil conservation follows from practices that have direct production benefits to farmers.

In forest areas, good land husbandry involves the maintenance of good ground cover (especially that provided by surface litter) through improved forest management. Depending on the local circumstances forest management may involve total protection (to maintain bio-diversity reserves, or to protect critical water resources), selective logging, reforestation and the development of commercial fuelwood and timber plantations. In pasture areas, good land husbandry is not just concerned with maintaining a continuous sward of grasses but also ensuring the dominance of palatable species within the pasture. This requires the development of improved pasture management systems for natural montane grasslands and, where appropriate, specially planted pastures.

Need to Shift the Emphasis

The management of mountain ecosystems requires a shift in emphasis away from top down physical planning by outside technical experts to bottom up participatory planning with the rural communities taking centre stage in the appraisal and planning process. What is needed is a shift:

From priority given to reducing downstream sedimentation (concern with the off-site costs and benefits).	**To** priority given to improving land husbandry in situ (concern with the on-site costs and benefits).
From assessing land capability according to the bio-physical properties of the land.	**To** characterising, and understanding, the socio-economic circumstances of the different land user groups.
From ensuring catchment protection through increased regulation and restriction on land use activities.	**To** an increasing emphasis on lifting local constraints to enable mountain communities to manage their land resources (soil, water and vegetation) in a productive and sustainable manner.
From conserving soil and water by physical structures.	**To** water management and enhancing soil productivity by improved agronomic and silvicultural practices.
From a single-sector approach (e.g. forestry or agriculture) to project design.	**To** a multi-sectoral and inter-disciplinary effort (e.g. developing integrated farming systems combining crop, livestock & tree production).

From top-down physical planning solely within the topographic boundaries of a watershed.	**To** bottom-up participatory planning in conformity with catchment management principles but within the cultural, administrative and political boundaries of mountain communities.
From starting with the knowledge and technologies for soil and water management of professionals.	**To** starting with the knowledge and existing technologies of farmers and other resource users.
From professionals lecturing, promoting their ideas and retaining control of the development agenda.	**To** professionals listening and learning, encouraging rural land users to express their ideas, and handing over to them control of the development agenda.
From data collection and analysis, and planning primarily by professionals.	**To** incorporating data presentation, analysis and planning by mountain communities, with professionals as facilitators (community consultants).
From extracting information from mountain communities using standardized questionnaire surveys.	**To** an array of participatory methods of learning from, with, and by mountain communities.
From identifying priority needs and options by professionals.	**To** the identification and selection of priorities by mountain communities, with assistance from outside technical expertise.
From blanket recommendations centrally determined and disseminated.	**To** an à la carte menu of demonstrated practices offered to farmers, foresters and herders for them to test, evaluate, and select those deemed appropriate to their needs and circumstances.
From technology development by research scientists on-station (predominantly in the lowlands).	**To** participatory technology development that enables farmers to build on indigenous soil and water conservation practices with the technical support of researchers based in the mountains.

Rapid Rural Appraisal and Participatory Rural Appraisal

Participatory planning relies heavily on the use of rapid rural appraisal (RRA) and participatory rural appraisal (PRA) techniques. A variety of RRA techniques have been developed that can be used to identify and analyze the circumstances of mountain communities, diagnose their problems and design conservation orientated solutions. With RRA, the analysis and identification of solutions is still primarily done by the experts. It is bottom-up in the sense that it is based on detailed discussions with the target land users, but it is still largely appraisal by outsiders.

RRA has been used to elicit a range and quality of information and insights inaccessible with more traditional methods, not only for farming systems development but also for a range of other social and rural development issues. Experience from a number of countries has shown that RRA is a cost effective way of obtaining relevant information on rural household circumstances. It is believed to be an effective tool for quickly characterising the circumstances of rural households engaged in small-scale farming and/or forestry activities within mountain areas.

RRA has recently evolved into the approach termed participatory rural appraisal (PRA). RRA has been described as mainly extractive, whereas PRA in contrast is participatory. With RRA outside professionals go to rural areas obtain information and then bring it away to process and analyze. With PRA outside professionals still go to rural areas, but their role is more to facilitate the collection, presentation and analysis of information by rural people themselves.

A Multi-sectoral and Inter-disciplinary Approach

It is clear that while the processes that degrade the land are bio-physical the causes will often be a product of the socio-economic and political circumstances in which the land is used. Tackling land degradation therefore requires the involvement of a range of disciplinary specialists (both natural and social sciences). The consequences of land degradation will be of concern not only to those agencies with direct responsibility for the management of mountain ecosystems, but also to a wide range of other government and non-government organisations involved in rural development issues within mountain regions.

The implications are that the management of mountain ecosystems requires an integrated and multi-sectoral development approach. While the Departments of Agriculture and Forestry, can be expected to be the lead technical agents in a mountain development programme, agencies in many other sectors may have to be actively involved (e.g. public works, finance, law, etc.), yet more may have an interest in the outcome (e.g. health, industry, energy, etc.). Practical difficulties may arise in coordinating the activities of different government departments, bureaus and agencies, all with different sectoral concerns, priorities and work programmes.

It is now generally recognised that planning teams involved in catchment management should contain specialists with different disciplinary backgrounds.

Typically such teams have included an economist, an agronomist, and a forester. Depending on the area and its development potential the team may include one or more specialists in livestock, irrigation, soil conservation, marketing, etc. These days they may include a sociologist, in belated recognition of the need to 'consult' the beneficiaries. Most such planning teams follow what can be described as a multi-disciplinary approach.

What is needed is an inter-disciplinary rather than multi-disciplinary approach. The two terms are often wrongly assumed to mean the same thing. In practice they represent different development approaches. Although a multi-disciplinary approach involves the active participation of a number of different disciplinary specialists, it is categorised by the fact that each specialist largely plans, executes and evaluates separately his/her component of an overall programme.

While an inter-disciplinary team will contain a similar range of disciplinary expertise as a multi-disciplinary one, the major difference is that all of the team members work together to mutually plan, execute and evaluate a programme. The emphasis is on promoting disciplinary interaction with each member contributing to a common analysis from his/her own technical perspective. When formulating mountain development programmes the aim is to arrive initially at a consensus understanding of the circumstances (bio-physical and socio-economic) of the mountain communities. The inter-disciplinary interaction then continues into the development and appraisal of improved land uses and farm management practices, as well as the planning of any project interventions required to assist their adoption.

Alternative and Complementary Development Thrusts

It is possible to recognise three distinct, but interrelated strategies, or development thrusts, that can be followed in the management of mountain ecosystems, namely:

- **Prevention Thrust**
- **Policy Thrust**
- **Corrective Thrust**

Prevention Thrust

The priority must be to protect and sustain the productive capacity of land not yet degraded. This calls for a prevention thrust approach where the strategy is one of preventing land degradation from occurring by enabling farm households (and other mountain land users) to adopt land use enterprises, field level technologies and farm or forestry management practices that yield short-term production benefits (i.e. are financially attractive) while being conservation effective (i.e.

maintain or enhance productivity). The prevention thrust approach is based on the assumption that it is technically possible to use land productively to meet the present generation's short-term needs, while at least sustaining the land's long-term productivity for use by future generations.

The prevention thrust approach involves the following:

- The selection of land use enterprises whose physiological, management and conservation requirements match the characteristics (land qualities) of the mountain ecosystem in which they will be undertaken.
- The identification, development and dissemination of conservation effective production technologies - ideally ones that have a positive short term production impact (are financially attractive) and both a short and long run conservation pay off (environmentally sustainable).
- As a minimum, the prior screening of all potential technologies to ensure, to the extent possible, that their adoption will have no negative environmental impact (i.e. they should be at worst conservation neutral rather than conservation negative).

Policy Thrust

There is more to solving the problems of land degradation than just the development of improved technical recommendations. The underlying cause is often a failure in government policy and/or the institutions set up to effect the policy. It is here, with sufficient political will, that the greatest advances could be made in promoting improved mountain eco-system management. All that may be needed is a change in government policy (e.g. over land tenure rights, or crop pricing and marketing) or the effective implementation of existing policies and strategies so as to create the right policy environment for the adoption of improved conservation farming/ forestry practices at the field level.

As a general rule the land use practices of individual farm households are strongly influenced by the policy environment in which they operate. Also the way in which specific national policies are executed may be contributory factors to low farm/ forestry productivity and land degradation at the local level. Given their position within the government hierarchy, those technically responsible for land use planning at the local level will neither be able to change existing government policies directly nor introduce new ones. Likewise the ability of community leaders to modify the wider policy environment with regard to its impact within their community is usually very limited. While recognising these institutional limitations the policy thrust approach believes that those involved in participatory planning have a responsibility to identify areas where there is a need for policy changes and to, either advise on how existing policies could be modified, or to formulate recommendations for new ones. Such policy recommendations can then be forwarded to the relevant senior decision makers for their consideration and, hopefully, action.

The fact that villagers and government planners working at the community level cannot themselves change national policies should not deter them from notifying those who can that there is a need to do so. If policy makers are not advised of the need for change they are unlikely to initiate change themselves.

Scope may exist for developing local policy interventions within the broader national policy environment in order to tackle specific local land use problems. For instance, participatory planning could lead to individual mountain communities formulating their own local land use bye-laws with the rules and regulations agreed on and policed by the community. In this way any punishments imposed for their infringement will conform to the community's social and cultural norms.

Experience suggests that an approach with a policy thrust will be required as a key element in most (if not all) programmes intending to promote better land husbandry in mountain areas. A policy thrust approach can be important not only in preventing land degradation arising in the first place but also in helping to stop it, once it has developed. It involves designing and implementing policies that:

- Eliminate possible conflicts between policies designed to promote short-run production and those designed to encourage long-run sustainability (conservation);
- Acknowledge, and to the extent possible accommodate, the diverse perspectives and development priorities of the different interest groups (e.g. individual farm households, mountain communities, and urban dwellers, and the government or society as a whole);
- Avoid inequitable development within individual catchments, i.e. policies designed to promote catchment protection should not impose unacceptable social and economic costs on upstream farming communities for the primary benefit of those downstream (users of irrigation water, hydro-electricity consumers, etc.);
- Enable individual farm households and mountain communities to take responsibility for sustainably managing the natural resources at their disposal. This to be achieved through the passing of appropriate enabling (rather than coercive enforcement) legislation and the adoption of a participatory appraisal and planning approach to agricultural/forestry development.; and,

- Positively encourage, via appropriate incentives, adoption of strategies that conserve the environment for use by future generations. In the context of the policy environment in which farmers operate, the ideal incentive should be tangible short term production benefits (e.g. higher crop yields, reduced input costs, increased production of fodder and fuel). The conventional approach has been to go for policies that involve offering financial incentives such as cash payments, food for work or free farm inputs. If the Government revenue budget cannot sustain such payments post-project (as is typically the case) then such incentives cannot be considered appropriate.

Consideration of the above will be important in preventing land degradation from developing and in promoting good land-use management through the adoption of appropriate farm/land use enterprises and technologies. The last point, with its emphasis on incentives may be important when it is necessary to correct degradation (particularly soil erosion) that has already developed.

Corrective Thrust

Whereas the ideal is to prevent land degradation from occurring in the first place, in many mountain areas the processes of degradation following misuse of the land will already have had an adverse impact on the on-site soil productivity and downstream sedimentation. It then becomes necessary to consider adopting a corrective thrust strategy where the primary emphasis is to correct the current non-sustainable situation. This to be done by removing the underlying causes, adopting improved practices designed to stop further degradation, and where appropriate taking specific measures with the intention of restoring the land to a productive condition. Where it is necessary to adopt a corrective thrust approach, following a participatory planning approach will ensure that it is the community that takes the decision to adopt corrective measures, rather than having these imposed by an external planning team. Participatory planning will also facilitate communal conservation activities, where correcting existing degradation requires action at a level wider than the individual farm holding (e.g. catchment rather than farm planning).

The corrective thrust strategy has some parallels with the past physical planning approach to catchment management in that it may involve:

- The use of physical structures and other cross-slope barriers to control runoff and prevent further soil loss. The literature abounds with detailed information on various types of physical structures to combat erosion. In recent years this has expanded to include a range of vegetative techniques that are proving more acceptable to farmers in that, in addition to controlling surface runoff, and/or stabilising gullies, they can offer direct production benefits (e.g. provide fodder, green manure, fuel, etc.);

- The rehabilitation of severely degraded land by mechanical means (e.g. gully plugs and check dams) and the reforestation of devegetated areas; and,
- In a worst case scenario, the 'closing' of severely degraded areas, relying on the self regenerating capacity of the soil, over time, to restore the land to a condition where, with improved management, it could again be used for productive purposes.

Where cost effective, the corrective thrust could also involve:

- The planting of pasture leys, contour hedgerows of leguminous shrubs, and other forms of improved fallows to restore topsoil structure and raise soil organic matter levels;
- The application of large quantities of organic manure and smaller amounts of chemical fertiliser to improve the chemical properties of degraded soils (altering pH, correcting nutrient deficiencies particularly of trace elements); and,
- The use of civil engineering measures (e.g. spur dykes, revetments, silt retention dams, etc.) to reduce stream bank erosion and exclude sediment from downstream irrigation works.

To be successful any recommendations arising out of the adoption of a corrective thrust approach must be based on an understanding of the underlying causes of the land degradation (which may be due to the socio-economic circumstances of the land users rather than the bio-physical properties of the land). The major failing of the conventional top-down physical planning approach was to ignore the cause and merely treat the visible symptoms of degradation.

Strategy Linkages

The above categorisation of the key strategies is simplistic because the three thrusts are not necessarily mutually exclusive. For example, policies can help or hinder either the use of appropriate land use management practices to prevent land degradation, or the development of suitable corrective measures. Also, in areas where some degradation has occurred the need may be for immediate corrective measures, backed up with appropriate preventative measures to maintain and enhance the land's productive potential. Consequently, a combination of the three strategies is likely to be required for the effective management of mountain ecosystems. Each situation will be different hence the key to success will depend on recognising what the primary emphasis should be for a particular project or programme, and in getting the correct balance between the different thrusts.

ENVIRONMENTAL APPRAISAL

All proposals for implementing development activities within mountain ecosystems should be screened at the outset to determine whether they should be subjected to detailed environmental appraisal and, if necessary, a full environmental impact assessment. Environmental factors need to be taken into consideration from the earliest stage of a project and followed through all stages - from identification, design, implementation and monitoring through to evaluation. Primary responsibility for taking account of the environment rests with those designing the project. At the project appraisal stage environmental factors should be part of an interdisciplinary appraisal that embraces the full spectrum of economic, social, cultural, political, ecological, legal and technical issues. Those involved in project implementation and monitoring are likewise responsible for ensuring that environmental concerns are adequately addressed both during and post project. Project and programme proposals in which the environmental or social concerns have been dealt with inadequately, or are thought likely to have unacceptable environmental or social costs should be identified, and rejected, before they reach the funding and implementation stage.

Initial Screening

An initial environmental screening of a development proposal should be undertaken at the project idea or identification stage, when it is easiest and least costly to expand, reject or substantially modify a proposal. This initial screening is intended to highlight any significant environmental impacts. It involves viewing the proposal from four main standpoints:

- What kind of area will it be located in?
- What sort of development is being proposed?
- How could it affect the environment? and,
- How serious could the impact be?

Note the more times a proposal registers according to the following checklists of potentially significant impacts the more substantial should be its subsequent environmental appraisal.

What Kind of Area?

Given the steep slopes and ecologically fragile nature of most mountain ecosystems development activities in mountainous areas can be expected to require special attention with regard to their potential environmental impact. Within mountain regions development proposals within, or affecting, the following areas will require even more close attention:

- tropical, sub-tropical and montane natural woodlands and forest (especially primary forest);
- habitats providing important resources for vulnerable groups (e.g. indigenous or tribal peoples);
- national parks, nature reserves, all other conservation areas, and the areas immediately bordering on them;
- areas containing endangered species of fauna and flora, or high concentrations of bio-diversity; and,
- areas of unique historic, archaeological or scientific interest.

What Sort of Development?

Among the main categories of project proposals with a significant impact on the environment in mountain areas are the following:

- important policy initiatives likely to affect the environment e.g. changes in agricultural subsidies, modifying the conditions for granting timber licences, deregulation of the tourism sector;
- major changes in land tenure;
- major changes in land use and exploitation of renewable natural resources e.g. logging in primary forests, establishment of tree plantations, conversion of forests and/or montane pastures to crop land, opening virgin areas to settlement, changes in farming practices and introduction or intensification of pesticide and fertilizer use;
- substantial changes in water resource use e.g. river basin management, damming water courses, river flow extraction/diversion;
- major infrastructure development e.g. dams and hydropower development, road construction;
- non-renewable resource use e.g. rock quarrying, sand and gravel extraction, mining of mineral deposits; and,
- industrial processes that may contaminate air, soil and water with toxic and hazardous waste and by-products e.g. paper and pulp mills, mining and smelting installations, and leather tanneries.

How Could it Affect the Environment?

The repercussions of development on the environment in mountain areas can be grouped as follows:

- **Socio-economic impact**: Falling living standards, particularly of the poor, could precipitate a further vicious downward spiral of environmental degradation as they exploit the land to meet their immediate survival needs. Living and working conditions may deteriorate as a result of resettlement, cultural shock, loss of traditional livelihood systems, and risk to health and safety. Impacts may vary between men and women, or between different social groups, especially where property rights to land and other natural resources are so differentiated;

- **Land degradation**: Deforestation, soil erosion, overgrazing, sedimentation are some of the danger signs;
- **Water pollution**: This can result from uncontrolled sewage discharge from human settlements, effluent from local industries, contamination from agricultural and forestry chemicals, etc.;
- **Air pollution**: May locally be a problem in urban settlements, and in the vicinity of industrial processors;
- **Damage to wildlife**: The impoverishment of fauna and flora by loss of habitat, bio-diversity, and/or individual species, or genetic erosion of economically or scientifically important groups;
- **Cultural, historic and scientific** losses. Damage to sites of cultural, historic and/or scientific importance;
- **Climate**: adverse changes especially of the hydrological cycle; and,
- **Beneficial aspects**: Development may be beneficial, e.g. reduce pressure on natural resources, restore and protect key areas, and prevent soil erosion and floods.

How Serious Could the Impact Be?

The main factors to take into account in mountain areas are:

- Would the impact be positive, mainly benign or harmful?
- What would be the scale of the impact, in terms of area affected (on- and off-site), numbers of people or animals, etc?
- What would be the expected intensity of the impact?
- What would be the duration of the impact? Effects may be delayed.
- Would the impact be cumulative?
- Are the effects likely to be irreversible?
- How certain or uncertain are the effects (what level of confidence is there in forecasting these effects)?
- Are the effects politically controversial?
- Are any laws, conventions, regulations, or directives infringed?
- Have the main economic, social and ecological costs been quantified?
- Would the effects have a different impact on men and women, or on particular social groups?
- Would the project have an indirect impact on the economic, social and ecological conditions of the area? and,
- Are there investments, policy changes or management initiatives which could reduce any adverse environmental impact?

Environmental Appraisal Tasks

Where the initial screening indicates that there is potential cause for concern then the proposals would need to be subjected to a more detailed environmental appraisal. This appraisal should:

- focus on the main areas of potential environmental sensitivity touched on by the proposal (i.e. those identified during the initial screening) and assess how far the proposal impinges on these and any other concerns;
- identify what the main impacts of the proposal are likely to be and the linkages with the ecological and human systems affected;
- determine the main benefits and costs (damage) to the environment;
- assess the importance of these effects (including indirect and long term effects and externalities) by, where possible, quantifying and attaching economic or monetary values to them, or by applying objective judgements about their severity. This analysis should involve the mountain communities, take account of qualitative as well as quantitative parameters, and consider the impact according to social group and gender;
- consider whether more can, or should, be done to prevent or mitigate any or all of the effects;
- identify where such action is required e.g. at the field level (technical changes in land use or management practice), at the community/village level (changes in the community organisation and structure, education, information), and at the government level (changes in national policy and the mandate and operation of institutional support services);
- analyze the implications of such actions on the economic, financial and technical viability of the proposal, the timing of its start and the impact on public finances; and,
- come to a judgement on the overall result of the environmental appraisal i.e. can the proposal proceed as formulated, does it require modification and reappraisal before implementation, or should it be rejected outright as environmentally unacceptable?

Full Environmental Impact Assessments

A full Environmental Impact Assessment (EIA) is a process of systematic study used to predict the environmental consequences of a proposed major development activity. Its aim is to ensure that potential risks are foreseen and necessary measures to avoid, mitigate or compensate for environmental damage are identified and costed. In some cases (e.g. dam development) a full EIA would normally be undertaken as part of the decision-making process. Also, in many countries an EIA is a legal requirement before certain categories of development proposals can be approved, for instance large scale power generation, major industrial developments, airports and mineral extraction activities.

A full EIA would need to be commissioned where:

- certain highly sensitive cases are identified following the initial screening;
- the type of development proposed requires an EIA by law; or,
- after an environmental appraisal, the impact is considered large, potentially damaging, or uncertain.

Organisation

If a full EIA is deemed necessary the next step is organisation of the EIA study. This entails:

- commissioning an independent co-ordinator and inter-disciplinary expert study team (the disciplines to be decided at the scoping stage);
- identifying the client i.e. who the EIA is for - the key decision-makers responsible for planning, financing, authorising and controlling the proposed project;
- identifying and reviewing laws and regulations that will affect these decisions;
- establishing contact with each of the key decision-makers; and,
- determining how and when the EIA's findings will be communicated.

Scoping

The first task of the EIA study team is 'scoping' the EIA. The aim of the scoping is to identify the most significant environmental issues, the timing and extent of the analysis required, the type and sources of expertise, how to gather the data and where from. The scoping process can benefit the EIA by identifying the significant environmental issues and the most important consequences of the proposal early on to avoid delay and additional cost at later stages.

The EIA Study

The EIA study involves five basic tasks, namely:

- **Identification**: to identify and assess the effect of the project with regard to its likely environmental impacts - *What would happen as a result of the project?*
- **Prediction**: to predict and characterise the impacts' causes and effects, and their secondary and synergistic consequences for the environment and the local community - *What would be the extent of the changes?*
- **Evaluation**: to evaluate the predicted adverse impacts to determine whether they are significant enough to require mitigation - *Do the changes matter?*

- **Mitigation:** to analyze the situation and determine what (if any) measures can be proposed to prevent, reduce, remedy or compensate for each of the adverse impacts 'evaluated' as significant - *What could be done about them?*
- **Documentation:** to document the study and present its conclusions in a form that is readily comprehensible to those responsible for deciding whether the project should proceed to funding and implementation - *How could decision-makers be informed of what needs to be done?*

DESIGN CONSIDERATIONS

There are a wide range of design considerations that will need to be taken into account when formulating proposals for the integrated management of mountain ecosystems. These will vary depending on the sectoral nature of the particular proposal and will embrace a variety of different policy, technological and institutional factors.

Agricultural Development

Mountain farmers have typically exhibited a high degree of adaptability and managerial capability in response to the specific constraints and opportunities found in mountain areas. Agricultural development proposals should thus start from the indigenous agricultural knowledge of mountain farming communities, the bio-diversity of their existing farming systems, and the variety of agro-ecological niches exploited. The development of new and improved technologies for mountain agriculture will require:

- knowledge of the farmers' bio-physical and socio-economic constraints and opportunities so as to identify their location-specific problems;
- participatory appraisal and technology development mechanisms to provide effective involvement of, and feedback from, farmers and extension workers;
- assessment of technologies in the context of the limited resource base of mountain farmers;
- the conduct of location-specific technology verification;
- inter-disciplinary (natural and social sciences) co-operation in the design of research trials and assessment of the results;
- careful selection of technologies to ensure that they are both productive and conservation-effective;
- subsequent monitoring of the impact of technologies on household income and the environment; and,
- respect for, and building upon, indigenous knowledge and resource use.

Farmers rarely adopt complete technological packages, rather they tend to select from an array of recommended technologies and practices those perceived as most appropriate to the conditions in which they operate. Mountain agricultural development projects should therefore aim to provide farmers with the basic principles (e.g. contour planting, use of hedge rows and other cross slope barriers, rotations, ground cover, etc.), offer a range of locally appropriate options that match different agro-ecological niches (e.g. several alternatives rather than a single recommended practice), and provide the necessary support services (nurseries, credit, technical advice, etc.). Farmers are then free to choose and experiment and in so doing put together their own farming package based on their individual needs. Technologies intended to improve mountain agriculture should ideally be:

- **simple** - be readily demonstrated to, and understood and implemented by farmers;
- **low cost** - be within the financial reach of farmers, have limited labour requirements and require no foregone benefits (e.g. land taken out of production);
- **productive** - lead to substantially increased benefits some 50-100% better than existing practices (i.e. higher crop yields, increased fuelwood, guaranteed fodder supplies), preferably within the first year of adoption;
- **maintainable** - requiring, annually, limited effort or purchased inputs to maintain;
- **low risk** - non susceptible to climatic variations (drought or waterlogging) or market fluctuations (supply exceeding demand);
- **flexible** - leave scope for future developments (a cereal variety can be changed after one season but a decision to plant a long lived perennial tree crop is not so easily reversed); and,
- **conservation effective** - contribute to the maintenance of soil productivity (e.g. increase ground cover and soil organic matter levels, improve surface infiltration, reduce runoff, prevent surface movement).

In addition to the above points the following are key design considerations with regard to agricultural development in mountain ecosystems:

- Can existing agricultural practices meet the immediate demand for more food from an increasing population without causing non-sustainable exploitation of the natural resources?
- Have the technologies been validated under conditions that correspond to the specificity and diversity of mountain agriculture locations (most agricultural research trials and stations are located in lowland areas)?
- Do technologies exist for improving crop and livestock production in mountain areas? Little if any R&D work has so far gone into the improvement of the indigenous crop varieties and livestock breeds traditionally raised in mountain regions.
- Can low external input farming systems meet the welfare needs of the mountain communities, or does food security require greater use of purchased inputs (improved seed, fertiliser, pesticides, etc.)?
- Do farmers have access to adequate amounts of organic matter (livestock manure, compost and/or green manures) to maintain their soils in a productive condition?

- Is any expansion of horticultural production likely to contribute to deforestation e.g. increased demand for wood for making fruit boxes or wooden stakes for supporting vegetable plants?

Tree Planting Programmes

Tree planting programmes may involve farmers integrating trees into their crop and livestock production systems (agroforestry), the establishment of woodlots on an individual or community basis (social forestry), or as a large scale reforestation exercise (plantation forestry).

Agroforestry

Agroforestry is a collective name for land use systems where woody perennials (trees, shrubs, bamboos, etc., are deliberately grown on the same area of land as used for the production of agricultural crops and/or animals. This can be either in some form of spatial arrangement or in a time sequence. To qualify as agroforestry, a given land use system must permit significant economic and ecological interactions between the woody and non-woody components.

The term agroforestry covers a large number of separate land use practices involving a wide range of different woody species, crops and/or livestock. These may be traditional land use practices or research derived technologies. There is no one practice that can be termed agroforestry. Hence, it is a mistake to specify agroforestry as a component of an integrated mountain ecosystem management plan without making it clear as to what is actually involved. The following design issues will need to be considered when selecting an agroforestry option:

- what specific agroforestry practices to adopt;
- which tree species, crop varieties, and/or livestock breeds will make up the component parts;
- what are the input requirements e.g. labour, fertilizer, seed and seedlings;
- what management practices need to be followed, e.g. silvicultural, crop, animal and land husbandry practices, particularly if different to the way each component would be managed separately;
- what are the expected production levels e.g. quantity of firewood, fodder, green manure, crop yields, livestock carrying capacity, etc.;
- what are the conservation benefits e.g. runoff reduction, improved ground cover and raised soil organic matter levels; and,
- how does it fit within the local social and economic setting e.g. do farm households have the resources of land, labour, capital and management skills required, will it have a positive, or negative, impact on household income levels?

Social Forestry

"Forestry for local community development", "community forestry" or "social forestry" are alternative terms for programmes designed to assist rural communities and individuals to better meet their needs for tree products - fuel, timber, poles, food, fodder, etc. Social forestry usually focuses on the planting and raising of trees and shrubs (afforestation) on a communal or individual basis. It may also involve rural communities in managing and exploiting local natural woodland and forest areas. A basic feature of recent social forestry programmes is the active involvement and participation of the beneficiaries in the forest management process.

Participatory social forestry calls for quite radical changes to conventional forestry practices. Particularly in terms of selecting what to grow, how to organise planting and management and what form government involvement and support should take in situations where foresters have a supportive rather than executive role. The following design issues will need to be considered when formulating social forestry proposals:

- Are the anticipated benefits to the participating communities and individuals consistent with their priorities and possibilities, and commensurate with any inputs (labour, land, cash, etc.) they would be expected to make?
- Can the costs and benefits associated with tree planting and harvesting be shared between, and within, rural households equitably?
- Are there socially and culturally acceptable mechanisms (e.g. traditional rules and regulations) within the community for controlling the use of communal forest resources (cutting of trees, as well as collection of minor forest products)?
- Should tree planting be promoted as a community (e.g. village woodlots), or an individual household (on-farm) activity? Note on-farm trees and communal forests where they co-exist, are likely to provide different inputs into the local system and so form complementary components of an overall social forestry system.
- What role do trees currently, or potentially could, play within the community or individual household livelihood system?
- Are individual tree species to be planted for a single purpose e.g. to provide firewood or timber (as with conventional forestry species) or are they multi-purpose e.g. firewood, poles, green manure and fodder (as with many agroforestry species)?

Plantation Forestry

Reforestation in mountain areas frequently takes the form of plantation forestry. That is the planting of one, or a limited range of, tree species on an extensive basis.

Key design considerations related to plantation forestry are as follows:

- Is the plantation to serve primarily a catchment protection or production role? If the latter is this for timber, poles or fuelwood? Note the specific role will affect choice of tree species to plant and forestry management practices to be followed.
- Will there be any foregone benefits as a result of the plantation? For instance - loss of bio-diversity and minor forest products by replacing natural forest with uniform plantations; loss of grazing areas by planting trees in grasslands.
- What rights of access will local communities retain, or be granted, to the plantation areas? Rights to gather fuel, fodder and livestock bedding materials from such areas may be important to the livelihoods of local people. However, over extraction of grasses, litter and tree prunings will reduce the conservation-effectiveness of the plantation as well as impoverishing the soil nutrient status.
- Water erosion and sediment yield can be minimized in plantation areas by: maintaining undisturbed streamside buffer strips; maintaining continuous tree roots on landslip-prone sites; selective felling rather than wholesale clear felling; care in the location, design and maintenance of access and harvesting roads.

Grazing Management

An increase in livestock numbers has been an important response mechanism of many mountain farmers to deteriorating economic and environmental conditions. However, it is clear that current growth rates are unsustainable in the face of widespread deforestation and overgrazing. Key design considerations related to grazing management are as follows:

- Are the grazing areas de facto open access resources or common property resources, i.e. can anyone graze their animals in the area, or are the grazing rights restricted to the members of a clearly defined social or cultural group?
- Is there a tradition of group-organised/communal livestock-rearing practices for both the grazing and management of pastures? Have these been weakened or discarded? To what extent could they cope with present livestock numbers and economic pressures?
- Do individual households have a socio-economic rationale for wanting to maximise livestock numbers, e.g. for social prestige purposes or as an insurance against hard times?
- Is there a ready market for the disposal of surplus stock?
- Do farm households have the resources (labour, crop residues, access to sources of fodder, etc.) for intensive livestock rearing (e.g. stall feeding) as an alternative to extensive grazing?

Tourism Development

Tourism is increasingly seen as having an important contribution to make to the economic development of mountain areas, by generating additional revenue for mountain communities and providing a variety of employment opportunities. The spectacular, and highly variable, nature of mountain landscapes are natural assets which if exploited in the right way will enhance the economy of mountain areas. Inappropriate tourism development however may contribute significantly to the degradation of the natural, socio-economic and cultural environment within a mountain ecosystem. Tourism development in mountain areas will be largely directed at promoting one of two types, namely:

- **Eco-tourism:** nature based tourism involving visits by small special interest groups to natural habitats. This may require the restriction of visitor numbers to minimize disturbance of the wildlife, and avoid damaging the landscape, that the visitors have paid to come and see; and,
- **Recreational tourism:** tourism that exploits the scenic aspects of mountain landscapes and their unique natural resources (clean air, water, snow and ice, geomorphology, etc.) for recreational purposes, such as sightseeing, summer trekking, winter sports, mountaineering and white water rafting. This may involve small groups of visitors, but this type of tourism is drawing ever increasing numbers of visitors into mountain areas.

The following are some key design considerations in relation to tourism development:

- Steeply sloping mountain areas have low resilience to the impact of mass tourism and any environmental damage may be permanent or take years to correct;
- Tourists may outnumber the local inhabitants at peak periods causing social and cultural tensions;
- Isolated communities in remote mountain villages that have had limited past contacts with the 'outside world' may have a low resilience to, or tolerance of, alien cultures and values;
- Mass tourism needs to be supported by appropriate infrastructure development if it is not to over burden local roads, water supplies, garbage and sewage disposal systems, hotel and restaurant facilities, etc.;
- Any major influx of tourists will significantly increase the demand for food and fuel. This may locally stimulate increased production of fruit, vegetables and other foodstuffs and encourage firewood plantations. However it may accelerate deforestation and expand cultivation onto marginal soils and slopes; and,

- Tourism related employment opportunities may be highly seasonal and may compete for scarce labour at critical times in the agricultural calendar, thereby affecting agricultural productivity.

Policy Considerations

There is more to the design of proposals for the integrated management of mountain ecosystems than merely selecting the most promising technological options. Farmers' land use practices are strongly influenced by the policy environment in which they operate. It is therefore critically important that consideration be given to whether there is a need to change the policy and institutional environment (and if so how) to enable any technological options to achieve the design objective of productive and sustainable development.

The first requirement is to identify those elements of the existing policy environment (prices, markets, subsidies, extension messages, etc.) that will influence agricultural, forestry and tourism land use practices, and to review their effect on natural resource sustainability. It is necessary to distinguish between those influences that conform to the stated goals of government policies and those that relate to problems in implementation, as the actual results of a particular policy may be quite different from the stated goals. Governments may have the right mountain development policies but lack the manpower and financial resources to implement them. The proclamation of protected mountain catchments may inadvertently end up increasing social inequalities by imposing costs on poor hill farmers for the benefit of better off lowland irrigation farmers.

Macro-level Policies

Issues that are likely to be considered in the formulation of macro-level policies for the development of mountain regions will include:

- the relative contribution of mountain development compared to lowland development within the national economic development plan;
- the relative social, economic and political returns to public sector investment of promoting economic development in high potential areas versus poverty alleviation in marginal areas (note the costs of development and service activities in the mountains, on a per unit or per capita basis, will invariably be higher than in the lowlands);
- extraction of mountain resources (mining, logging, etc.) for short term revenue maximization or long-term sustainable economic development that preserves and enhances the natural resources;
- competition between the forestry, agriculture, energy, and tourism sectors for land, manpower and investment finance;

- local self-sufficiency and food security versus more emphasis on cash crop production;
- the effects of pricing policy on exploitation or management of forest resources, food or cash crop production, the use of water for irrigation and/or hydro-power generation, etc.; and,
- maintaining a political balance between urban and rural areas, and between different ethnic groups and geographic regions.

The starting point for any macro-level economic development policy has to be an inventory of the natural resources of the mountain region concerned. There is no point formulating a specific development policy, such as to promote fruit and vegetable production, without first checking if this is a realisable aim given the local topography, soil types, climate, and market accessibility. Reliable natural resource data - specifically soils, climate, vegetation, hydrology and topography - are needed if sound mountain land use and conservation policies are to be developed. Regrettably the natural resources of mountain regions are usually less well surveyed and documented than those of the lowlands hence further survey work may be needed before an adequate inventory can be compiled.

Micro-level Policy Options

The promotion of development activities within a specific mountain locality may require micro-level changes in the policy environment. Key policy design issues that may need to be considered are as follows:

- **Participatory Development**: A 'bottom-up' participatory approach that involves the local people in the planning, appraisal and implementation of development activities is the key to productive and sustainable mountain development;
- **'Holistic' Development**: Given the bio-physical diversity of mountain ecosystems and the wide range of agro-ecological niches available the need is for a holistic and multi-sectoral development approach. Such an integrated approach is necessary to permit the conservation, enhancement and management of the natural resource base to sustain forestry, crop, and/or livestock activities and where appropriate tourism and water resource development;
- **Niche Exploitation**: A diversified development strategy (e.g. multiple crop, livestock and/or forestry production activities) can profit from the many agro-ecological niche opportunities in mountain environments;
- **Rural Household Livelihood Systems**: Rural households in mountain ecosystems will seek to meet their livelihood needs from a range of farming and non farming/off farm activities. Development stategies should acknowledge

the different component enterprises (on- and off-farm), and evolve from the needs and circumstances, of individual rural household livelihood systems;

- **Equity**: Social and economic equity should be key development policy objectives. Development interventions should confront inequalities between different social and ethnic groups to reduce the chance of inter-group conflict. Failure to take into consideration different gender perspectives can lead to further marginalisation of women and does not contribute to the sustainable development of mountain areas;
- **Land tenure**: Before they can be expected to 'care' for the land, mountain communities, and individual farm households, will need to feel that they have secure, and long term, rights of access to the crop, pasture and/or forest lands they use to meet their welfare needs. In some societies this may require a policy intervention involving the granting of private legal land title, in others security of tenure may come from government recognition of customary usufruct rights;
- **Legislation**: Legislation should be directed at enabling mountain communities to take direct responsibility for the preservation and management of their natural resources. It should not be directed at enforcing restrictive land use rules and regulations formulated by 'outsiders';
- **Incentive Payments**: Direct incentives such as cash payments, food for work, and free farm inputs have commonly been used, in donor funded projects, as inducements to encourage the construction of conservation works in mountain areas. However, experience has shown that a policy of using financial incentives or subsidies to promote soil conservation, and encourage specific development activities, is not a viable option unless it can be sustained from government revenue budget resources and/or locally managed revolving funds;
- **Market Development**: Mountain farmers are generally acutely aware of prospects in the local market place and will respond to perceived market niches within their resource constraints. There is scope for policy interventions to improve market access (targeting of infra-structure developments), to find new markets for traditional mountain products and to introduce new products for which there is a demand; and,
- **Pricing policy**: Policy interventions can be used to influence commodity and input prices to encourage environmentally beneficial activities or discourage environmentally damaging ones. Under pricing the rights to harness the products found in different mountain niches (e.g. forests, water, energy, minerals) may lead to over-exploitation. Attaching a low value to forest products, and therefore also to forested land, will discourage reforestation and may encourage the conversion of forest to crops or pasture.

Technological Options

When selecting technological options to tackle specific field level problems it is necessary to consider:

- whether to pursue a preventative or corrective development thrust;
- the constraints and opportunities associated with individual agro-ecological mountain niches;
- where in the mountain ecosystem land use improvements are needed i.e. in the crop lands, forests or grazing areas, and what specific land use enterprises are involved;
- the type of degradation to be tackled (water or wind erosion, other forms of soil degradation, deforestation, overgrazing, water resource degradation, etc.); and,
- the area-specific socio-economic, cultural and political environment in which the options are to be adopted.

With regard to the last point it is important to remember that while current agricultural and forestry enterprises and management practices may accelerate land degradation, technical remedies will only succeed if they can function within, and address, local socio-economic constraints.

Water Erosion Control

The dominant soil degradation process in mountain ecosystems is water erosion. Whether or not water erosion occurs at a particular site will depend on the erosivity of the rainfall received, the soil's infiltration capacity and erodibility, slope length and angle, and the amount of ground cover provided by surface litter and growing plants.

Rainfall erosivity

Erosivity is related to rainfall intensity. The higher the rainfall intensity the greater its capacity to cause erosion. Rainfall erosivity is a factor that cannot be modified by man's actions. The only option open is to reduce its impact by providing protective ground cover through appropriate crop management and revegetation practices. In an agricultural context the aim must be to ensure the least amount of bare soil at the time the most intensive rainfall can be expected (usually at the start of the rainy season).

Soil erodibility

Soil erodibility is a measure of how vulnerable or susceptible the soil is to erosion. This will depend on the soil's structure and structural stability, texture, organic matter content, porosity, and permeability. Erodibility is initially an inherent property of the soil, but can change as a response to management. A soil's erodibility can be increased or decreased by changes in soil organic matter. Within mountain areas, land that has been used for rainfed annual crops (particularly shifting cultivation) typically has a low soil organic matter content, when combined with coarse topsoil textures and weak surface structure this makes for a highly erodible soil. A soil's erodibility can be reduced by management practices designed to raise the organic matter content of the topsoil.

Slope length and angle

Slope length and angle in the geomorphological sense are unalterable, but their values with respect to erosion can be modified by conservation measures. Effective slope angle can be altered only by terracing. However, the cost of terrace construction and maintenance (especially the labour requirement) is high. A shortage of labour within the household can result in low quality terracing which may actually increase soil erosion, should runoff concentrate at low points. Also crop yields may be reduced if during terrace construction the original topsoil is removed or buried and crops end up being planted in less fertile subsoil. It is important that any conservation project promoting terracing should have a mechanism for monitoring the quality of terrace construction and maintenance.

Effective slope length can be reduced by conservation measures of the barrier type. These may be physical structures (e.g. earth banks, stone walls, storm drains and cutoff ditches) or biological barriers (e.g. grass strips, barrier hedges). When considering the use of barriers for erosion control a distinction should be drawn between impermeable and permeable barriers. Impermeable barriers are those, such as ditch and bank structures which check all runoff, either by diversion or by retaining it in situ until it can infiltrate into the soil. Permeable barriers are those which allow some proportion of runoff to pass through. Examples of the latter would be contour stone lines, hedges or grass strips.

By allowing some runoff to flow through them, at a greatly reduced velocity, permeable barriers have an automatic safety valve to cope with the occasional storms of very high intensity, which would overtop and destroy earth banks. Hence, contour grass strips and hedgerows may be technically suitable alternatives to earth banks in high rainfall areas. Grass strips and hedgerows can also contribute directly to on-farm production by providing fodder, green manure, fuel and mulch.

In semi-arid areas crop production is limited by moisture availability. Production benefits may follow the adoption of measures that encourage the conservation and infiltration of rainwater, such as the construction of impermeable cross slope barriers, retention ditches and level and backward sloping bench terraces. However, the risk of mass movement increases with increased slope angle, therefore caution should be exhibited in mountain areas, when adopting conservation farming practices that increase infiltration and reduce runoff. Retaining more water in situ may actually accelerate land degradation by mass movement.

There are disadvantages to relying on structures alone to solve soil degradation problems because:

- conservation structures have high direct costs (especially labour) for both initial construction and annual maintenance;
- they may involve foregone costs by taking strips of land - the width of the bank, channel and/or terrace riser - out of crop production, without necessarily producing any immediate benefit to compensate for the reduction in cropped area;
- they can counter only the effects of runoff - they have no effect against rainfall itself (raindrop impact); and,
- they can prevent gully formation - but have no effect on declining soil fertility as a result of continuous cropping in the inter-bank areas.

Conservation structures provide a means of dealing with excess storm runoff, but on their own cannot substitute for improved conditions of soil structure and cover in the inter-bank areas. They can be used safely and effectively only in support of better crop and livestock husbandry.

Ground cover

Ground cover is the factor that has the greatest impact on the rate of erosion by protecting the soil surface from the impact of erosive rains. It is also easily modified by changes in land and crop management practice. Cover may be provided by the leaves and other parts of plants growing above the surface (the canopy) or the dead materials deposited on the soil surface below the plants (litter). In a natural system, the litter would be composed of leaves, stems, twigs, branches, seeds, fruits, etc.. In cropping and agroforestry systems the canopy will be provided by the growing crop and the leaves of any woody perennials, while the litter may consist of deliberately applied mulch and/or crop residues.

Perennial tree crops with cover crops beneath have the potential to reduce erosion to a fraction of its rate on bare soil. Hence, when planting perennial tree crops, as an alternative to annual crops in mountain areas, consideration should be given to interplanting cover crops. Cover crops should not only be conservation effective, but also offer productive benefits. For perennial cover crops to be accepted by farmers they must be easily propagated, require little management, be shade tolerant (so they will continue to provide surface cover as the tree canopy expands) and have some economic value as a food crop, green manure and/or fodder.

Chemical Degradation

Chemical degradation, specifically in the form of acidification and nutrient decline, may be a problem in mountain areas. Montane soils derived from non-volcanic parent materials are generally naturally acidic and low in weatherable minerals. Past misuse may make a poor situation worse. In particular, failure to replenish the nutrients lost by leaching and removal in harvested products (including the collection of grasses, litter and brush from forest areas for fodder, fuel and livestock bedding) can lead to the steady impoverishment of the nutrient status of montane soils.

Nutrient deficiencies cannot be made up solely by the addition of composite chemical fertilizers. The highly acidic nature of many montane soils means that elements such as phosphorus are rapidly fixed and unavailable to plants. High rainfall when combined with coarse textured and very porous soils results in soluble elements like nitrogen being rapidly lost by leaching. Nutrient deficiencies are best overcome by the application of organic manures supplemented with chemical fertilizers. Liming, to reduce soil acidity is generally not a cost-effective option in mountain areas. Currently the only practical way to ameliorate soil acidity would appear to be the addition of large quantities of organic manure.

Biological Degradation

Where montane soils have been overcropped and overgrazed they are likely to be deficient in the biological processes needed to both maintain their physical structure and to supply essential nutrients to plants. Although montane soils may start with a relatively high organic matter content (compared to lowland soils), following years of misuse this may be reduced to a very low level. Organic recycling practices (composting, burying crop residues, green manuring and the application of animal manures) will improve soil structure, and thereby root penetration and erosion resistance; augment cation exchange capacity; and act as a store of nutrients, that can be slowly converted to forms available to plants.

Physical Degradation

Physical degradation, especially loss of topsoil structure following cultivation, is a concern within mountain areas as it reduces the ability of the soil to withstand erosion. Sealing and crusting of the topsoil can occur where ground cover is insufficient to protect against the impact of raindrops. Both compaction and crusting may be problems in areas heavily trampled by livestock. Compaction, sealing and crusting will reduce infiltration thereby increasing runoff and the likelihood of water erosion. The only realistic option for improving topsoil structure is through the raising of organic matter levels either by digging in organic manure, or by growing a grass or herbaceous legume cover crop (pasture). This may also reduce the risk of sealing and crusting. It is better to prevent compaction from occurring in the first place, by controlling livestock movements and regulating grazing, as corrective measures (e.g. deep ripping by tractor) are likely to be costly and technically difficult in mountain landscapes. In severe cases it may be necessary to 'close' an area and rely on the regrowth of the natural grasses, shrubs, and trees to slowly restore the soil's physical condition.

Institutional Considerations

The integrated management of mountain ecosystems is multi-sectoral in nature and embraces both the bio-physical and social science disciplines. Thus the co-operation of different interest groups and technical specialists is needed to plan and implement mountain development programmes.

At the community level programmes to promote sustainable mountain agriculture and forest management may call for co-operation between different social and ethnic groups within the same locality. They may also have a direct or indirect impact on the activities of other local interest groups such as logging companies, traders, and large scale commercial plantations. Success in resolving conflicts of interest within mountain communities will depend to a large extent on the existence, strength and organisational structure of local people based institutions.

At the government level success will depend on the favourable resolution of a range of institutional issues. This will include appropriate mechanisms for inter-departmental co-operation, and the co-ordination of activities undertaken by different government line agencies. It will also depend on the availability of the necessary manpower with the appropriate disciplinary skills, and effective extension research linkages.

The following are some of the key institutional considerations related to the design of mountain development proposals.

- **Community Organisations:** Community level 'peoples' organisations can provide a forum, not under direct government control, in which local peoples' wishes can be articulated, problems analyzed, plans formulated, and agreements reached on how particular interventions are to be implemented. Management of such organisations should be in the hands of responsible, responsive and respected leaders.

- **Institutional Strengthening:** If governments are to provide the back-up services that mountain communities need to plan and implement their own field solutions they will need to strengthen the relevant development support institutions. It will not be enough simply to provide more finance and personnel (welcome though that would be). What is needed is to reorientate the training, extension and research programmes of these institutions to the realities of mountain specificities and the opportunities for bottom-up participatory planning, and implementation, of development activities .
- **Institutional Collaboration:** Differences in strategies, approaches and even technical methods between government departments and donor agencies may lead to duplication of effort and confusion or resentment on the part of land users. There must be an institutional framework that enables different development support agencies to collaborate, and operate, in an integrated and participatory manner rather than compartmentalised on a geographic area or disciplinary interest basis.
- **Involvement of NGOs:** Government programmes should acknowledge the presence and the potential of Non-Governmental Organisations (NGOs), which often have comparative advantages when it comes to contact with natural resource users at the local level.
- **Advisory Support:** Sustainable mountain development requires an integrated extension message. This requires close cooperation between the different subject matter specialists, and extension services responsible for advising on crops, livestock, horticulture, forestry, etc. Agroforestry, by definition requires the integration of the traditional disciplines of agriculture and forestry. Subject matter specialists should be able to combine their different recommendations to enable generalist agricultural extension workers at the grass roots level to present a 'holistic' land husbandry and conservation-with-production message.
- **Training:** Training is a vital ingredient of mountain development programmes, both for programme personnel and participating land users. Developing skills amongst the beneficiaries not only 'demystifies' technology, but also acts as a powerful incentive to increased involvement in conservation-with-production activities. Promoting a participatory approach requires changes in current training approaches and curricula so as to create new attitudes, skills and awareness within professional people. Changing from a top-down to bottom-up approach creates retraining needs at all levels.
- **Research:** Research should be conducted in an inter-disciplinary manner and include specialists from both the natural and social science disciplines. Priority should be given to 'on-farm' research and participatory technology development and address the specific constraints and opportunities of the mountain environment. On-station research should be formulated in response to problems and concerns identified at the farm/field level. This may call for the relocation of experimental stations and research staff from the lowlands to the mountains.

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