MODULE 2.1

Rehabilitation of Degraded Lands

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Objectives

- To identify and understand better the causes and processes and the extent and consequences of land degradation
- To identify and understand the constraints and the opportunities available for rehabilitation of degraded lands and the major challenges to be faced
- To highlight experiences and lessons learned in rehabilitation of degraded lands in the Asian region

What is land degradation?

The term 'land degradation' is used widely in different ways. At its simplest, land degradation is the diminution of the biological productivity expected of a given tract of land. Degradation is keyed to human expectations which vary by land use. Indeed, each type of land—farmland , wild land or rangeland, for example—is nothing more than a set of expectations about the form its biota should take. The concept of degraded lands therefore is somewhat subjective, and a condition that constitutes degradation on a particular type of land may be considered normal elsewhere (WRI 1988-89). Typically, however, on degraded land soil is impoverished or eroded, less usable water is available due to increased surface runoff or contamination, vegetation is diminished, reproduction of biomass is lowered and biodiversity is reduced. The diminution that degradation embodies is expressed in many ways, depending on the type of land.

Degraded lands are either inherently unproductive or have been made so due to faulty land management practices. Degraded lands or wastelands rather loosely indicate a variety of deteriorated lands that are degraded due to various natural and biotic hazards and are unfit for productive use, primarily agriculture. In India, wastelands have been defined as degraded lands that have deteriorated for lack of proper soil and water management and can be vegetated with reasonable efforts.

Definitions aside, the fact is that such barren degraded lands/wastelands with little or no vegetation at all cover the landscape as unsightly reminders of past mismanagement of land resources and now pose serious environmental problems.

Rehabilitation, as the word suggests, entails making the degraded land useful to humans again. It seeks to optimise the production of usable biomass of a site. The main purpose is utilisation.

Restoration is much more ambitious, it aims to reinstate entire communities of organisms closely modelled on those occurring naturally (Jordan et al., 1988). Because it strives to optimise the biodiversity of a given site, restoration does not emphasise resource utility.

Rehabilitation makes no pretension about authenticity and admits of no philosophical preconditions favouring native over exotic species. In fact the choice may be economic; conceivably, rehabilitation could convert degraded lands to a completely new use, if that best served human needs (Cairns 1986). Rehabilitation is more relevant to the immediate needs of the people because it emphasises the fact that production can ameliorate hunger, fuel shortages, and poverty.

Are there different stages of degradation?

Degrees of degradation

Degradation may connote different meanings to different people and which land should be considered degraded or not may be debatable. But generally speaking any land that is not supporting its normal wealth of natural resources and is suffering from accelerated depletion and degradation is considered to be degraded land. This could lead to the deterioration and destruction of a particular spot or parcel of land itself ,which could affect adjacent lands and downstream lands. De-

graded lands are generally denuded and dry and lose their productivity gradually in the early stages but rapidly later. Soil moisture and water-holding capacity is low. Low infiltration and increased runoff result in loss of nutrients and topsoil followed by rill, sheet, and gully erosion. In the beginning, degradation may be very slight and almost unnoticeable, but, as the decline and degradation accelerates and gains momentum, it can be colossal, chaotic, and irreversible. Degrees of degradation vary very widely from place to place and country to country and observer to observer but, generally, degradation can be broadly classified as follows.

- Pre-degradation/threshold stage

The normal natural state is under immense pressure and resources are being exploited to the uppermost limit of their endurance or carrying capacity or natural recovery. Natural resources are either not in an improvement or decline situation, or are in a *status quo* situation. The situation must not be allowed to go beyond this level. If this stage is diagnosed properly in time as a pre-degradation stage, degradation can be prevented by following appropriate preventive measures. Prevention is better than cure.

- Beginning of degradation or early stages of land degradation

First and early symptoms of degradation start appearing, e.g., thinning of vegetative cover, lowering of organic matter, decreasing soil moisture, hardening of soil, exposure of topsoil, poor regeneration, poor stunted growth, slight disturbance of upper thin layer of topsoil. At this stage, the process of degradation is very slow and if appropriate protective measures are taken degradation can be controlled effectively, easily, cheaply and quickly. 'A stitch in time saves nine' this adage applies fully.

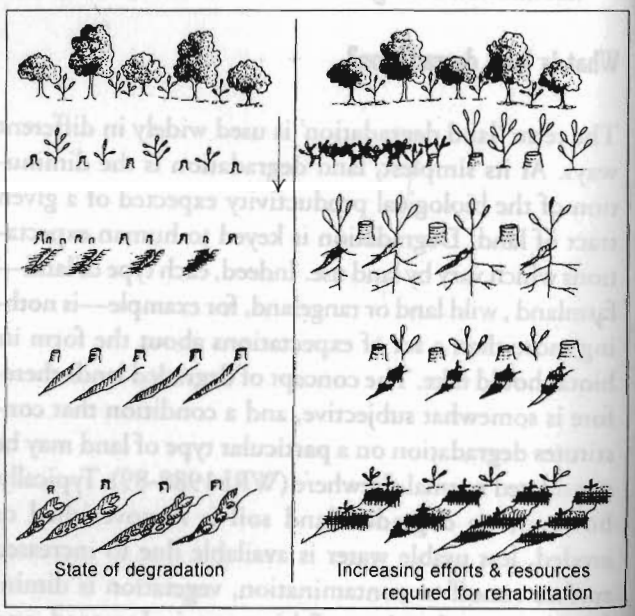
- Medium/moderate land degradation

Degradation is increasing in intensity, vegetative cover is very poor and in the gradual process of disappearing. Production is declining and soil erosion is taking place. Soil depth is diminishing but some soil is still available for plant growth. At this stage rehabilitation is still possible through biological means and vegetative growth.

- Seriously/critically degraded lands

No vegetative cover is visible. Topsoil has been eroded away by severe soil erosion. Plants cannot grow on their own without outside help. Formation of gullies and exposure of parent rock material are evident. The natural resources, particularly the soil, water, vegetation ,and biodiversity have disappeared, and economic and ecological conditions have reached the point of no return. At this stage biological means alone and conventional planting techniques cannot rehabilitate the land. Bioengineering and simple engineering structures for moisture retention and soil formation, and special plantation techniques with suitable plant species, need to be adopted. At this stage, the costs, effort and time needed for rehabilitation are quite high. The chances and degree of success are also much lower than they would have been if rehabilitatation had been undertaken at an earlier stage.The following proverb explains this simply and fully.

For the want of a nail the shoe was lost.
For the want of a shoe the horse was lost.
For want of a horse the rider was lost.
For the want of the rider the battle was lost.
In losing the battle the kingdom was lost
And all for the want of a nail



What is the extent of degradation? What are the major causes?

Land degradation is among the most chronic economic and environmental problems and burdens in the mountainous regions of Asia. In the past, pressures were few and well within the production, carrying capacity ,and restoration ability of the land. But now the demand and removals are heavy and well beyond the carrying capacity of the land. The result is that a vicious cycle of depletion, degradation, scarcity, and poverty is growing

bigger and bigger year after year with very few exceptions.

The extent of land degradation and the major causes of degradation are given below in Table 1.

What are the major categories of constraints causing land degradation?

Four major categories of constraints causing land degradation can be broadly characterised as follow.

- **Geophysical:** includes conditions such as rocky outcrops, boulders, gravels in the soil, too steep slopes, salinity, alkalinity, waterlogging, landslides, exposed sites, poor nutrient and moisture conditions
- **Environmental:** includes interaction of rainfall, snow, temperature, erosivity of rain and wind, moisture and nutrient balance, overexposure to radiant energy.
- **Biological:** includes interaction of humans and animals with the resources, pests and diseases, and ecological imbalance.
- **Socioeconomic:** includes attitudes and reactions of the people individually or collectively.

What are the consequences of land degradation?

Land degradation in Asia is causing very serious and alarming consequences. The main pressures and consequences are shown in Figure 1.

Degraded land accelerates soil erosion and valuable topsoil is washed away from mountain slopes and gets deposited in streams, rivers, reservoirs ,and on prime farm lands damaging and destroying them. The costs of repairing, maintaining, and reconstructing them are almost impossible to bear. On degraded lands, a valuable resource—the topsoil—is removed from upstream where it is desperately needed and dumped downstream where it is absolutely unwanted, thus it is doing double damage and is a double disaster.

What are the main objectives and goals of rehabilitation of degraded land?

When degradation can no longer be tolerated the response to the problem is either abandonment and bear

Table 1: The Extent and Major Causes of Land Degradation in the Mountainous Regions of Asia

Country	Extent of Land Degradation	Major Causes of Degradation
Afghanistan	62 % of the land area (39.8 million ha of mountainous area) seriously affected	**Natural Factors** High potential for degradation—steep slopes, unstable geology, short periods of heavy rainfall, high-speed winds, flooding, drought
Bangladesh	7 % of land area (1 million ha of hill area) affected	
Bhutan	35 % of the land area (1.6 million ha of hill area) affected	**Demand Factors** Rapid increase in human and livestock population
China	22 % of the land area (209 million ha) affected	Unsound Management Practices Uncontrolled and excessive grazing, poor soil management practices, improper forest harvesting, unmanaged mining activities, shifting cultivation
India	53 % of the land area (17.3 million ha) affected	
Myanmar	2.6 % of the land area (17.6 million ha) degraded	
Nepal	13 % of the land area (1.8 million ha) estimated to be degraded	**Harmful Practices** Setting fires to forests, environmentally unsound infrastructural activities
Pakistan	25 % of the land area (20 million ha) estimated to be degraded	**Macro-policy-related factors** Land ownership problems, unplanned organization, inappropriate land-use practices, lack of environmental protection measures in infrastructural development activities
Philippines	27 % of the land (8.2 million ha) is degraded	
Sri Lanka	10 % of the land area (0.7 million ha)	
Thailand	19 % of the land (10 million ha)	

Source: Bhatta 1990

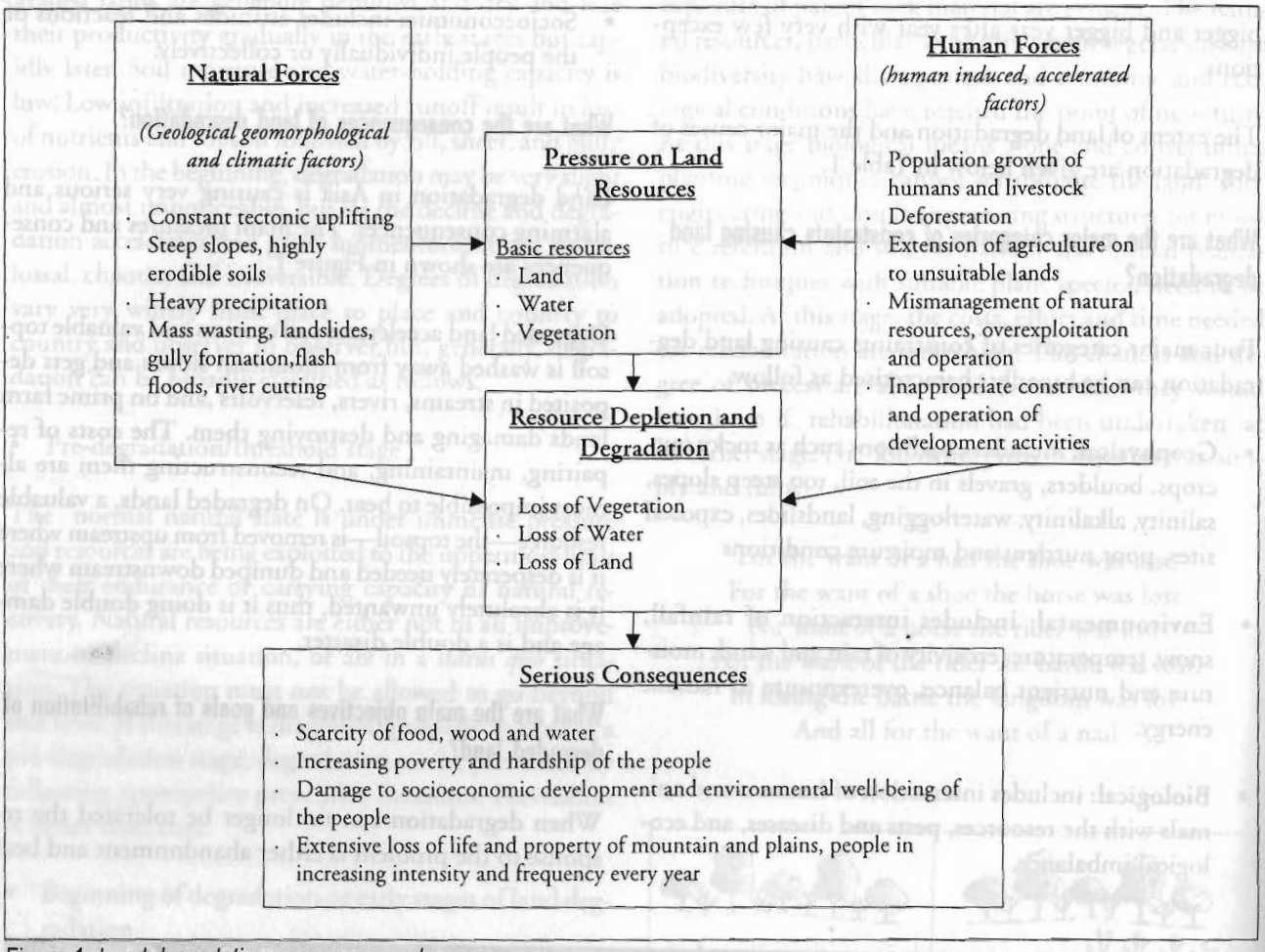


Figure 1: *Land degradation : pressures and consequences*

the serious consequences ahead or assisted recovery or rehabilitation. Abandonment is most prevalent. Short periods of abandonment of temporarily degraded lands ,such as shifting cultivation, nomadic pastoralism and seasonal migration, are practised.

The main objectives and goals of rehabilitation of degraded lands are fourfold

- to halt the depletion, deterioration ,and degradation of the resources;
- to regain and maintain the productivity of the land;
- to ensure sustainability and proper land use; and
- to establish equity in distribution of benefits from rehabilitation of degraded lands.

Fulfilling these four objectives is the key to the well-being of millions of people and sustainable utilisation of natural resources for the present and future.

What are the major challenges?

The major challenges to be faced and solved satisfactorily are as follow.

- How to halt immediately the depletion and degradation of the basic natural resources: soil, water and plants, and the wholesome natural environment; deforestation; soil erosion; nutrient losses; sedimentation; drying up of water springs; flash floods; biodiversity; and valuable environmental losses? How to contain and control the degradation effectively?
- How to rehabilitate the damage done: restore degraded and destroyed forests, rangelands, watersheds, farmlands, waste and barren lands, and restore lost biodiversity and degraded ecosystems?
- How to relieve the pressures on the resources from excessive numbers of people and livestock, bring it down to within the carrying capacity of the land and maintain it and increase sustainable supplies that meet demands?

- How to reduce the demand for and consumption of land-based products, minimise wastage, increase utilisation and efficiency, and adopt suitable alternatives?
- How to correlate removal of resources and their regeneration and develop an effective system so that the regeneration is always more than the withdrawal? How to reorient and equip policy-makers, planners, and implementors to accept concepts and strategies and change their attitudes to work for the above objectives and goals?
- How to optimise and make the wisest use of the existing available resources according to the land capability and resource productivity on a sustainable basis ,combining social needs, compulsions of the poor, and the needs of the environment?
- How to meet the increasing needs of man and animal, achieve economic growth, and alleviate the poverty of the people and raise their living standards while conserving valuable natural resources, fragile ecosystems, and the environment in the mountains? Currently we see a'cut and do not cut', 'exploit and do not exploit' 'use and do not use' 'cultivate and do not cultivate' syndrome, one purpose acting against the other, how to optimise the balance?
- How to increase production and productivity of forests, rangelands, and farms to meet the needs of the people and environment on a sustainable basis?
- How to produce and make available the needed agricultural, forestry, and rangeland products to the people according to their requirements and ensure just and equitable distribution?
- How to generate and enhance income and employment opportunities ,through conservation measures supported and supplemented by primary production systems (crops, agroforestry, pastures, horticultural crops, etc.); secondary production systems (animal husbandry, poultry, pigs, goats, sheep, rabbit rearing, apiculture, sericulture, etc); and tertiary production systems (processing for value-addition of the two) in a symbiotically integrated and developed manner in perfect harmony with the needs of the land, people, and the environment?

What are the major constraints to rehabilitation of degraded lands?

- Natural forces
- Human/induced pressures, development disasters
- Socioeconomic factors
- Lack of awareness and understanding regarding the multiple and long-lasting benefits to be derived from natural resource conservation and serious disastrous consequences of land degradation
- Inappropriate land-use practices and increasing the extension and intensity of cropping
- Policy, legislation, institutional and implementation weaknesses
- Lack of human resource development and mobilisation
- Lack of people's participation, particularly of women and disadvantaged people
- Inadequate and inappropriate education, training, research and extension
- Confusion and uncertainty of land ownership, tenure, use and management
- Lack of financial support and inadequate incentives
- Lack of immediate benefits to farmers and the longer time frame required

What are the major opportunities available for rehabilitation of degraded lands?

Mountainous regions, because of their geophysical richness, location, history and culture, geology, soil, water, agriculture, forestry, pasture, animal husbandry, fauna and flora, scenic beauty, and majesty ,together with vast manpower, hydropower potentials, and, as perennial sources and watersheds of thousands of rivers and streams, can no more be neglected. The people in the mountains and around them are now realising that sustainable development based on a three-dimensional approach—ecological, economic, and sociological—is required to halt depletion and degradation of the resources and to rehabilitate them quickly and effectively. Delays in repairing the damage and preventing injury will be too costly and at times may even become irreversible. In many cases repair might well be beyond the reach and capability of the countries in the region.

The time has now come to learn from experience and to build for the future on the basis of recent develop-

ments, knowledge , and new skills. The resources and opportunities available that can be used are as follow.

- The increasing awareness and growing political determination and people's active involvement in natural resource conservation and management
- Existing degraded land with forest, farm, and pasture land potential
- A set of policies and legal measures is being adopted and can be improved upon to act as simple and effective tools for rehabilitation, resource development, and resource management
- A wide range of indigenous and exotic trees, shrubs, grass, crops and other plant species to suit different climatic, soil and environmental conditions which can rehabilitate, protect, and produce required products in increasing volume and serve multiple objectives
- Good biophysical conditions, growing periods, potentials for restoring and increasing productivity and production, hungry consumers of products, and good markets
- A body of science, technology, knowledge and experience, new concepts, practices ,and new skills in participatory watershed management that are being enriched by growing research and development in the region and in the world
- Chances of obtaining local and external financial and technical resources
- Increasing local, national, regional ,and international collaboration and cooperation in rehabilitation of degraded lands, natural resource conservation, management and environmental improvement, closer networking and sharing of experiences through regional/international institutions such as PWMTA, FARM, WATMANET, ICIMOD, RAS, FAO/ UNDP, SAARC
- Substantial comparative advantages of mountain specificities, attributes, and niches
- Immense energy of human resources and wealth of natural resources and great diversity
- Economic, land-use, agricultural, forestry and water resource policies, laws , and regulations that could be revised, rewritten, and reformed to meet the needs of the people and the environment and to aim towards wise management and use of natural resources on a sustainable basis through regional and international cooperation to benefit the entire Asian region by using and conserving genetic resources, biodiversity , and majestic mountain ecosystems and fauna and flora as a heritage of mankind and as a scientific and natural asset for present and future generations
- Forestry or agriculture or animal husbandry alone cannot improve the living conditions of the people and halt environmental degradation, therefore integrated resource-use programmes involving agriculture, animal husbandry, horticulture, apiculture, sericulture, and small-scale and cottage industries producing secondary and tertiary value-added products should be undertaken.

Experiences and lessons learned in rehabilitation of degraded lands

Land degradation is not only a local, national or regional problem: it is global. Land degradation in mountain watersheds has become an issue of worldwide concern. Almost 25 per cent of the population of the world lives in the mountain watersheds of Asia and the Pacific region. By some estimates, 27 per cent of the land area has already been damaged—much of it irreparably. Land degradation has inflicted heavy and far-reaching losses of life, property, and the environment in increasing intensities and frequencies year after year. Countries and people, GOs, NGOs and INGOs have realised the seriousness of the situation and are making efforts to address the problem in various ways and at various levels. Despite these efforts the enormity and scale of the problem is so complex and widespread that very few successes have been achieved and the problem remains far from being fully tackled. The rate of degradation far exceeds the rate of rehabilitation. However, there are some encouraging examples of recent concepts, knowledge, practices and skills and successful efforts and experiences in the region that can be cited, studied, and replicated with suitable modifications for creating successes in other parts of the region. Some of these are discussed below.

ICIMOD's and national collaborating institutions' (NCI) experiences in rehabilitation of degraded lands in the mountain ecosystems of the Hindu Kush-Himalayan (HKH) region

Degradation of the mountain environment and poverty of the people in the HKH region have been the focus of much discussion and development interven-

tions. An acute crisis of food, fodder, fuelwood ,and water (too little during the dry season, too much during the monsoon) and a deteriorating natural resource base and biodiversity have been causing serious concern among the people, GOs, NGOs, and INGOs. Realising this, ICIMOD, in close collaboration with national partner institutions of the HKH member countries and with financial support from donors, has been engaged in developing an understanding of the extent of the forces and processes underlying land degradation in order to identify measures for restoring and developing degraded lands using options that are field tested and economically, environmentally, and socially viable; and which are owned and supported by local peoples' close participation. More details can be gathered from ICIMOD. NCIs' project sites and activities can be observed and studied and information updated.

Mountain Resource Management (MRM) Project, Nepal

The Mountain Resource Management (MRM) Project in the Jhikhu *Khola* Watershed (11,000 ha), Kabhre District in the middle mountains of Nepal was initiated in 1989. The project has three components.

- Baseline inventories were established for soils, forestry and agricultural land use, population dynamics ,and socioeconomic conditions. All information was placed into a geographic information system (GIS) for analysis and documentation of resource constraints and environmental degradation.

- An environmental monitoring programme was established to determine the rates of soil erosion, the rates of deforestation, soil fertility decline , and adaptations of indigenous knowledge to hydrology and soil and water management.

- Monitoring and understanding of socioeconomic conditions and relationships between biophysical conditions, soil fertility, and indigenous knowledge.

Steps were also taken to rehabilitate a degraded site and use it as a demonstration site, illustrating how alternative crops, fodder trees, and nitrogen-fixing hedgerows can be incorporated into traditional systems for greater benefits.

Main findings of the project

- Understanding the degradation process is the key to successful rehabilitation of degraded lands. Deforestation, soil erosion, and soil fertility are important biological-physical factors that need consideration.

- The key issues in environmental degradation of a micro-watershed have been identified as water management; soil fertility maintenance; rehabilitation of agricultural land, grazing land, and forest; and soil erosion control.

- Land-use changes were documented between 1947 and 1995 and the results showed that deforestation was significant between 1947 and 1972. Increases in the forest cover have occurred over the past 15 years but the quality of the forest (in terms of biodiversity, standing biomass, and understorey) has declined. Forest expansion—dominated by pine plantations—occurred mostly on intermediate slopes. At the same time, agriculture intensified from an average of 2.1 crop rotations per year to 2.7 crop rotations, and expansion of agriculture has occurred in marginal environments. This expansion occurred at the expense of grazing and shrubland. The former is of particular concern since animal feed was identified as one of the critical resource shortages (Schreier et al. 1991) and hill agriculture is heavily dependent on manure to maintain soil fertility (Shah et al. 1991).

- A significant finding is that between 55 and 80 per cent of the annual loss of soil occurs in two storms, and it is during the pre-monsoon season that the soils are most prone to losses. This was confirmed by the stream flow measures for which the sediment rating curves during the pre-monsoon season were significantly higher than during the monsoon season. Ground cover during the pre-monsoon period is the critical issue controlling soil erosion in upland agriculture in the watershed , and techniques to reduce this risk by alteration of ground cover at the time the first monsoon rains arrive need to be introduced. The soil losses appear to be of significant benefit to lowland farmers with irrigated rice land. The annual sediment input and dissolved nutrients in the water improve the nutrient status of these fields suggesting that poorer upland farmers are losing nutrients to rich lowland farmers.

- Soil fertility problems are widespread. Soils are acidic, low in cations and organic matter, and generally deficient in phosphorous. Since there is considerable litter transfer from forests to agriculture, it was shown that soil fertility in the forest is the poorest, followed by shrub and grazing land. Only irrigated land has a nutrient status that is considered adequate for sustained production, and higher inputs are needed in all other parts of the land-use systems in the watershed.

- Forest degradation cannot be measured effectively by forest cover but needs to include measures of biodiversity, biomass yields, site fertility, and other site conditions. The overall losses of forest land have been substantial and, combined with changes of soil fertility and biodiversity, the current situation is of serious concern in terms of maintaining production capacity and resilience. Major changes in policies were mainly responsible for the creation of a downward cycle.

- Soil erosion is of key importance since agricultural expansion has moved on to marginal lands that are more vulnerable to degradation.

- Active afforestation programmes should focus on degraded areas since they are the greatest cause of sediment transport. They are more effective if they are carried out in the context of agroforestry where nitrogen-fixing trees are planted on terraces between agricultural plots. This provides protection against soil erosion and improves the soil nutrient conditions on these sites and has the potential to improve animal feed production.

The Rehabilitation of Degraded Lands in Mountain Ecosystems' Project

ICIMOD, in collaboration with national collaborating institutions (NCIs) of four member countries (China, India, Nepal and Pakistan), initiated this project in 1992. The main objectives of the project are

- to develop a better understanding of the extent, forces, and processes underlying degradation and

- to identify measures for restoring and developing degraded lands in different mountain ecosystems by using options that are field tested and found to be economically, environmentally, and socially viable.

Table 2: **Rehabilitation of Degraded Ecosystems' Project: Countries, NCIs ,and Site Information and Achievements**

Country and NCI/ Site Location	Land Area, Land Use, Tenure and People	Achievements
China		
Kunming Institute of Botany, CAS; K.I. of Ecology, CAS; Chengdu Institute of Biology, CAS; Damai village, Baoshan, Yunnan Province Altitude 1,370-1,750 m	45 ha-denuded forest land, community forest, 136 households	Establishment of training and demonstration facilities; better understanding of role of communities and individual landowners in the rehabilitation of degraded lands
India		
G.B.Pant Institute of Himalayan Environment and Development, Arah Village, Almora, U.P. Altitude 1,490 m	9 ha, abandoned farmland 86 households under village *panchayat*	Identification of suitable tree, shrubs, grasses for rehabilitation of degraded lands; cooperation between research agencies, local government, NGOs, farmers; training and extension
Nepal		
Department of Forests, HMGN; forest user groups of two villages; District Forest Office.		
Site I. Godavari, Lalitpur District Altitude 1,550-1,780 m	Formerly government forest land, 30 ha degraded forest/shrubland transferred to ICIMOD for research and training	Various R & D activities are in progress and the site is being developed as a research training and demonstration area
Site II. Bajra Pare and Dhaireni Altitude 900-1,000m	7.8 ha and 15.9 ha denuded forest land, handed over to two forest user groups as community forest	Land-use management plan preparation and implementation; socioeconomic biomass surveys for assessing the status and monitoring changes in future
Pakistan		
Pakistan Forest Institute Sinkyari valley, Manshera District. Altitude 1,400-1,550 m	15 ha abandoned farm land and 18 households' private land	Actual rehabilitation and improvement of biological-physical conditions for demonstration and learning; direct benefit to local user groups and marginal farmers through improved land management practices, soil erosion control, water management and increased production of biomass

Table prepared based on ICIMOD 1993; Pei Shengji et al. 1993

Five field sites were chosen in four countries for this action research project. Countries, national collaborating institutions (NCIs), site-specific information and achievements are given in Table 2.

Major achievements/observations of the project

- Rapid population growth is the main factor causing mismanagement of land and inducing and accelerating land degradation because of very few non-land based income and employment opportunities.

- Meagre land holdings of less than 0.5 ha/capita, poor shallow soils, insufficient manure and fertilizer input, overexploitation of farmland and forest land, and declining production. Scarcity of food, fodder, and fuelwood and poverty of the people forcing them to extend farming on to marginal, highly fragile lands.

- Natural resources ,namely soil, water, and forests, are under immense pressure to meet the daily basic needs of the people. The mountain watersheds are caught in a vicious cycle of high population growth, poverty, underdevelopment—environmental degradation and deteriorating development prospects.

- Inappropriate land-use policies, development policies, tenure arrangements, land laws, customs, traditions ,and practices also have affected land resource conservation and utilisation badly.

- Excessive removal of forest products, excessive grazing, forest fires, deforestation and loss of biomass cover are inducing and accelerating land degradation.

- The scale and dimensions of degradation have been further exacerbated by ecological sensitiveness, natural pressures or fragilities and disturbances. The consequences could be irreversible.

How to cope with the problem of land degradation?

The need for viable options. The issue of land resource management is not just an environmental problem. It can be traced back to basic demographic, economic, cultural, technological, and natural forces. Thus its solutions also lie in the improved sustainable management of available natural resources, efficient and productive farming systems, a rapidly expanding infrastructural base, and expansion of non-agricultural employment opportunities and income generation.

It is usually the small poor farmer, the poorest of the poor, living in the upper watersheds who are suffering most. Given their extremely poor resource base it is very unlikely that they will willingly destroy the very basis of their survival. Then why are they doing it? What are the overwhelming compulsions for deforestation and the extension of agriculture on to marginal lands resulting in degradation? The search for the solution must begin with the mountain farmer. The interest and needs of the farmer; an understanding of the land users' design regarding allocation ,use ,and management of resources; and the users' problems and prospects must be well understood for effective and sustainable management of land resources. Identification of problems, measures adopted for rehabilitation of degraded lands, and the responses and results are summarised in Table 3.

Appropriate approach for rehabilitation of degraded lands. Not only is a biophysical approach required but it should also be economic, environmental, sociocultural, and people-based.

Rehabilitation of ecosystems and their sustainable development—more specifically the sustainable management of natural resources—are closely interlinked, interdependent, and integrated. The interplay of ecology, sociology, economics, anthropology and culture needs to be consolidated for a comprehensive rehabilitation strategy. The ultimate objective of rehabilitating the ecosystem is to manage natural resources in a manner that satisfies current needs as well as allowing for a variety of options for the future. Ecosystem rehabilitation and management are part of a dynamic process and should be monitored continuously to assess effects and impacts; to improve interventions, baseline surveys and monitoring systems should be established from the beginning of the activities.

The land ownership, tenureship, use, and management patterns and the basic resources of soil, water, forest, pasture, and farm land are of great importance. To whom the land and the resources belong—whether it is private, community, religious, government ,or unallocated or any combination of these patterns or confused or disputed ownership—is critical for identifying and designing rehabilitation strategies, approaches and technologies. Generally privately-owned lands are least degraded, followed by community-owned, government-owned, and disputed lands. Owner's, user's or manager's presence and care are vital in preventing, protecting, checking ,and rehabilitating degraded lands. Someone has to be responsible and accountable for the protection and supervision of the resource.

Table 3: Identification of Problems, Measures Adopted for Rehabilitation of Degraded Lands, and the Responses and Results

Problems	Rehabilitation Measures	Responses, Results
Policy and institutional		
1.1 People not involved in resource management. Lack of institutional mechanism.	People's participation from inception to project implementation and post-rehabilitation work. Training and extension of village rehabilitation committee, users' group formed under existing village-level organization. Co-ordination between Forest, Agriculture Departments, Village Committee, people and project.	Local people are the owners, managers and users, and trained manpower. Forest, land-use management plans prepared and implemented.
1.2 Uncertainty of land boundaries, extent, ownership, management and use, current status of degradation not exactly known.	Land areas clearly identified, determined and demarcated on ground and maps prepared. To assess the current status and monitor changes base-line surveys of vegetation, soil, water and socioeconomic surveys of local people undertaken.	Land limits and the land users well defined and determined; current status of resources well known and future changes are positive and are being monitored.
1.3 Resource-use policies, traditions, practices are weak, ambiguous and centrally controlled.	Local people decide about resource-use pattern, intensities, and practices among themselves.	Local resource-use rules, conditions prepared and strengthened.
2. Biological		
2.1 Overexploitation of land resources, deforestation, overcutting, overgrazing, forest fires.	Local people decide not to overexploit, overcut, and graze on the site, and fire protection measures taken. Preparation and implementation of forest and land-use management plans.	Forest protection, stall-feeding of livestock and fire protection is greatly helping natural regeneration and growth of plants; forest and land-use management plans are operational.
2.2 Serious soil erosion, difficulty in natural regeneration, very slow growth and high mortality of plants due to serious degradation.	Selection of suitable pioneer, colonising species that naturally grow well on poor degraded sites; nitrogen-fixing species. Sloping Agricultural Land Technology (SALT) and Other Appropriate technology (OAT) with plant hedgerows, trench and ditch planting, plant nursery establishment.	SALT, and knowledge of appropriate species and OAT very helpful.
2.3 Shortage of fodder, fuelwood and forest products, and difficulty in obtaining desired materials.	Seed sowing and plant nursery establishment of the most favoured suitable fodder, fuelwood, multipurpose tree species and grasses.	Availability of choicest seeds and seedlings for planting to meet the needs of the people.
3. Engineering/ bio-engineering		
3.1 Scarcity of water during dry season and excess of water during heavy rain causing soil loss, nutrient loss, gully formation and land degradation.	Simple, cheap water ponds and tanks to collect rainwater, irrigation channels, check dams, drainage ditches, vegetative protection belts, shelter belts, establishment. Check dams, silt traps conservation farming techniques, contour cultivation, alley cropping.	Availability of water during dry period improved and damage during heavy rains reduced. Simple engineering and bio-engineering practices very useful and effective.
4 Economic		
4.1 Poverty of people, low income, scarcity of food, fodder, water and fuelwood, unemployment	Socioeconomic surveys to assess status and needs of people. SALT/OATs. Models for food and biomass production and income generation. Rabbit rearing, goat husbandry, bee-keeping.	Adoption of SALT and OAT models encouraging. Increase in food, biomass availability, and income and employment opportunities.
4.2 Declining production, slow growth, shortage of fertilizers, manure, and nutrients	Biomass mulching, compost manure, organic fertilizer, biofertilizers. Nitrogen-fixing tree species in SALT and introduction of OAT.	Use of biofertilizers and organic manure and introduction of OATs/SALTs producing good results.

Table 3: Identification of Problems, Measures Adopted for Rehabilitation of Degraded Lands, and the Responses and Results (Cont'd)

Problems	Rehabilitation Measures	Responses, Results
5 Ecological		
5.1 Ecological degradation, loss of biodiversity and environmental depletion.	Reforestation, conserving farming practices, increasing vegetative cover and productivity due to soil and water conservation and improving measures ecological equilibrium.	Increased availability of protective and productive plant cover due to better conservation and utilisation of land resources.
6. Lack of human resource development	R & D activities, training, extension and demonstration activities.	Human resources development very useful and effective.

Table prepared based on ICIMOD 1993; Pei Shengji et al. 1994.

The impact of land degradation is felt not only in biological-physical terms but it extends deeply into the economy and environment. Rehabilitation ecology has to integrate effectively ecological, economic, sociocultural, and political dimensions of the social processes and perceptions. To achieve long-term environmental benefits and goals for the larger society, immediate and short-term benefits to on-site people must be preferred and given priority to ensure success, sustainability, and local people's fullest participation.

Main strategies for rehabilitation of degraded lands

A three-pronged strategy was adopted.

- Direct interventions on degraded lands (on-site). These consist of adopting appropriate land use, protective and productive activities such as establishing vegetative cover, desired changes in land use, and on-site activities affecting appropriate land use, soil conservation, forest management, agroforestry, etc.

- Indirect interventions. Policy and legislative reforms, population control measures, conservation education, development of suitable technologies, increase in awareness, training, extension, land-use planning, land ownership and tenurial rights, incentives for promoting positive land use and rehabilitation, and disincentives and punishment for inducing and accelerating land degradation.

- Interventions outside degraded land (off-site). These focus on off-farm employment, support and contributions from the lower watersheds and adjacent communities to reduce and minimise negative impacts, and help the affected site and people.

How to rehabilitate? What are the appropriate measures?

Socioeconomic measures: ensuring people's participation for success and sustainability. Awareness arousing by highlighting the problem of degradation and identifying its causes and serious consequences for the present and future generations. The urge and search for solutions must come from the sufferers and stakeholders after they realise that grave consequences result from not solving the problem and bright prospects for a better future proceed from the rehabilitation of degraded lands. People's own initiatives and efforts will ensure success and sustainability of the rehabilitation, maintenance and further development of land-based resources. Another major achievement is that once the people understand about the value of sustainable management they become the custodians of their resources and will safeguard them from degradation in the future. This knowledge is instilled not only in local people but is also disseminated throughout the neighbourhood quickly and effectively. In Nepal, a forest user group (FUG) was formed by the villagers so that they could own and manage their site. 3,000 m of high-density polythene pipe was provided to bring water to the village for a plant nursery and the FUG's drinking water supply. The pipe laying was completely done by the villagers themselves. Forest management plans were prepared and implemented by the FUG with the assistance of the Forest Department and the Project. People participated fully from inception to completion. Similarly, in China and India, local people were involved and land-use management plans were prepared and implemented. Income-generating activities such as bee-keeping, goat husbandry, and rabbit rearing were introduced. The growing of fruit trees, high-value cash crops, and medicinal and aromatic plants was taken up. Socioeconomic surveys were conducted to assess the status, needs, and interests of people and to monitor changes. Training and extension activities were conducted with excellent results of demonstration and dissemination.

Biological measures. Primarily consist of appropriate forestry, agroforestry, agrosilvicultural, silvipastoral, agrosilvipastoral, horticultural, pastoral, and sericultural systems and practices and their combination, adopted

for socioeconomic and ecological benefits. These are permanent, sustainable, and cheap but need a longer time frame, better protection , and continuous monitoring and improvement. Biological measures are not only protective but are productive as well and are a growing investment providing economic and environmental benefits for all time.

Biological measures adopted are as follow.

- Biomass surveys and monitoring, studies of indigenous knowledge, useful and suitable species for nitrogen fixing, soil conservation, fodder, fuelwood, timber, multipurpose uses, medicinal and aromatic values, higher-income generation cash crops, fruit trees, flowers, grasses, live fencing, seed collection, plant nursery establishment ,and seedling production
- Species' performance trials, growth records, natural regeneration
- Natural forest, shrubland management practices
- Preparation and implementation of forest, land-use and management plans
- Shelter belts, protection belts
- Natural regeneration enriched by sowing and planting of suitable seedlings of plants, grasses, trees, fruit, growing of crops, crop rotations
- Sloping agricultural land technology (SALT) and other appropriate technologies (OATs)
- Biogas plant installation as an alternative energy source and to reduce pressure on forests
- Bee-keeping for income and better pollination
- Compost manure, fertilizer, mulching, biofertilizer

Simple and cheap engineering measures (including bio-engineering). These consist of simple engineering check dams, gully control structures, walls, water tanks, reservoirs, trenches, drop structures, etc. These are secondary, expensive, and costly to maintain. Use is limited generally, and utility decreases over time. These may be necessary under certain critical circumstances but should not be preferred over biological means.

Simple and engineering structures, including bio-engineering structures established, are as follow.

- Pipelines, water channels for drinking water and irrigation
- Drainage lines to divert and drain excess water safely; also channels and tanks to collect rain water in the ponds for irrigation and livestock use during the dry season
- Check dams and stone walls in gullies, silt traps, use of local materials such as stones, bamboos and indigenous traditional technologies undertaken
- Maintenance of abandoned and damaged terraces

People and Resource Dynamics' Project (PARDYP)

This project evolved from the above-mentioned successful ICIMOD/NCI projects. It builds on the achievements and lessons learned in the past. The goal is to improve the understanding of environmental and socioeconomic processes associated with degradation and rehabilitation of mountain ecosystems and to generate wider adoption and adaptation of proposed solutions by stakeholders.

This project became operational in 1996 on five sites in four ICIMOD member countries. In China, India, and Nepal, research and development activities are being conducted in close cooperation with national collaborating institutions and local people. Summary of the sites, NCIs, and activities is given in Table 4.

Appropriate Technologies for Soil-Conserving Farming Systems' (ATSCFS) Project

The main objectives of the project are the identification, testing, and proving of soil conservation technologies that can reduce soil erosion to an acceptable level (10-12 t/ha/yr), that can maintain soil fertility, and are simple, cheap, effective and acceptable to mountain farmers. ICIMOD, in close collaboration with the national collaborative institutions of six ICIMOD member countries—Bangladesh, China, India, Myanmar, Nepal and Pakistan—and the International Board of Soil Research and Management (IBSRAM) and the Asian Rural Development Foundation (ARLDF), and with financial assistance from the ADB, initiated and implemented the ATSCFS project on ten sites from 1994 to 1997 as the first phase (Table 5). The second phase is on-going. These project sites are now well established and successful examples of soil-conserving farming systems. They are being used as demonstration and training grounds for policy-makers, professionals, and farmers.

Table 4: PARDYP Project: Countries, NCIs, Site Information, Important Aspects and Expected Outputs

Country and NCIs	Site, information	Important aspects and expected outputs
1. China/Kunming Institute of Botany, Chengdu Institute of Biology, Baoshan Hydrologic Research Survey Station, Baoshan City Bureaux	Xi Zhuang watershed, rural agrarian, patches of degraded lands, extensive area of scrubland and forests	• Research agenda widened • New local, national and international partners to provide specific contributions • A common framework for socio-economic and bio-physical interventions to be developed and systematically implemented
2. India/G.B.P. Institute of Himalayan Environment and Development, Kumaon University, Munch, CHEA, Tea Development Project, Kumaon Development Vikas Nigam, Block Development Council, Village Forest Panchayats	Bheta Gad. Garur Ganga watershed, 2,230 ha, several degraded lands, different land-use patterns	• Well-defined watersheds as study sites • All activities to be implemented under unified methodology. Expected Outputs: • Generation of information in the fields of hydrology, meteorology, soil erosion and fertility
3. Nepal/ICIMOD, HMGN Departments of Forestry, Hydrology, Meteorology, Soil Conservation, Nepal Agricultural Research Council, Tribhuvan University	Yarsha Khola watershed, 5,338 ha, farming, forestry, livestock, different land uses and degraded lands Jhikhu Khola watershed 11,121 ha, farming, forestry, and variety of degraded lands	• Improved understanding of natural resource dynamics in selected watersheds of the HKH • Agronomic initiatives to combat decline in soil fertility • Conservation initiatives to combat soil erosion and land degradation • Improved understanding of the role of communities in watershed management and planning
4. Pakistan/Pakistan Forest Institute, NWFP Agriculture University, District Forest Officer	Hilkot Sharkul watershed, agropastoral subsistence farming, different land uses and degraded lands	• Strengthening partnerships between local, national and international collaborators • Demonstration, training, and dissemination of results and information for wider application

Table prepared based on ICIMOD 1996, 1997 (b)

Table 5: ATSCFS Project: Countries, NCIs and Project Locations with Approximate Agroecological Zone and Successes and Achievements

Country/NCI	Project site, elevation	Approx. agro-ecological zone	Successes/ achievements
Bangladesh/Chittagong Hill Tracts' Development Board (CHTDB)	Alu Tila (CHTDB), 500m	Tropical humid	SALT, OAT adopted by 1,000 families in shifting cultivation areas. Corn and potato yield higher with SALT
India/G.B.P. Institute of Himalayan Environment and Development	Mokochong, Nagaland 400m	Tropical-subtropical humid	SALT, OAT demonstrated and promoted, shifting cultivation farmers interested
China/Chengdu Institute of Biology, Ningnan county	Ningnan county, 1,000m	Subtropical sub-humid dry	29 nitrogen-fixing trees tested in hedgerows, mulberry in between, effective in gully control, soil loss from traditional farming is 6-21 times higher than with SALT
Myanmar/Myanmar Agricultural Service	Lashio, 1,000m	Subtropical humid	SALT models developed
Nepal/ICIMOD Nepal Agricultural Research Council (NARC)	Godavari, 1,500m Mugling, 400m	Warm temperate humid Subtropical sub-humid	16 nitrogen-fixing trees tested and best identified extending on to adjacent sloping farmlands soil loss reduced from 2.8 t/ha/yr to 0.4 t/ha/yr
Department of Soil Conservation, HMGN	Tistung	Cool temperate	SALT/OAT developed
Pakistan/Pakistan Agricultural Research Council (PARC)	Begowal	Dry temperate	Bean yield higher with SALT

Table prepared based on ICIMOD 1994, 1997 (a).

Lessons learned from the ATSCFS Project

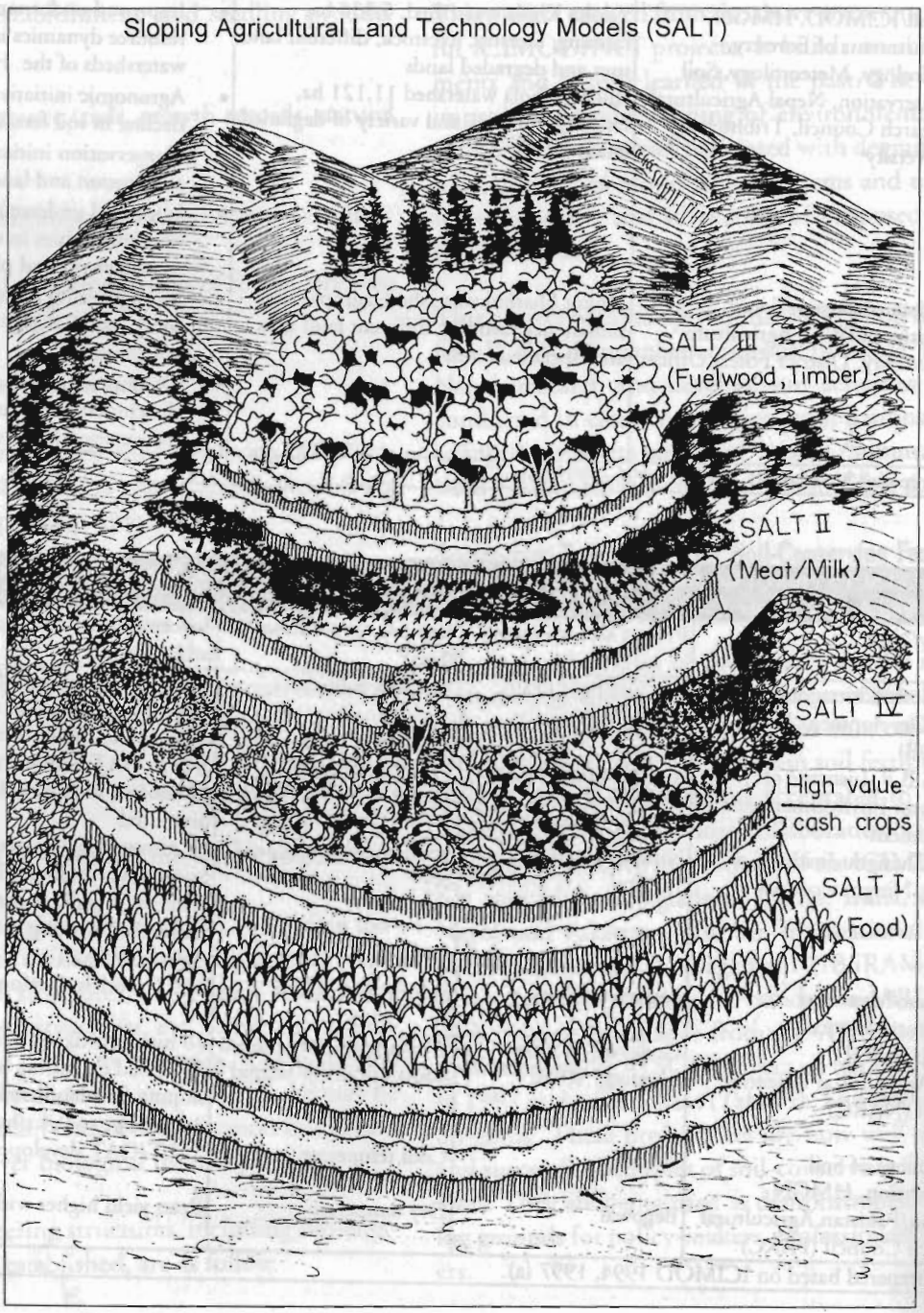
- **SALT (Sloping Agricultural Land Technology)** agroforestry system using hedgerow barriers of nitrogen-fixing plant species and its various following models are appropriate and suitable for controlling plant species' soil erosion. They also produce food, fodder, and fuelwood, and enrich soil fertility.

Models	Major products
SALT I	Food
SALT II	Meat/milk
SALT III	Fuelwood, timber
SALT IV	High-value cash crops

Combinations of cereal crops, horticultural crops, high-value cash crops, and most suitable nitrogen-fixing tree species (NFT), their planting techniques, pruning size, timings, and intensities have been determined. Runoff has been controlled and soil erosion reduced, infiltration increased. Increases in organic manure, moisture holding capacity of soil increase in nutrients particularly nitrogen, phosphorus, and potassium.

- **Other appropriate technologies (OATs)** were the following.

  - Polythene film technology
  - Water harvesting and management, irrigation and proper drainage



Mulching, compost-making, effective micro-organism (EM)
Biofencing/live fencing, appropriate species identified
Urea molasses block
Goat husbandry
Rabbit rearing
Bee-keeping
Protection belts/shelter belts
Fish farming
Duck raising
Pig raising
Floriculture

- Water has been identified as a key factor in all aspects of sustainable mountain farming systems. Both excess and scarcity of water is harmful and damaging. Safe passage and harvesting during excess to be used for scarcity period adopting local materials in simple, cheap, and environmentally friendly technologies are most useful and successful.

- Technologies for seed collection, storage, germination, and plant nursery techniques and plant propagation methods developed and used.

- Dissemination of knowledge and information through workshops, seminars, demonstration, training, literature, and video films from the grassroots' level to professional policy level undertaken. Farmer households, village level, country, national, regional and international institutions, GOs, NGOs, INGOs and other agencies and institutions all participated.

- Based on the success and achievements of the first phase of the project (1994-97) the second phase (1997-2000) has been extended to substantiate the preliminary research results and expand the demonstration, training ,and extension component.

- Better understanding of lowland and upland linkages/interactions/issues and appropriate action

- Policy and legislative improvement and implementation—institutional development and sectoral linkages

- Introduction of the concept and practice of conservation farming systems to minimise soil erosion, conserve moisture ,and improve productivity by water, soil and plant management.

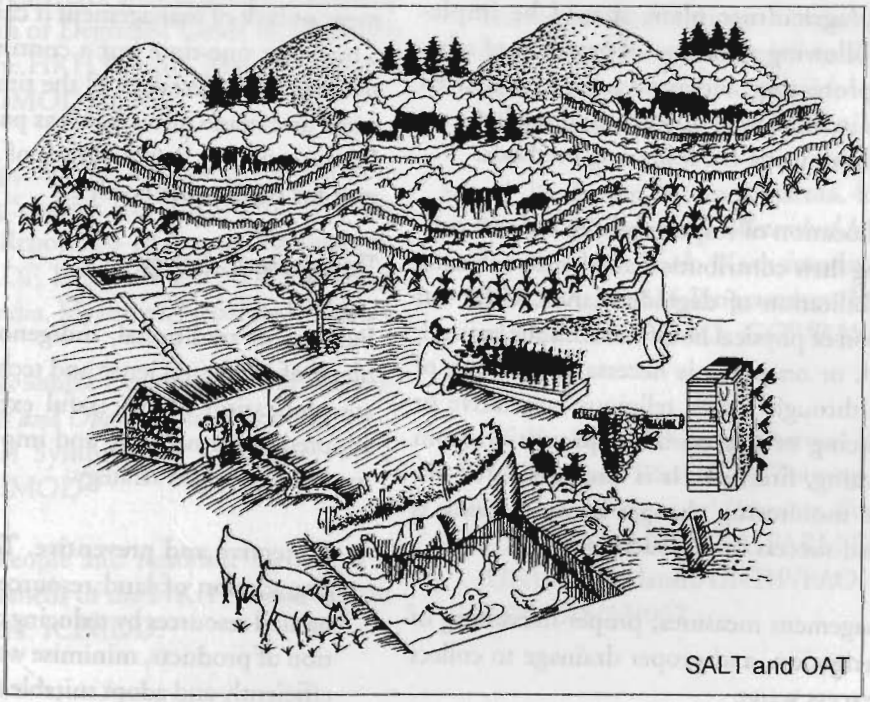
- Improving education, training, research, and extension.

- Human resource development and fullest mobilisation

- People's active participation and greater involvement of women and disadvantaged people

- Holistic, participatory integrated watershed management approach

- A complete production-cum-conservation farming package for the mountain farmer comprising appropriate means, materials, tools, and technologies for delivering socioeconomic and environmental benefits to increase land value



SALT and OAT

Key steps for rehabilitation of degraded land

1 The first step is to examine the historic events that led to the degradation, consider carefully the various constraints and assess the role of various processes in degradation. Analyse, diagnose and identify the main constraints and their importance.

2 The second step is to investigate the attitude and responses of local people regarding rehabilitation of degraded lands, and their interest, needs ,and commitments towards it. Clear identification of people involved and the determination of the area of degraded land must be established. Land ownership, tenurial rights, management, uses, people's cooperation in terms of protecting the land from cutting, grazing and fires, and maintenance and operation of plant nurseries, etc must be agreed upon.

3 The next step is to study and evaluate the effect of past rehabilitation measures taken, if any, their failures or successes, and people's experience and suggestions for improvement.

4 After the local people agree fully and decide to rehabilitate the degraded land the programme can commenc with a reasonable degree of success. Quick economic gains will be attractive to the people along with long-term social and environmental benefits.

5 After ensuring the commitment of people's fullest participation the rehabilitation programme should be prepared and implemented. Land-use management plans, forest management plans, and agroforestry/agriculture plans should be implemented by following a package of practices of rehabilitation, protecting and producing the desired bioproducts in increasing quantity and quality on a sustainable basis using the following methods.

- Clear-cut allocation of responsibilities of local people regarding their contribution and benefit-sharing in the rehabilitation of degraded lands. Clear-cut determination of physical boundaries on the ground, on the map, or on paper is necessary. Securing of boundaries through social, religious, vegetative or physical fencing or flag posts for protection from cutting, grazing, fires, etc. It is also useful for observing and monitoring changes because seeing is believing and success breeds success.

- Water management measures, proper harvesting of water for irrigation, and proper drainage to collect and drain excess water.

- Soil conservation measures.

- Vegetative conservation measures

- Construction of simple and cheap engineering and bio-engineering structures if needed.

- Selection of appropriate land use, forestry, agroforestry, agriculture or a combination of these to suit the land capability and the people's interest and needs. Indigenous species are more suitable than exotics because of certainty, sustainability and global biodiversity.

- Application of soil amendments to enhance growth

- Seed collection, storage, establishment of plant nursery, seedling production, seed sowing, planting, maintenance, protection and management

- Appropriate technologies: sloping agricultural land technology (SALT) and other appropriate technologies (OAT) can be adopted.

- Maintaining and improving the productivity of land and ensuring sustainable supplies— fair and equitable sharing of benefits by the stakeholders for success and continuity.

Conclusions and recommendations

Degradation and rehabilitation are not static or fixed but are dynamic and changing. With proper management the situation can improve and with mismanagement or lack of management it can deteriorate. It is not a one-shot one-time but a continuous and regular activity to be undertaken all the time. It should be inculcated and made into a habit as part of the customs, behaviour, culture, and practices of mountain people forever for sustainable results.

Three-pronged strategy

Full use of traditional, indigenous knowledge with a blend of modern science and technology and appropriate replication of successful experiences needs to be adopted in formulating and implementing the following three-pronged strategy.

- **Protective and preventive.** To protect and prevent degradation of land resources reduce pressures on natural resources by reducing demand and consumption of products, minimise wastage, utilise resources efficiently and adopt suitable alternatives. Follow the

maxim 'prevention is better than cure'. Do not allow degradation.

- **Rehabilitative and curative.** Rehabilitation of the damage done to degraded land resources—soil, water, plants, ecosystem and biodiversity—by adopting appropriate measures and treating the wounds on time. Early treatment is cheaper and quicker, the response is better and the results are more successful. Remember the maxim 'a stitch in time saves nine'.

- **Productive and sustainable.** Increase productivity and production in a sustainable manner for economic and environmental gains.

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