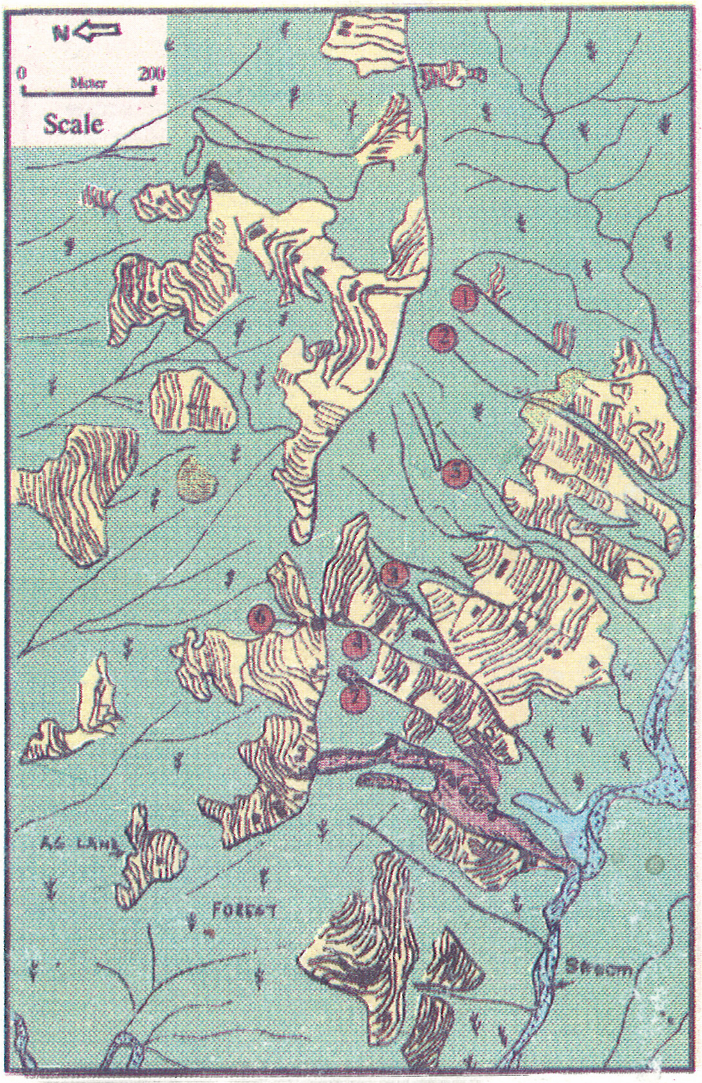
RESTORING MOUNTAINOUS REGIONS

A STRATEGY AT THE LOCAL LEVEL



Landscape changes in Ikudol VDC

A CASE STUDY OF THE RESTORATION OF DEGRADED LAND RESOURCES IN THE HILLS OF LALITPUR DISTRICT, NEPAL

Madhukar Upadhya

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AUTHOR'S REMARKS

This study is an effort to come up with indigenous solutions to the problems of soil erosion and land degradation in the hills of the district of Lalitpur (about 30 km south of Kathmandu). Although the ideas expressed in this report developed while the author was working in the districts of Lalitpur and Kavre as a Soil Conservation Officer for the Bagmati Watershed Project, the experiences and observations described are purely personal and have nothing to do with the author's official capacity.

As it was not intended to be a formal research paper, this report does not contain any statistical analyses.

The author assumes full responsibility for any errors or omissions.

The author believes that this study may interest those individuals who are keen on restoring degraded mountainous regions of the Himalayas where poor farmers live.

The author is grateful to the farmers in the study area, without whose support he would not have been able to produce this report.

The author wishes to thank Mr. M. P. Acharya and Rajendra K. Shrestha for word processing the script and all the experts who reviewed this report and made valuable suggestions for improving it.

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1. GENERAL BACKGROUND

The degradation of our mountain ecosystem has become a major concern for land managers. Continued deforestation, and overgrazing, the rising pressures to cultivate marginal land and unavoidable natural erosion processes have collectively led to increasing soil and nutrient loss in the uplands. It is estimated that about 53 percent of all erosion and soil loss comes about through natural processes and that about 47 percent is caused by human activity. The mid hills and mountains of Nepal suffer from a great deal of soil loss due to their fragile nature and steep slopes and to uncontrolled human activity.

The 1960's was a period of record economic growth for most poor countries in the world, but food production could not keep up with population growth (Eckholm 1976). In Nepal a considerable loss of productivity on rainfed agricultural land has occurred over the last few decades. In addition on the hills, valuable land is lost to landslides and gullies. People living in the hills and mountains already face economic hardships and cannot cope with this increasing loss of productivity. Continued loss of soil due to erosion reduces productivity so much that even fertilizers cannot compensate for the loss of nutrients. Similarly, land lost to gullies and landslides can never be reclaimed for food production. People are thus forced to cultivate even steeper slopes, which are actually unfit for cultivation, and to sacrifice forest cover to cultivation.

Cultivation on steep slope

There are several instances of such severe environmental degradation that people have become environmental refugees in their own homelands. The midhills of Nepal make up about 67 % of the total land area of the country and almost 60% of the total population live here. However, hill and mountain areas provide just 34 % of the nation's food. Carson (1992) states that researchers and even farmers themselves believe that the soil in the hills of Nepal is not as fertile as it once was and that soil is being degraded. And in fact, they are right. Ongoing, catastrophic soil degradation is occurring on both the alluvial and alluvial/ colluvial soils in the middle mountain physiographic regions of Nepal.

2. THE CHALLENGE

The need for forest land for fuelwood, timber, fodder, and for expanding food cultivation will persist and even increase as human and livestock populations grow. Our hills and mountains must support the needs of the local inhabitants and their offspring. Further depletion of the natural resource base of our mountains would result in additional pressures on an already hard-stricken population. Needless to say, we need to at least maintain, if not improve, the quality of our hills and mountains for the generations to come.

As far as restoration of mountainous regions is concerned, a great deal of emphasis has been placed on the reforestation of denuded mountain slopes. However, we must realise that degradation is not limited to forestland alone.

Degradation of grassland, shrubland, and agricultural lands exists as well. Degradation of agricultural land affects the farmer more than degradation of other types of land because the livelihood of a family depends on the productivity of its farmland. Moreover, most farmland in the hills acts as a "nutrient sink", that is, it absorbs valuable nutrients harvested from forestland and grassland and used as manure.

A great deal of the good quality cropland in the hills continually loses topsoil through erosion because of the prevailing methods of using resources. Failure of terraces, landslides, and gullies are common phenomena in the hills. These phenomena contribute to the decrease in food production, which in turn results in a decrease in the carrying capacity of private land in the hills. Consequently there is a rise in pressure on community land as farmers seek new land to cultivate. Farmers have lived with these problems for generations and seem to take them for granted. It seems that farmers in the hills have lost confidence in farming. This attitude has resulted in temporary and sometimes permanent migration to big cities.

People in the hills keep animals largely for manure, which is needed for growing maize and millet. A lot of their time is spent collecting fodder for the animals providing this manure.

In Fig. 1, I have attempted to show that a significant part of the valuable nutrients collected by poor farmers from forests in order to fertilize food grains is lost without being noticed. Each farmer has to raise more animals and collect more fodder in order to maintain or to increase his level of food production. Eventually, when it becomes unprofitable to cultivate his land, the farmer abandons it and cultivates a new slope or migrates elsewhere.

It was once believed that the deforestation of natural forests results in the declining productivity of agricultural lands. But in reality, the opposite may be true. In fact, Thapa and Weber (1990) state that the destruction of forest and pasture is a spillover effect of declining crop productivity.

Degradation of agricultural land requires that the farmers provide more inputs. This creates more pressure on forestland as more fodder is collected in order to feed the larger number of animals needed to provide the manure necessary for maintaining the level of crop production required to sustain the family.

The widespread degradation of mountain is not simply due to the "more people need more fuel/fodder scenario". Given the present rate of soil and nutrient loss from the hills, the productivity of hilly agricultural land will continue to decline even if forests are restored.

In short, the primary cause of degradation of mountains land is the high demand for fodder, which feeds the animals producing manure in this inefficient soil nutrient system. Replanting degraded forests addresses one symptom of degradation rather than tackling the cause. The long-term effectiveness of this strategy is questionable since unless the demand for fodder can be reduced, pressure on forest land will increase at a rate greater than can be sustained by rehabilitation activities.

Reducing the demand for fodder by increasing the efficiency of the farm-level soil nutrient system tackles the heart of the problem and hence gives the forest a better chance of regenerating naturally.

Again, cultivated land belongs to individual families and forestland belongs to communities. Work done by a farmer to increase the productivity of his own land is seen to be directly beneficial to him. Thus, such work is more likely to be undertaken than work categorized under the more nebulous concept of "forest development by the people" in which the benefits of an individual's input are less clear.

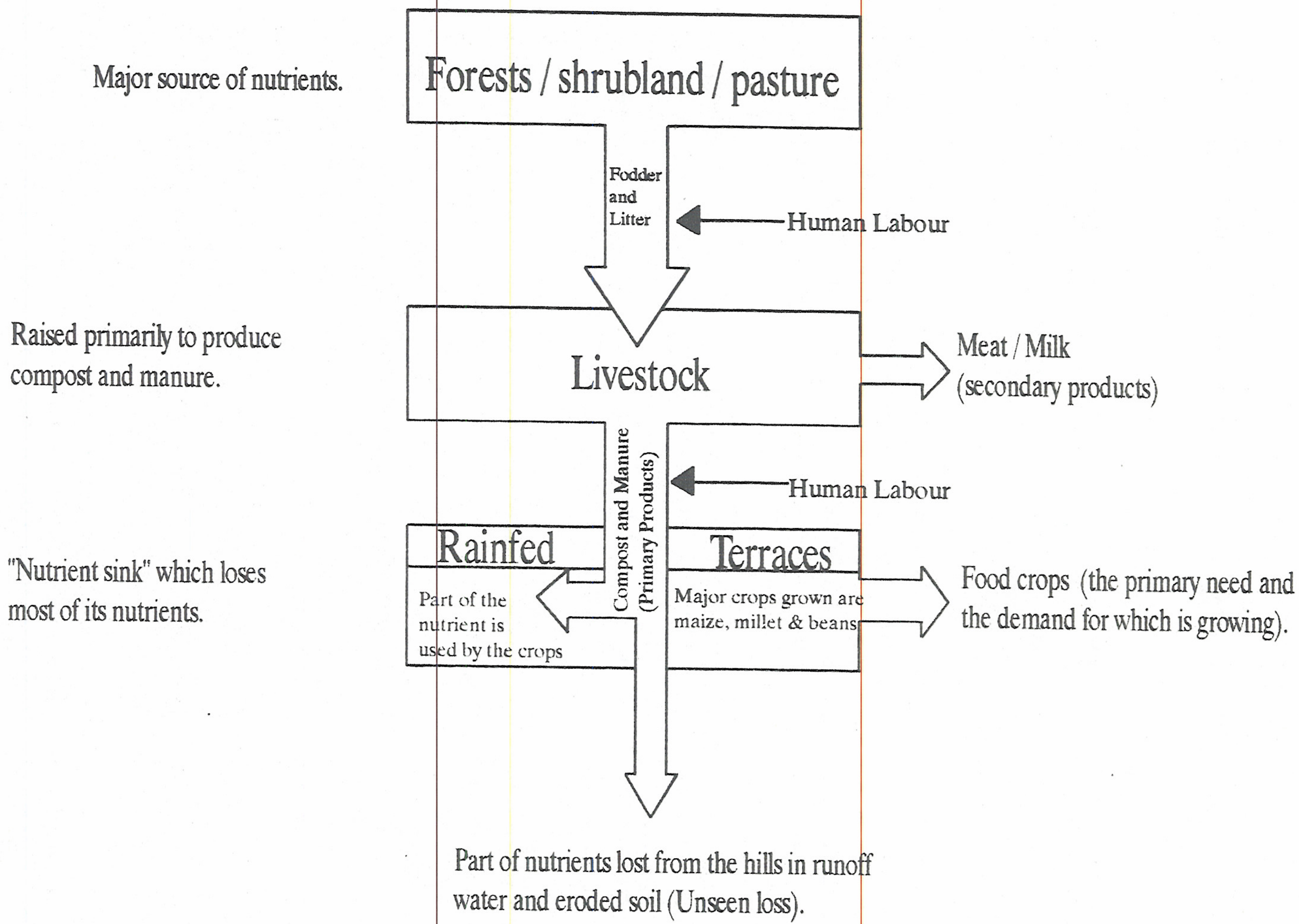
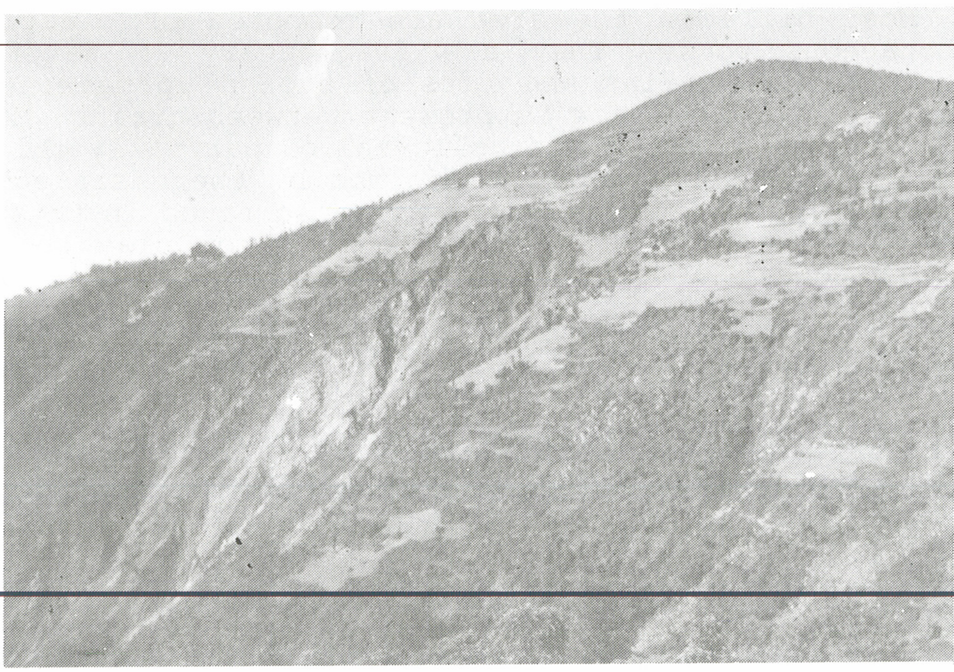


Figure 1. The concept of "nutrient sink"

Maintenance, restoration, or development of existing, depleted or potential resources such as soil, water and forests is only possible when individual families are motivated to act. An individual will probably act only when he sees that his efforts directly benefit his family. Still, any efforts in resource management should yield not only individual, short-term benefits, but also common, long-term benefits. Short-term benefits motivate farmers to work towards managing their resources and long-term benefits help reverse the trend of environmental degradation in the hills.

A quick return on resource management can be achieved only through proper management of individual farmland. To raise the confidence of farmers in resource management practices it is necessary to maintain or increase the productivity of their farmland. Improvement of the overall environmental condition of the hills must be started from within the agricultural production system. Possibly the most cost-effective method for improving the overall soil fertility status is to reduce the losses that occur in the agricultural production system (Carson, 1992).

With this view in mind, a Community Resource Management Strategy (CREMS) was developed and introduced in the severely degraded hills of Lalitpur district in 1987. Five years of experience in implementing CREMS has demonstrated that the farmers are convinced and motivated by this technique for the conservation of land resources in the hills. Experience shows that farmers can increase their crop yields through proper management of terraces and monsoon run-off. Such management also protects them from the dangers of erosion and landslides. Farmers need to be shown and educated about water and terrace management techniques.



Degraded hills of Dalchoki

3. INFORMATION ABOUT THE ENVIRONMENT OF THE STUDY AREA

In order to understand the gravity of the soil erosion problems that face the hill farmers of the villages of Ikudol, Bhattedanda, Bhardev, and Dalchoki in Lalitpur, it is necessary to be aware of the following information:

Topography

The hills of Lalitpur form an intricate system of moderately steep to very steep hills and mountains. The ridges and valleys of these hills were created by rivers flowing from north to south and from east to west.

In general, southern slopes are less steep, and have less forest cover, higher rates of erosion (probably as a result of a speeded up weathering process caused by temperature variations and rainfall), and greater human and livestock activity than other slopes. Most landslides and gullies are found on southern slopes. Such landslides and gullies continually change the local topography and hydrological patterns.

Climate

A variety of climates, ranging from warm sub-tropical in the valleys to cool temperate in the high ridges, is found in these hills. This variety has endowed the area with rich flora and fauna which change with the altitude. About 80 % of the annual rainfall occurs within the four months of the monsoon season. The mean annual temperature range from a minimum of 12° C to a maximum of 22° C., with extremes of 36° C. to less than 0° C.

Geology

Most hills in the area are composed of clastic and carbonaceous rocks. They are fragmentary in nature and contain coarse grains and bits of broken up materials. A fairly large pore space is present between grains. Much of the soil in the uplands is colluvial or partially colluvial in character. Residual soils formed by the disintegration of underlying parent materials are also found in this area. The soil texture in the hills ranges from clay to gravel and includes all combinations thereof. In terms of the degradation of soil resources, we note that colluvial deposits are usually unconsolidated and hence are prone to mass failure, while residual soils suffer from surface erosion.

Land Use

Already about 20-25 % of the land in the hills is under crop production. Population pressure is evident in the growing pressure on available land and in the expansion of farming onto new land, which, for reasons of topography and soil quality, is not suitable for cultivation. Degraded forests and shrubland form a major part of the total land area. Landslides and gullies, although they form a very small portion of the total land area, contribute significantly to the loss of food-producing area.

The presence of terraces under many patches of natural forest indicates that these patches were once cultivated. Similarly, abandoned cultivated terraces that have turned into grassland are also present.

Hill Farms

Most hill farms have been established on colluvial deposits, which are weak and prone to landslides and erosion. People have settled on such deposits because they are easy to cultivate. Some farms are found on residual soil.

Socio-economy of the inhabitants

Agriculture is the main occupation of the hill people. There are few other employment opportunities in the hills. People live mainly on what they can grow on the slopes of the hills and on the flat plains of the valleys. Some development projects and cottage industries may to some extent have helped the local economy in selected places.

Farming is a dawn-to-dusk, hand-to-mouth existence. Agriculture is poorly developed and yields depend on the size of land holdings rather than on the quality of farming techniques. Farmers work at the subsistence level and use traditional hand tools for farming. There is a food shortage for about 3 to 6 months of the year, during which period people migrate to the cities (Kathmandu, Patan and the Terai) to earn a living as laborers or porters. Some farmers raise buffaloes and produce milk or khuwa (a sweet milk spread) for additional income.

The social structure and behavior patterns in the hills are traditional. Poor people occupy degraded land while good land belongs to richer people. Rich people generally belong to the Brahmin and Chhetri castes. Tamangs, the poorest people in the area, are usually found along the ridge.

4. PROBLEMS OF THE AREA

The problems in this area are not unique. In fact, they are almost the same as those elsewhere in the country. Therefore they will be described here only briefly.

Poverty: The majority of the farmers living in the area are very poor. They can produce enough food for only 6-9 months of the year. In order to feed their families, they have to migrate elsewhere and work as unskilled labourers. They also suffer from all other problem associated with poverty, such as minimal education, poor health, and so on.

Lack of fuel/fodder: The quality of the natural forest has declined so much that farmers must feed their animals dry corn stalks during the winter. Farmers who raise buffaloes for milk, feed their animals corn stalks and concentrates only. Fuelwood is in a very short supply. Twigs and branches are used to cook food.

Lack of water: Immediately after the monsoon season the hills become so dry that there is hardly any water for winter crops. With the help of government and non-government projects, farmers have hooked polythene pipes to distant sources of water in order to meet household needs for drinking water.

Landslides/gullies: Landslides and gullies are very common in this area. Many of them are active during the monsoon season. In the areas around Bhardev and Nallu, the scars of hundreds of landslides which occurred in 1981 are still visible. Many of them are in and around cultivated areas.

Steep slopes: The hills are very steep, making mobility, let alone farming, quite troublesome. That development workers, once they reach the villages in the valley, rarely go to the ridges where the poorest, most unskilled, and deprived people live, is testimony to this fact.

Declining productivity: Over the last five years I have noticed that several cultivated areas have been abandoned. Upon careful examination I could see that other areas had been abandoned even earlier as well. Abandonment is the result of declining productivity. When it is no longer profitable to cultivate his land, a farmer moves elsewhere.

Abandoned land

5. TACKLING LAND DEGRADATION

5.1 Community Resource Management Strategy (CREMS)

Terrace improvement is one of the soil conservation activities implemented by the government of Nepal. Part of the cost of the improvements is subsidised by the government. The object of terrace improvement is to control soil erosion on cultivated terraces in the hills. Terrace improvement is done either by levelling terraces or by planting suitable grass/tree species along the terrace bunds. This activity never picked up momentum in the past, probably for the following reasons:

- Improvement work was oriented only toward physical targets (e.g. 100 hectares/year).
- Farmers placed more importance on the subsidy than on the actual work.
- Food production was not given due consideration while improvement works were being designed.
- Technical know-how was absent and the physical and socio-economic characteristics of the area were not adequately taken into consideration.
- The different factors responsible for land degradation were not fully understood.
- Conservation measures already used by the farmers were not promoted.

However, my experience in Lalitpur shows that a terrace improvement programme which is properly designed with a well-thought out technical foundation can motivate people to manage land resources in a sustainable way.

Since the terrace improvement programme developed in Lalitpur incorporates several other conservation activities (see 5.4) in addition to terrace levelling, this programme is now identified as the "Community Resource Management Strategy" (CREMS).

5.2 Objectives of CREMS

CREMS has the following objectives:

1. Reduce soil and nutrient loss and thereby increase agricultural production in a sustainable way without using inputs not found locally.
2. Reduce waste of resources.

3. Make farmers aware of their ability to manage resources.

4. Stimulate local participation in resource management.

5. Create a foundation for achieving sustainable agricultural development and for improving environmental quality.

5.3 Approach of CREMS

The CREMS takes the following approach to managing a degraded environment and its land resources.

- The entire slope of a watershed is taken as the target for improvement.

- The interdependency of all natural resources (soil, water, forest) is considered and problems are considered to be the net result of interacting components. Private land (farms) and community lands, (forest, grass, and shrub land), are treated as a single management unit.

- The farmer is the focal point of any improvement work. The farmer is involved in each activity. The farmer is considered first and then only are the problems affecting him considered.

- Problems are addressed one after another in sequence.

- A package programme is developed for each household.

- Local resources are used efficiently.

- The indigenous conservation measures used by the farmers are identified and promoted.

- The community, in the form of a users' group, is made responsible for constructing ponds, trails, drainage systems, etc.

5.4 Major Components of CREMS

CREMS has the following major components.

i) Run-off Management

As damage in the hills is caused by excess water and by oversaturation of slopes during the monsoon season, it is necessary to control excess water. Run-off management is therefore a very important component of CREMS. Management starts right in a farmer's homestead because this is the place where the most run-off accumulates. Hence, the drainage network is built outward from the homesteads.

ii) Water Conservation

Water is conserved by levelling terraces or by planting grasses on the bunds of key terraces, and by digging conservation ponds and trenches at strategic locations.

iii) Soil/Nutrients/Organic matter conservation

Soil, nutrients, and organic matter are conserved by using the techniques for water conservation and in addition, by ensuring that run-off is properly managed.

iv) Slope Stabilization

Slopes are stabilized by employing the above measures, as well as by building stone works and/or planting vegetative protection.

v) Promotion of Vegetative Cover

To make the best use of all wasteland, grass and tree plantation is done. Depending upon their suitability grasses such as Amriso, Citronella, Napier or Babio are planted. Among trees, mostly fodder - yielding trees are chosen.

CASE STUDIES

CASE STUDY - 1

1. EVOLUTION OF CREMS

After having worked for over 10 years in the field of soil conservation and watershed management across the Himalayas, I was more than ever convinced that the activities usually carried out in the field to promote soil conservation and watershed management did not produce the results necessary to convince farmers to make conservation works an everyday part of their farming lives.

Most scholars had too narrow a view of the causes of environmental degradation. Although scholars identified the cause as widespread deforestation, field observations always indicated that there are other important causes such as geology, farming technique, land use practices, and socio-economic and cultural realities. These factors are equally or sometimes even more responsible for environmental deterioration than is deforestation. In fact, any successful soil conservation and watershed management programme must tackle all the causes and not limit itself to just one.

One limitation of the original efforts in soil conservation and watershed management was that their aim was to manage and conserve public land only. In the absence of a comprehensive policy for working on private land, private land was ignored except as recipient of terrace improvement activities. And although farmers had developed some methods of land management and conservation on private land, these methods were practiced only on a small scale and without an overall system.

Another problem with conservation works was that it was dominated by reforestation. And other rehabilitation measures recommended by government agencies were either very expensive or required using materials such as gabion wire, that had to be imported. It was obviously beyond the average farmers' ability to replicate such measures. As a result, farmers wanting to practice soil conservation in the hills started to depend heavily on government projects and ceased being self-reliant.

Moreover, conventional conservation work is often so expensive that it cannot be justified if one considers the cost of the treated land itself. For instance, treating a medium-sized landslide or gully with conventional methods may cost Rs. 100,000, but the value of the area treated might be far less. The economic return on such an investment would be greater and maybe quicker if the money was spent on buying fertilizer or digging a new irrigation canal.

In the context of the weak Nepalese economy we cannot afford to ignore this reality. At the same time, however, we cannot and should not neglect the genuine need for conservation activities if we want to save our land resources from becoming national sacrifices. It seemed to me that we needed technology suited to our particular situation.

Advocates of soil conservation have always believed that the impact of conservation activities can only be seen in the long run. And of course conservation works need to be ultimately geared towards long-term benefits. But the absence of short-term benefits and in the use of a time frame only for long term impact, farmers resisted soil conservation and watershed management. Consequently, conservation work lost its importance among planners, despite its necessity in the hills. If farmers are to make conservation work the real concern, they must be readily able to see immediate returns on their efforts.

When I first began working as a watershed manager, my responsibilities were limited to find sites (for gully and landslide control programs, or stream bank protection, and for plantation), which enabled a project to meet the targets it had set. Walking up and down the hills in search of 'good' sites for a project became more and more frustrating and ceased to even remotely satisfy me. I was also unhappy that development work became so politicized in the 80's. Even soil conservation and watershed management activities became political tools. In addition, conservation activities were so randomly implemented that they had any real impact.

My observations of the problems with the original conservation programmes and my own frustrations led me to explore the question of how to make conservation work simpler, more human, less expensive, and within the reach of poor farmers, and yet at the same time how to guarantee quick returns. I started to explore the traditional methods of conservation and to learn more about the farmers in the hilly area of Lalitpur district. At the same time I tried to relate the problem of land degradation to local biophysical factors. It became obvious that there was qualitative (loss of productivity) as well as physical (landslides, gullies) degradation taking place in the hills.

Since it was not difficult to show examples of physical degradation to the farmers and to see the same ourselves, I focused on finding ways to control that type of degradation. Qualitative degradation, on the other hand was difficult enough for me to assess, let alone to show examples of it to the local farmers. I had to rely on the farmers' self reported crop yields for the past and the present. Though many studies (See Sherchan and Baniya 1991) have indicated a steady decline in agricultural productivity in the hills due to erosion, if farmers do not agree that productivity has indeed declined, there is nothing we can do to persuade them to restore productivity. Therefore, I decided to tackle the problem in reverse. If I could show that conservation works resulted in greater harvests on their farms, farmers would definitely be eager to practice conservation on their own.

During a field visit I had come across two conservation - minded farmers from the villages of Ikudol and Bhattedanda in Lalitpur district. The farmer from Bhattedanda managed water, including monsoon runoff, in such a way that there was very little waste. With his efficient use of water he was able to increase his production of winter vegetables substantially (see Case Study 4). Soil in his bari was more fertile, moister and more friable than that in neighboring baris. The farmer from Ikudol had benefitted from making his terrace more stable. He had levelled the upper two terraces in front of his house in order to grow winter vegetables. His experience was that levelling reduced the risk of having the edge of the sloping terraces below fail. This result was probably due to the increased infiltration on the levelled terraces reducing runoff in front of the house (see Case Study 6). I found one common element in both examples : both farmers were managing water on their individual farms.

I also looked into the traditional methods of water management on community land. Farmers built community ponds to store water for livestock during the winter. Many of these ponds dried up after February or March. Farmers then started to water their cattle at nearby streams. In addition, village trails were used as a form of public drainage to divert excess water during the monsoon.

What was lacking was a total water management system that integrated conservation measures already executed on private and public lands. Such a system would be developed to get rid of excess water during the monsoon and to hold as much water as possible during the dry period. Since traditional drainage systems, ponds, and terrace levelling had already proven effective, I wanted to expand these same techniques onto the entire slope. My project was to be one of the activities of the Bagmati Watershed Project. My terrace improvement programme, as it was termed, was executed in Bhardev W. No. 7 (see Case Study 5). The first-year results not only encouraged farmers to practice terrace improvement techniques but also motivated field personnel to work with as many farmers as possible. No longer was my job limited to the frustrating task of finding landslide and gullies to control. My new programme generated quality and not just quantity results.

CASE STUDY- 2

2. LANDSCAPE CHANGES

In geological terms, hill slopes are transitional, both in process and in form. Changes in landscape are usually too slow to be witnessed. Land is shaped by mass wasting, river cuts, and erosion, but water flowing down the face of the land is the dominant agent of change. It becomes a matter of concern when this alteration affects the livelihood of the inhabitants within a shorter time span than they can cope with.

Upon detailed analysis watershed degradation shows a regular sequence of events and gradual changes which take place in the landscape. Although geology, vegetation, topography, and landuse, all have their roles in landscape formation and destruction, hydrology plays the most vital role in shaping the landscape and in destroying it.

Mass wasting, or landslides, is one of the most visible changes that take place in the landscape. Geologists can explain very precisely the causes of landslides and can predict where they might occur. Such information is very crucial for road construction and for selecting a site for dam construction. But for people who have lived for generations in landslide prone areas such as Lalitpur, this type of information does not help much. What these people need is information about how to control a landslide or to reduce the risk of a new landslide. Merely explaining the geological causes of a landslide is not sufficient. Although restoring vegetation or changing landuse patterns are time-taking and therefore not readily accepted solution to controlling landslides, there is another way of preventing villagers from becoming environmental refugees in their homelands. Managing drainage is a speedy and effective method for controlling land degradation.

A brief account of land scape change focussing on hydrology is given below:

The village of Chila (Fig 2) in Ikudol in Lalitpur District is situated on the ridge of a mountain. The southern slope of the mountain is much steeper than the northern slope and has been severely degraded by numerous gullies. Its settlements seems to be older than those on the northern slope. Agriculture land occupies almost the same area on both slopes. There are five distinct valleys on the northern slope and four valleys on the southern slope, all of which drain the mountain.

The agricultural farms on the northern slope are established on the ridges and the drainage lines have clear access to the stream below. On the southern slope, however, several deep gullies extend from the ridge to almost halfway down the slope before they disappear (See Nos 1,2, and 3). How can gullies of this size suddenly disappear ? How can there be farms at the deadends of such gullies ? Some secondary gully heads advance in directions different from that of the original one. (See Nos 4 and 5). What happened to the original head ? There is an old pond (See No. 6), probably as old as the settlement. Is there any link between the pond and Gullies Nos. 4 and 7 ? Answers to the above questions may lead to the conclusion that the runoff from the catchment has changed its course so frequently that new gullies have formed and old ones stabilized. This answer should also warn us that the area is very weak and that if runoff gets into the old gullies the farms at their ends may be easily washed away. Furthermore, annual precipitation is highest at the ridge, (Ries 1991). All this supposition suggests that it is necessary to examine how excess water flows down the hill. Understanding this fundamental question may help to establish a proper water management system and to design low cost rehabilitation measures.

Fig.2 Landscape changes in Ikudol VDC.

In Fig. 3 one notices that several mature trees have been planted in a depression in some farmland. The trees run down the slope in almost a straight line and lead to what appears to be an old gully at whose head there is a bunch of trees. If this gully ever existed how did it stabilize ? Is there any link between the depression and the gully ? Are the trees at the gully head and the ones on the farmland of the same age ? One may guess that the depression in the middle of the farm used to be a shallow gully. Somehow the runoff from above got diverted and as a result, the gully died. Then the farmland was cultivated but the standing trees were left uncut. If this is indeed what happened, then the farmer needs to make sure that no runoff gets into the depression. If it this were to happen the depression would surely become a gully and his cultivated land would be washed away.

A similar situation existed in Bhardev where farmers had cultivated gully beds. It is interesting that the gullies in Bhardev did not ordinarily fill with flowing water as a normal gully would, but the heavy downpour of September 1981 again made these gullies flow. This resulted in the destruction of all the farms established in those gully beds.

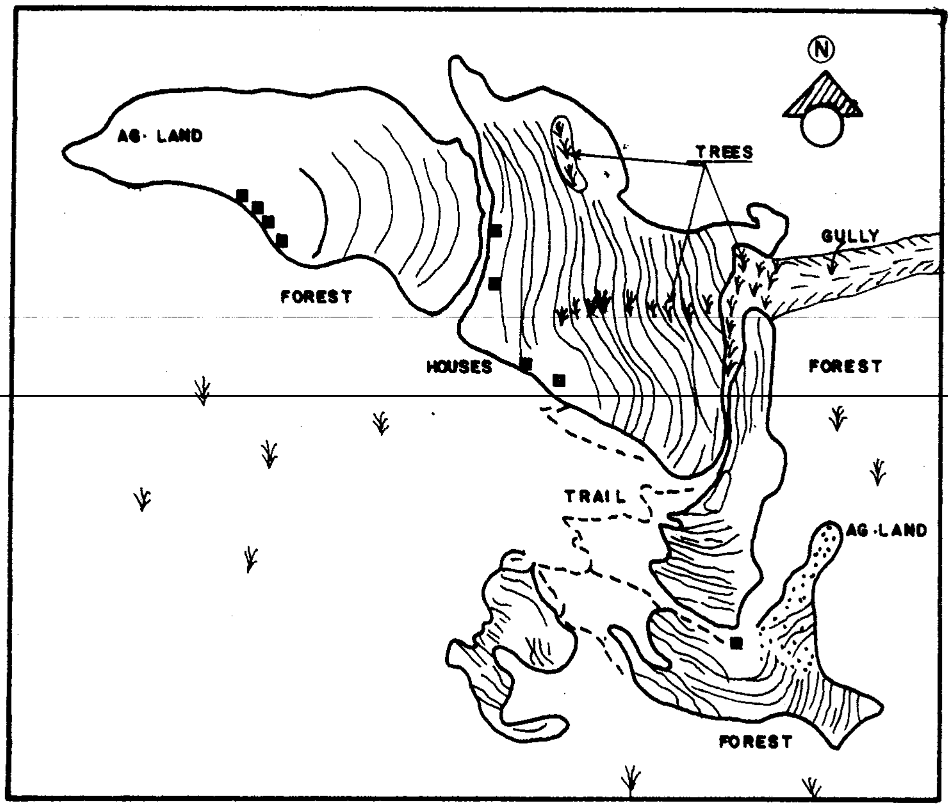


Fig.3 Landscape changes in Bhattedanda VDC.

3. ENHANCING FOOD PRODUCTION

Throughout the proceeding pages I have emphasized one major point: the loss of nutrients from soil causes crop yields to decrease. Hithertofore, deterioration of the quality of privately owned land has not received the attention it deserves from environmentally concerned professionals or from the government. Of course government agencies do give farmers the good advice to plant fuel and fodder trees on private land. According to Gilmour (1991), the number of trees on private land in Kavre district has increased by 300% in the past two decades. Similarly, in the Phewatal Watershed area in Pokhara, the Watershed Project has been emphasizing tree plantation on bare slopes for the last 15 years. With this increase in plantation, fuelwood production has increased substantially, but at the expense of grazing land for livestock. Indeed, villagers do state that the number of livestock per household has decreased. Due to the corresponding decrease in manure, this decrease in livestock probably has had a negative impact on the production of food grains on bari lands. Thapa and Weber (1990) write that advocates of the afforestation programme tend to overlook the fact that the destruction of forest and pasture is a spillover effect from deteriorating farming conditions and especially from declining crop productivity. The growing pressure on natural resources could be considerably alleviated by investigating a way to increase the carrying capacity of farmland in the hills.

One of the aims of CREMS is to convince farmers that they have the ability and skill necessary for enhancing crop production on their bari without using additional inputs. The main environmental factors operational for plant growth are: radiation (including light), heat, water (including solutes in water), and soil. Efficient use and management of these factors is essential for enhancing production. Although we cannot alter the climate or the inherent properties of soil, we can modify other factors like topography and vegetation in order to reduce soil and nutrient loss and simultaneously reduce erosion and conserve moisture. Such steps will result in an improved yield of agricultural crops, both annual and perennial.

About 500 farmers from six villages (Bhattendanda, Ikudol, Dalchoki, Nallu, and Bhardev, and Chaughare) have participated in CREMS so far. Their farms are located on ridges as well as in foothills. Some farms are on steep slopes and others on flatter slopes. The concept of improvement was the same for all the farms, but the specific activities implemented differed from site to site. The cost of improvement was higher in the ridges than in the foothills. Besides building drainage systems, diversion channels, and doing grass and tree plantation, each farmer levelled two or three terraces in front of his house. Farmers in the ridges made narrow (1-1.5m) terraces and used stone work to protect the risers. In the foothills farmers made wider terraces and planted locally collected Babio slips planted 30 cm. apart on the bunds.

Because a detailed study of the impact of the improvement works was out of the scope of the Bagmati Watershed Project, soil characteristics and the level of fertility before improvement were not recorded. It was left up to the farmers to judge whether or not improvement activities resulted in any change in crop yields.

Maize yield

Roughly 50 % of the participating farmers in Bhattendanda and about 50 % in Bhardev reported that their maize yields in the first year after improvement were better than in the previous year. However, most farmers agreed that there was an increase of 10-15 % and the results were not as encouraging on the farms in the ridges. The improvement in soil quality, reflected in darker soil color and higher moisture content, indirectly supports the claims of higher yields. A farmer from Bhainse village said that the soil became moister after levelling. This additional moisture content encouraged him to plant winter vegetables. The quality of maize plants when they were about 1m tall was much better in a farm in Bhardev. In the second year, a farmer from Ikudol with a farm in the foothills proved that he had been able to increase maize production from 20 pathi to 27 pathi (an increase of 35 %). He reported that beans planted on improved terraces in the second winter after levelling looked very healthy.

During a field visit to Nallu in April 1991 two adjacent terraces, one improved and one not were compared. Both terraces belonged to the same farmer. Maize was sown on the unimproved terrace one day before it was sown on the improved terrace. Both terraces were at the same elevation and aspect. They both received the same treatment as far as manuring and hoeing were concerned. Comparison showed that the maize plants on the improved terraces were healthier and twice as high as those on the unimproved one. There were fewer weeds on the improved terrace, probably because of the shading effect of the tall plants. It was then decided to compare the yield in September. Since the comparison was not for any statistical analysis, we measured two plots, each 23m x 4.5m - one on the improved terrace and one on the unimproved terrace. The maize was harvested from both these plots and weighed before it was dried. Similarly, the maize stalks from both terraces were weighed. (In this area maize stalks are used as animal feed in the winter).

The results were as printed below:

Treatment	Plot size (mxm)	Area (m2)	Maize cobs Kg	Yield kg/m2	Maize stalk Kg	Yield kg/m²	Increase (%) on improved
Unimproved	23x4.5	103.5	40.8	0.39	96	0.92	Maize cobs 30%
Improved	23x4.5	103.5	52.8	0.51	144	1.39	Stalk 51%

This significant increase in maize production encouraged us to carry out more detailed measurements in the same area in 1992.

After farmers had finished sowing maize, six plots (3 each on improved and unimproved terraces) were located by fixing pegs. The size of each plot was 6.5 m x 4 m. All the plots received the same treatments as far as manuring and hoeing were concerned.

In September 1992, we harvested maize from each plot on the same day. The maize cobs and green stalks were weighed immediately. After the cobs had dried the weight of maize kernels was measured. The results were as given below.

Pair Plot	Items	Production on unimproved plot (Kg)	Production an improved plot (Kg)	Difference
		Plot # 1	Plot # 4	
A	Cobs Stalks Kernels	7.0 15.5 2.0	18.0 34.0 7.0	157% gain 119% gain 250% gain
		Plot # 2	Plot # 5	
B	Cobs Stalks Kernels	18.0 45.5 8.0	29.1 56.0 11.5	61% gain 23% gain 43% gain
		Plot # 3	Plot # 6	
C	Cobs Stalks Kernels	19.0 25.0 8.0	25.0 35.0 13.5	31% gain 40% gain 68% gain

Since plots 1 and 4 in pair plot 'A' showed an unbelievable difference in production, these results were rejected. Taking the average of pair plots B & C, it is clear that production of maize stalks and kernels increased by 29% and 56% respectively.

The characteristics of maize cobs grown on the improved and unimproved plots were also different. Cobs grown on the unimproved terraces were shorter and the top fifth of the cob had no kernels. Cobs from the improved terrace were longer and there were kernels up to the tip.

It should be pointed out that the levelling did not result in the waterlogging effects Upadhya et. al. (1991) noted on improved terraces in Kulekhani.

Most of the participating farmers from Nallu and Bhardev reported only a slight increase in their maize yields. Farmers could not assess the actual increase in production probably because they did not harvest the crop from improved plots separately and because the area that was improved was very small as compared to the total land area. For these reasons yields did not show any substantial increases.

However, Gyan Bhadur Ghalan of Nallu Village did state that before he improved his farm he could produce only enough maize for 10 months of the year, but now he harvests enough maize not only to feed his family for the entire year but also enough surplus to make the local beer needed to celebrate Dasai (a big festival in September or October)

Vegetables

Even in the ridge settlements of Dalchoki, each participating farmer now has one or two terraces of green vegetables in front of his house. Farmers now grow cauliflower, onion, garlic, and broadbeans in their improved plots. These plots used to be dominated by green mustard and radish.

Fodder

Babio plants planted on terrace edges have not yet produced any substantial amount of fodder. On one farm in Dalchoki, Babio was about 30 cm tall and tillering had covered the spaces between the individual plants. Some farmers in Bhardev cut Babio three times a year and saved it to use as fodder in the winter.

Concerns with regard to terrace levelling

* Farmers generally believe that the area of a sloped terrace decreases when it is levelled and that crop production thereby decreases. It is true that the surface area of the terrace does decrease; however, the aerial space providing the light and air necessary for heterotrophic plant growth is the same on both sloped and levelled terraces. Therefore, the nominal decrease in land area resulting from levelling does not affect crop production at all.

* It is also believed that levelling exposes the subsoil of the upper part of the sloped terrace and therefore that either crop production decreases for at least a few years or that the farmer has to use additional manure to maintain previous production levels. In reality the upper part of a sloped terrace is characterized by coarse and sandy soil mixed with gravel and hence is infertile to begin with. On such a terrace the total production is not affected by exposing subsoil. Decreases in crop production were reported by a few farmers in Dalchoki and Bhardev where levelling involved digging deeper than 50cm. These decreases in production were probably due to the covering of good soil in the fill area with coarse soil from the upper part of the sloped site rather than to exposing subsoil in the upper part. It may be necessary to set aside top soil before levelling in cases where more than 50cm will be dug up.

* Farmers usually like to keep sloped terraces for ease of ploughing. Drought animals can walk over the small risers of sloped terraces easily. Farmers do not need to undo the yoke to take bulls from one terrace to another. Farmers in Nallu and Bhardev expressed their concern regarding the difficulty in ploughing after levelling, but somehow, farmers also expressed their willingness to take extra time and labour in ploughing if their efforts were going to pay off. In any case, on contemporary farms, there are paths for walking animals from terrace to terrace.

4. WATER CONSERVATION

The midhills receive about 80 % of their total annual rainfall during the monsoon. Most of this rain is lost through runoff, evapotranspiration and various other hydrological processes. Only part of it is retained in ground water and in soil, both places where water is necessary for the survival of living things.

The decreasing level of moisture in the soil as winter progress is reflected in a sequence of increasingly damaging events in plants from the inhibition of cell growth to the slowing down of respiration. Cellular growth appears to be most sensitive to water stress; one sees a slowing of shoot and root growth if there isn't enough water. If soil moisture can be maintained even for just a month after the monsoon, the roots of young plants can penetrate deep enough to absorb moisture from the deeper layers of the soil; this moisture is unavailable to shallow roots in the dry upper layer of soil.

Traditional methods of water conservation

Hill villagers traditionally make small ponds to collect rainwater. This is an easy and quick way to conserve water. Such ponds are used mainly for bathing buffalo. In areas such as Dalchoki, Ikudol, Chaughare and Sankhu, settlements in the ridges of Lalitpur where milk production is major source of income, such ponds are very common. However, with the introduction of polyethylene pipes to bring drinking water from far away water sources, the importance of such ponds has gradually declined. In the absence of periodic maintenance, sediment has filled many ponds.

Considering the multiple uses a pond can be put to, it is frustrating to see these ponds filled with sediment. The following example shows how efficiently stored water can be used before it leaves a hilly area:

A farmer in Bhattendanda village in Lalitpur district built two ponds (about 5m x 2m size) on the terraces in front of his house in order to store rain water. Water from the tap is also collected in these ponds. He has used the water in the following ways:

- He has planted cardamom around the ponds.

- He irrigates the vegetables grown in the terraces below.

- He has planted lemon trees and Napier grass on the outer slope of the pond embankments.

- He grows winter vegetables in the area between the cardamom and lemon.

- He has about 50 fish and a few ducks.

- He drains the pond every other year, scrapes the floor and uses the dirt as manure for vegetables.

- And surprisingly, he also tried to run a small water mill using the pond water, but it did not work well.

The above example indicates that the monsoon run-off can be recycled for multiple uses before it drains off the hills. Even a community pond, which cannot be used in all the ways the private pond described above was, helps in at least two ways.

1. It retains a considerable amount of water which otherwise would contribute to uncontrolled run-off.

2. It allows more water to be absorbed by the soil, thus keeping the surrounding land comparatively moist.

3. It increase ground water storage making more water available in the springs during winter.

See Case Studies Nos. 5 and 6, Gully and Landslide Stabilization Work, for a discussion of how ponds have been used as conservation measures.

5. GULLY STABILIZATION

A gully is a steep vertical-sided ephemeral stream valley with a steep head that is actively eroding headword, usually into a water-gathering wash slope (catchment).

Gully formation is one of the biggest problems in the hills. Gullies destroy good agricultural land, damage settlements and wash out trails. Technically speaking, they are the climax of land degradation.

The gully of Khordanda Pakho (Fig. 4) in Bhardev Village Ward No. 7 of Lalitpur district started to develop several years ago. It destroyed a number of cultivated terraces on either side of it. The gully became a real nuisance to the villagers when the debris leaving the gully began to destroy the main trail leading to the village. The gully had created a vertical cliff 4-5 meters high right below the trail and people avoided crossing the gully during heavy storms for fear of being washed away. There was no way to make a detour because there were cultivated terraces on both sides of the main trail. Furthermore, the gully had cut deep through the fertile land below the trail.

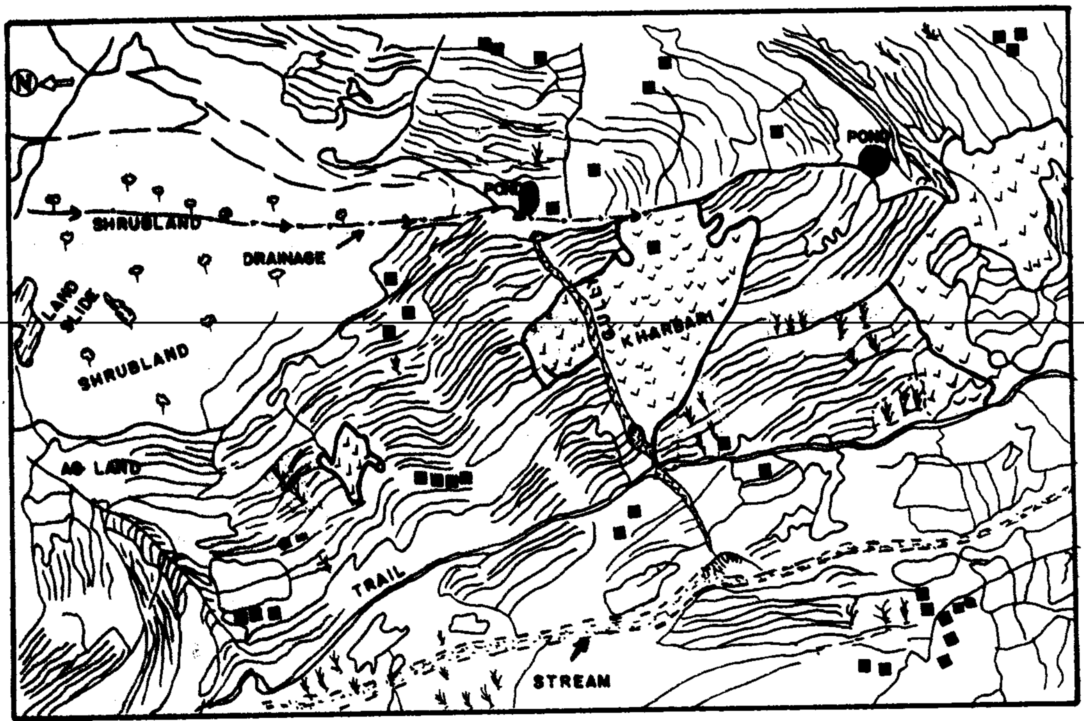


Fig. 4 Gully problem in Bhardev VDC.

In 1988 seven gabion checkdams were built above the trail to stabilize the gully. The total cost of the structures was about NRs. 90,000.00. It was also planned to put a few more checkdams in the gully below the trail.

The idea behind the construction of checkdam was to hold back the flowing debris, reduce the slope of the gully at certain intervals, and to stabilize the gully. However, the results were not as expected. In the following monsoon, two out of seven checkdams failed completely; the others were either deformed or were left hanging due to the effect of scouring. The gully had widened further in a few places. The failure was probably due to two basic reasons.

1. The checkdams were built at narrow sections of the gully which were already comparatively stable. However, the excavation for the checkdam construction disturbed the side slopes of these narrow sections and made them vulnerable to erosion.

2. It is understandable that the contractors hired to carry out the checkdam construction limited their aims to its completion only. Despite regular and good supervision, it was likely that workers collected stones for filling the gabion boxes from the closest place available: the gully itself. However, collecting stones from and breaking them near the area around the construction site made the side slopes and gully bed weaker and thus contributed to the later damage.

Stabilization of the Khoradanda Pakho gully was not achieved using checkdams. In fact, checkdam construction may have actually contributed to the disruption of the gully. Following checkdam construction, the problem near the trail was reduced but not solved and there was no sign of the beginning of the stabilization process. Since checkdams had not worked and since it is obviously difficult to revegetate any active gully, another solution was sought.

This solution was found, interestingly enough, while carrying out terrace improvement activities. In 1988 and 1989 cultivated terraces in Ward No. 7 were improved under the terrace improvement programme. One of the activities involved channeling the overland flow from above the terraces through a drainage channel to a safe place. Because of the amount of work involved, farmers in Ward No 7 could not take the drainage channel designed to collect the runoff all the way to a safe gully. Therefore they decided to connect the drainage channel to an old, traditional, but almost dead pond which already existed about 20m above the Khordanda Pakho gully. The pond was excavated further to retain the runoff water coming from the shrubland above the terrace. Surprisingly, the pond never actually filled with runoff water; this indicated that the pond had become more able to absorb water after excavation.

Although the idea behind building the drainage channel and excavating the pond was to divert run-off water, it also had an extremely beneficial side effect. No runoff water came into the Khordanda Pakho gully as it once had used to. As a result, there was no surface movement of the gully in 1989. Surface stability during the monsoon allowed natural vegetation to appear. All the checkdams that were damaged or deformed in 1988 remained the way they were. Rainfall within the gully did not cause any problems. Observations at the end of the monsoon season of 1990 showed no signs of any slope failure or scouring in the gully. Young Utis plants and other tree and grass species were seen growing in most parts of the gully.

It should be pointed out that the gully received no further treatment after the checkdam construction. The three years of stability that seemed to have resulted from water management allowed the process of stabilization to begin. The threshold stability of the gully has probably increased as well. A simple traditional pond seems to have done what seven checkdams failed to do. It is also supposed that water seeping from the pond maintains the soil moisture in the gully that encourages plant growth.

After seeing the results of this pond, the farmers in Ward No. 6 built two more ponds where small gullies were active.

Key points

- Water management plays an important role in gully control works.

- Under favorable geologic conditions, i.e. inward bedding of rocks, gully formation may be checked or a gully may be controlled by constructing catchment ponds in suitable locations.

- Surface erosion of a gully has to be stopped before natural, seeded, or planted vegetation will flourish.

- Attempts to control gullies merely by using structures like checkdam are only treating the symptoms, not the root, of the problem.

6. LANDSLIDE STABILIZATION

A landslide is a failure of a hill slope in which masses of soil and rocks suddenly rush down, leaving behind a large wound in the landscape which may widen following subsequent slides or which may be cut by gullies.

Landslides can be common in regions with steep and precipitous slopes. Landslides often destroy houses, farmland and trails, and sometimes take lives. Stabilization of landslides is thought to be very expensive work. Nevertheless, landslides need to be stabilized when they become a threat to lives and property.

Landslides cause problems for the farmers in Lalitpur. The following are two examples of landslide stabilization activities carried out using the concept of CREMS.

A story about the Bhaise landslide in Bhattedanda

A landslide in Bhaise (Fig. 5) was one active landslide in the Bhattedanda Village Development Committee. It was a translational landslide on a very longand steep

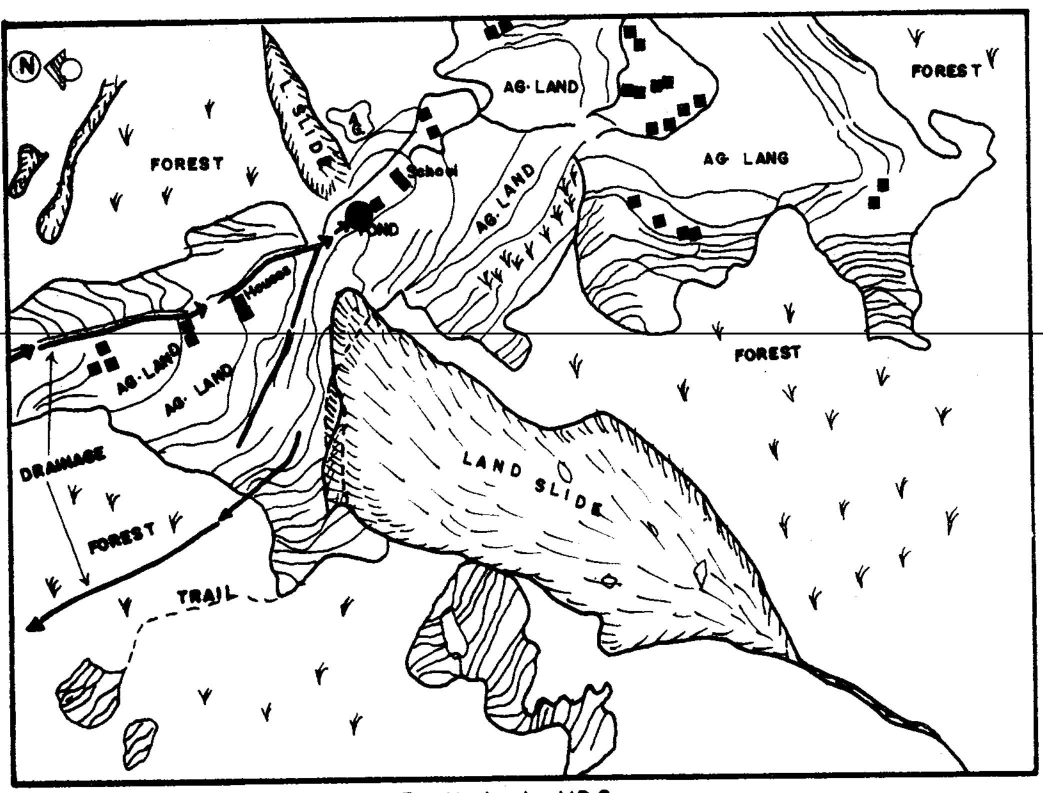


Fig. 5 Landslide of Bhainse, Bhattedanda VDC.

slope. The upper part of the landslide was wider than the lower part, and its tapered end behaved more like a gully than a landslide. This tadpole shaped suggests that this landslide had probably developed from a natural drain or a long narrow gully.

The landslide was very active until the year of 1987. It was still advancing towards the cultivated terraces above it and about six productive terraces (approx. 0.25 hectares) had already been damaged by the slide. It had become a great threat to the farms and houses of Bhaise. Farmers had tried to plant trees and grasses in order to stabilize the slide, but the landslide scarp (the damaged cultivated terraces) was very unstable and as a result planted materials were either buried or swept away by sliding debris.

Construction of simple retaining walls was proposed for the fiscal year 1987/88, but this project turned out to be impossible because of the steepness and the length of the slope. More complex anchored or masonry retaining walls cost more money than could be justified for spending on a slide that endangered so few hectares of farms and only some houses. Therefore, the landslide stabilization proposal was dropped.

Later that year, farmers asked for a trail and terrace improvement programme in the village. During the survey of the trail and the terraces, it was found that the main trail in the village also served as a drainage channel draining runoff from the village into a pond in the middle of the village. In the course of time the trail had deepened (which normally happens), and therefore accumulated more water from lower areas than it had in the past. Unfortunately, the connection between the drainage channel (the depression in the trail) and the pond had disappeared because of sediment deposits. Therefore, instead of flowing to the pond, the runoff from the trail flowed to the natural drain on the steep slope. Because this natural drain had a nominal threshold it could not handle the additional runoff. This situation resulted in slope failure.

It was decided to integrate the improvement activities on the trail, the pond, and the terraces in order to stabilize the landslide.

First, the pond was excavated further and a stone wall was built to prevent its sides from caving in. Second the trail was paved with stones to prevent it from deepening. In addition, the drainage channel from the trail was reconnected to the pond and a diversion channel was made along the terraces above the head of the landslide. These channels were paved with stones where necessary. Finally terraces above and far away from the diversion channel were levelled in order to increase infiltration and reduce overland flow. Terrace edges were planted with Babio grass and Ipil Ipil. Utis trees and grasses like Amriso were planted at the head of the landslide.

The total cost of these activities was about Rs. 50,000.00. The affected farmer donated 50% of the labour required to construct the diversion channel and to level the terraces. He grew and planted the trees and grasses on his own.

Observations in September 1991, three years after the improvements were completed (during which period the slide had experienced three average monsoons), indicated very satisfactory results. Surface erosion, even on the steep parts of the slide, had stopped. Utis trees planted at the head were about 4-5 meters tall. One couldn't see the head of the slide because it had a dense vegetative cover.

The diversion channel worked fine. In fact, at the extreme right side of the slide, in an area which had not been a problem before, a new slide had developed, but it was easily controlled with the diversion channel. The trails had stopped deepening.

The pond, however, was not in such good condition. It had collected a considerable amount of sediment and needs to be cleaned periodically for drainage to be effective.

The farmer was also advised to prune the tall Utis trees in order to reduce the weight of the trees at the landslide head. This sounded odd to the farmer, who had not heard of cutting standing trees in a landslide area, particularly when they were established with such difficulty.

A story about the Bhotedanda landslide in Dalchoki

The landslide in Bhotedanda (Fig. 6) was the biggest landslide in the Dalchoki Village Development Area. There were a number of old as well as new landslides in this area. The entire eastern slope of Bhotendanda had eroded and later stabilized by itself, but the slide in the centre was still active and was advancing further uphill. The total length of this landslide was about 500 m with a maximum width of about 50 to 75 m in the centre. The landslide head had destroyed some of the cultivated rainfed terraces that existed above the slide. There was still degraded forestland above the cultivated land, although some forestland has been replanted with pines by the District Forest Office some years ago. The main trail of Dalchoki passes across the slope between the forest and the terrace.

In aerial photos this area looked terribly degraded and therefore was selected for terrace improvement activities in the fiscal year 1988/89 in order to save the few cultivated terraces from further damage.

The existing drainage pattern in the area was studied. It showed that a natural depression beginning in the forest and running all along the slope was guiding monsoon runoff to the present head of the landslide. At the landslide scarp a 75cm wide and 3m long chute-like formation was discovered; this structure revealed that the runoff at the head of the landslide was of relatively high volume.

To treat the landslide, the following measures were taken. First, a big drainage channel, 1.5 m wide and 30 cm deep, was dug along the main trail to collect the runoff from the forest. The channel ran to the other side of the hill, which has a gradient of about 2%. In short, the runoff from the ridge area of the Thosne Khola Watershed was directed to the Nallu Khola Watershed. Second, an old pond at the watershed divide was renovated in order to hold water for watering livestock and for conserving moisture in the soil. Part of the runoff in the channel was directed into the pond. In addition, right above the landslide head, at the natural depression that guided the runoff to the landslide, a small earthen embankment was made to ensure that no water would flow into the landslide, even during heavy storms.

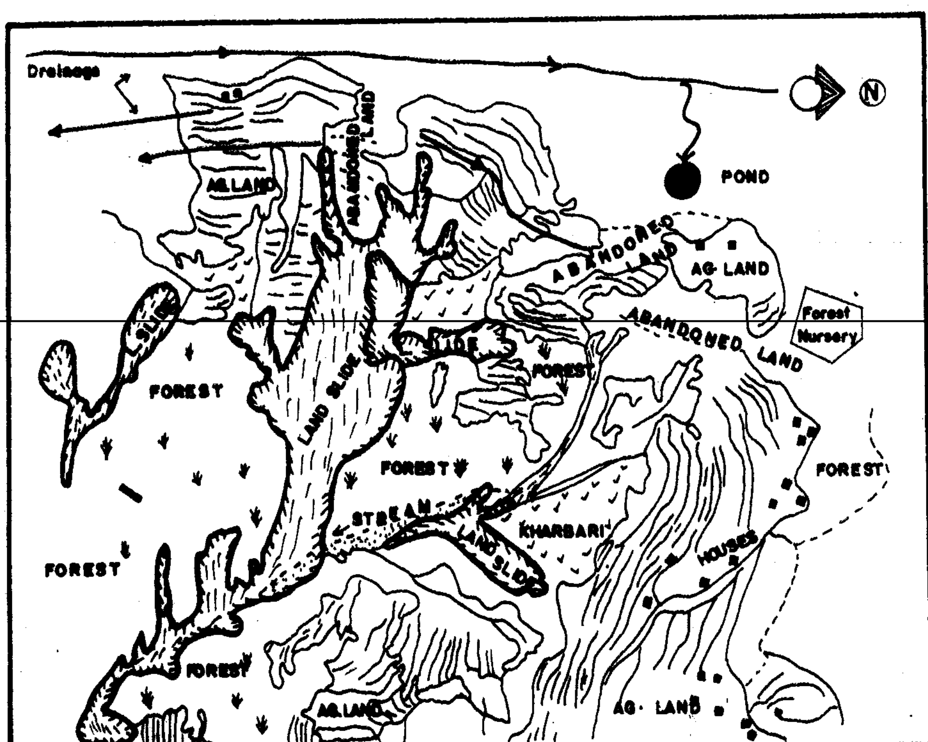


Fig.6 Landslide of Bhotedanda, Dalchoki VDC.

Finally, runoff or excess water on the cultivated terraces was diverted by making three parallel diversion channels, (each about 50 cm wide), across the slope of the cultivated areas. The upper two terraces in front of the houses were levelled to increase infiltration. Nothing was done within the landslide itself.

A big storm in 1989 caused numerous small slope failures in the adjoining hills. This was also the year when the district of Chitwan also reported flood damage. But the slide in Bhotedanda did not fail. Since the affected farmer was probably convinced that the landslide would not damage his terraces anymore, in 1990 he planted over 3000 Utis seedlings (brought from the nearby DOF nursery) in the landslide in order to put the land under fodder and fuelwood production. The landslide survived the heavy monsoon rain of 1990 as well. The planted Utis were about 1m. tall in September 1991.

Key Points

- Landslides should not be treated in isolation.
- Landslides can be controlled with proper water management.
- Landslides can be controlled without heavy structures.
- Surface erosion has to be stopped before vegetation can establish itself in a landslide.

The two above-mentioned landslides, which were not only damaging cultivated terraces and adding sediment to streams, but also threatening the villages they were located in, have not been active in five years. They even survived the unusually heavy rain of July 1993. Hopefully, they will become more stable as the vegetation planted in and around them grows and thereby becomes more effective. Note well that these stabilization activities were achieved solely through runoff management.

7. FLOOD RISKS

People in the villages of Bhardev and Nallu experienced a big flood in 1981. It destroyed several houses and claimed a number of lives. About 200 animals were either buried by debris or washed away in floods. Tens of hundreds of small landslides occurred in just one short morning. All the fertile land Bhardev and Nallu had was buried under debris. Life in the valley became so difficult that people were forced to go to cities in search of jobs.

In July 1993, another devastating flood washed over the nation. It mainly affected the five central districts of the country, including Lalitpur. The watersheds of the Bagmati River in the district of Lalitpur and in the adjoining district of Kavre were heavily damaged. Thousands of people and an uncounted number of livestock in the districts downstream were killed. The fertile land downstream was covered with debris and thousands of families were displaced.

In Bhardev and Nallu, however, the situation in 1993 was different than it was in 1981. The 1993 flood affected the areas of Lamatar and Godawari (to the north of the Bhardev valley), and Bukhel (to the south of the Bhardev valley). But Bhardev, which must have received the same amount of rainfall, was not as severely affected as these areas. The stream in Bhardev was not laden with sediment as it was in other valleys. No new landslides developed in Bhardev or Nallu. In fact, except for some minor terrace edge failures, Bhardev and Nallu did not suffer from any damage.

Although it is too premature to state so conclusively, I tend to believe that the introduction of CREMS as a system for managing runoff in Bhardev and Nallu resulted in such a reduction of flood risks that the 1993 flooding posed no threat.

A detailed study of the effects of water management (as developed in CREMS) would take a long time and would require methodical data collection and analysis. Nevertheless, it is worth studying CREMS in order to achieve the very necessary goal of reducing flood risks in our fragile watersheds.

8. EASY AND DIFFICULT ASPECTS OF CREMS

Easy aspects	Difficult aspects
- uses simple technology	-requires prudent design
- uses local materials	-requires some knowledge of geology, sociology and economics and a good knowledge of natural resources and hydrology.
- generates a high degree of people participation	-yields a lot of paper work
- is inexpensive	-requires dedication
- creates no contractor/labor hassle	
- is maintainable by farmers	

9. CONCLUSIONS

If we want future generations to live in these areas, there is a greater need today than ever before to save our hills and mountains from the present rate of man-made degradation. The growing population will require ever more food, fodder and fuelwood in the future. The present rate of declining productivity in the hills will make us even poorer. We need to consider all natural resources as different parts of a single system in which the farmer is at the hub. It is the farmer who makes use or overuse of the resources and it is only he who can conserve these resources. Since the farmer is desperate to produce more and to lead a better life, all efforts at establishing a conservation programme should begin with him.

If we analyze how the different components of the natural system work together in a particular place and make the farmer the focal point of any improvement activity, all farmers will unite to conserve natural resources because they will see the benefits for today and tomorrow.

References

Carson, B, 1992 "The Land, the Farmer, and the Future". Occasional Paper no 21, ICIMOD.

Eckholm, E.P., 1976 Loosing Ground: Environmental Stress and World Food Prospects. W.W. Norton Co. Inc. N.Y.

Gilmour, D.A., 1991 "Trends in Forest Resource Management in the Middle Mountains of Nepal." Soil Fertility and Erosion Issues in the Middle Mountains of Nepal. workshop proceedings, Kathmandu.

Ries, J., 1991 "Man Made Soil Erosion in the High mountains Regions: A Case Study of Bamti/Bhandar." Soil Fertility and Erosion Issues in the Middle Mountains of Nepal workshop proceedings, Kathmandu.

Sherchan, R.K. & Baniya, B.K. 1991 "Crop Production and its Trend in Response to Soil and Nutrients." Soil Fertility and Erosion Issues in the Middle Mountains of Nepal workshop proceedings, Kathmandu.

Thapa, G.B. and Weber, K.E., 1990 "Managing Mountain Watersheds: The Upper Pokhara Valley". Division of Human Settlements Dev. AIT, Bangkok.

Upadhyaya. G.P., Sthapit, K.M. and Shrestha, K.N.,1991 "Runoff and Soil Loss Studies in Kulekhani Watershed: Results 1985-90" Soil Fertility and Erosion Issues in the Middle Mountains of Nepal workshop proceedings, Kathmandu.

Beautiful land of Sankhu VDC. Note that a gully is advancing uphill. Such degradation can be easily stopped and the overall productivity of the land can be increased substantially by simple techniques of CREMS.

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