III. The Farmer

Since the advent of man and his agricultural systems there has been a tremendous change in the Nepalese landscape. If one were to fly over the country, one could not help but be impressed with the pervading influence of man on the environment. Tremendous terrace systems, clustered villages, an intricate network of roads and pathways, and an ominous reduction of area under forest. There are many farmers wresting a living out of the land. Far too many! The common perception is that man has taken too much. Indeed, the land has been squeezed dry and the environment has been seriously and irreversibly degraded. The farmer can no longer maintain soil fertility because the land has nothing more to offer. So the story goes.

While this theory makes for profound seminars, it fails to squarely address the real problem and does not provide an insight into the potential solutions. The problems are a result of bad management and solutions are based on encouraging more enlightened management, if there is a will to do so. What is happening in Nepal now has happened before; periods of growth and development are followed by periods of stagnation and crowding. Malthus has been proven wrong before, primarily because production systems are not static. Nepal is at another critical point in her history with many options to make changes for the better or for the worse. A brief look at Nepal's carrying capacity from a historical perspective provides a framework with which to project the future.

The Carrying Capacity of the Nepalese Landscape

Planners and development workers alike have long been interested in the concept of carrying capacity. How many persons can be supported by the land? At what point will the system break down and productivity stagnate, or plummet, resulting in economic and social upheaval? Is the present agricultural system in Nepal sustainable? and, if not, what can be done to make it sustainable? There are no simple answers to these questions, as biological carrying capacity is a function of management of components of the system and the definition of the boundaries that you assign to it. Unlike natural ecosystems, man has the ability to radically alter nutrient and energy flows as well as to expand the sphere of influence of a given ecosystem. He can import chemical fertilizer - he can earn money outside his village - he can move to the city and take an industrial or service job. While the traditional subsistence farmer of Nepal once could be virtually isolated and maintain a sustainable agricultural system, this no longer appears to be the case. Politics, socioeconomics, and, lastly, management practices are actively changing in response to many local and outside pressures.

Local, regional, national, and international movements of goods and services make the concept of the closed ecosystem inappropriate for most of the Nepalese farmers of today. The majority of Nepalese farmers receive a significant portion of their cash income from outside the subsistence realm. The growth rates of major urban centres like Birgunj, Pokhara, and Kathmandu exceed 8 per cent, whereas remote village populations remain virtually static through out-migration. Nepalese farmers are looking, and will increasingly look, beyond traditional enterprises to support their households. Possibly one of the better ways to address the future possibilities is to look briefly at the progression of land management from a historical perspective.

Pre-man

At this stage the country was in a state of dynamic equilibrium. Natural resources were being manipulated by the climate, geology, and biotic resources. Although there were earthquakes, floods, landslides, and fires, they were natural.

Hunter/Gatherer

This stage developed from pre-pliocene times. Man's influence on nature was restricted to temporary changes in animal and plant populations. Populations were maintained at a very low level and impact on the environment was minimal.

Shifting Cultivator

With the introduction of grain crops, such as millet, thousands of years ago, man began a simple form of cultivation in Nepal. Forest areas were cut down and burned. Seeds where dibbled or scattered on the soil and domestication of some animals began. When weeds became noxious or the soil fertility of his fields dropped, the farmer cleared another patch of forest and repeated the process. Populations initially rose and the carrying capacity of the landscape was much greater than during the hunter/gatherer stage. It is assumed that this method of sustenance did not proceed too long before some forms of more permanent agriculture arrived from Mongolian influences to the north and from Aryan influences to the south. In Nepal, some remnants of shifting cultivation are still practised by a few *Chepang* and *Magar* groups in the Mahabharat Lekh and by *Rais*, *Limbus*, and *Sherpas* in the upper Arun Basin. While this system had the potential to be destroyed through overpopulation, more permanent forms of agriculture were usually adopted.

Permanent Subsistence Agriculture

With the advent of rice cultivation and the later introduction of maize (around the 15th century), the traditional agricultural cropping patterns developed more or less as we see them today in the more remote regions. This system was almost entirely subsistence oriented with very little movement of goods or services in or out of the agricultural production centres. Salt and iron were the only provisions regularly acquired from the outside. These were traded for a number of local products. Forests were used for timber, firewood, and fodder and, initially at least, there was little need to develop a sophisticated management system of either the forest or grazing lands as the total demand for forest products was low compared to the resources available. Free grazing of livestock was the rule on fallowed agricultural land and forest land (Regmi 1971).

Since 1950-The Panchayat Era

After the end of autocratic Rana rule, new ideas began to flood into the country. Among these were the need for public education, public health services, use of improved agricultural production methods, and the desire for a Government that was committed to development of the country. The most important change for Nepal as a whole was the rapid increase in population. The most significant change to agriculture was undoubtedly the introduction of winter wheat that fit nicely into the rice-fallow and maize-fallow systems. As the population continued to increase, the demands on fodder resources expanded rapidly. Fields that were traditionally fallow in the winter had been used to graze livestock and *in situ* manuring was instrumental for maintaining the fertility of the crop land. In this newly evolved system, demand for compost increased at the same time as the area available for fodder production decreased. Consequently, the farmer had to substantially increase his exploitation of the forest resources to an historically unprecedented level, particularly to harvest fodder.

Unfortunately for Nepal, this was the time when forests were nationalised. Rather than encouraging the farmers to develop appropriate forest management systems, it severely suppressed innovative local management. The common story is that the Nepalese farmer went wild, cutting down every tree in sight. This is highly unlikely. The damage to the forests was most likely due to an increased demand for forest products and a decreased interest in their management. Lands with assured tenure and in private hands are very well managed. Conversely, public lands, particularly those over which the forest department has control, have been severely degraded by poor management.

There are other signs of change within the system: men are increasingly looking to off-farm employment to support their family, women are more and more making the decisions and carrying out major farm activities, urban areas are receiving an influx of villagers, and educated sons are leaving the farm with parental blessings, with no intention of returning. The present system, as with previous systems, had a set "carrying capacity" which has been exceeded. However, changes are ongoing and will continue to occur to correct present stresses in the system. The question is, to what degree can the Government of Nepal orchestrate changes for the collective good of the people of Nepal? The production systems of the farmer are described in this chapter and specific soil fertility management practices are discussed. A brief look at the farmer's socioeconomic and institutional environment then provides the basis on which a soil fertility management strategy is developed.

Production Systems

The landscape of Nepal is a managed landscape. The majority of land is used for arable agriculture, livestock grazing, or forestry. By understanding how man currently manages these production systems, one is in a better position to understand the environmental situation and, more particularly, how soil fertility is being maintained and whether the system is sustainable (Schroeder 1985).

When assessing the overall sustainability of an agricultural system, it is useful to look at nutrient levels and flow between the different production systems. There is a high degree of interdependence between cultivation, grazing, and forestry. It is virtually impossible to adjust one aspect of the fertility flows without affecting the others. Nepalese farmers are usually active in all five production systems on a day to day basis. Unlike the classic sectorial approach used in Europe and America to define and upgrade their production systems (agriculture, forestry, livestock, fisheries, etc), Nepalese farming communities and individual farms are highly integrated. Productivity of one production system has direct bearing on the productivity of the others (Mahat 1987 and Yadav 1992). Without forest there are severe constraints on cattle, without cattle there is no compost, without compost there is no cultivated land, and without cultivated land there is no grain. It is a highly appropriate saying of the late King Mahendra "*Hamro dhaan, haariyo baan*" (Our wealth is in our forests).

What is going on in one production system has a direct bearing on the other four. Any sectorial approach to soil management must recognise and build around this fact. In Table 1 the major production types and their extent are given.

Table 1: Relative Proportions of Production Systems* in each Physiographic Region

(In percentage)

Physiographic Region	Irrigated Rice	Rainfed Cultivation	Home** Garden	Grazing, Shrub & Degraded Forest	Closed Forest	Other***	Total Area ('OOO) ha
Terai	50%	6%		6%	26%	12%	2110
Siwaliks	7%	5%		16%	68%	4%	1886
Middle Mountains	7%	15%		54%	22%	2%	4443
High Mountains	1%	6%		45%	40%	8%	2959
High Himalaya		0.2%		31%	2%	67%	3349

* The totals are gross areas taken from LRMP 1986. Actual total areas are somewhat less.

** Area proportional to the population. There are over 3.5 million households in Nepal and the average home garden might cover 25 square metres. Over the whole country this would account for 9,000 ha of production.

*** Snow, ice, rock.

The five major traditional production systems are described here in relation to fertility management. These production systems are found in each of the Tropical, Subtropical, Warm Temperate, and Cool Temperate Agroecological Zones (see Annex 3). While overall management considerations for a given production system are similar regardless of the zone, the species, varieties, and cropping calendars are different.

Irrigated Rice Land (Khet)

According to the Irrigation Master Plan (HMG/N 1989) over 923,000 ha of Nepal's cultivated land is irrigated, at least on a supplementary basis, during the monsoon. This amounts to over 35 per cent of the total cropping area of Nepal. From this total, over 594,000 ha occur in the *Terai*, 84,000 ha in the Siwaliks, 218,000 ha in the Middle Mountains, and 26,000 ha in the High Mountains.

Under the present traditional agricultural system, rice is grown wherever arable lands below 1,800 metres can be serviced by irrigation water. Rice is the most prestigious grain crop in the country and farmers measure their wealth according to the amount and type of *Khet* they own. As an example of this sense of importance of *Khet*, when asked what they would do with windfall cash, both men and women within the Jhikhu Khola watershed indicated thev would purchase more *Khet* (Kennedy et al. 1991). This is a universal sentiment in Nepal. Rice trades for 2 to 3 times the price of any other grain and it forms an important component of many religious and festive events. A traditional village greeting asks, literally, if the subject has eaten rice, when the intention is more like "How are you?".

In the traditional land taxation act, the classification focuses primarily on irrigation water availability throughout the year, as it assumes that water is the major constraint facing agricultural production. Irrigation water is essential for most rice production in the country.

According to government statistics, between 1980 and 1990 the national average yield for rice rose from 1,949 kg/ha/yr to 2,366 kg/ha/yr, with a range of from 800 to 7,000 kg/ha/yr.

With a rice yield of 2,500 kg/ha/yr, nutrient removal would be roughly 30 kg of nitrogen, 15 kg of phosphorous, and 45 kg of potassium from each hectare of land.[1]

While rice is the dominant crop and grows throughout a significant portion of the monsoon season, a number of different cropping patterns occur with the rice production. Some of these are given below.

Cropping Pattern	% of Total Rice Land
Rice-Fallow	31
Rice-Cereal*	32
Rice-Winter Crop	10
Maize-Rice	8
Other Patterns	19

* mostly winter wheat (after LRMP 1986)

Reasons for choosing a particular cropping pattern are varied, but elevation, water availability, availability of chemical fertilizer and compost, natural soil drainage conditions, local climate, and land tenure are the dominant factors influencing the farmer's choice.

Rice cultivation is unique and the rules of tillage and fertility management are quite distinct from upland soil management. Rice soils must be puddled in preparation for planting. In this process, the soil structure is destroyed, oxygen is removed from the rooting zone, and a dense impervious plough plan is encouraged. During the rice growing period, water is kept on the surface as much as possible. While these conditions are highly undesirable for upland crops, rice thrives (Plate 3).

There are a great many advantages to this seemingly inhospitable soil climate, and the rice plant is able to capitalise on them.

- Under anaerobic conditions, no matter what the original soil acidity, the pH is neutralised and toxic elements, such as iron and aluminum, if originally present, become unavailable.
- At the same time, neutralizing the pH permits important soil nutrients, such as phosphorous, that are strongly bound in most soils to become more readily available.
- Sediment-laden irrigation water in the monsoon season, while considered a problem in advanced countries, acts to fertilize the soil and bring in nitrogen, phosphorous, and organic matter.
- Standing water in rice fields inhibits terrestrial weed growth, while at the same time encouraging the growth of azolla and blue green algae, both nitrogen-fixing species .
- Surface soils are not subject to the kinetic energy of intense rainfall as they are protected by the water. Surface erosion is negligible.

From the above it can be understood why, in the recent past, the traditional rice farmer did not need to rely heavily on fertilizer (compost or chemical) at the low levels of productivity of the common rice-fallow system. In fact, in spite of the importance given to rice as a dominant crop, farmers did not actively seek to fertilize it- although some nutrients were supplied by free-grazing animals. Rather, they devoted their scarce compost resources to upland crops and maize, for which response to compost was readily observable. This sheds new light on the importance of rice in the Nepalese hill-farming system. Rice was preferred, in part at least, because it was able to produce a reasonable crop on a sustainable basis without draining the farmer's limited compost supply. This was a major soil fertility

1. This includes straw removal from the field, which is the normal practice. A considerable portion of these nutrients do find their way back into the system through compost production, etc.

management strategy for the hill areas and most of the *Terai* before 1960.[2]

For irrigated land under the landlord-tenant arrangement, rice is the principal sharecrop, whereas winter crops, being only recently introduced, are not systematically included in the rent agreement. As winter cash crops become more important, major changes in tenancy agreements are expected. In general, wealthy farmers tend to have more irrigated land in proportion to their total landholdings than do poorer farmers.

Villagers have been diligent in developing water sources for irrigation in spite of apparently insurmountable obstacles. Some of the irrigation canals cross major obstacles and have been constructed and maintained at great local expense. The Nepalese hill farmer has already developed all the easier irrigation water sources. Those left undeveloped present considerably greater challenges in construction and maintenance and generally involve resource levels beyond those available in the village.

On many so-called rice soils in the hills, irrigation duty is very high, often exceeding 5 litres per second per hectare.[3] Percolation of this excessive water is terribly wasteful and has a negative effect on the soil. Hard won soluble nutrients, in particular nitrogen and potassium, are being rapidly leached from the system. When irrigation water lacks calcium, the acidification of the irrigated soils is accelerated.

Ongoing periodic, catastrophic soil degradation is occurring on the alluvial and alluvial/colluvial soils throughout the Himalayas, particularly in the Siwalik and Middle Mountain Physiographic Region. Debris torrents issuing out of unstable drainage systems are resulting in waves of destruction of *khet* near the rivers *(bogor khet)*. Farmers in Nepal, over the years, have learned to live with these destructive forces and have developed effective methods of land reclamation. Low lying alluvial terraces and alluvial/colluvial fans which now support lush rice and winter crops have usually, in the recent or distant past, been reclaimed from unproductive gravel and boulder beds brought down as catastrophic debris torrents. As discussed by Carson (1985) and Bruijnzeel and Bremmer (1989), these processes are most often the result of natural erosion and only rarely a direct consequence of deforestation. An economist trying to determine the value of irrigated land, in the mind of the Nepalese hill farmer at least, should look at the labour cost of reclamation of these devastated lands.

Given the dynamic geomorphic nature of most Nepalese river systems, it is rarely recommended to invest heavily in engineered structures to protect low lying rice land from exceptional flooding because such efforts are rarely cost effective. Gabions are a reasonable short-term solution for protecting valuable engineering structures and, to some extent, highly productive alluvial terraces, if the erosive power of the river can be effectively dispersed.

Chemical fertilization is generally carried out on irrigated lands where cash cropping is possible. Chemical fertilizer use can reduce the intense pressure already felt on the scarce compost resources available to the villager. Fertilizers are not so harmful to irrigated land, because of the buffering effect of sediment-laden (and often calcium rich) irrigation waters.[4] In the more accessible agricultural production pockets of the *Terai* and along the north-south trunk roads, some of the rice and wheat are used as cash crops, and so the farmer is able to purchase the required inputs. This, in turn, opens up other possibilities for promoting changes to the fertility management of the soils.

With the rapid acceptance of winter wheat and other intensifications of the cropping system on irrigated lands, the nutrient requirements of *khet* have increased dramatically. Chemical fertilizers and compost are being used in ever-increasing amounts in response to the needs of the winter crop and to take advantage of the higher yielding varieties of wheat and rice.

While puddling is beneficial to the rice crop, the massive structure, impenetrable plough pan, uncertain soil reaction, and questionable nutrient availability left behind when the rice is harvested have a strong negative effect on the winter crop. For these reasons, farmers are required to use as much compost as is available in an attempt to ameliorate these negative soil conditions for the following crop. This intensification of *khet* production has a serious effect on

2. This generalisation does not apply to the Kathmandu Valley in which a very different agricultural system has evolved based on the *Newari* farmers working the lacustrine-based soils.

3. In Pokhara, the irrigation scheme using water diverted from the Seti River has found irrigation requirements in excess of 10 litres per second per hectare.

4. When large amounts of chemical fertilizer are being added to soils that are already strongly acidic, and the irrigation water lacks dissolved calcium, soil acidification does occur. In America, fertilizer use can increase the soil organic matter by the additional yield of crop residue which is usually ploughed into the soil. In Nepal, because farmers usually harvest all parts of the crop, this benefit is not realised from chemical fertilizer.

other components of the village land production system. The scarce nutrients made available through compost, that were traditionally reserved for the upland soils, are now also required on the rice soils to meet the requirements of the winter crop.

New ways of increasing nutrient flow, particularly nitrogen and phosphorous, to the *khet* will be instrumental in any overall fertility management strategy. It will have to involve a reassessment of nutrient foraging, particularly of grazing and forestry lands, and recognise the trade-offs with importation of nutrients from outside the closed village system.

Rainfed Cultivated Land (Pakho or *Bari)*

Rainfed cultivated land *(pakho* or *bari*) accounts for 1,717,000 ha (64%) of the cultivated land in Nepal (HMG/N 1989). Of this total, over 61 per cent of the *bari* and *pakho* occur in the Middle Mountain Region. Maize is the dominant crop and is grown on 81 per cent of the rainfed land in the country, usually relayed or followed by a cereal crop, pulse, or mustard.

According to recently released agricultural statistics (HMG/N 1990), over the last 20 years average national yields of maize have dropped from 1,869 kg/ha/yr in 1970 to 1,599 kg/ha/yr today. Millet and barley yields have remained almost the same over the period at 1,162 kg/ha/yr. The largest increase in grain yields has been with wheat. In 1990 the average yield was 1,415 kg/ha/yr; a 67 per cent increase over the 20 year period. If these data are reasonably accurate[5] the inescapable conclusion is that farmers are diverting more fertility resources to rice and wheat production on irrigated land to the exclusion of maize, millet, and barley production on rainfed land. There are many indicators that this is indeed happening and that the result is the apparent "decline" in soil fertility (Plate 4).

Using the above-mentioned average yields for 1990, the maize crop at 1,599 kg would remove 75 kg of nitrogen, 25 kg of phosphorous, and 50 kg of potassium.[6] Wheat, with a yield of 1,415 kg, would remove 35 kg of nitrogen, 15 kg of phosphorous, and 30 kg of potassium. These amounts are generally replaced by compost additions each year.

The majority of Nepalese hill farmers own and manage rainfed cultivated land for their primary source of food grains. In the hills the vast majority of this *bari* is terraced on slopes between 15 and 25 degrees. On such slopes, individual terraces are small, commonly to 3 metres wide and 3 to 15 metres long. A farmer usually owns 4 or 5 plots of such land which are not contiguous. The concern over catastrophic destruction of the land and/or crops makes the farmer wary of depending on all his land resources from one small area. Resource-poor farmers own proportionally more *bari* than *khet*, and the *bari* they do own is of poorer quality. Decline in soil fertility is most strongly felt on the marginal *bari* owned by the poorer farmers.

The fertility management of rainfed lands has evolved very differently from that of irrigated lands. In the early stages, a shifting cultivation system was in place. The farmers relied on long fallow periods with natural vegetation to recondition soil exhausted by cultivation. As the upland agricultural system developed and livestock became increasingly integrated into the farming system, the fields became permanent and compost (via cattle grazing and fodder collection from the adjacent forest lands) supplied the nutrient requirements for upland cultivation. Nepalese farmers traditionally used between 10 and 20 tons of compost per hectare of rainfed land. As previously mentioned, increased use of winter wheat, pulses, and cash crops on the *khet* has diverted compost away from rainfed lands. Given the great increase in requirements for compost to meet the relatively new winter crop requirements, an unprecedented scarcity of compost has developed. Typically, in upland crop production, the farmer has chosen to forgo production on his most distant rainfed fields, because his compost resources are most economically spread on the fields nearer home. The traditional fertility management system is under considerable strain, the evidence can be seen everywhere with the abandonment of once productive cultivated rainfed land. As a conservative estimate, between 10 and 20 per cent of the rainfed cultivated lands of Nepal are temporarily fallowed or abandoned these days, primarily because of the lack of fertilizing material for their land.

Farmers are increasingly planting multipurpose trees on their own *bari*. In the last 30 years, Gilmore (1991) found a 300 per cent increase in the number of trees on private lands. Gilmore concluded that the farmers, responding to local

5. There is always considerable doubt when assessing government-produced data for trends and this type of analysis has been consciously avoided during the development of this paper. However, in this case, the reduction in yields is obviously not fulfilling desired government projections and may be realistic.

6. Phosphorous and Potassium as oxides.

forest product shortages, have decided that the increase in production of fodder and firewood more than compensates them for the small loss of grain caused by the shading effect of the trees. To this, it must be added that those same *bari* had very little alternative use, given the severe compost scarcity in the area.

The lack of land per se is not the major constraint to increasing grain production on rainfed lands in the hills. There is a persistent and misleading myth, strongly adhered to in Nepal, that farmers are universally expanding their cultivation areas to meet food needs. Increased cultivation of *bari* has only occurred in response to an increase in urban markets - which, to date has only affected a relatively small strip of land around the Kathmandu Valley.

Chemical fertilizers play a significant role in maintaining the fertility of these soils. With the exception of the *Terai sal* forests, the only other area where active clearing of forests is taking place (seemingly for cultivation) is where cadastral surveys are to be carried out. Only cleared land can be deeded land, so the farmer tries to expand his holdings by clearing and ploughing land even though he is perfectly aware it cannot be maintained in its cleared form.

It is on the marginalised *bari* that the majority of agriculturally-induced soil degradation is occurring. Poor crop stands with inadequate compost additions are prone to serious erosion as the fields become increasingly marginalised. As soil fertility declines, harvests become scantier and rates of erosion increase. Eventually, poor fertility management and surface soil erosion reduce productivity to such an extent that the farmer gives up on the piece of land, at least temporarily.

Home Garden

Around many homesteads in Nepal, the farmer manages a small garden. At its simplest, a few red peppers, some garlic, and local greens might be grown in a small patch near the compost pile. Perennial crops may include a few horticultural or agroforestry tree species. Around some of the major urban centres of Nepal, kitchen gardens have expanded to become significant commercial enterprises supplying high value goods to the market place.

Many opportunities are made available to greatly increase production, primarily because of the proximity of the kitchen garden to the homestead. Waste water from the kitchen can be used to start seedlings or irrigate annual crops; proximity to the animal stalls ensures a high rate of compost production; the pilfering of high value horticultural crops is reduced; and intensive weeding and other agronomic practices are conveniently carried out. For crops for which ripening time is variable, the proximity to the home makes for efficient and timely harvesting. Night soil, although not systematically used, does enrich the soils around the homestead.

Given the above, it is not surprising that the kitchen garden, though small in total area, is an important part of the overall production system and has successfully been used as an entry point into the enhanced productivity of the farming system. Those technologies that are particularly successful in the home garden can be replicated on farmers' lands outside what was traditionally perceived as the home garden. This appears to have been the method for the spontaneous expansion of mandarin orange production in many hill regions.

The Horticultural Master Plan (ADB 1991) stressed that the most important constraint to increasing kitchen garden production was the lack of markets for most horticultural products. Surprisingly, farmers themselves are not keen on consuming fruits and vegetables, and, at the same time, the markets in which they can be sold are not well developed.

According to the Master Plan for Horticultural Development (ADB 1991), the Nepalese on average consume only 28 kg of vegetables and 7 kg of fruit annually- which is very low compared to other Asian countries. This is why horticultural crop markets are so poorly developed within Nepal.

Livestock Production

Livestock production is an integral part of the farming system. Milk products, meat, and leather are produced for consumption by the homestead and market. The farmer's fields are ploughed by oxen and his lands are fertilized by livestock manures. Most of the nutrient movements between all five production systems are facilitated by cattle, buffalo, goats, and sheep. Virtually all lands are grazed to some degree at some time in the year and the heavily grazed areas are responsible for much of the environmental degradation of village lands. The Land Resource Mapping Project (1986) roughly calculated livestock fodder requirements, proportioning agricultural and forest sources. These are presented in Table 2.

Table 2: Proportional Fodder Demands from Crop Waste and Forest Lands

	Livestock Units Per ha	Total TDN* t/ha	*TDN From Farm t/ha	TDN From Forest t/ha	Dry Matter From Forest t/ha
High Mountain	6.1	6.7	1.7	5.0	20.0
Middle Mountain	4.5	5.9	2.4	2.6	12.9
Terai	3.4	3.8	3.2	0.6	1.5

LRMP 1986
*TDN - Total Digestible Nutrients

From this table it is readily apparent that, as one goes higher into the hills, there is an increasing demand on the forest to meet fodder needs. In the Middle Mountains, 52 per cent of livestock feed comes from the forest. It is this forest-based fodder resource that supplies the nutrients for agricultural production to make up for the nutrients leaking from the system.

Fodder deficiencies, severely aggravated in the pre-monsoon, are seen as a primary constraint to enhancing livestock production. While farmers have a number of strategies to deal with the shortages (including planting trees on private land and timing the lactations of milch buffalo to avoid the fodder shortage period), there are still many opportunities to increase value-added production even if the total number of livestock are reduced.

Most villagers, particularly the poorer ones, are totally dependant on grazing lands to meet their animals' grazing needs and must exploit them heavily. Concurrent with this heavy exploitation is an almost complete lack of any management to enhance the future production of the site. Many of the grazing areas, particularly those found near the village, are actually no more than resting sites where the non-productive livestock are gathered to pass time, out of harm's way. While grazed soils are not exposed by the plough, severe trampling, particularly during the monsoon, compacts the soil, reducing the soil's infiltration rate to the point that even moderately intense rainfall results in serious runoff and soil erosion. Rates of erosion in excess of 200 tons per ha per year are common on grazing lands in areas below 1,000 metres. As one moves higher on to the mountain slopes and rainfall intensities drop, so does the erosion damage. On high elevation grazing land or "*kharka*", snowmelt does cause some severe gullying. However, in general, heavy grazing pressure in many of the higher elevation production pockets does not degrade the soil resource as it does in tropical areas.

While the physical effect of the livestock trampling the surface soil is the most detrimental aspect of free grazing, the selective destruction of good fodder plants by livestock gradually alters the plant community. Over time, the palatable species are lost and one is left with much less useful species such as *Artemisia*, *Eupatorium*, and *Berberis*.

Free grazing of livestock is the single most serious cause of marginalisation of agricultural and forestry lands and changes are required to make this land use productive and sustainable.

Fire is a management tool used extensively throughout most of the forested areas of Nepal to encourage a flush of green vegetation, especially when livestock feed is desperately needed at the end of the dry season. Farmers are usually reluctant to discuss their burning practices with outsiders, because the act is strongly discouraged by the forest department. Nevertheless, farmers have good reason to burn and will continue to burn until there are changes in the tenurial arrangements of the so-called common lands or National Forests.

Livestock herd management itself is also a critical issue, with large herds of cattle seemingly required to maintain both strong, healthy bullocks and an adequate breeding stock to maintain the herd. Livestock ownership is virtually universal among the traditional farmers of the hills. Cattle are owned by all farmers. Richer farmers tend to own a few buffalo, while the poorer farmers raise goats. Generally, it is considered that to support one hectare of crop land, 6 livestock units are required. Not surprisingly, Nepal has the highest livestock densities per cultivated hectare in the world (Plate 5).

The apparent inability to cull the lower quality cattle forces a large number of scrub animals on to the common lands. This, in turn, causes tremendous damage to the vegetation and soil. It is often countered that these animals are essential to produce manure to meet the farmers' compost needs, and that the manure resource alone justifies the predominance of non-productive animals in the system. Quite the reverse is true. As long as these animals are in the system, the farmer is not motivated to look at more environmentally sound cropping systems, involving fodder legume rotations, horticultural perennial crops, and more intensive forest and grazing land management. Fortunately, farmers themselves are not as rigid as some of the cultural anthropologists studying them and have developed many ways of reducing cattle herd size. As more productive (and profitable) livestock are employed, the problems will sort themselves out.

With no restriction on grazing animals, manures cannot be selectively used on lands of the farmer's choice. Initial interest in fodder legume production requires an interest on the part of the farmer to feed higher quality fodder to livestock that in turn provide nutritious food and/or cash to the farmer. The difficulty of protecting fruit trees and off-season vegetables from free-grazing livestock, at present, severely dampens the farmer's enthusiasm for this type of production. Finally, it has been recognised that the regenerating capacity of severely degraded Nepalese forests is tremendous - once the ever present free grazing animals are removed. For all of these reasons, free grazing must be recognised as a major contributor to land degradation and, at the same time, a major obstacle to upgrading soil fertility management (Plate 6).

Forestry Production

At present over 6,306,700 ha of forest land exist in Nepal. This accounts for over 43 per cent of the total land area. Wherever population pressure is high - for example, in the Middle Mountains - these forest areas are heavily utilised for firewood, fodder, litter, and timber. Where use is intense, the forests are heavily thinned, lopped, and grazed in the understorey. The materials that are removed from the forest contain energy and nutrients, which, to a large degree, maintain the fertility of the hill agricultural system. Unfortunately, as in the grazing areas, lack of assured tenure has severely restricted interest in improved management of forest areas.

Leaves and twigs make up the litter that generally covers most forest floors and they are extensively used as bedding and in compost. Litter collection can seriously alter the forest floor hydrology and leave the soil surface open to high rates of surface soil erosion. The constant one-way flow of nutrients from forest soils will also have some negative long-term effect on the soil's chemistry. However, the significance of nutrient removal in the geomorphologically active, forested slopes of Nepal, where new material is always coming to the surface, is not clear (Plate 7).

Grazing within the forest is also common and the negative effects are the same as for grassland and brush areas. Burning, however, introduces the additional hazard of possibly setting a crown fire which destroys forest resources critical for supporting the overall farming system.

Even taking the most optimistic projections of developing government-run plantations, Nield (1986) found that forests were still being degraded around three times faster than they were being planted. To give the government attempts at plantations even less cause for optimism, it is recognised that over 75 per cent of the trees that have been planted are pine, a tree that acidifies the soil and is of almost no value to the local farmer in fodder production, for which his greatest need is felt.

As with grazing land, the biggest obstacle to better management of the forests is the lack of some form of assured tenure to the villager. Community forestry and lease-hold forestry provide two options that are central to the enhancement of fodder production and, through livestock, increase fertility of agricultural soils. While community forests appear to be able to manage tree production, there are no clear successes with the management of high quality fodder trees and improved grasses on community lands. Private initiative and private ownership are required before most farmers will be willing to invest in planting and maintaining higher value produce. Where villagers have unofficially divided up the forest land among individuals, high levels of management have been noted.

Traditional Soil Fertility Management

Until recently there has been little interest on the part of agricultural researchers in investigating the indigenous soil fertility practices of Nepalese hill farmers. It was assumed that the uneducated farmers were ignorant of how to manage soil fertility. Tamang (1991) strongly refutes this and points to many examples of innovative management by the small hill farmer in the face of numerous constraints. Agricultural scientists have been slow to understand the complexity of traditional soil fertility management and consequently have been unable to substantially improve traditional management systems. For the Nepalese hill farmer, managing soil fertility has been essential to his survival. It is not surprising that many sophisticated and labour-intensive methods have been developed over the years to maintain soil productivity (Shrestha and Katwal 1992). A summary of nutrient flows of a typical Middle Mountain farming system is presented in Figure 1. Some of the more common methods are described below.

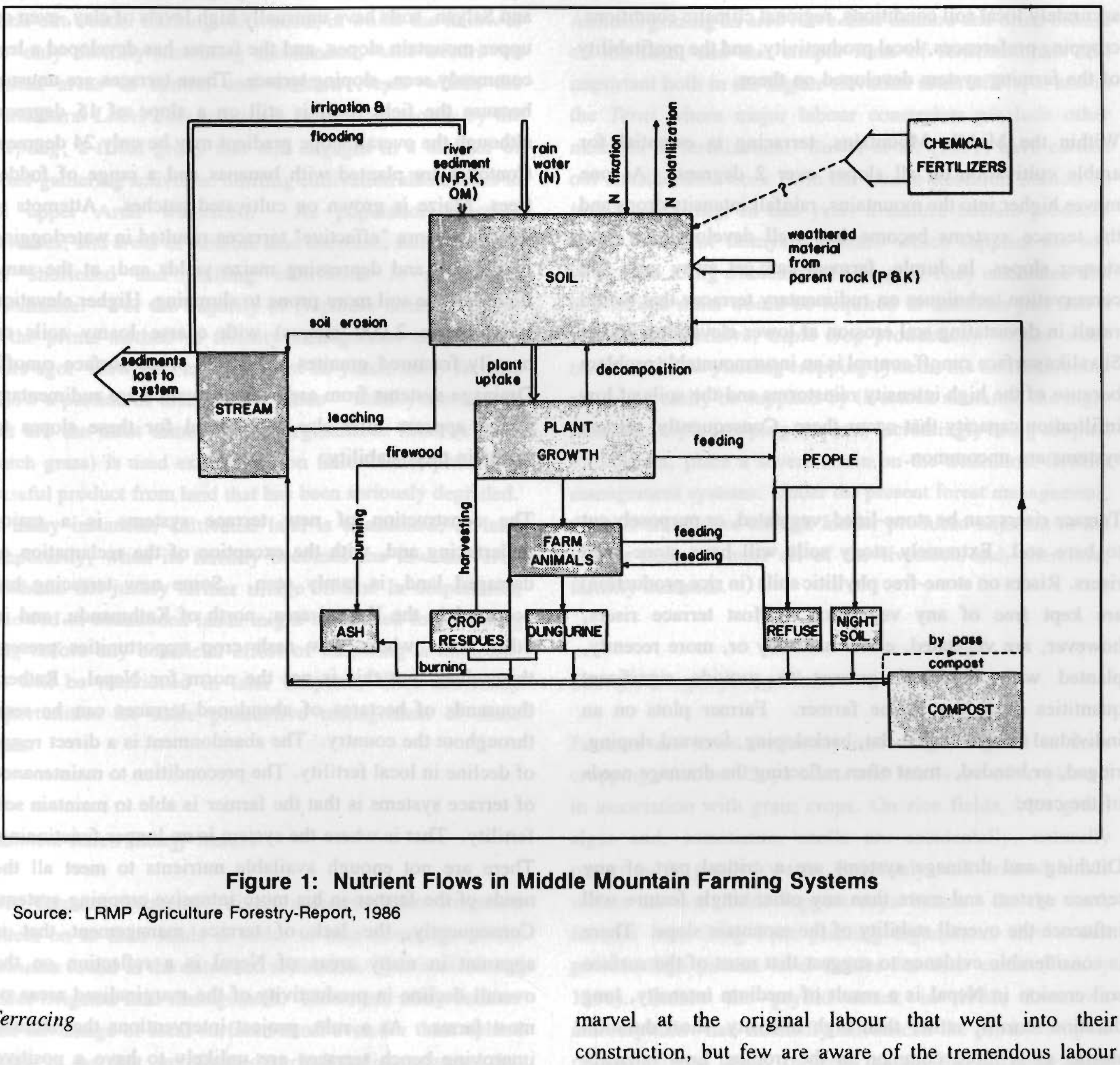

Figure 1: Nutrient Flows in Middle Mountain Farming Systems

Source: LRMP Agriculture Forestry-Report, 1986

Terracing

Terraces are a critical aspect of upland management in Nepal, primarily because of their ability to substantially reduce erosion and, secondly, to make tillage and other agronomic practices much easier to carry out. Very early in the development of stable, permanent agriculture in Nepal, farmers recognised the value of terraces as the major precondition for the maintenance of soil fertility. The existing bench terrace systems found in Nepal are a trademark of the Nepalese farmers' determination to maintain their agricultural systems. Many casual observers marvel at the original labour that went into their construction, but few are aware of the tremendous labour that is associated with maintaining bench terraces on the unstable mountain terrain of Nepal (Plate 8).

There are a great number of terrace types in Nepal, each reflecting the physical and socioeconomic attributes of the village lands on which they occur. Irrigated rice terraces are flat and bunded, rainfed terraces tend to be gently outward or sideways sloping so as to join terraces at different levels. Different production systems within different climatic zones in Nepal support distinct terrace forms. Terraces can range from perfectly groomed, flat fields with substantial, vertical rock-lined risers to a simple row of banana trees and a small pile of stones cast off the field along the contour of an otherwise uniform slope. Most rainfed terraces fall somewhere in between, with a gently outward sloping run (2 to 5 degrees) and a strongly sloping riser (60 to 75 degrees). Regardless of their surface form, they generally reflect accurately local soil conditions, regional climatic conditions, cropping preferences, local productivity, and the profitability of the farming system developed on them.

Within the Middle Mountains, terracing is essential for arable cultivation on all slopes over 2 degrees. As one moves higher into the mountains, rainfall intensity drops and the terrace systems become less well developed on ever steeper slopes. In Jumla, farmers can get away with soil conservation techniques on rudimentary terraces that would result in devastating soil erosion at lower elevations. In the Siwaliks surface runoff control is an insurmountable problem because of the high intensity rainstorms and the soils of low infiltration capacity that occur there. Consequently, terrace systems are uncommon.

Terrace risers can be stone-lined, vegetated, or purposely cut to bare soil. Extremely stony soils will have stone-lined risers. Risers on stone-free phyllitic soils (in rice production) are kept free of any vegetation. Most terrace risers, however, are vegetated, either naturally or, more recently, planted with improved grasses to provide significant quantities of fodder to the farmer. Farmer plots on an individual terrace can be flat, backsloping, forward sloping, ridged, or bunded, most often reflecting the drainage needs of the crop.

Ditching and drainage systems are a critical part of any terrace system and more than any other single feature will influence the overall stability of the mountain slope. There is considerable evidence to suggest that most of the surface soil erosion in Nepal is a result of medium intensity, long duration storms, rather than high intensity, short duration storms as is more common in the tropics. Low intensity rainfall may not have sufficient energy to break up soil structure but, if surface runoff is concentrated and not properly controlled, soil loss from these channelised areas can be severe. Recent work in the Bagmati Watershed Project has emphasised the importance of surface water control to overall slope stability. By the simple diversion of concentrated runoff water into stable channels, they have been able to stabilise previously active landslide areas and whole terrace systems.

Areas with high intensity rainfall and low soil infiltration rates are virtually unterraceable. The lower the elevation and the greater the clay content of the soil, the greater will be the hazard. The marls and mudstones of the Siwaliks are an example of land that cannot be safely terraced. Attempts that have been made have resulted in whole slopes being washed away with the monsoon rains. In areas of Tansen, Gulmi, and Salyan, soils have unusually high levels of clay, even on upper mountain slopes, and the farmer has developed a less commonly seen, sloping terrace. These terraces are unusual because the field itself is still on a slope of 15 degrees, although the overall slope gradient may be only 24 degrees. Contours are planted with bananas and a range of fodder trees. Maize is grown on cultivated patches. Attempts to introduce more "effective" terraces resulted in waterlogging of the soil and depressing maize yields and, at the same time, left the soil more prone to slumping. Higher elevation sites (above 2,000 metres) with coarse loamy soils on heavily fractured granites have little or no surface runoff. Drainage systems from areas of cultivation are rudimentary and it appears little else is required for these slopes to maintain their stability.

The construction of new terrace systems is a major undertaking and, with the exception of the reclamation of damaged land, is rarely seen. Some new terracing has occurred in the Kąkani area, north of Kathmandu, and in other areas where new cash crop opportunities present themselves; but this is not the norm for Nepal. Rather, thousands of hectares of abandoned terraces can be seen throughout the country. The abandonment is a direct result of decline in local fertility. The precondition to maintenance of terrace systems is that the farmer is able to maintain soil fertility. That is where the system is no longer functioning. There are not enough available nutrients to meet all the needs of the farmer in his more intensive cropping system. Consequently, the lack of terrace management that is apparent in many areas of Nepal is a reflection on the overall decline in productivity of the marginalised areas of most farms. As a rule, project interventions that include improving bench terraces are unlikely to have a positive effect, unless the productivity and profitability of the overall farming system is improved at the same time.

Fallow

Most soils, given a break from crop production, will have their fertility renewed to some degree. The period of time in fallow and the choice of vegetation used during the fallow period will enhance fertility when cultivation is again taken up. Fertility alone is only one aspect of rejuvenation during fallow. Noxious weeds, impossible to remove in some of the marginally productive soils, can be eliminated, given a long enough fallow period with the right species. Weeding, by normal tillage methods, may be impossible on excessively stony soils, whereas the proper bush fallow can effectively shade out weeds. Shifting cultivation, in which the fallow is the only fertility-sustaining mechanism, still occurs on limited areas in central and western Nepal within the Mahabharat *Lekh*. This activity is carried out mostly by the *Chepang*, a tribal group that still engages in a number of forest-gathering activities. Shifting cultivation also occurs in the upper Arun watershed. As population pressure increases, and areas of suitable land decrease, fallow periods are shortened and shifting cultivation is no longer sustainable. For the majority of Nepalese farmers, fallow as the prime method of fertility management ended many years ago. However, as of the past 20 years, many farmers fallow a portion of their upland fields - usually those lands that are the most remote and marginalised. *Khar* (a local thatch grass) is used extensively on fallow land, producing a useful product from land that has been seriously degraded. In many instances, cultivated land is abandoned, at least temporarily, when its fertility becomes too low and crop yields do not justify further tillage efforts. In desperation, fallowed or abandoned lands might be opened for cropping long before any beneficial effect of fallowing is obvious. As will be mentioned in later chapters, there are many opportunities for more productive management of these lands.

Sediment-laden Runoff Waters

Rice farmers frequently divert sediment-laden irrigation waters on to their lands in order to take advantage of the nutrients found in the entrained sediments. This is discussed under irrigated land management. However, many farmers take advantage of local surface runoff even for their upland crops. In the past, uninformed agriculturalists assumed that the ditch structures, often found above agricultural land were purely to protect the farmland from heavy surface runoff. Local interceptor ditches on the upper side of the terraced fields not only collected heavily sediment-laden water, but also diverted it to individual fields of the farmer's choice. Irrigation and fertilizer benefits are both realised from this activity. While there is not a lot of cultivation in the Siwalik hills themselves, water and nutrient runoff, harvested from the hills during intense rains, is important to production on the alluvial terraces below. A portion of the *bari* throughout Nepal does receive a little channelised water whenever the farmer finds manageable water upslope.

In Situ Manuring

Animals grazing an area leave their manure and urine behind on the land, and this simple form of fertilization is still important both in the higher elevation areas of Nepal and in the *Terai* where major labour constraints preclude other methods of fertilization. Suwal et al. (1991) have carried out considerable work from the Lumle Research Station on *in situ* manuring. In one year, a mature buffalo produces about 4 tons of farmyard manure which supplies the soil with 10 to 13 kg of elemental nitrogen. They calculated that 6 livestock units would be required to maintain just half a hectare of intensive, triple crop production. While under traditional, low yielding cropping systems the nutrients could relatively easily be supplied by livestock manures, the high-intensity, triple cropping systems, increasingly being adopted by farmers, place a severe strain on the traditional fertility management systems. Under the present forest management, there is simply not enough fodder produced adjacent to the village lands to meet all of the livestock and, therefore, fertility demands.

Use of Nitrogen-fixing Plants

Farmers are more frequently including a legume in their cropping rotation. Soya beans and lentils are often planted in association with grain crops. On rice fields, blue green algae and, sometimes, azolla are accidentally, naturally occurring in ponded water. Relatively well-drained bunds within the rice fields support soya beans. On the *bari*, farmers have long been planting leguminous shrubs that provide high protein level fodder for their cattle (Pandey 1991). Before the psyllid attack in 1988, *Leaucena leucocephala* had markedly influenced the productivity of rainfed terrace lands. In many cases, the nitrogen-fixing species provided high quality fodder for the production of more profitable livestock, which in turn increased the productivity of the overall system.

Green Manuring

Subedi (1989) has carried out considerable investigations on the traditional use of green manuring by local farmers and considers it to play an integral role in the farmer's overall fertility management strategies. Green manures are used extensively in nursery seed bed preparation in many parts of Nepal. Many common, locally available species, such as *Artemesia vulgaris*, *Vigna umbellata*, *Sespania sp*, *Cassia toda*, *Albizzia sp* and a number of grasses, are used traditionally by Nepalese farmers. The role of these green manures is three-fold. First, to provide nutrients needed by the crop; secondly, to improve the physical condition of the soil by using them as a mulch or by incorporating them into the soil; and, thirdly, to protect newly sown seeds and seedlings from birds and insects through both their physical and chemical effects. It is recognised that the materials used for green manure usually have little or no value for fodder and become green manure by default. In many cases, better management of the adjacent non-agricultural lands for fodder could produce a higher value commodity than these green manure species.

Terrace Riser Slicing

Wherever stone-free, terraces on soft, deeply weathered phyllites occur, the farmer, as part of his overall terrace management system, slices 1 or 2 cm from the terrace riser and deposits it on the field below. The farmer does this to control weeds on the terrace that will compete with his rice crop, control rodents that have dug into the terrace, and also to provide small, but significant, amounts of organic matter to the field below. It is surprising to non-specialists to see just how quickly these terrace systems actually disintegrate if this high level of management is not kept up. Within one or two seasons, the terraces are often hard to identify.

Compost

Compost[7] is by far the most important soil additive used by Nepalese farmers to manage fertility. Next to virtually every house in the hills a compost pile will be found. The compost is made up of animal manures, forest litter, and agricultural and household waste, including ash from cooking fires. A sign of ultimate desperation for the local farmer is the selling of his compost pile, as it is well recognised that his next crop is solely dependant on that compost. Reported rates of compost use range from 0 to 58 tons per hectare but are most commonly between 0 and 23 tons per hectare for rice crops and 20 to 28 tons per hectare for maize crops (Suwal et al. 1991). The Lumle group has carried out significant investigations on traditional compost use. Their work will be of increasing importance in the future. There are many criticisms of the local farmers' management of compost, but this is quite likely based on incomplete knowledge of the farmers' opportunities and constraints. Excess nitrogen volatilisation and potassium leaching are seen as the major problems of traditional compost management and will be discussed later.

Chemical Fertilizer Use

Chemical fertilizers are increasingly being used by Nepalese farmers, as they intensify their cropping systems and expect greater yields on a per hectare basis. Recently, the Nepal Fertilizer Sector Management Study (Crown Agents 1991) calculated that 12 per cent of the present grain crop yield in Nepal was a direct result of chemical fertilizer use. In 1980, over 22,000 tons of elemental nutrients were imported as chemical fertilizer. By 1990 this had increased to over 56,000 tons (HMG/N 1990). Sherchan (1991), after exhaustive studies on composite maize varieties, found that a fertilizer mix of 40 to 50 kg of nitrogen, 30 to 40 kg phosphorous, and 10 tons of farmyard manure was profitable and attractive to the hill farmers in the Pakhribas area. In the same study, he found that local rice varieties did not respond well to fertilizer additions and were uneconomical at any application rate. In general, nitrogen and phosphorous fertilizers have consistently shown a favourable response to a wide variety of introduced species; and to a lesser extent to local species. Potassium, on the other hand, only occasionally shows a response with traditional cropping patterns.

Farmers, particularly in areas with good access and with marketing opportunities, are using chemical fertilizer. A candid interview with farmers carried out by Tamang (1991) in the Jhikhu Khola watershed nicely sums up the farmer's viewpoint. Farmers liked chemical fertilizer because:

- it was now possible to cultivate soils throughout the year;
- crop yields had increased greatly - even the non-productive white soils could grow maize; and
- cash made available from selling surplus crops was important for running the household.

7. Compost here is used to mean any combination of livestock manure, animal bedding, agricultural crop remains, ash, and kitchen refuge that is stored in a pile by the home and carried to the field as needed or when time is available. Lumle researchers use the term farmyard manure (FYM) rather than compost because the material is often not well composted.

On the other hand farmers did not like fertilizer because:

- it makes the soil hard and difficult to plough;
- it reduces the moisture-retention capacity of the soil, increasing drought hazard for upland crops;
- yields of some crops were now declining after a period of high production; and
- farmers were increasingly at the mercy of fertilizer traders who were unable to supply to the farmer in a timely or cost-effective manner.

While the trends towards increased fertilizer consumption are clear, there is also a growing realization that fertilizers alone do not provide a complete fertility management package. Grain yields at the Bhairahawa Agricultural Farm showed significant declines when nitrogen fertilizer was used exclusively over a ten year period. Declines, although less drastic, were also observed when nitrogen and phosphorous were used together. When a "complete" NPK fertilizer was used, yields were better but not as good as when organic matter in the form of farmyard manure was applied alone. Although it should have been apparent from the start, it is now recognised that an important synergistic response occurs when the right proportions of chemical and organic fertilizer are used. There is a role for both organic and inorganic fertilizers in Nepal and the polarisation of interest groups to make either/or choices is counter to sensible soil fertility management.

Erosion and Fertility Management

Rainfall erosion acts to remove the most fertile surface soil and leave behind a less fertile subsoil. If the soil surface is maintained in a bare state, as occurs in marginal, rainfed cultivation or heavily grazed areas, each rainfall event has an opportunity to remove soil, either by direct kinetic energy or, as is more likely, by the erosive force of channelised surface runoff. Soil erosion, more than any other single factor, is responsible for the increased marginalisation of peripheral agricultural and forest lands.

Generalists and specialists alike often assume a direct correlation between deforestation and erosion - "the more natural forests are used and degraded, the greater will be the degradation of Nepal's soil resource". The surprising fact is that there is virtually no evidence to support this view. Lopping branches and cutting down trees have relatively little effect on the soil hydrological properties that influence erosion. In many situations, a grassland and a good forest are equally able to protect the soil. However, a growing body of literature suggests that increased marginalisation of rainfed agriculture and the increased pressure of low quality livestock on grazing lands are the primary causes of erosion (Gilmore 1991 and Wymann 1991).

There is an ongoing attempt to equate this form of soil erosion with downstream sedimentation and infer that changes in land management will automatically lead to significant changes in the sediment loads of major river systems. With the exception of small, isolated watersheds, data to support this theory are scarce. However, a casual study of the major river systems of the Himalayas will demonstrate that natural, geological forces are resulting in the vast majority of sediment within the river system. Better land management cannot be expected to result in improved river flow characteristics, but better land management is required to sustain the Nepalese hill farmer.

Throughout the hill regions of Nepal, particularly at lower elevations where rainfall intensity is highest, erosion is a major contributor to the decline of soil fertility. In Table 3 estimated soil and nutrient losses are given for major production systems of Nepal below 1,000m.

The Socioeconomic Condition of the Nepalese Farmer

When addressing the overall soil fertility situation, there has been an unfortunate reliance on strict biophysical analysis (even though inadequate) and an inexplicable exclusion of socioeconomic analysis. The net result is experimentation, and even demonstration, on how to improve soil fertility that has little relevance to the local farmer's situation.

In the final analysis, the farmer's social and economic setting will dictate if, or how, she might adopt interventions from the outside. Where socioeconomic information has been collected, it has often remained unused when developing the soil fertility programme. The few "successes" of government and donor-driven crop productivity enhancement programmes were often a result of enrichment of the rich farmer and further impoverishment of the poor farmer. Some of the recent block production programmes in the *Terai*, associated with irrigation, have increased overall productivity but only at the expense of the small farmer who, for many reasons, is unable to take advantage of the offered technologies and credit and his situation further deteriorates.

Table 3: Estimated Nutrient Loss by Rainfall Erosion Associated with Different Production Systems*

	Irrigated Rice Terrace	Rainfed Bench Terrace	Rainfed Marginal Land	Grazing (Degraded)	Forest (Good)
Soil Loss Depth mm	0	0.4	1.0	8.0	0
Soil Loss t/ha/yr	0	5.0	20.0	100.0	0
Organic Matter Loss kg/ha/yr	0	75.0	300.0	1500.0	0
Nitrogen Loss kg/ha/yr	0	3.8	15.0	75	0
Phosphorous Loss kg/ha/yr	0	5.0	20.0	100	0
Potassium Loss kg/ha/yr	0	10.0	40.0	200	0

(modified from Carson 1985)

* Calculated based on a topsoil with the following analyses:

Organic Matter	1.5 %
Nitrogen	0.075 %
Phosphorous	0.1 %
Potassium	0.2 %
Bulk Density	1.3 g/cm^3

Although these tables are based on inadequate field erosion measurements, the results can be considered to be good approximations of the overall situation. There are a number of important points to consider and these have been given in the following points.

1. Irrigated rice fields are not eroding. In many irrigated rice systems there is actually a net gain of soil through sediment additions from diverted monsoon runoff.

2. The well-managed bench terrace systems have rates of soil loss that can be relatively easily maintained by normal compost additions.

3. It is on the marginal agricultural lands that nutrients are being progressively depleted. Under such management, topsoil quality will decline (and productivity with it) to such an extent that the farmer will abandon the plot of land.

4. On heavily grazed land, the erosion is even more serious, although the total area impacted in this manner is actually small.

A soil fertility management strategy must address marginal agricultural land management and grazing as focus points for enhancement.

Severely eroded, overgrazed sites (Plate 9) are common throughout Nepal and make a lasting impression on government officials and donors alike. Such sites are used in photo essays to justify swift, expensive, and usually unsuccessful remedial action through a wide range of government and consultant-originated ideas. Land degradation is a symptom of existing socioeconomic conditions and, as a result of only attacking the symptoms, requires infinite resources to fuel non-sustainable development. Many of the "Hot Spots" identified by nationally-based inventory and subsequently used to determine priorities for soil conservation fall into such a category. Official government projects, largely funded by foreign aid, throughout the whole of Nepal have repeatedly attempted, without success, to improve specific tracts of degraded land through direct intervention by using fencing and hired guards to stop grazing, fires, and other village activities that damage the soil. Unfortunately, when the project has run its course, the land quickly returns to its initial, degraded state because the underlying cause for overgrazing or promoting burning has not been addressed.

In the same light, while chemical fertilizer use may result in increased yields, it is only sustainable if using fertilizer is economically viable. It is generally conceded that chemical fertilizer will increase yields "significantly". This has captured the imagination of agricultural planners who have been given the task of increasing Nepal's agricultural production. In reality, for many small hill farmers in Nepal, available cash would be much more wisely employed to service debt rather than investing in the marginal returns to fertilizer. Big, wealthy landlords in the *Terai* also have much more profitable ventures than reinvesting in subsistence-oriented agriculture on their own land. Contrary to the "official" line, the farmer would be irrational if he adopted fertilizer use and not "ignorant" or "stupid" as he is commonly claimed to be. A closer look at the farmer's decision-making processes is required.

Indigenous Farming System

The key to developing more productive and sustainable agricultural systems in the future depends on an in-depth analysis of what is going on at present (Gill 1991). Farmers make decisions based on the opportunities and constraints they face on a day to day basis. If one is to develop more appropriate innovations for the future, it is essential to understand the relevant aspects of the farmers' socioeconomic environment as it influences the biophysical environment today. The farmer has successfully integrated a wide number of activities, including rainfed and irrigated cultivation, livestock management, gathering products from the forest, marketing of specialised crops, etc. However, the scientific disciplines of agriculture and forestry, which have done so much to advance production in the West, have failed to become a significant force in raising the production of Nepalese hill farmer. The farmer's present decisions on how to manage the soil resource provide the basis for developing more productive and sustainable soil management in Nepal (Shrestha and Katwal 1992). If the farmer is reluctant to use chemical fertilizer, his reasons are going to be central to an overall analysis for developing fertility strategies. If a farmer refuses to use compost in an officially prescribed way, an understanding of the farmer's concerns will be the first step in developing more appropriate compost management.

Farmers' Motivation

An understanding of the farmer's motivation sets the ground rules with which to develop a tactical approach to enhancing soil fertility. Farmers are interested in the results of soil fertility, not soil fertility per se. The present management of village land resources makes tremendous nutrient and energy demands on the locally available land resources. Fodder, litter, firewood, timber, and food are harvested from the local environment, some with careful husbandry, others with apparent reckless abandon. More productive and intensive agricultural systems extract more, not only out of the land but also from the local farmer, in the form of labour. Over the last 40 years there has been an ever-increasing need for more productive agricultural systems to support the increasing local population. Running concurrently with this is the impoverishment and abandonment of marginal lands as farmers run out of fertilizing material, labour, and capital to service them (Jodha 1992). There comes a critical point, however, at which the combination of increased labour and fertility requirements are not able to compete with alternative employment outside the agricultural production sector. Investments off the farm are more lucrative than investments on the farm. Out-migration and off-farm employment have become significant forces influencing a farmer's decision on if, and what, to farm.

It is of significance that virtually all small farmers wish their sons to get a good education and the farmer will make great sacrifices to that end. However, the farmer's motivation is not for the son to learn how to manage the farm better but, rather, for the son to escape from the farm so that he will possibly not have to work so hard.

Virtually all farmers are able to agree on one point. They do not have enough cash and their present overall farming system cannot provide the cash they need. Unless the farm becomes more profitable and returns to labour increase instead of decrease, as has been happening in the last 30 years, the farmer is strongly motivated to quit the farm. Because of the fertility constraints discussed in this paper, it appears that cash crop production is the only significant approach towards the increasing profitability of the system. It is only by an increase in the profitability of the system that the farmer will be motivated to manage his soils in a more productive and sustainable manner.

Target Farmer

When discussing agricultural research priorities and what technology should be extended to enhance fertility management, the answers will be very different depending on whether the client is a rich or poor farmer. In the past, many programmes began with the generalised premise that Nepal is desperately poor and as a group the farmers are also poor. Equitability issues were rarely considered and programmes were based on the view that lead farmers would provide the focal point for development. Not surprisingly, lead farmers are invariably the wealthier farmers and what is relevant extension material for them may well not be for the poor farmer. In order to address the national soil fertility management problems, it is imperative that the inequities of natural resource control be considered. The differences in the characteristics of wealthy and poor farmers are considerable and are summarised below.

In general, wealthy farmers have:

- large landholdings (>1 hectare per household),
- a larger portion of better-quality lands,
- a greater portion of irrigated rice lands,
- rice (and, to a lesser extent, maize) as their most important grain crop,
- a greater number as well as more productive livestock,
- enough rainfed land for them to produce their own firewood and fodder needs on their private lands without collecting from forest areas,
- capital resources to invest,
- little interest in agriculture - many other investment opportunities in the village prove to be more lucrative, including money lending, truck transport, and trade,
- the ability to hire labourers to fulfill agricultural duties, including livestock maintenance,
- indentured labourers and tenants working their land,
- children with a higher education level,
- political power, and
- they are of a higher caste,

At the other end of the spectrum, poor farmers have

- small landholdings (> 1/2 hectare per household),
- poorer quality land,
- a greater portion of the marginal, rainfed upland fields,
- a reliance on maize, but millet and buckwheat are important grain crops,
- fewer, as well as less productive, livestock-often they look after the wealthier farmer's livestock,
- to get most firewood and fodder needs from communal lands rather than private lands and to a large extent are responsible for the exploitive management of marginal lands,
- debts and are cash-starved generally,
- to perform their own labour,
- children with fewer education opportunities,
- no political power, and
- they are of a lower caste.

Both groups of farmers are intimately in tune with their own environment and the opportunities and constraints that they face. They are rational in the decisions that they make. Although Nepalese farmers have a strong cultural heritage, this fact rarely creates an insurmountable obstacle to development. When targetting recipients of any development programme, the above check list indicates what type of innovations might be considered appropriate. Communal grazing lands and marginal rainfed lands are the domain of the poor. Research and extension on improvements for upland crops will have much more relevance for the small farmer. Meeting the needs of the poor farmer must be one of the primary goals of donor-driven development projects, not only on compassionate grounds but also because most of the serious environmental degradation is a direct result of his/her activities.

Extension

Adoption of new soil fertility management practices by the Nepalese hill farmer depends on criteria that extension agencies and research efforts for one reason or another have failed to address.[8]

In general, extension workers are not motivated. If they are motivated, they lack a clear understanding of the farmer's agricultural system. If they also understand the agricultural system, the technologies that they are entrusted to extend are irrelevant to the needs of the farmer. Finally, where there exist a few models of successful extension, the inability to "scale-up" any extension activity appears to be a severe limitation. Unquestionably, there is tremendous opportunity for improvement of extension within the Government and by non-government organisations (NGOs), but it is predicated on a strong client orientation and based on local interest rather than Central Government targets.

8. Individual agriculturalists in Nepal are intimately aware of the problems as can be seen from the papers presented in seminars, but the nature of their employment and the structure within which they work often stifles a farmer-oriented approach.

Appropriate Extension Messages

Bunch (1982) used a check list of "appropriateness" in judging the merits of new technologies for the small, resource poor farmer. To ensure success, a new technology should:

- meet with the felt needs of the villagers,
- increase productivity, quality, and/or profitability of the overall farming system significantly,
- be able to demonstrate success rapidly,
- utilise resources that are readily available to the small farmer,
- assume a low or at least an acceptable level of risk,
- be labour rather than capital intensive, and
- be simple.

Most workers recognise that productivity must be increased significantly to be of interest to the small farmer. However, there is a misunderstanding of the word significant. What might be statistically significant to science may well not be significant to the farmer and vice versa. Qualities that have been considered insignificant by the researcher (such as straw yield in rice breeding) may be a critical component of a farming system. Increasing rice grain yields at the expense of straw may be unacceptable. In the area of soil fertility, it is well recognised that high yielding varieties have greater fertility requirements which may or may not be possible for a farmer to manage in a particular farming system. In normal risk management, anything new involves risks. The farmer must be convinced that the new technology is worth the risk. Where only small changes are required, small incremental gains are acceptable. However, with extension recommendations involving unfamiliar crops or with the complete revamping of whole cropping systems, productivity increases of 70 per cent might be required to interest the farmer.

Dependence on Local Resources

The more remote a production pocket is from roads and outside markets, the greater is the reliance on local landscape for nutrient and energy needs. The better the access to the production pocket and the more sophisticated the market, the greater is the dependence on outside forces. When considering the changes required to make agricultural production sustainable, the planner must weigh the advantages and disadvantages of the self reliance of a community versus interdependence of local, regional, and international communities. If fertilizer transport subsidies are not sustainable, do not encourage them, because in the future the farmer may be dependent on a resource that at some point will not be available.

The Institutional Environment

Government institutions have the potential to strongly influence how a farmer uses his land. The Ministry of Agriculture's mandate is to lead the way in research and extension on agricultural problems; the Agricultural Inputs' Corporation supplies improved seed, fertilizer, and pesticides; and the Agricultural Development Bank provides loans to farmers and agro-businessmen. The Department of Roads has a critical role to play in opening up remote areas to agricultural inputs from the outside and providing an opportunity for moving produce to the markets outside the previous "market-shed". Customs and Excise departments strongly influence agro-entrepreneurs in their interest (or disinterest) to invest in agricultural enterprise. For all of the development attempts made, few government (or donor) initiatives have had any lasting positive effect on the small farmer.

Forestry, as we have seen, has a critical role to play in the nutrient cycling of traditional agricultural systems; although this is not reflected in the operation of the present Ministry of Forests. The Forestry Ministry and the Ministry of Agriculture have little in common and they jealously guard what they consider to be their domain. This is most strikingly reflected in the concrete marking pillars that the Forest Department has been using to mark out and distinctly separate the domain of the forest from that of agriculture in many village areas of Nepal. Considering traditional land management in Nepal, these imposed boundaries are not only meaningless but result in pointless hardship where the forestry administration is able to impose its regulations. The small Nepalese hill farmer is dependant on forest lands to maintain the productivity of his overall farming system (Yadav 1992). And yet, the Forestry Department is heavily biased towards timber production and has generally seen the farmer as an encroacher and common thief on forestry-administered government lands. The control of their access to and removal of farmers from forest land has dominated the Forestry Department's philosophy and actions up until the present. Great efforts are being made, particularly by donors, through projects such as the Nepal-Australia Forestry Project, to reverse this attitude, but change has been slow. Until recently, the role of the Department of

Agriculture was meeting targetted goals of agricultural production while Forestry Department activities have been centred around achieving targetted goals for plantation and protection through the services of forest guards. As in all bureaucracies, walls are built up between the various institutions, effectively preventing any beneficial cooperation. In Nepal the word "agroforestry" is shunned by both the departments of Forestry and Agriculture and is carefully avoided in official correspondence. Even within the ministries themselves, antagonisms exist that preclude cooperation leading to more relevant extension programmes (Plate 10). As discussed later, the special role of fodder, livestock, and compost in the overall soil fertility management strategy makes it essential that government agencies orchestrate their work more closely if they are to provide an effective service.

Many land resource studies in Nepal, including the Land Resource Mapping Project (1986), have investigated resource allocation and concluded that only if the Central Government divested power and authority to private enterprise and the farmers themselves could significant improvements in natural resource management be made.

The Central Government has embraced the concept of grass roots' development, in theory, but now must put it into practice. There is an ongoing, donor-driven push to accelerate the decentralisation process and divest power to lower levels of government and, ultimately, the people themselves. The Forestry, Irrigation, Livestock, and Horticultural Master Plans (HMG/N 1988, HMG/N 1989, HMG/N n.d., ADB 1991) (some of which are still in a preliminary stage) have all been remarkably consistent in stressing the facilitating role of the Government to empower local resource management. Herein lies an unexcelled opportunity for positive change, particularly given the recent changes in Nepal's Government.

The "bottom up" approach to development is based on the premise of villagers becoming empowered, making their own decisions about what they want, and cajoling the bureaucracy to provide the services that they require. Although the recent changes in the Government are encouraging, it is hard to see how these two opposing philosophies can be reconciled. Until the small farmer is understood and becomes, for the bureaucracy, the client who demands service, rather than the humble recipient at the end of a long and tenuous bureaucratic chain of command, the Government and donors have little to offer towards sustainable management of village lands.

While the elected Government has changed, the bureaucracy was, and to a large degree still is, based on the autocratic and rigid hierarchical structure of the Rana Regime. In this dawning of democracy in Nepal, possibly one of the most important issues to be resolved is to put politicians firmly in control of the bureaucracy, while at the same time ensuring that politicians are sensitive to the needs of their constituents. Along with this, local representation and a local tax base are also necessary to facilitate local management of local resources.

The strengths and weaknesses of the various insti-tutions have been closely investigated by many reports (Jodha et al. 1992) and it is not the purpose of this study to echo their findings. In brief, there have been many attempts to strengthen institutions, none of which have succeeded. Until the concerted philosophies and goals of the institutions are appropriate, no amount of strengthening will improve the life of the small farmer.