IV. The Future

The Government must consider many aspects outside the realm of soil fertility when promoting productive and sustainable agricultural systems. Under the previous government regime, the production system stagnated. Historically, the development of Nepal's resources has experienced a slow progression towards increasing carrying capacity. Periods of stagnation and lack of major change occurred along with spurts of expansion. While there is tremendous uncertainty about Nepal's future in this period of stagnation, and although there are many indicators that the overall situation is deteriorating, there is also considerable opportunity for promoting positive change.

A concerted effort will be required on the part of the Government to facilitate the necessary changes. Minor or even major shuffling of the various government agencies will likely, as in the past, make no difference to the development effort. A new philosophical approach is required. The "top down" system of management has failed to satisfy the basic needs of the people. Government control has stifled, rather than encouraged, private enterprise on the farm and in industry. Culturally, Bista (1991) portrays a convincing and pessimistic outlook for the future given the fatalistic outlook of the elite who hold the seat of power. However, the mere recognition of these problems is a positive step towards finding solutions. The increased awareness of local user groups and the rapid proliferation of NGOs are strong indicators of the willingness on the part of the Nepalese people to lead in privately induced development. It is hoped that the newly-formed democratic government, and the bureaucrats under it, can govern and administer the nation based on the collective will of the citizens of Nepal. Without that commitment, there is little reason to expect positive change.

Opportunities for Enhancing Soil Fertility

There are many excellent management practices now being carried out by the small farmer. However, technical improvements are still possible on many fronts of soil fertility management. Only when these technical improvements are translated into increased productivity and profitability will the farmer be willing or able to accept them.

In the previous chapter the management of nutrients within the traditional farming system in Nepal was discussed. This chapter will suggest ways in which to manage nutrient flows both to be sustainable and to optimise returns to the farmer.

Reduce Loss of Nutrients from the System

Possibly the most cost-effective method for improving the overall soil fertility status in Nepal is to reduce the losses that occur in the system. Potentially valuable resources are being converted into someone else's problem as sediment clogging, irrigation canals, high groundwater nitrate levels, and downstream pollution. Erosion seriously degrades the soil resource. Excessive leaching of over-irrigated soils, volatilisation of nitrogenous materials, burning of organic matter, and mishandling of human wastes are all lost opportunities. Reducing losses of nutrients by changes in management of the above provides the most direct, and possibly greatest, return on investment to the farmer.

Reduce Surface Erosion. Loss of topsoil by surface soil erosion is recognised as one of the most serious problems facing the small, resource poor farmer in the hill regions of Nepal. Increased degradation of already marginalised upland soils results in the loss of soil nutrients. A loss of only 1mm of topsoil (a minimum that would occur) on marginalised uplands can be translated into the loss of 10 kg of nitrogen, 7 kg of phosphorous, and 15 kg of potassium per ha.[9] Farmers are most concerned about soil erosion because they recognise that the compost or fertilizer that they have just added is literally washed away by rainfall erosion. There is increasing evidence that the classical method of predicting soil erosion may not provide a useful model for the terraced landscapes of Nepal. As discussed in Annex 3, rainfall intensities are relatively low and soil infiltration capacities relatively high throughout the Middle Mountains of Nepal, but erosion is still occurring. It appears that the

9. Assuming a soil with an organic matter level of 1.5 %, nitrogen level of .075%, phosphorous level of .05 %, and a potassium level of .1 %.

management of surface drainage and storm runoff above and within terrace systems is critical for the management of soil erosion.

Regardless of whether the method employed to reduce surface erosion is by increasing rainfall interception of the soil or safe removal of runoff water from slopes, either will have a strong positive effect on regional soil fertility. Consequently, soil conservation techniques are crucial in an overall soil fertility strategy for Nepal. Fortunately, most good agronomic and forestry practices also have the benefit of enhancing soil fertility, productivity, and sustainability at the same time.

The driving force for conservation should be that it is in the farmer's short and long-term interest to do so. Soil conservation for conservation's sake alone will be of little or no interest to the small farmer. For this reason, the western-based idea of a soil conservation driven project is misdirected within the Nepalese context. The end product must be measured in produce and money. A sustainable, productive landscape is a result of, not a condition for, economic well-being.

Reduce Amount of Irrigation Water Used on Pervious Soils. Excessive soluble nutrients are lost through deep leaching of pervious irrigated soils, any method used to reduce water loss will preserve soluble soil nutrients including nitrates and potassium. Unused water can be redirected to expand the area under irrigation. The most obvious way to reduce consumption of water is to irrigate crops other than rice on the coarse-textured soils. Irrigation duties for maize may be less than 1/5 the requirement for puddled rice.

Reduce Volatilisation of Nutrients from the System. Nitrogen losses through volatilisation can be significant and any methods to reduce such losses should be considered. Major nitrogen losses occur during compost production and incorporation into farmers' fields. Present studies being undertaken by researchers at Lumle will bring new understanding into an area long ignored by agronomists.

Some of the biggest volatilisation losses occur through the burning of grasslands and brush forests. Whenever burning of any type occurs, nutrients, including nitrogen and sulphur, are lost into the atmosphere. Organic matter, which is so critical to the whole production system, is lost when burning occurs to enhance pre-monsoon grazing. The management of the coarse, high carbon/nitrogen ratio organic material on grazing and forest lands is critical and will have to involve integration of agriculture, livestock, and forestry activities.

Reduce the Loss of Nutrients from Night Soil. The present misuse of human waste is a serious nutrient drain on Nepalese agriculture. The nutrients lost to agricultural production through the indiscriminate disposal of human wastes are in excess of all of the chemical fertilizer now imported into the country. The average household produces 28 kg of nitrogen, 4 kg of phosphorous, and 8 kg of potassium as organic waste and, through lack of care, a significant portion of these nutrients are ineffectively lost to the system. If only 50 per cent of the nutrients are recycled on to farmland (by chance or design), this would result in an additional 70,000 tons[10] of elemental nutrients available for production systems. (At present, Nepal only imports 50,000 tons of elemental nitrogen, phosphorous, and potassium.)

Hill farmers use nearby fields, grazing areas, and pathways for eliminating body wastes, but the process is one of chance whether the nutrients will be recycled. The *Newars* of Kathmandu Valley, before the days of chemical fertilizer, made extensive use of night soil in market gardening. Now the *Jyapu* farmers find it more convenient to use chemical fertilizer and most of Kathmandu and Patan's human wastes foul the holy Bagmati River, or even worse, the streets. Some toilet designs already exist that use little water and can safely convert waste into fertilizing material but as yet they have not been given the priority they deserve. At present, only the *Sherpas* of eastern Nepal actively use human waste in compost for their agricultural soils.

While present sensibilities may preclude such intensive use of night soil for orthodox high caste Hindus in Nepal, temporary latrine pits adjacent to the homestead in rural areas can be used productively for perennial tree establishment. Where farmers have already adopted this simple technique, the fertilizing value of their own waste becomes much more apparent and the farmers begin to experiment themselves. This would be the first step in getting the Nepalese farmer to recognise night soil as an important resource to be managed rather than squandered.

The simple separation of human wastes from potential water supplies would do more for the development of Nepal than

10. This figure is based on very rough calculations and is only meant to indicate the order of magnitude of the problem (and opportunity).

any other single innovation yet attempted in Nepal. Greatly reduced child mortality and lowered child and adult morbidity would be a direct result of a successful sanitation programme. From the farmer's nutritional point of view, the increased ability to absorb nutrients as they pass through his/her stomach would be more beneficial than all agricultural improvements developed over the last 20 years. Implementation of a sanitation/fertility recovery programme affects the "sensibilities" of many and as such would be unpopular. However, a serious Government will have to become more serious about sanitation, sooner or later.

Develop Alternative Fuels to Dung in the *Terai* and in the Dun Valleys. The loss of livestock manure that is burned for cooking purposes is an increasingly serious drain on agricultural production for poor farmers. While the ash is returned to the land it does not contain nearly the amount of nitrogen it would if used as compost. The physical effect on soil structure and the buffering effect on low pHs are two important reasons for using more compost on the *Terai* soils. Fast growing tree species now being planted on marginal lands in the *Terai* provide considerable opportunities for improving this situation and should be encouraged.

Improve the Efficiency of Nutrient Use

The nutrients that are now within the village fertility management system have the ability to be used in many different ways for a wide variety of crops. A number of techniques can be used to enhance the efficiency of these nutrients.

Improve the Quality of Compost. Compost is the single most important soil fertilizing material in Nepal and the improvement of its management would have significant spinoffs for agriculture. Before the quality of compost can be improved, it will be essential to dramatically improve the resource scientist's understanding of its physical and chemical nature, how the farmer makes it? and what role compost plays in soil amelioration? It is apparent that many of the recommendations regarding compost management are made with little or no field-tested, scientific justification. A "theoretically" correct, yet probably inappropriate, recommendation is that farmers should not let their compost dry out before incorporation because nitrogen is lost through volatilisation. Such analyses without attention to the farmer's management system also make results less extendable. If the labour needed to bring the compost to the field is the major constraint, it makes good sense to let the compost dry out so that more can be brought to the field with each journey. Likewise, it is also "theoretically" correct to assume that incorporation of distributed compost, once spread on the field, is essential. Again, this assumes that nitrogen is the primary constraint. Maybe it is not. The compost may be acting as a mulch to protect the soil from surface rainfall erosion. On certain sites the net effect of a surface mulch in reducing erosion may be much greater than a "timely" incorporated compost. These are just two examples of an incredible research vacuum that is hindering concerted efforts to improve the farmers' present fertility management systems. At Lumle ongoing experimental work with compost use under farm conditions provides a critical new look at the process of compost improvement. Subedi et al. (1989) found that wet application and immediate incorporation of compost improved yield in some cases and not in others. Laboratory analyses of soil fertility did not always reflect the actual productivity of crops grown on those soils. Subedi indicated that more study is required in order to understand the complex interactions of compost management.

A clearer terminology of compost quality is desperately required for agronomists and soil scientists so that they can begin to address overall fertility management within the system. It is almost useless to record that a certain number of baskets (*dokos*) of compost have been added to a field and assume that tells one all one needs to know about fertility management. If the compost is made from pine needles and a minimum of dried goat manure, it will differ tremendously from well-rotted compost made with oak forest floor litter, ash, buffalo manure, and urine. Agronomists and soil scientists must cooperate to understand how and why compost is being used and only then enter the more serious domain of making recommendations for improvements.

Increase Quantity of Compost. Quantity of compost is another critical issue. Given the tremendous increase in demand for compost, as discussed in the preceding chapters, changes within the system will be required to ensure that compost quantity is increased. Increased production of high quality fodder will be central to this goal. Better management of fodder production systems and the livestock feed will ultimately be required. Systems of compost distribution and location of livestock stalls relative to the farmlands will have to be modified to reduce the labour associated with the increased compost production.

Maximise Returns on Compost Use. Understanding how farmers manage their compost resources may provide more insight into the overall productivity constraints of village lands. The present proportioning of compost by a farmer on his lands should provide useful information on how the farmer allots scarce resources. The higher the value of the crop being fertilized with the compost, the greater the returns of a given fertilizing unit. Rather than land itself being considered as the primary constraint to increasing production, it might be more appropriate to think of compost as the primary constraint. Instead of discussing yields in terms of tons per hectare, it might make more sense to discuss yields in terms of productivity or profitability per unit of fertilizer and/or compost required. This would be closer to the real constraints facing many hill farmers.

Reduce Labour Associated with Compost Distribution. Labour constraints are usually associated with the management of compost resources. Reducing the requirement for labour will in effect improve the allocation of compost resources. Developing higher quality compost, reducing weight and/or bulk of compost, and possibly producing compost where it will be used, by moving the livestock stalls to the field, are all changes that could be considered. With the increasing production of fodder on *bari* there will be a much stronger incentive to feed the animals on the site rather than carrying fodder between field and household and then carrying the compost produced back to the same field. In many areas of Nepal, farmers move livestock from homesteads to fields at markedly different elevations to take advantage of a crop by-product or forestry species that can be fed to livestock from a nearby source. The resulting manure or compost is then used on the nearest appropriate field with a minimum of labour expended.

Increase the Use of More Valuable Perennial Crops. Crops that can be productive and which exploit deep soil nutrients and water can give a new lease to mountain agriculture. The five major land use types - irrigated land, rainfed land, kitchen garden, grazing land, and forest land - have a potential to support a wide range of perennial crops. From a strictly ecological point of view, solutions involving perennial crops are excellent, but there are a number of constraints that must be overcome before the farmer can become enthusiastic. To ensure that the new crop provides some regular cash income for the small farmer is of primary importance.

Use Crop Varieties with Low Nutrient Requirements. Riley (1991) has strongly recommended that the great diversity of traditional varieties and landraces of major grain crops be preserved; in part to take advantage of their different soil nutrient requirements. The present extension trend to replace all local varieties with a single improved variety will have a very negative impact should chemical fertilizers become scarce. Local varieties have the ability to produce low, but stable, yields under adverse soil fertility conditions.

Encourage More Extensive Use of Mulches. Mulches have considerable potential for protecting soil surfaces from erosion, enhancing soil moisture, and reducing weeds and are already used by farmers for a number of crops under different conditions. Mulching materials and ways to incorporate them into existing farming systems should be a major focus of research agronomists, particularly where high rates of erosion are identified (such as in off-season potato production). Many of the waste weed species, if harvested at the right time, can provide a weed-free, protective mulch. Initially *Artemisia* (*tite pate*) and *Eupatorium* (*banmara*) should be considered. Other non-vegetative mulches, such as stones, wood ash, or rice husk, can be useful to ameliorate undesirable soil characteristics also.

Facilitate Production/Conversion of Nutrients to a More Useable Form

If nutrients can be made or converted into a more useable form on site, rather than imported from the outside, there are obvious advantages to remote hill farmers.

Introduce Green Manures-cum-Fodder Species into the Farming System. While there are already a great number of leguminous and non-leguminous trees, shrubs, and plants within the Nepalese agricultural system, there is potential for considerable improvement. This is particularly so on marginal agricultural plots. Subedi (1989) studied a number of green manuring plants that were being used by farmers for different purposes and provides a qualitative assessment of their value. A large number were used in the nursery establishment of rice and to a lesser extent millet. At present very little green manuring is done on *bari* anywhere in Nepal. The ideal fodder tree must grow rapidly and have high quality fodder that is available during the months of March, April, and May when all other sources of feed are absent. It must coppice well and be able to survive the rigours of survival on a terrace riser. In their work in Bahunipati, World Neighbours (1991) found that the coppice height of trees used for green manure and fodder was critical to successful adoption by farmers. If trees were too low, free-grazing goats would strip them, if they were too high, grain crop yields were suppressed by the shading.

Cultivated green manure-cum-fodder must provide either high quality livestock feed and/or an edible seed and, at the same time, not compete with other crops that are currently producing satisfactorily. In some instances, the addition of the green manure crop does not require major increases in labour. There are a number of such species in Nepal that meet these criteria, and these should be the focus of on farm research-cum-demonstration plots. Some of the ongoing work of World Neighbours (1991) with introduced and local legume species has been very promising. Sun hemp, velvet bean, jack bean, and pigeon pea have all found 'niche' within marginal rainfed terrace systems and have obvious advantages for farmers (Plate 11).

<u>Research Inoculation of Micorrhizal/Azotobacter to Improve Performance of Plant Root Systems.</u> Many plants have associations with fungi and bacteria that are of benefit to both. While work on micorrhiza and azotobacter has been carried out under experimental conditions, results are not yet conclusive. On agricultural plots, yield increases have often been insignificant but possibly all of the important parameters affecting yield were not understood. There is an increasing need to research the use of soil inoculum to assess how important it is for production.

Bring Fertilizer in from Outside the System.

If the village has something to offer to an outside market, whether an agricultural commodity or even labour, there is the opportunity of importing and paying for nutrients that originate outside the village. Chemical fertilizers have the potential to play an important role in enhancing overall soil fertility and greatly boosting the agricultural production within certain farming systems. Obviously, changes in the way fertilizer is used will be required to avoid some of the potentially serious problems that can arise.

<u>Promote Proper Use of Chemical Fertilizers</u>. It has been well demonstrated that the yields of the major grain crops can be significantly increased with judicious and timely applications of chemical fertilizer. The best response to fertilizers is elicited through the use of improved seed varieties and by paying careful attention to cultural practices, including watering and plant stand densities. Unfortunately, there is a lot of confusion in Nepal regarding the pros and cons of fertilizer use, and this confusion has begun to be reflected in misdirected government programmes.

Experimentation on fertilizer use should be focussed on maximising the marginal return to increased fertilizer use. Although nitrogen, and to a lesser extent phosphorous, responses are documented for most crops on most soils, this, in itself, is no cause for the extension of chemical fertilizer use. In many cases, farmer practices have not been used for the control, and so the results may have little significance to the small farmer. Sometimes trials compared the use of chemical fertilizer and the use of no fertilizer whatsoever, ignoring the fact that the farmer was already using between 5 and 20 tons of compost for his crops. Lack of compost use (or proper documenting of its quality) in any fertility trial makes it extremely difficult to interpret the results.

Many farmers, particularly in the Kathmandu area, have been complaining about the lack of continued response to fertilizer, and some farmers are actually reporting a reduction in yield after as short a period as five years. Urea appears to be the main fertilizer of concern to the farmer. In some cases, such as at Rampur in Chitwan, repeated nitrogen fertilizer use, without proper organic matter management, has seriously degraded the physical and chemical properties of the soils on the station. Soil acidification, exacerbated by chemical nitrogen fertilizers, appears to be a major problem in Nepal in the more accessible areas of the Central and Eastern hills. In areas of increasing soil acidity, sources of limestone will have to be found and processed for use as a regular soil amendment.

The government research thrusts for maximising yields are rarely meaningful to the Nepalese farmer. Economic justification is required concurrently with the trials to show that chemical fertilizers not only increase yields but also increase income. At present, it is obvious that subsistence farmers are not interested in using scarce cash to buy fertilizer for use on subsistence grain crops, in spite of the apparent returns on investment.

Regardless of the nature of the farm, soil organic matter management will be increasingly important to farmers using chemical fertilizer.

<u>Increase the Availability of Chemical Fertilizers</u>. The current sporadic availability of fertilizer supplies is severely hampering those farmers wishing to use chemical fertilizer on their cash crops. Until this problem is resolved, the production potential of many commercially-oriented farmers will be severely curtailed. The Government must adopt a policy that assures that farmers who want fertilizer can get it when they need it. It appears that only by putting distribution in the hands of private traders will significant

improvements be made (Crown Agents 1991). Given Nepal's present and projected financial situation, fertilizer prices must reflect true costs. Subsidies will only further cripple the economy and give an artificially low substitution value for local compost-based fertilizers. The net result could delay the development of more sustainable soil resources.

At present all chemical fertilizer is imported. Nitrogen fertilizer in the form of urea may eventually be produced in Nepal if a major source of hydropower is developed. Phosphorous poses a potentially more serious problem for the future. Even if leguminous crops and factories can supply nitrogen, phosphorous will become increasingly deficient in production systems. All phosphorous fertilizer is imported, although low grade phosphate deposits do occur in the country (Pradhananga 1986). Researchers must determine if there is any way in which local, low analysis phosphates can be used. Limestone for reducing acidity is increasingly being recognised as critical in many areas of Nepal. Local sources of limestone will have to be exploited within agricultural pocket areas, as the amounts required to treat acidic soils are too bulky to transport over long distances (Plate 12).

A Soil Fertility Management Strategy for Nepal

In previous chapters, the physical, socioeconomic, and institutional backgrounds to soil fertility management have been discussed. Specific recommendations for technical innovations have been given. However, the lack of technical solutions is rarely the major obstacle to accelerating agricultural development. A soil fertility management strategy must be based on a holistic outlook and integrate many seemingly unrelated components that directly or indirectly influence soil fertility management. These components are discussed below.

Develop a Strategy Based on Increasing the Productivity and Profitability of the Farming System

There have been major shortcomings in developing sustainable soil management programmes of both government and donor-driven projects. While maintaining soil fertility and long-term sustainability are worthwhile goals, programmes to address soil management issues must be tied intimately with soil productivity and profitability. There is nothing particularly attractive to farmers about developing long-term sustainability strategies when their primary concern is with day to day survival.

A farmer making good returns on his investment of labour or capital will be encouraged to manage the soils as required to keep productivity up. On the other hand, farmers working marginal lands and receiving little return for their labour will become discouraged and lose interest in working the land. Outsiders' attempts to "make the soil better" without a clear economic motivation for doing so are bound to yield disappointing results. Donor-driven extension is rarely sustainable. Concern over the laboratory soil sample analyses that indicate very low levels of nitrogen, phosphorous, and organic matter and low pH does not, in itself, help to formulate a strategy for soil fertility management. The key to any successful soil management strategy must be tied to increased productivity and returns on investments in labour, money, land, or fertilizing material-whichever resource is considered to be scarce by the farmer.

Many projects have fallen into the trap of enticing farmers to adopt what are considered by professionals to be appropriate soil management techniques. When the project enticement ends, whether it be through free fertilizer, food for work, or money, the farmer reverts to his pre-project activities and recreates his pre-project problems. A recent review by the Rapti Project in the Midwestern Development Region concluded that the farmer was making the right decision to ignore extension messages, provided by the line agencies, as they would not benefit by adopting them. It was not that the messages were "wrong" but that they did not match the farmers' problems. In a wide range of rural development projects in Nepal, there have been attempts to construct "improved" bench terraces on farmers' marginal lands, promote surplus horticultural production, encourage fertilizer use at highly subsidised prices, and force protection of overgrazed lands without providing alternatives. These are all examples of well-meaning but inappropriate extension activities. Any programme to improve soil fertility must understand the Nepalese farmer and his socioeconomic and physical environment.

Recognise that Market-driven Forces Are an Essential Component for Extracting the Subsistence Farmer from His Present Plight

The traditional subsistence agricultural system no longer offers the farmer sufficient returns on his labour to motivate him to adopt new innovations. However, wherever clear market indications are present, the Nepalese farmer is quick to produce for those markets and, in doing so, provide the opportunity to begin to manage his land in a more productive and profitable manner. It is only after this marketing opportunity occurs that the farmer will show enthusiasm for enhancing the fertility of his soil on a sustained basis. This market-led force appears to be the key required to motivate the farmer to put his farm in order. Knowingly or otherwise, most of the successful agricultural development projects that have occurred in Nepal were hinged on the presence of this market force (Banskota 1989).

Recognise What Are the Scarce Resources

A primary step is the identification of scarce resources. Many independent surveys of Nepalese farmers have been carried out within farm households and, with regard to the perceived limitations, farmers are surprisingly consistent. These limitations include those covered below.

Water. Invariably the major perceived limitation to increasing production is lack of water. Farmers universally recognise the possibilities of increased production by using more irrigation water, not only for the value of the water alone but also for the value of the dissolved and suspended nutrients that have made irrigated land more fertile in areas where nutrient resources are scarce. However, it is also recognised that harnessing new irrigation water sources in the settled hill regions of Nepal can be extremely expensive and beyond the ability of the unorganised small farmer. Possible improvements to existing irrigation systems include lining canals to increase water delivery and reduce slope instability, improving the efficiency of water use on site and, in some cases, using alternative, highly profitable, but less water-demanding, crops. In any of these improvements, the local user groups' intimate involvement seems crucial to the success of such programmes.

Irrigation is not the only way to increase the amount of water available to crops. Soils can be managed to increase substantially the efficiency of rain interception and soil water-holding capacity. Many of the characteristics of a fertile soil are as much related to their physical as chemical conditions. Substantial increases in productivity are possible by better management of soil water even without irrigation. This is most closely tied to organic matter management.

Land. The second scarcity most often considered by the small farmer is the land resource itself. Small hill farmers, on average, own 0.4 ha of cultivated land, with which they must support 5 people. However, large land-holders, particularly in the *Terai* and in the Dun valleys, can own huge tracts of land that are worked by tenants. Redistribution of lands from the large holders to the landless and smallholders is a major political issue and was heavily exploited by candidates in the 1991 election. However, while land resource tenures strongly affect land management, a report of this nature cannot predicate a land management strategy assuming significant changes in land reform. Agricultural planners and politicians alike are constantly referring to this land hunger that forces increasing cultivation on to marginal and grazing lands. Given the large areas of abandoned rainfed land in the remote hill areas, it must again be stressed that lack of soil fertility, rather than land scarcity itself, restricts local level production. Clearing, ploughing, and sowing seed on infertile soil is not a profitable venture.

Labour. Household surveys invariably point to severe labour shortages in agricultural production systems for both subsistence and commercial production. Cropping calendars point to periods of extreme work loads, particularly burdensome for the women who tend to work much longer hours than men. In many cases, the farmer is attracted to off-farm occupations because the returns to farm labour are so low. Techniques of increased fodder production and better compost utilisation can obviously increase soil fertility; but, it is essential that the returns to their labour justify the more intensive management.

Capital. Every farmer interviewed will discuss the lack of money as a serious constraint to production. Not only are small farmers broke, but they are also in debt and any cash they have is used to service debt. Real interest rates on loans are often as high as 60 per cent from private lenders. Loans from public institutions are not much different after one takes into account the various hidden costs. Given the risk factor, it is easy to understand why capital is a scarce commodity, particularly for investment in agriculture.

Fertilizing Material. This brings us to the fifth most commonly mentioned scarcity regarding natural resources and that is fertilizing material - compost, manure, and chemical fertilizer. Soil fertility is probably the single most important limitation to increasing productivity that farmers can actually directly modify on an individual basis. Changes in management techniques that affect the uptake, transfer, and utilisation of soil nutrients alone can make marked changes in the soil fertility of village lands.

A farmer will only adopt a soil management or conservation technique if he can see some increase in returns for the commodity that he feels is scarce. Labour saving or cash saving may be more critical than promoting productivity increases at any cost. Sustainability issues must follow or, at best, be concurrent with increasing returns on investment. A farmer will not forgo a maize crop to plant green manure on marginal uplands because he is told it is good for the soil. When yields drop to a certain level, the farmer is forced to look at alternatives for managing that land. Intercropping a green manure that is also a good fodder species may increase the maize crop yield, reduce erosion, and produce a high quality fodder. Providing this enhanced fodder resource can be connected into enhanced livestock production; this combination can provide the entry point to village development. Successful development programmes throughout Nepal have been based on this simple innovation (World Neighbours 1991).

Oddly enough, virtually all research analyses of productivity look at yields on a per unit land area basis. Some traditional farmers consider the return on seed sown to be the most meaningful measure of productivity. Land scarcity in itself is not the major constraint to production where significant areas of fallowed or abandoned fields occur. In such cases, alternative units should be used to determine productivity. Yields per unit of compost and/or fertilizer or yields per unit of labour are possibly more relevant to the farmer than yields per hectare. For instance, it may be relevant to describe yields in kilogrammes of grain per particular quantity and quality of compost. Looking at farmer practices, some of the farmers' apparently irrational behaviour may suddenly seem more rational! Recognising the scarce resource and developing trials based on those units should have a far-reaching effect on agricultural research and how it is conducted.

Develop a Strategy that Includes the Effect of Accessibility on Fertility Management

The distance from a road and/or market will strongly influence the degree to which chemical fertilizer can be used versus the need for reliance on forest and grazing land for nutrient replenishment. Clearly, different programme emphases might be required to improve fertility for remote regions of Nepal compared to areas with good road access. To a large degree, the "Green Revolution" has been concentrated on the *Terai* and in the readily accessible interior valleys of Nepal. Areas more than a few hours' walk from road heads are unable to adopt fertilizer recommendations that have been assumed to be appropriate. The planner must not only consider the cost of the movement of fertilizer in, bút, in the absence of local markets, the cost of also moving the crop out. This often sheds new light on the feasibility of chemical fertilizer. The infrastructural map, such as that developed in the Horticultural Master Plan (ADB 1991) provides a simple way of planning overall chemical fertilizer use, development strategies (Annex 3). In general, any significant movement of fertilizer beyond a one-day walk from a road is not recommended.

Develop Separate Strategies for Subsistence and Commercial Markets

Differences in commercial and subsistence demands will influence the types of crop, livestock, etc that can be considered. These differences in demand will also strongly influence fertilizing possibilities. If cash crops are not grown, long experience in Nepal shows that the farmer is reluctant to use chemical fertilizers. The recent block trials of the Fertilizer and Related Inputs Project (FRIP 1991) have reconfirmed what has been common knowledge. While tremendous increases in yield were realised, the lack of commercial outlet in the more remote block production areas left the farmer with a glut of grain that he could not sell to recoup his loan for the initial inputs. Chemical fertilizers and cash crops must be considered together, at least until agricultural household systems become more sophisticated.

Cash crop production must be market led. Without clear, well-defined markets there is no advantage to promoting crops that cannot otherwise be locally consumed. With cash crop production, the farmer has the opportunity to purchase fertilizer from the outside, and he is less dependant on the adjacent forest and grassland resources to maintain fertility. At present, commercial grain production is never far from a motorable road. Trials on timing and placement of the proper fertilizer, the crop response, and the economic significance of the response are of relevance to the commercial farmer. Timely fertilizer availability is critical to the cash crop producer. Certain cash crops, such as potatoes, ginger, and other horticultural crops, also require considerable amounts of compost, which results in competition for compost from subsistence crops. In such cases it is assumed that a portion of the cash received for the sale of the cash crops will be used for buying chemical fertilizer.

Most of the production within the hill regions is subsistence based and farmers are unwilling or unable to devote scarce cash to procurement of fertilizers. Less than 5 per cent of all fertilizer use extends beyond the immediate reach of roads and this is with subsidies that are recognised as a serious burden for the Government. The production focus in these areas and on these crops should be to increase the quantity, quality, and efficiency of use of local nutrient sources for production.

Actively Promote a "Bottom Up" Approach to Development

A wealth of experience in Nepal shows that the "bottom up" approach to development, such as that used by many NGOs, results in significant and sustainable development. The international NGOs, such as Care, Action Aid, Save the Children, United Mission to Nepal, and World Neighbours, have facilitated the farmers to make impressive production and profitability increases in otherwise seriously disadvantaged communities. User group formation and only small monetary inputs in the early stages have resulted in significant and sustainable development (Plate 13).

On the other hand, the "top down" approach that has been the primary mode of stimulating development by the Government and major donors has failed miserably in Nepal. The reasons have been made clear in a large number of reports that have examined Nepal's institutions. The Government has an important role to play in Nepal's future, and it is time to define clearly both the Government and the farmers' responsibilities. Facilitation rather than implementation should be the primary role of the Government. Entrepreneurial behaviour rather than submission should be encouraged in the farmer.

Focus on the Small Farmer

Most of the positive results of development projects have been directed towards the rich farmers. They are able to adopt new technologies much more rapidly and their adoption allows bureaucrats to meet the targets set for them. However, the client should increasingly be the small farmer, if not for compassionate reasons then because that is where most of the resource degradation is caused. Targetting the small farmer requires that the focus of research move away from irrigated rice land and high inputs of chemical fertilizer and pesticides and towards sloping rainfed land and compost. Upland, rainfed soils are the major source of production for poor Nepalese farmers. These upland areas are being seriously degraded. They do not receive development attention commensurate with their importance in solving resource-conservation problems. Better management could result in a dramatic improvement in the long-term sustainability of farming systems in the hills of Nepal. Development experiences in Nepal have shown promising opportunities for development in this area (Sharma 1992).

Build on the Indigenous Agriculture and Forestry Management System

Agricultural planners should recognise and make use of the existing techniques used by the farmer as a starting point for developing recommendation domains. While there have been recent efforts to document soil characteristics, such as laboratory analyses of nitrogen, phosphorous, potassium, and pH, the information is of little use to land managers because it can rarely be tied to the actual productivity of agricultural or forestry soils.

A better understanding of compost production, distribution, and method of incorporation into the soil is required before meaningful soil fertility programmes can be developed. Work done by the Lumle scientists in their fertility thrust is an example of the kind of research that is required to understand present soil management. Rapid Rural Appraisal (locally adopted as *Samuhik Bhraman*, literally "travelling together") is a technique that should be adopted as one of the important research tools for Nepalese agricultural scientists (Pound et al. 1992 and Chand and Thapa 1992).

Offer Proven Technologies that are Relevant to the Individual Farmer

The farming systems used in Nepal are complex. The farmer's land is heterogeneous. Individual farmer's opportunities and constraints are infinitely variable. It is highly presumptuous of agriculturalists to develop a few "packages" for everyone and assume that the small farmer will adopt them to the exclusion of his own tried and tested farming methods. Farmers have personal likes and dislikes, some are highly industrious and frugal, others are unmotivated and alcoholic. The farmer has to make his own choice on each individual technology. Extension agents can only be as successful as their message is relevant and, in most cases, the message has been irrelevant.

Think Integrated, Act with Discrete Innovations

Integrated rural development projects look perfect. On paper, in fact, they function poorly because of the problems of integrating bureaucracies that do not like to be integrated. Separated from the realities of traditional Nepalese agriculture, the work of single sector scientists has little relevance to the hill farmer. Any innovation the scientist may wish to include within a recommendation domain should be based on the work of an interdisciplinarian study team. It is important to let the farmer decide what he wants to do and let him "integrate" it within his own system. Both donors and the Government should concentrate on ensuring that relevant technology is available. The Swiss decision to focus on forest management is a positive one. Get something right and hand it over to the farmer to be worked into his own personal system.

Develop a Long-term Strategy Based on Immediate Results

Do not expect a farmer to be overly interested in any long-term fertility strategy unless it puts food on the table or money in the pocket today. Motherhood issues with global consequences will not sell ideas to the farmer. When the long-term goal is sustainable soil management, the strategy should be to introduce production technologies that are interesting to the farmer and which provide immediate results but which, at the same time, have long-term beneficial effects. Planting improved grasses at the beginning of the monsoon which can be ready for harvesting by the end of the monsoon will encourage the farmer to participate in other development ideas. While everyone knows that planting mangoes is an excellent idea, the five or six years wait before the first fruits are ready will dampen most farmer's enthusiasm.