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Living in a Fragile Ecosystem:

Indigenous Soil Management in the Hills of Nepal

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This Gatekeeper Series is produced by the International Institute for Environment and Development to highlight key topics in the field of sustainable agriculture. Each paper reviews a selected issue of contemporary importance and draws preliminary conclusions of relevance to development activities. References are provided to important sources and background material.

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LIVING IN A FRAGILE ECOSYSTEM: INDIGENOUS SOIL MANAGEMENT IN THE HILLS OF NEPAL

Devika Tamang

Several individuals and organisations have expressed concern about soil fertility problems in Nepal. A majority of those consulted while conducting the present study indicated that natural factors such as heavy seasonal precipitation, the erosion-prone nature of the soil, its steep topography and the removal of ground cover, make the country's hill soils particularly vulnerable to leaching of organic matter and micronutrients.

Conventional wisdom separates and analyses in detail components that contribute to the problems of declining soil fertility - soil characteristics, compost, chemical fertiliser, soil erosion, landslides, irrigation, etc. But farmers view soil fertility as one of the major components in the regime of soil management. From their perspective, water, fertility, and labour management are interdependent, interactive and inseparable components of soil management.

There are three issues of particular importance to most individuals and organisations:

1. Soil acidification

According to conventional wisdom this problem has arisen because the organic matter content has fallen so low, and acidity and aluminium toxicity have consequently built up so high, that the soil has lost, or is in severe danger of losing, its buffering capacity. Moreover this problem is being made worse by two current developments: the introduction of chemical fertilisers, particularly ammonium sulphate and urea whose application increases soil acidity; and the use of pine needles in compost. Both developments are officially encouraged: in agriculture the policy is to promote the use of chemical fertilisers, and in forestry there is a heavy preponderance of pines in the seedlings released by the Department of Forests.

2. Decline in agricultural production

Some of the factors contributing to the decline in agricultural production are increasing cropping intensity with consequent nutrient depletion, increasing soil acidification, decrease in the number of livestock and hence the quantity of manure for compost, decrease in access to vegetation for making compost, decrease in application of organic material, etc.

3. Soil erosion

The high rate of erosion of the top fertile layer of soil from sloping and poorly maintained terraces and areas with insufficient vegetative cover are of particular concern.

Methodology

Exploratory and topical Rapid Rural Appraisal (RRA) was used to conduct the studies. Semi structured group and individual interviews, transects, matrix ranking, and triangulation was used to collect the information. In order to select both small and large farmers their houses (size, roofing material, living area and size of livestock shed) were considered as indicators of agricultural prosperity (McCracken et al, 1988). These proved to be relevant indicators of prosperity in all the study Districts.

High population density, steep topography and intense monsoonal precipitation make the hill areas particularly vulnerable to erosion of soil fertility, while variation in elevation, precipitation and temperature contribute to a diversity of natural and cultivated vegetation. Scientists have found hill soils to be acid in a belt located between approximately 2000 and 5000 feet (600–1500 metres) in an area ranging from the Kali Gandaki to the easternmost border of the country. Of the many rivers in Nepal which flow from north to south the Kali Gandaki in the West appears to delimit a basic difference in climate. Therefore, on the basis of existing data, important agro climatic factors were considered in selection of the study districts.

A major problem of the hill areas is that many of them are relatively inaccessible. Transportation is mostly by pack animal and porters which seriously affects access to chemical fertiliser, seeds, implements, etc. and limits farmers's options in soil management. Access to transport for both inputs and outputs largely determines cropping pattern. Generally, if markets are accessible the emphasis is on cash crops. If they are not the emphasis is largely on subsistence crops.

Soil Fertility Management Practices

The farmers say that with sufficient amounts of water, compost, and labour, a suitable climate, and appropriate management any soil can be made fertile and productive. This is absolutely correct.

The division of labour along gender lines is found in all areas. Collection, processing, transportation, and application of all the materials used for soil fertility management is women's work. Men are usually involved in using chemical fertiliser and pesticides. Constructing, repairing and scraping terraces, making and maintaining waterways, canals, making structures to collect silt and soil, which are all concerned with water management are done by men.

1.Compost

Advantages of Compost

There is no doubt among the farmers about the advantages of compost. They say it would be impossible to grow food as they do now without it and that it is good for the soil because:

- It makes soil friable (loose, light, and crumbly) and easier to plough because there are fewer clods.
- Excess water percolates through and moisture retention capacity is improved. Composting helps to regulate the amount of moisture in each plot according to the farmers' requirements.
- Allows air into the soil and makes it easier for the plant roots to breath (improves aeration).
- Poor soil can be improved over time by application of compost.
- Reduces and remedies the negative qualities of chemical fertiliser.
- Reduces and remedies 'sourness' in soils.
- Provides nutrients for plant growth.

Type of Compost

Compost made only from vegetation is held to be useful for improving aeration and regulating water percolation and moisture retention. Large amounts of leaf litter and green vegetation need to be collected to make this type of compost. Due to decreasing amounts of vegetation available and lack of labour, this type of compost has become uncommon.

Compost made only from livestock manure is needed to provide nutrients and to maintain soil fertility. Such compost is common in areas where there are large numbers of livestock or the transhumance system (*goth*) exists. In other areas the farmers say that over 50 years ago they made compost from manure, but due to a decrease in fodder they tend to keep less livestock so that this practice has disappeared.

Compost made from manure and vegetation combined is more common to compensate for the shortages of manure, vegetation, and labour.

Quality of Compost

This varied according to the quality of the vegetative (Subedi & Gurung, 1991) materials and the nutrient value of livestock manure used. The best quality (which has most manure, fine and friable) is applied to the seed bed. The second quality, consisting of decomposed manure and vegetation, is applied to *bari*[1] land. The lowest quality, composed of a little manure and large pieces of partially decomposed vegetation, is applied to *khet*[2] land. The farmers use the best compost to produce vigorous seedlings. *Bari* land needs good quality compost as it is planted for crops demanding higher fertility, e.g. maize, and much of the soil nutrients need replacing as they are leached annually. Water and silt provide much of the fertility in the *khet* land and as crops requiring low levels of nutrient are planted, e.g. paddy, good quality compost is not essential.

Vegetation

Many plant species are used to make compost during different seasons in the year. Farmers are aware of the nutritive value of vegetative materials but do not always use them for compost.

Animal Manure

The farmers recognise that the various animal manures have different nutritive values[3] and that some add little to the fertility of the soil. Table 2 shows how the farmers ranked the various animal manures.

Chicken manure has the highest nutritive value and buffalo manure the lowest. In Kavrepalanchok the farmers noted an adverse relationship between an animal's size and the nutritive value of its manure – the smaller the animal the higher the value while the larger the animal the lower the value. They also noted that bat manure has the highest nutritive

1. Agricultural land where rice cannot be grown (due to insufficient water, steep slopes, cool temperature, high elevation, etc.) and where the major crop is maize or potato.

2. Agricultural land usually located in a valley bottom or consisting of level terraces and/or relatively flat land and where the major crop is rice.

3. In Nalma and Bhorletar (Lamjung District) three comparatively rich farmers had taken loans from the Agricultural Development Bank to build Bio-gas (Gobar-gas) plants. The gas was used for cooking and lighting. Because they did not have enough livestock manure for the plant they had built a toilet and human waste was also used. However, they did not use the slurry from the gas plant for agriculture because (a) when human waste was included no one wanted to carry it; and (b) the slurry is relatively liquid and plastic containers are needed to carry it. Since carrying is usually done by a group of persons, several large containers (which cost Rs. 230–250 each) would have to be bought. The women of the household who had initially been in favour of the gas plant now despair at the prospect of carrying all the slurry themselves and the stigma of handling human waste.

Table 1: Vegetation Used in Compost

Local Names	*Botanical*
Sal	*Shorea robusta*
Simtara Kaiyo	*Wendlandia exserta*
Salla	*Pinus roxburghii*
Banmara	*Eupatorium andenophorum*
Patlay	*Canstanopsis hystrix*
Uniyou	*Dryoptheris fellix-mas*
Angeri	*Lyonia ovalifolia wall.*
Rangbang	
Guras	*Rhododendron arboreum*
Charibang	*Sambucus adnata*
Thotney	*Ascogonum molle*
Chinak	*Crotalaria juncea*
Utis	*Alnus nepalensis*
Jhigano	*Eurya acuminata*
Ampi	*Pirularia eaulis*
Ghurpis	
Pati	*Artemisia vulgaris*
Chilaune	*Schima wallichi*
Katus	*Castanopsis indica*
Khirra	*Sapium insigne*

Table 2: Ranking of nutrient value of manure

Animal Species	Farmer	Scientific N	P	K
Chicken	Highest	1.46	0.51	0.51
Sheep		0.60	0.13	0.99
Goat		0.60	0.13	0.99
Pig		0.50	0.18	0.42
Cattle		0.60	0.13	0.66
Buffalo	Lowest	0.33	0.25	0.10

Sources: FAO Soils Bulletin No. 40, 1977; PAC Working Paper 12/87, 1987

value and used it exclusively to revive 'dead' soils, i.e. those that have become unproductive. The manure is gathered by farmers in areas with bat infested rock caves and bartered for paddy at the rate of 1 kg of paddy for 1 kg of manure.

However, there is an increasing shortage of compost due to (a) decline in preferred species, (b) shortage of fodder which has led to fewer livestock being kept, (c) increased need for compost due to introduction of winter crops in some areas and continuous cultivation with no fallow in others, (d) shortage of labour (Most children now go to school so are not available to herd livestock or to help with housework which left adults free to collect fodder and vegetation from forest, etc. Also it has become essential for young men to go to urban areas and earn cash for school expenses, chemical fertiliser and food).

2. Chemical Fertilizers

The farmers' groups agreed that the rapid increase in population, division of land into smaller plots through inheritance, and the subsequent need to grow more food have made it essential to increase crop yield. In order to do so they have intensified cultivation to a state where there is little or no time for fallow. They cannot sustain this intensity without chemical fertiliser.

Over the past ten or twelve years they have been using various chemical fertilisers such as urea, ammonium sulphate, super phosphate, 20–20–0. Farmers with easy access to the market use more than those who live far away. However, the latter often walk two days in order to buy it. Chemical fertiliser is used only on seed beds in areas with limited access to markets.

Disadvantages of Chemical Fertiliser

These are known to all the farmers but they still use it whenever possible. The drawbacks of using it on its own are:

(1) It makes the soil hard and dry and difficult to plough.

(2) It increases the labour requirement for ploughing and breaking clods.

(3) It reduces the moisture retention capability of the soil.

(4) Chemical fertiliser is not a real *maal*[4]. It is an agent that sucks the organic material out of the soil and makes it available to the plant in a very short time. This process of extracting the *maal* slowly kills the soil.

Advantages of Chemical Fertiliser

As far as a majority of farmers are concerned its advantages are as follows:

(1) It is possible to cultivate the land throughout the year. This has enabled many small farmers with 2 to 4 *ropanis*[5] of land to grow sufficient food. Small farmers who live near markets have been able to earn a cash income.

(2) Collecting materials, processing, transporting, and applying compost require large amounts of labour. Applying chemical fertiliser reduces this requirement.

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4. A local term which generally means organic materials that stabilize, conserve or improve soil and soil fertility.

5. Local measurement of land (20 ropanis = 1 ha.).

(3) It has made white coloured soils productive which compost by itself could not accomplish.

(4) It increases yield in a short period of time. This is of particular interest to tenant farmers.

(5) It is easy to apply, one can learn by observation or simple instruction from other farmers.

Applications of Chemical Fertilizer and Farmers' Own Experiments

The farmers say the major constraint to using it is determining the amount needed. Farmer-to-farmer extension and experimentation play a crucial role here. The farmers who are far away from markets generally use it on seed beds. They said they learned about its advantages and application rates from relatives or friends who live near markets and have experience in using it. As a first step they apply the fertiliser as taught by other farmers in a small area. Several trials are done to learn how to get consistent results. During the trial period they frequently discuss their observations and results with other farmers.

The farmers who live near markets used to apply chemical fertiliser according to information from radio programmes or the recommendations by field staff of the Department of Agriculture. However, they were not getting consistent results this way and the agriculture field staff could not explain the variations. The farmers came to the conclusion that neither the man on the radio nor the government staff knew anything about the matter. The problem is that the rates recommended by those two sources take no account of important soil characteristics such as texture, consistency, water percolation, moisture retention capacity, etc.

The farmers themselves then devised and conducted a series of small scale trials. The objective was to learn about (a) the reaction of chemical fertiliser in various types of soils and its effects on the productivity of various crops, and (b) the optimal amount needed for various crops. The farmers considered the following factors in their own trials:

- Chemical fertiliser (Urea, Complex, 20–0–20)
- Soil texture (clay, loam, sandy, gravel)
- Soil colour (red, black, greyish brown, white)
- Location (low land, up land)
- Source of water (Rainfed, Irrigated)
- Crop/vegetation (Paddy, Maize, Millet, Wheat, Mustard, Potato, Cauliflower, Tomato and in seed bed where appropriate)

They visited their trial plots daily and discussed among themselves any changes they observed. Their observations were as follows:

- The fertiliser dissolves quickly in water and much of it is leached;

- It gives the best results on irrigated land, increasing the yield of various crops at least three or four-fold;

- White soils requiring enormous amounts of compost in order to be productive give amazing yields with chemical fertiliser. Never had they seen so much maize or paddy grow on these soils;

- The soil to which it had been applied was more hard, dry and difficult to plough and more time was needed to break up clods.

Application of Compost and Chemical Fertiliser

The farmers also wanted to determine (i) what would happen if compost and chemical fertiliser were both applied to the same plot, and (ii) how to reduce the negative effects of chemical fertilisers. They observed what other farmers were doing, collected information, conducted several trials and learned the following:

- Planting potato in Kavrepalanchok: They used material consisting of leaf litter and straw from the top of the compost heap. They put chemical fertiliser (complex) over the compost, then covered the rows with soil and after a few days planted potato. The fertiliser was needed for a good yield and the compost because: (1) It acts like a sponge to soak up water, retarding percolation from the plot so that although the fertiliser dissolves in water it is retained in the soil for a longer period. (2) The compost loosens the soil preventing compaction around the roots. (3) It helps to offset the negative effects of the fertiliser.

- The yield from up land from using compost and chemical fertiliser together is higher than when either is used separately.

- The yield of winter crops from low land is higher when both compost and fertiliser are used especially with potato.

- Adding chemical fertiliser accelerates the decomposition of vegetation.

- The negative effects of the fertiliser are reduced when compost is applied.

3. Soil Collection

The farmers are acutely aware of the loss of soil from their land and seem to collect soil continuously. They construct and keep in good repair terraces, irrigation canals and stone walls to conserve soil and increase their land area which is done by trapping soil deposited by the river in the monsoon. This type of work requires a lot of labour.

Water Runoff

In the monsoon, flood waters deposit some soil on terraces, terrace slopes, in diversion and irrigation canals, etc.

River

Rivers and streams transport various materials including silt. In all the study Districts in areas near the river the farmers had made large silt traps to harvest soil. Several areas were enclosed by low stone walls with spaces for water to enter and exit from the enclosed areas. Some of the farmers said that in the monsoon the level of the river would rise and flood the fenced area depositing silt. After three or four years the area fills up and there is sufficient silt to grow crops. In this way some of the farmers have increased their cultivated land and reclaimed areas damaged by floods.

Landslide

Farmers are acutely aware of landslides which on the one hand cause destruction and on the other provide opportunities to expand cultivated area and harvest soil.

Visually the most impressive example of soil harvesting is in Bhujung. Ninety per cent of the cultivated land comes from soil reclaimed from landslides and built into terraces which occupy the lower fans of the landslides. The farmers explained that this method of collecting soil takes several generations.

Table 3: Scraping Terrace Slopes

Reasons for Scraping (Khet land)	***Reasons for Not Scraping (Khet land)***
The terrace slopes produce soil and vegetation that provide *maal*. This is particularly useful as a labour saving device if the land is situated far from the house.	Grass from terrace slopes located near the house provide a source of fodder during the monsoon and save labour in the busy season.
Removes pest habitat.	Terraces located near the house bear greater human traffic and the vegetation to some extent reduces damage by binding the soil.
Removing grass from terrace banks/slopes far from the house discourages others from entering the *khet* to cut grass and in the process damaging crops.	**(*Bari* Land)** Vegetation reduces movement of the soil and retards erosion.
Reduced human traffic on the terrace edges decreases damage and amount of labour needed for maintenance and repair on the terrace banks/slopes.	Vegetation traps soil eroded from the terraces.
	It provides a source of fodder in the monsoon period.
	Vegetation to some extent binds the soil and reduces.

Terrace Slopes

The hill region located south of the Himalaya and north of the plains (Terai) consists of chains of mountains running the entire length of the country from east to west. Because there is no other land to cultivate these steep mountain slopes have been carved into terraces. There are approximately 1,133,900 ha. of terraces in the hill region of Nepal and they all have been constructed and maintained entirely by farmers over several generations (Carson et al, 1986). After every crop harvest the farmer carries out maintenance work on the terrace slopes.

The farmers said that terrace slopes on *khet* land, situated far from their houses are more likely to be scraped than others. Their reasons for scraping or maintaining vegetation on terrace slopes are presented in Table 3.

Factors Considered by Farmers in Soil Management

While conducting the study I learned that farmers view soil fertility as only one of three major components of a soil management regime. Water, fertility, and labour management are seen as interdependent, interactive, and inseparable components of soil management. For the soil to become and remain productive, they are all needed.

Soil management is not easy. The farmer needs to consider many factors. Water, labour, and the ingredients for soil fertility are not available in the amounts or periods they are needed and the farmer is continually trying to manage excesses or shortages of these major components. Soil management is the cumulative result of a series of decisions made and implemented by the farmer to allocate resources as effectively as possible, in the process of which he/she takes numerous factors into consideration.

Table 4: Factors Considered by Farmers in Managing Soils

Water Management	Fertility Management	Labour Management
Precipitation Slope Aspect Soil Texture & Depth Water Source Water Temperature Cropping Intensity Labour Information	Precipitation Temperature Regime Soil Texture/Consistency Access to Inputs Access to Markets Land Ownership/Tenure Labour Information	Location of Land Land Ownership/Tenure Livestock Ownership/Tenure Sources of Labour

Water Management

Availability of water varies according to season with an excess in the monsoon and moisture stress in the dry season. Both excess and shortage have to be properly managed. In the monsoon the strategy is to divert all runoff and allow standing water to percolate through soils quickly. In the dry season moisture has to be conserved. The farmer is experienced and skilled at implementing these completely diverse strategies and achieving successful results. The results have to be successful because the price of failure is starvation.

The farmers see water both as an agent that wears out the fertility of the soil (through erosion and leaching of nutrients) and brings fertility with silt, organic materials in flood waters and the pH of the water itself.

The factors that influence water management change continually and the system the farmer designs tries to utilise the advantages that emerge from the changes in the various factors. The farmers understand the whole process and have acquired experience and skill in designing, improving, strengthening, and managing a dynamic water management system.

Precipitation in the form of rain, hail, and mist is the major source of moisture falling directly on the land. Although they have no control over it the farmers know the local precipitation pattern and how best to manage it. Hail is viewed as wholly destructive and there are few effective measures the farmer can take to minimise the damage.

Slope of the land is important as it determines the rate of water runoff. Slope is controlled and manipulated through the construction of terraces so that the rate of runoff is more or less determined by the farmer by the angle of slope, size, direction of and type of bunds on the terrace.

If farmers can determine the rate of water runoff, they must be aware of the erosion of top soil from these sloping terraces so why do they allow it to happen? When this was put to them they replied:

> *"Yes, we know that the top soil in which we have put compost and other ingredients and which is the most fertile is being eroded every year. Yes, we know that because of soil erosion the yield from this terrace is poor. Despite these disadvantages we allow these terraces to be steeply sloped. If the slope were changed and they became level we would gain by reducing soil erosion and better crop yield but we would lose the whole terrace. In June when the monsoon begins all the soils are dry, they absorb much of the early rains becoming wet and very heavy. But the rain continues and in Bhadra (Aug/Sep) the terrace, completely saturated with water, would not be able to withstand the increasing burden and would collapse".*

The priorities in manipulating runoff are first to conserve the existence of the terrace, second to conserve soil,and finally to reduce loss of nutrients and organic material.

Aspect helps determine temperature, hours of sunlight received, and the rate of moisture evaporation. At a given altitude, a south facing slope is warmer and drier, as it is exposed to longer hours of sunlight, than a north facing slope which is cooler and moister. However, variations do occur due to the shadow effect, i.e., a south aspect may be in the shadow of another mountain. The farmer can only respond to this by moving to a more suitable site or by using shade tolerant crops and land races.

Soil Texture and Depth are major factors determining the rate at which water percolates through the soil. The farmers control this by using ingredients such as leaf litter (partially decomposed and in large pieces to allow better aeration of the soil and improve water percolation), manure (to improve soil structure and water holding capacity), mulch (to decrease the rate of moisture evaporation), and rice husk (to break up the structure of clay soils and ease ploughing). The texture of at least two levels of soil is considered – the top which is reached by the plough and the layer directly under it.

Water Sources available for agriculture are classified by the farmers as either permanent or temporary. Permanent sources can be controlled and when using them the farmer is not overly concerned with moisture conservation. The farmer cannot control temporary sources of water as from rainfall, floods, etc. and hence the attention is on conserving moisture during periods of stress and diverting water during periods of excess.

All the water that comes to agricultural land whether from rivers, runoff from rainfall, permanent or temporary springs, is known and categorised and where possible water considered to be 'fertile' is used. Generally water that flows down from the village carrying with it materials such as manure, urine, dry and rotten vegetation, etc. adds fertility to the soil. Water coming from areas where livestock are kept, where there is forest with good soil and leaf litter, etc. contribute to the fertility of the soil. The farmers explained that the 'fertility' of the water is usually evident from plant growth. The scientists describe the 'fertility' of water in terms of pH. Both the farmers and the scientists know about water 'fertility' and pH; they simply express it differently.

Temperature of Water from various sources is known and categorised as 'hot/warm' or 'cold'. The farmers explained that the temperature of the air, soil and water are all important for plant growth. Soil temperature varies with aspect, location, vegetation, etc. but most important is sunlight, over which they have no control. Water is a major factor that can be used to influence fluctuation in soil temperature. Usually, spring water is warm because it is shielded from the cold, it absorbs the heat accumulated in the soil during the day and it maintains its temperature by absorbing the heat released by the soil in the night. River water is considered to be cold. Where there is a choice, water from a 'warm' source is selected (especially for paddy).

Cropping Frequency and choice of crop depend directly on the availability of water and/or moisture. In some areas hail strongly influences the farmers' choice of crop.

Labour is the major component needed to implement all water management decisions. Human labour is needed for construction and maintenance of the terraces, irrigation structures, and diversion canals.

Information is regularly collected, exchanged, and generated by farmers in order to improve their systems. They observe what others are doing and experiment with new designs (using new materials, information, ideas) for water management. These small experiments are checked daily for changes and the outcome discussed with other farmers (if possible daily). The most important source of reliable information to a farmer is another farmer.

Fertility Management

The emphasis in the farmer's soil fertility management system is on overall improvement of soil structure and providing a source of plant nutrients. Improving the soil structure not only provides a better environment for plant growth but also has a positive impact on water management and reduces labour requirements.

Precipitation provides moisture, but water is also an agent that dissolves and leaches plant nutrients. When applying compost, manure, chemical fertiliser, etc. the farmer takes into consideration the amounts that will be lost through leaching.

Temperature Regime throughout the whole agricultural cycle determines the cropping intensity which determines the amount of nutrient needed for plant growth. Although they would not understand the terminology, farmers know that nutrient availability is dependent on the mineralisation rate of the organic material put in the soil. They also know that this rate depends on temperature. When temperature increases the mineralisation rate increases with nutrients quickly becoming available to the plant and vice versa. In applying compost and manure the farmer considers the temperature regime which determines the mineralisation rate and in turn influences the amount of materials used. The differences in temperature regimes at various elevations are also well known as are variations due to aspect and shadow effect.

Soil Texture and Consistency are seen as key factors in regulating the availability of nutrients, moisture, and air to the plant. The farmer determines the texture and consistency of the soil by applying various ingredients such as silt, soil, and vegetation from terrace risers, composted vegetation and manure, leaf litter, crop waste/residue, etc. He/she knows that continual effort is needed to improve the texture, consistency, and overall structure of the soil.

Access to Inputs needed for soil fertility determines the options available to the farmer. At least three major inputs are needed i.e., materials, labour, and cash.

It may sometimes appear that an input is available when it is not. For example, leaf litter may be abundant in a nearby forest, but if the local community has agreed not to allow collection the farmer cannot use it. Or chemical fertiliser may be on sale but if the farmer has no cash they cannot buy it.

(a) Materials: A wide variety of materials are used for soil fertility management. Vegetation (used in compost, mulch, ash, green manure, etc.), manure and chemical

fertiliser. In order to use these materials the farmer needs access to vegetation (forest), livestock and livestock fodder.

(b) Labour is needed to implement all soil fertility management activities (collection, processing, transportation, and application of all ingredients used) and for livestock (herding, fodder collection, health care, etc.).

(c) Cash is needed to buy chemical fertiliser and to hire labour.

Access to Markets is a major factor influencing fertility management decisions. Where there is a market cropping intensity tends to be high, land more valuable and the cropping pattern therefore evolves from subsistence to cash crops. The crops tend to occupy the soil throughout the year with no fallow, crop choice is dictated by the market and preferably consists of those with high, quick cash returns (usually vegetables). In response to the continual cropping and high nutrient demanding crops, fertility management changes. Demand for plant nutrient, organic material and moisture increases. Large amounts of nutrients in quick succession are needed. The use of vegetation and manure (which need 3–6 months to compost) does not fulfil the demands for fertility. The farmers therefore concentrate on finding options that simultaneously fulfil the increased demand for plant nutrient and maintain the structure of the soil. This has lead to their experimenting with and learning about the complementary use of chemical fertiliser, compost, and partially composted vegetation plus manure and crop waste/by products (straw, husk).

Markets provide a means of earning cash income which the farmer can use to buy chemical fertiliser, pesticides, fungicides, a wide variety of vegetable, fruit and crop seeds/seedlings, tools, and materials (plastic sheets, pipes, containers, bags, etc). These all increase the strategies open to the farmer in managing soil fertility.

Land Ownership/Tenure: This determines the investment that will be made in soil fertility management. The landlords parcel their land out to tenants to cultivate and do no actual work. They provide neither vegetative material for compost or mulch nor livestock manure. In areas where chemical fertiliser is available, however, the landlord provides half the amount needed. It is sometimes a condition of the agreement that the tenant must apply a certain minimum amount of compost to the land.

Owner cultivators invest most in their land, applying the maximum amount of compost, green manure, mulch, etc. These farmers are the most dynamic in experimenting, improving and using the best possible strategies (so far as resources permit) to conserve and collect soil and improve soil structure. They know that they will get the benefit of such long- and short-term investments.

Tenant farmers have no such assurance and apply compost etc. because it is the only material accessible to them (it costs no cash) or because it is in the terms of their agreement. Because chemical fertiliser is the only input (other than seed) that landlords provide more tenants are keen to use it. It also increases crop yield in a short period of time which suits the tenant.

Labour is needed to implement all activities needed for soil fertility management. Several thousand hours of human labour are needed to collect, process, transport and apply leaf litter, livestock manure, compost, green manure, mulch, ash, straw, husks, etc. The farmer knows that labour is the key component in soil management. In all the study Districts they use chemical fertiliser, which they regard as a labour saving device especially on the seed beds.

Sources of Income: Interest and investment in maintaining and improving soil fertility is greatest among farmers whose major source of income is from agriculture and livestock. Those who derive most of their income from other sources (e.g. teaching, army service, pension, etc.) do not depend on the condition of the soil for their survival and hence are less interested (which does not mean they are completely uninterested). However, some cash income has become important to farmers as they turn to using materials such as chemical fertiliser.

Information concerning soil fertility management is continually collected, exchanged, and generated by farmers who have been experimenting with a wide variety of materials such as manure, various species of vegetation, ash, and other materials for a long time and who have recently (in the last eight to ten years) been learning about chemical fertiliser. Their only source of reliable information is other farmers.

Labour Management

Labour is the key component in the management of soils and both its quantity and quality are important. In most areas visited men do all the work needed for water management and women the work for fertility management except in the case of chemical fertilisers and pesticides, where men play an equally important role.

However, in the past several decades there has been increase in population resulting in both an increased demand for food and a surplus of labour. Because of the need for more food (which agriculture has not been able to fulfil) many of the men have gone to the towns and cities to earn a cash income. Since most of the 16 to 40/45 year-old men are no longer available, the women, children and old men left in the village have to do all the work. To achieve this people have to work longer and they have to prioritise work which means some jobs are done less often than formerly. For example, less time is available to collect leaf litter, fodder, etc. from the forest, leading to less compost being made and fewer livestock kept. Sometimes land that is a long distance from the house may be abandoned if it becomes uneconomical to work due to the cost of labour and/or the unavailability of compost. Land with labour intensive soils, such as heavy clay that needs large amounts of leaf litter to make it easier to plough, 'sour' soils requiring large amounts of compost to be productive, areas where drains and waterways and so on would have to be constructed may be abandoned.

Overall, there is a further decrease in agricultural productivity due to a shortage of high quality labour. The labour a 25-year-old man who wants to make a living out of agriculture is different from that of a 50-year-old who has returned to the village to die. It is not just a

matter of physical strength but also of interest. An increasing number of people see agriculture as having no future and education as a means of allowing their children to escape from this unrewarding, unending work (not a single farmer wanted his/her son to be a farmer, they wanted them to earn a lot of money and live in town).

Location of Land: Land value is determined not by soil quality but by location. Land adjacent to the house is the most valuable. This is because it requires less labour to manage it. The farmer is free to choose what he/she wishes to grow -vegetable, fruit, flowers, etc.

Land that is located some distance from the house requires more labour to manage. Also the type/species of crops grown and frequency of cropping have to be chosen after consultation with other farmers who have land in that area. For instance if one farmer grows an early maturing variety of rice or maize while the others grow a late maturing variety the former will suffer great losses as all the birds, rats, and other pests will concentrate on that one small plot, whereas if they all grow the same variety losses still occur but they are spread out and each farmer loses relatively little. Should an individual not wish to farm his land because it is uneconomical to do so, but it is located in the middle of a large block which is all being cultivated, he/she is compelled to do so because the uncultivated land would serve as a refuge for insect and other pests which would be able to multiply undisturbed. This would mean the farmers round about would have to make frequent use of preventive measures to keep the pests down. In some villages livestock is allowed to graze on agricultural land during the winter making it almost impossible for farmers who wish to grow a winter crop to do so. If the livestock destroy the crop the farmer cannot claim compensation from the owner as in other seasons. Sometimes farmers put up fences to keep the animals away but they are often broken down as they are not strong enough to keep out buffalo.

Land Ownership/Tenure: Labour is the major constraint for big landowners who to some extent are dependent on their tenants for labour. Land tenure arrangements vary from one area to another and are a good indicator of labour availability in an area. Arrangements that seem generous indicate a labour shortage as the landlord has been forced to provide incentives. Land tenure arrangements that seem exploitative indicate a surplus of labour.

The owner cultivator's major constraint is usually area of land. They invest the most labour in soil management.

Tenants are largely dependent on landlords for their livelihood in a subsistence economy. Since it is not their land they are cultivating they are not much interested in making a large investment of labour to improve the soil. As long as some yield can be squeezed from the soil, just enough to keep living, that is sufficient. In a market economy the tenants have various options for making a livelihood and may not be interested in being tenant farmers.

Livestock Ownership/Tenure: Farmers keep livestock for various reasons - to provide manure to maintain soil fertility, for cash income through sale of animals, milk, wool, etc., for meat, power for ploughing, etc. They know that the nutritive value of the manure of different livestock varies – chicken manure having the highest value, second, goat and sheep, down through pig, cattle and buffalo.

Most farmers own some livestock - some goats or sheep, chickens, maybe a pair of bullock for ploughing and buffalo. Generally, they do not own all the animals they keep but share some under an agreement. These agreements differ from one village to another but they all hold the buffalo to be the most valuable of animals[6]. Usually when cattle, goat or sheep are given over to other farmers to keep, part of the agreement is that the keeper will pay for the animals' food, shelter and health care in return for ownership of the offspring.

The owner will give out a non-lactating buffalo to the keeper who will make arrangements for breeding. In order to keep a buffalo the prospective keeper first has to make a cash payment (approximately one third the future market value of a milch animal) to the owner as a guarantee against death or injury and undertakes to pay for the animal's food, shelter and health. In return he/she sometimes shares the milk, can keep the manure, but does not get ownership of the calf (especially if it is female; there may be other arrangements for a male calf). The owner sells the calf with the adult buffalo, the keeper getting half the proceeds of the sale but no return of the down payment. For example if the value of the dry animal is Rs.4000, the owner values it at Rs.6000 (if it is a possible milch animal) and the keeper has to pay Rs. 2000 in advance. The owner and the keeper then share the risk. When the animal is sold for Rs. 8000 the keeper and the owner each receive Rs.4000 while the latter keeps the deposit of Rs.2000, a total of Rs.6000.

The number of buffaloes is a good indicator of the prosperity of a village. Poor villages sometimes have not a single buffalo as the farmers cannot make the initial down payment to the owner. Instead they have large numbers of cows. These provide less manure than a buffalo, produce little milk and have to be fed until they die (for religious reasons, they cannot be disposed of like buffalo, and are difficult to sell).

Source of Labour: There are many sources of labour such as the household, exchange (perma), hired and tenant. Different farmer groups depend on different sources, the landlord depending on tenants. For the owner cultivator household labour is the most accessible but may not be sufficient. In periods of peak agricultural activity exchange and hired labour are frequently used. The household is the major source of labour for the tenant, with exchange labour frequently used too. However, tenants do not usually use hired labour as they and not the landlord have to pay for it.

6. This plus the fact that buffalo dung is the least valuable manure, suggests that manure is only a secondary reason for keeping animals. Sheep and goat provide manure with higher nutritive value, it is comparatively, dry, compact, fine in texture and light to carry, in addition the animal needs smaller amounts of fodder.

Conclusions

Beneficiary vs Client vs Partner

Over a period of several hundred years farmers themselves have developed, tested, implemented, evaluated, and modified systems of agriculture, livestock management, forest management (conservation, planting, harvesting, distribution, protection, propagation, etc.), soil management (conservation, collection, protection, etc.), irrigation management (construction, maintenance, distribution, etc.) and so on. However, despite these major achievements most Non Farmer Agriculturists (NFAs such as researchers, extensionists, social scientists, etc.) have been accustomed to describe farmers as 'beneficiaries' (as if farmers have nothing better to do but wait for benefits), and now as 'clients'. This is an improvement but still implies that the farmer is ignorant and needs the assistance and guidance of others, in the way that a layman needs a lawyer because he/she is ignorant of the full extent of the law and its implications. 'Participants' is another distasteful term. It describes persons who attend training workshops and contribute free labour as required. All these terms show the arrogance and ignorance of the NFAs who undermine and belittle the experience, skill, knowledge and the most valuable resource of our country.

However, this does not mean that the farmers' contributions are all good and those of the NFAs worthless. What it does mean is that we have to acknowledge and accept farmers as equal and respected partners especially in the field of natural resource management, while acknowledging that the NFAs have made important contributions too. Both have their strengths and weaknesses. Farmer knowledge and scientific knowledge are complementary, not contradictory.

Specifically in the area of soil fertility management NFAs concentrate largely on introducing and distributing chemical fertiliser (which contributes to soil acidity); lime (a possible remedy for soil acidity); pine trees (which to some extent have replaced local broadleaf forest, while pine needle litter is replacing other species in making compost which increases soil acidity); and improved breeds of livestock (which are more productive and provide farmers with more income, but need larger amounts of fodder, more investment, better health care, etc.). Different government agencies, the Ministry of Agriculture (Livestock, Horticulture, Agriculture), the Agriculture Inputs Corporation, the Ministry of Forest and Environment (Department of Soil and Watershed Management, Department of Forest), and the Ministry of Water Resources (Irrigation) all focus on different aspects of soil fertility management. Not only is there no cooperation or coordination in their efforts at all levels, they sometimes contradict each other.

A major portion of this report describes farmers' efforts to manage soil. It is evident that their efforts are more comprehensive, integrated, flexible, and better than any others that have been introduced so far.

All systems have their strengths and weaknesses, including the farmers' soil management system. Over the years the farmers have gained experience, skill, and knowledge and have found solutions to some of the problems. Soil management is a dynamic process and the problems change continually. However, with the decline in resources available to the

farmer (forest, livestock, cash, labour, etc.) it is becoming more and more difficult to remedy the weaknesses of the system. The present author is of the view that the way to proceed is by strengthening the farmers' existing system and the lead should be taken by the farmers.

Soil Acidity

The farmers know about this problem and have used compost to combat its adverse effects. However, unless heavy doses of organic fertiliser are continually applied, this condition recurs and cannot be completely eliminated. It has become increasingly difficult for farmers to find enough compost and hence it is essential to find other methods of treating the soil (i.e. use of lime).

Decline in Production

Both farmers and NFA acknowledge that there is a continuing decline in agricultural production. However, the reasons the two parties give differ substantially:

Cultivated Area

Farmers: The area of cultivated land has decreased. Large tracts of land (those needing a lot of labour for water and fertility management, those long distances from the house, needing high input of compost, etc.) have been abandoned in the hills. This decline is put down to shortage of labour (migration) and other agricultural inputs (compost, livestock, vegetation, etc.).

NFAs: They assume area of cultivated land has not decreased, but has in some cases increased (forest and grazing/pasture land converted into agriculture land). For example:

"Continued population pressure on land resources in the hills and mountains has resulted in expansion of farming on to marginal cultivable land, with ensuing environmental degradation – soil erosion, losses of soil fertility, a deterioration of forests and forest covers (NARC-ADB, November, 1991, Main Report, p. 15)."

Productivity

Farmers: They agree that cropping intensity in cultivated land has increased with a simultaneous increase in investment (labour, compost, chemical fertiliser, etc.) per unit area of land. Labour, compost, water and other inputs are now concentrated on smaller areas of land.

NFAs: They agree that cropping intensity has increased but is accompanied by yield decline.

Production

Increase in cropping intensity and the resultant need for compost and other inputs (of which there is a shortage) is seen by both as causing a decline in production.

Farmers: From the farmers' point of view the decline in production is due to large areas of land that were previously cultivated being abandoned in the hills; a decrease in agricultural labour due to migration; and limited resources (cash, vegetation, livestock, labour). Cropping intensity has increased on small areas of land. Productivity per unit area has increased while overall area of land cultivated has decreased. The increase brought about by increased cropping intensity does not fully compensate for overall loss of production from larger areas of land. Hence the decline in agricultural production.

NFAs: The decline is due to decline in soil fertility; increase in soil acidity; increase in population; and over exploitation of forest resources by keeping too many livestock.

Because their points of view differ the farmer and the NFAs tackle the problems from different perspectives. A combined effort would be more effective.

Hungry Season

Few farmers have sufficient food and a majority have a serious seasonal/overall deficit. For most farm families their land holding is so small that even if crop yield were doubled there would still be a food deficit. There is a major difference between the NFAs' and the farmers' strategies for addressing the hungry season. NFAs concentrate on increasing crop yield while farmers put the emphasis on increasing overall productivity and focus specifically on the hungry season by planting low yielding, short duration, local varieties of a crop that can be harvested during the period of food stress. Alternatively, they may harvest a crop such as maize, millet or potato before full maturity in order to get desperately needed food. This is not to say that the NFAs are not working hard but it needs to be pointed out that while low yield is undoubtedly a problem, NFAs assume it is the problem. Had they begun by asking farm families they would have learned that for the poorest among them, seasonal food deficits are their most serious problem. Thus we need to try every possible approach to solving the problem, not concentrate only on increasing yields but also find alternative crop varieties that can be harvested during the hungry season in different agro climatic zones.

Problem vs Solution Orientation

There is a major difference in the NFAs' and the farmers' way of tackling a problem. With a few exceptions most NFAs look only at the problems, which are soil erosion, soil acidification and decline in agriculture productivity. However, the farmers, who have to live with these problems every day, have moved far ahead in looking for practical solutions to them. They have not been completely successful but at least they have implemented several possible solutions. There is a need for NFAs to learn from the farmers how to concentrate on such practical problem solving. We need to change our way of thinking and working.

Notes

1. HMG Ministry of Agriculture-Winrock International Policy Analysis in Agriculture and Related Resource Management Project in Kathmandu provided full support for this study.

2. This report is a compilation of lessons learned in studies conducted in several villages in Syangja, Lamjung, Kavrepalanchok and Sankhuwasabha Districts in Nepal.

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