Chapter 13

Land Management Options in Western Kenya and Eastern Uganda

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In the recent past, the image of agricultural and environmental crises in Sub-Saharan Africa (SSA) has become increasingly common. Soil erosion and soil fertility loss are considered to be negatively affecting the productive capacity of the agricultural systems (Giller et al. 1997; Sanchez et al. 1997; Smaling, Nandwa, and Janssen 1997). These problems have been ascribed to many different causes: social (e.g., marginalization of the poor and women), political (e.g., structural adjustment programs), economic (e.g., poor availability and/or high prices of inputs, limited market opportunities), biological (e.g., increasing population and reducing land sizes), and physical (e.g., climatic change).

Many authors also have expressed concern over the increasing land degradation in the highlands of East Africa (e.g., Getahun 1991; Farley 1995; Hilhorst and Muchena 2000). Increases in agricultural production in the last decades have been achieved through intensifying agricultural practices, such as increasing the frequency of cultivation at the expense of natural fallows and through expanding the cultivated areas, especially into fragile environments such as wetlands and steep hillslopes, with negative consequences, including soil degradation from soil erosion and loss of soil fertility.

Blaming smallholder farmers for this degradation is overly simplistic in the least. Tropical smallholder agricultural production systems are, in fact, markedly dynamic and resilient, and many examples exist of adaptations in production practices to cope with and adjust to changes (Brookfield and Padoch 1995; Farley 1995; Goldman 1995). Smallholder farmers use a wide range of agro-ecological management techniques, resource management practices, and production strategies specific to their ecological and social environment to minimize risk and to cope with changes and shocks. These techniques can include agricultural intensification, expanded market orientation, intensification of crop–livestock enterprises, or increased capital and labor investment. However, the natural resource base represents an important capital to small-scale farmers, which will be (over)exploited where production constraints are too high, purchased inputs or labor are scarce or absent, or environmental conditions are too erratically variable for secure investment. For example, if the returns to investments are too low (even negative, as when staple commodity prices plummet during bumper harvests), periodically or repeatedly mining the soil's nutrient capital resource to support minimal levels of production can appear to smallholders as good economics.

Within this context, this chapter uses evidence from research and extension efforts in eastern Uganda and western Kenya to investigate land management, land use changes, and the policy environment within which smallholders have to operate and to assess their influences on smallholder farmers' production strategies. It complements the discussion in Chapter 12 by Aune et al., which focused on land management options being tested in the Ethiopian highlands.

Kenya and Uganda

Uganda is one of the low-income economies in SSA and is among the poorest countries in the world (DANIDA 1996). Kenya is better off and has a higher gross national income (GNI) (Atlas method) of US$340 than Uganda (US$280), but in recent years, the GNI for Kenya has been decreasing at alarming rates (World Bank 2002b). Data for 1997, 2000, and 2001 show changes in GDP of 2.1, –0.2, and 1.1 percent for Kenya and a negative growth forecast for 2002. In contrast, for the same years, Uganda had GDP growth of 4.7, 3.5, and 4.6 percent, with projected growth of over 5 percent for 2002 (World Bank 2002b). In Kenya, agricultural productivity showed negative growth between 1990 and 1994, and throughout the 1990s growth in agricultural output was substantially lower than the population growth rate of 3.4 percent. In both countries, poverty is most pronounced in rural areas. The features of rural poverty are multidimensional and include food shortage, malnutrition of children, frequent illness with high rates of HIV/AIDS, and widespread illiteracy. The distribution of poverty is uneven, with areas in the east and north of both countries being the poorest. In Uganda the proportion of the population living below the poverty line has been declining in recent years, but households engaged in crop farming remain the largest group of the poverty-stricken population, accounting for about 80 percent of the households below the poverty line (Appleton 1998).

Agriculture is the primary source of income for most Ugandans and Kenyans, accounting for around 40–50 percent of GDP, up to 90 percent of exports, and employing approximately 80 percent of the labor force in both countries in 1996 (World Bank 2002b). On average, rural households derive nearly three-quarters of their income from crop farming. Smallholders dominate the agricultural sector with over 90 percent of crop production being produced on farms averaging less than 2 hectares. However, smallholders in Uganda have difficulties obtaining credit for investment and to improve farming techniques. Hence, improving credit access and farmer extension are key recent interventions for boosting agricultural development in Uganda (FAO 1998).

Both sides of the border have similar agro-ecosystems and cropping systems, with eastern Uganda through to western Kenya representing a gradient with changing soil types, from the lowland ferralsols to highland nitisols in Uganda to humic nitisols in western Kenya, with increasing agricultural production and increasing population densities from west to east. This has resulted in a range of land use systems that respond to this gradient.

Eastern Uganda

The eastern Lake Victoria crescent, the southern-eastern Lake Kyoga basin, and Jinja-Mbale Farmlands agro-ecological zones of Uganda comprise Tororo, Busia, Bugiri, Pallisa, Kumi, Soroti, and Mbale Districts, with a population density averaging 129–456 persons per square kilometer (Wortmann and Eledu 1999). They are poorly endowed with natural resources: the soils are sandy, with low soil organic matter levels, highly susceptible to leaching, and consequently low in base saturation and rather acidic. Agriculture in this region shows productivity decline, as the rapidly growing population overexploits its land resources, resulting in recurrent food shortages and occasional famines. The most serious problems faced by smallholder farmers are related to the low land productivity that results in household food deficiencies and to low selling prices for crop products in good seasons (i.e., seasons of bumper harvests).

Western Kenya

The densely populated Western Kenyan districts of Siaya, Vihiga, Kakamega, and Busia share a similar agro-ecology to the Ugandan districts across their common border. Population densities average around 400 people per square kilometer but exceed 1,200 in Vihiga district. Political and economic marginalization of the region has led to widespread rural poverty, resulting in massive outmigration of (especially male) labor on a seasonal or permanent basis. (See Chapter 8 for more information on economic conditions and farming systems in western Kenya). The soils of the region include nitisols and ferralsols that are much more P-deficient than those in Uganda.

Soil Fertility Status

In the 1950s and 1960s soil surveys revealed that about half the land surface in Uganda was rated as medium productive, that is, soils giving good yields under good management (Harrop 1970; Foster 1976, 1981). However, the export of nutrients through runoff and soil erosion and as components of harvested crop products is increasing for most of the farming systems, contributing to the negative nutrient balances reported for Sub-Saharan Africa countries (Smaling, Nandwa, and Janssen 1997) and for the farming systems of eastern and central Uganda (Bekunda and Woomer 1996; Wortmann and Kaizzi 1998; Kaizzi et al. 2002).

It is not possible to accurately assess the economic cost of this nutrient loss, but from work in Ethiopia a conservative estimate of the annual costs of soil nutrient depletion alone is $100 million (Böjo and Cassells 1995). There is less information for the highlands of Uganda and Kenya, but from soil nutrient losses reported elsewhere, the magnitude of the problem is comparable (Stoorvogel and Smaling 1990; Braun et al. 1997).

A recent survey across Uganda showed that between 1960 and 2000, soil organic matter (SOM) content did not decline significantly, and there were no significant decreases in soil N levels. In contrast, levels of P, K, and Ca and soil pH had declined significantly over the 40 years (Ssali 2003). This is a slightly unexpected result, as typically SOM contents decline under cultivation with inappropriate management, and as a result, the C:N ratio widens, indicating lower SOM quality and lower nutrient-supplying capacity (Tiessen, Samprio, and Salcedo 2001). However SOM is never fully exhausted under overcultivation; instead, it is reduced to a lower equilibrium steady state (Buyanovsky and Wagner 1998; Belay, Claasens, and Wehner 2002). To reach that steady state may take many years: starting from virgin land, 10 years of cultivation may lead to a reduction of between 30 and 60 percent in the original SOM content. The level at which the steady state is attained and its trend depend on the measures taken during the cultivation phase and the effectiveness of fallow periods. It is likely that these soils already had reached a low equilibrium level after many years of cultivation before the 1960s.

In traditional tropical farming systems, SOM lost from the topsoil under cultivation was restored during extended fallows. The length of the fallow period would depend on the degree of land degradation and fallow management. However, in most tropical areas, poor land management and increasing pressure on the land rarely allow fallows to restore soil productivity. There is evidence that the rate of SOM loss and hence land degradation during the cultivation phase can be reduced through various management practices, including erosion prevention and minimum tillage (Machado and Silva 2001; Nandwa 2001; Roose and Barthes 2001), strategic use of organic and mineral inputs (Bationo and Buerkert 2001; Katyal, Rao, and Reddy 2001; Nandwa 2001; Belay, Claasens, and Wehner 2002), and other improved systems that exploit the benefits of fallows, biological nitrogen fixation (BNF), rotations, intercropping, and agroforestry (Katyal, Rao, and Reddy 2001; Nandwa 2001; Palm et al. 2001).

Replenishing soil N, P, and K is essential for sustaining productivity and rehabilitating eroded and nutrient-depleted soils. Soil fertility replenishment will result in positive benefits, such as increased vegetative soil cover and increased soil biological activity associated with enhanced crop production (Sanchez et al. 1997). Replenishment of N can be achieved through the use of either inorganic or organic fertilizers and/or BNF. Organic and inorganic fertilizers can mitigate the losses of P and K, and biological options may also improve the efficiency with which crops use these nutrients.

Land Management Technologies

National agricultural research institutions in Uganda and Kenya, in collaboration with international agricultural research centers, have developed an array of management practices and technologies that might effectively address local production problems. These include fertilizer use recommendations, use of legume cover crops, and biomass transfer options (from within or outside the farm) that improve soil fertility and provide fodder.

Fertilizer Recommendations and Limiting Nutrients

Soil fertility characterization studies through limiting nutrient trials have been conducted over many years in the region. Studies in the 1960s indicated profitable responses to applied N and P fertilizers for much of eastern Uganda for cotton, maize, groundnuts, and finger millet (Foster 1976). A recent study in Tororo (Uganda), using maize as a test crop, found large responses to N alone and higher responses to N and P combined (Waata, Jama, and Delve 2002). There was no response to K. These results, confirming those of previous trials (Foster 1976), indicate that N is the main limiting nutrient, followed by P, and that K should be addressed after the N and P problems have been solved.

In Kenya, the Fertilizer Use Recommendation Project (FURP 1995) conducted multisite fertilizer experiments from 1985 to the early 1990s and formulated recommendations for different regions and crops. Unfortunately, these recommendations are not detailed enough to assist smallholder farmers in optimizing their fertilizer use. Even if such recommendations were available, the profitability of fertilizer use is highly variable and dependent on agro-climatic and economic conditions at the local and regional levels (Vlek 1990). Access to fertilizers remains inconsistent and problematic: high unit costs, irregular supply, low cost of commodity crops, and the unpredictable fertilizer quality contribute to the low use of fertilizers by most socioeconomic groups (Heisey and Mwangi 1995; Swinkels et al. 1997).

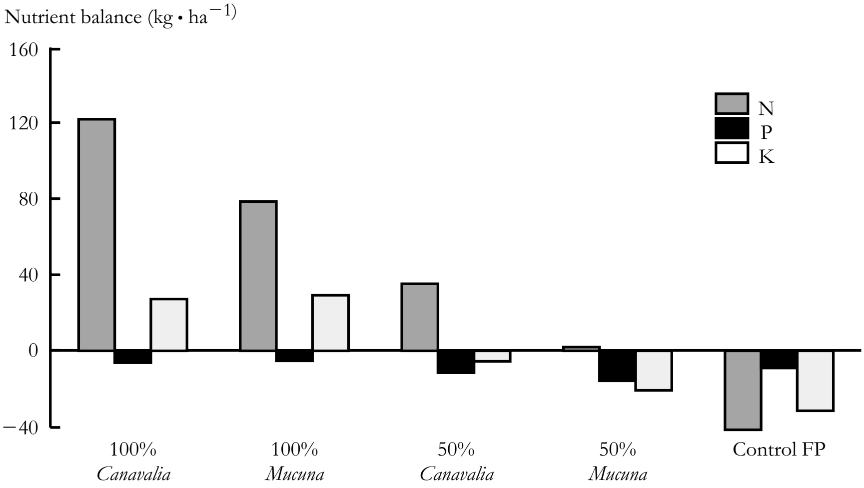
Legume Cover Crops

Legume cover crops (LCC) have been evaluated as a technology for improved land and resource management, appropriate to smallholder farmers with restricted access to inorganic fertilizers. *Crotalaria* species (*Crotalaria ochroleuca* and *Crotalaria grahamiana*) have proven very successful in western Kenya in improved fallow practices. Delve and Jama (2002) reported large increases in maize grain yield following sole crop *Mucuna pruriens* and *Canavalia ensiformis.* In contrasting soils and in contrasting agro-ecological zones of eastern Uganda, Kaizzi, Ssali, and Vlek (2002) also reported similar increases in maize yield following *Mucuna* fallows. However, where *Mucuna* was grown in relay with a maize crop, reduced maize yields as a result of competition for resources between the two crops have been reported (Fischler 1997; Kaizzi, Ssali, and Vlek 2002; Kuule 2002).

At average accumulation rates, green manure or LCC could entirely substitute for inorganic fertilizer N at the current average application rate in low-input agriculture systems (Becker, Ladha, and Ali 1995). Kaizzi (2002) showed that, in eastern Uganda, because approximately 43 percent of the plant N in *Mucuna* is derived from BNF, that BNF could contribute to the N requirements at moderate levels of output under favorable conditions (Giller et al. 1997). However, the N fixed by LCCs during the fallow period may not be a net addition to the system if increases in the yield of subsequent crops remove more N than was added by the legume. The excess applications of N in the LCC biomass above crop demand will be subject to losses (such as leaching or denitrification) during decomposition, especially during the early stages of crop growth, when N demand is not synchronized with release from decomposing LCC residues.

In eastern Uganda, results show that incorporation of legume cover crops in situ implies excess supply of N and K that is not matched by plant demand (Fig. 13.1). For example, incorporation of 100 percent of the above-ground biomass

Figure 13.1 Macronutrient balance for maize, grain, and stover production following incorporation of 50 or 100 percent of the above-ground biomass of a one-season sole crop fallow of *Mucuna* and *Canavalia*



Source: Delve and Jama (2002).

after a single season of improved fallow planted with *Canavalia* leads to a positive nutrient balance of more than 120 kg/ha of N and 30 kg/ha of K. An improved fallow using *Mucuna* also leads to positive nutrient balances of N and K if all of the biomass is incorporated. This is confirmed in another study carried out within the same agro-ecological zone, where dry matter and N loss by *Mucuna* was over 90 percent within 175 days (Kaizzi 2002). Management of the fallow rotation then becomes critical to maximize utilization of the resources, prevent nutrient losses, and provide enough nutrients, especially N, to maintain crop yields. This can be achieved, for example, through the use of deep-rooting species that can recover nitrate leached deeper into the soil profile.

Alternatively, Delve and Jama (2002) found that incorporation of either 50 percent or 100 percent of the LCC biomass produced in situ resulted in yields of maize grain and stover that were not significantly different from each other. This finding offers farmers alternative options for managing this technology, such as producing the biomass in one place, where half could be incorporated and the other half applied on an equivalent area for maize production. Alternatively, farmers might want to use 50 percent for incorporation and the remaining 50 percent for livestock feed, sale to other farmers, or to produce hay. Increasing the resource management options, and therefore the production options of the farming enterprise, is critical where the land area for nonfood crop production is limited and where cash is not readily available to buy inputs for crop and livestock production.

P Replenishment

Phosphorus availability is a major limiting factor for crop production on many soils of western Kenya because of both a low P content in the soils and their high P-fixing capacity (Mutuo 1999). Options available to farmers include the use of locally available rock P, inorganic fertilizers, and organic sources, such as *Tithonia diversifolia,* as P sources for crops (e.g., Buresh, Smithson, and Hellums 1997; Smithson et al. 2001; Mutuo et al. 1999). In addition to increasing P supply, farmers can improve the nutrient use efficiency of phosphorus fertilizers by crops, such as combining P fertilizers with organic residues.

Results of research on a P-fixing nitisol in western Kenya to study possibilities of replenishing soil P through addition of P fertilizers show that large, single applications of 150 kilograms P per hectare resulted in low nutrient use efficiency of applied fertilizers. More modest seasonal applications of 25 kilograms P per hectare increased maize yield and gradually increased available soil P, whereas the smaller rate of 10 kilograms P per hectare resulted in soil P depletion. These results show potential promise for seasonal application of small amounts of P fertilizers, which would be suitable for the small-scale farming systems of western Kenya (Nziguheba, Merckx, and Palm 2002). In another study, annual application of 1.8 tons DM per hectare of Tithonia applied to a P-deficient soil for three seasons at two sites resulted in maize yields consistently comparable and sometimes better than the maize yield following application of an equivalent amount of N in the form of mineral fertilizers (Jama et al. 2000).

Biomass Transfer with *Tithonia diversifolia*

A further option for land management to increase productivity is biomass transfer. For example, *Tithonia diversifolia,* common in hedgerows and along roads in western Kenya and eastern Uganda, is able to accumulate P and K in higher concentrations in its plant parts compared to other plant species and has shown good potential as a nutrient source for soil amendment. In western Kenya, *Tithonia* leaves (a high-quality resource) and maize stover (a low-quality resource) were applied alone or in combination with triple-super-phosphate (TSP) at a rate of 15 kilograms P per hectare. All treatments increased maize yields relative to the control, and yields increased in proportion to the amount of *Tithonia* in the residue–fertilizer mix where at least 36 percent of the total P applied in the mixture was supplied by *Tithonia* (Nziguheba, Merckx, and Palm 2002). Although the collection of *Tithonia* is highly labor intensive (roughly four minutes work per kilogram fresh matter), the economic returns were higher from the application of *Tithonia* alone than from sole fertilizers. Profitability was higher if *Tithonia* was collected from existing niches (to reduce labor costs) than when produced off site. Because the *Tithonia* gave higher net economic returns than equivalent rates of P in inorganic forms, it would appear that a high-quality organic input is as economically efficient (or more so) than inorganic fertilizers as a means of increasing maize yield and of supplying P to crops. The combination of *Tithonia* with fertilizers can be a beneficial use of scarce resources, with the greatest benefits in terms of yields and net benefits obtained by maximizing the proportion of *Tithonia* in the mixture.

One disadvantage of this management practice is that biomass transfer of *Tithonia* represents redistribution of nutrients within the landscape. At farm level, this practice is beneficial if the biomass originates from off-farm sources, but where the biomass is produced on-farm, it will lead to nutrient mining in one area and enrichment in another.

This technology is now being adapted on-farm. Because *Tithonia* decomposes quickly, many farmers in western Kenya now consider it more like a fertilizer (i.e., immediate effect, with little residual) and therefore less attractive than "farmyard" manure (compost of animal, household, and crop wastes), which "builds the soil fertility" for the long term. Increasingly, *Tithonia* is being taken directly to compost piles to "speed the rate of cooking" (i.e., decomposition) in the compost heap.

Soil Fertility Maintenance in Crop–Livestock Farming Systems

As discussed, maintenance of soil fertility is a key issue in agricultural intensification in Africa. When a mixed farming system is considered, the constraints to soil fertility replenishment become more severe because of competition between the allocation of land for crop production and livestock feed production. Farmers therefore must make choices in terms of resource allocation on their farms. Should the limited organic resource (available on-farm or purchased) be added directly to the soil, for example, through biomass transfer from farm boundaries and contour strips or additions of crop residues, or should the organic material be fed to livestock and then the manure added to the soil?

Intensification under the influence of increased pressure on the land restricts availability of manure from pastoralists and forces arable farmers to keep their own livestock for manure production, but many farmers do not possess suitable feed resources. Low digestibility, low protein content, and hence low intake, limit the utilization of many feed sources by ruminants. The option of treating the fodder with, for example, urea or alternatively supplementation with protein-rich concentrates is not available to all farmers, and where concentrates are used, they are fed mostly to lactating animals. The limited availability of high-quality feed resources will also encourage supplementation of livestock feeds, and as a result, there is increasing interest in the use of legumes as supplements to improve diet quality, provide additional dietary nitrogen, and provide better-quality manure (Savadogo 2000).

Within extensive livestock systems there is no direct return of manure to food cropping areas, as all manure is left on the grazing lands. However, manure deposited where the animals are housed overnight can be more readily collected and used. Animal production systems are inefficient converters of feed into animal products. A large fraction of the nutrients ingested in the feed is not retained in animal products but is excreted in feces and urine. This is particularly true of nitrogen, phosphorus, and potassium. In many mixed farming systems of the tropics, these excreta, when collected, represent the sole source of nutrients. The issue then is to capture these excreted nutrients by returning the maximum amount of manure to the cropland and through optimal management of the manure.

Closing the Nutrient Cycle

Integration and intensification that reduces the spatial separation of crop and livestock production systems offer the possibility of increased nutrient capture and recycling, such as converting crop residues into animal products and manure. As a result, a proportion of the nutrients that would otherwise be exported off farm, if that part of the crop were sold, can be returned to the soil in the form of manure, thus reducing nutrient losses. Losses in the crop-livestock-soil nitrogen cycle occur through leaching and denitrification, but most N is lost through volatilization of ammonia from feces and urine. The rapid loss of N from excreted urine means that it should preferably be applied to crop land immediately; unfortunately, very few farmers own facilities to collect and efficiently utilize this N, and hence, it is lost from the farming system. As more livestock are confined on-farm and are increasingly housed within limited- or zero-grazing units, manure collection should become more feasible (Ayantunde 1998). Manure management then becomes of paramount importance in these systems to optimize its use as a source of nutrients. However, in many areas, manure availability is insufficient to replace removed or lost nutrients, and inorganic fertilizers will be needed to maintain soil fertility.

Cycling of biomass through animals into manure that is used to fertilize the soil provides an important link between livestock and soil productivity in many farming systems of SSA. Many crop residues are characterized by high carbon and lignin contents, decompose slowly when added to the soil, and can immobilize available soil N during decomposition. Feeding of such residues to livestock can increase the rate of nutrient turnover through reduction in the immobilization of soil N and hence increasing its availability (Delve et al. 2001). Much of the feed offered to livestock is imported from off-farm sources, for example, roadside grasses and purchased concentrates, which form net imports of nutrients into the farm. Night housing and zero-grazing systems are examples of how improved livestock management practices can increase the amounts of manure and hence nutrients available to the farming system, provided the manure can be collected and utilized efficiently.

Economics of Land Management

Technologies for soil fertility replenishment often increase labor requirements and require more careful management (Kanté 2001), and options such as LCC or biomass transfer may withdraw land from agricultural production for varying periods of time, all of which represent economic costs to the smallholder farmer. Combinations of these technologies with inorganic fertilizers also increase the required capital investments. The returns to investment in these technologies vary enormously and are very sensitive to variations in the farm-gate prices of crop products.

For example, although LCC have given significant yield increases in the following maize crop, often these increases do not compensate for the loss of the one season of maize production or are insufficient to warrant the additional management and labor costs. As a result, technologies such as LCC will be appropriate only under specific conditions. In areas of high population density and consequently a high demand for cropping land every season, such as Vihiga in western Kenya, adoption of LCC is unlikely, even if the associated yield increases would compensate for the loss of maize production during the fallow. Alternatively, where population density is lower and natural fallowing still exists, such as the southern and eastern Lake Kyoga basin of eastern Uganda, the potentials for increased yields following improved fallows have been demonstrated and may be sufficient to promote adoption. The advantages of LCC are best utilized where land is out of production because of low fertility or high pest or disease pressures or where it would be left idle in a natural fallow system. In addition, the significant increases in maize stover production provide additional options for farmers, as stover can be used in livestock feed or bedding, soil erosion control, compost making, or mulching in perennial crops.

Agro-ecology also will influence the acceptability of alternative technologies. Positive economic benefits were recorded for most N replenishment strategies on highly productive soils in high-potential agro-ecological zones of eastern Uganda, but only *Mucuna* relay was profitable on low-productive soils (Kaizzi, Ssali, and Vlek 2002). In low-potential agro-ecological zones, none of the fertilizer-based strategies were economically viable at the current fertilizer and commodity prices on the less-productive soils, nor were the current farmers' practices. For the more-productive soils in low-potential zones, farmers' current practice is as profitable as alternative cropping strategies, but at lower production levels. Thus, there is no incentive for farmers on poor soils to adopt the alternative strategies under current conditions, even though current practice is itself not sustainable.

Opportunities and Constraints for Land Management Technologies

Improving soil fertility management options also means improving the access of farmers to new options by increasing their access to information from multiple sources. This greater access to a wider range of species and products gives farmers more flexibility in selecting management options and in decisionmaking as well as more opportunities to diversify their livelihoods or to pursue market-oriented activities. These technologies and the underlying knowledge have not been disseminated adequately to farmers and, therefore, still have had little effect at the farm level. Consequently, agricultural productivity is still declining in most of the smallholder farming systems. Although many studies have identified the need for improved dissemination of knowledge (e.g., Semalulu, Akwang, and Nakileza 1999), it is increasingly recognized that the best approach is active participation by farmers, local administrators, and the communities in general (Defoer 2000).

However, an assumption in developing new technologies is that providing farmers with "better information" leads them to make "better choices." It is also implicit that farmers' current choices are suboptimal. Nevertheless, the current strategies often appear optimal to land managers, given their current knowledge and resources. Hence, to be successful, interventions should increase soil productivity and potentially be profitable but also address the production objectives of the households and respond to the farmers' own understanding of the risks and opportunities of different options. Alternative technologies must address farmers' priorities of food security without creating additional risks and must also acknowledge constraints on the availability of land, labor, and inputs such as fertilizers and seed.

Because most resource-poor farmers need to produce a food crop every season, they are understandably reluctant to invest present resources for only the possibility of future increased production. As a research farmer in Emuhaya, Kenya, commented, "It's better to have even one *gorogoro* [tin] of maize [from a depleted field planted with maize] than to be guaranteed no maize at all this season by planting a cover crop we can't eat."

Farmers also often cite the increased labor requirements for incorporating LCC or collecting biomass as major constraints. In western Kenya schoolteachers have been found to use the "free" labor of children to harvest *Tithonia* to apply to school plots. Without access to this labor, it is unlikely that most farms could manage to apply *Tithonia* at the recommended rate, because each hectare demands up to 370 days of labor, compared to 1–7 days per hectare to apply an equivalent amount of nutrients in the form of manure or inorganic fertilizer (Mango 2002). Finally, new technologies must contend with problems of supply: the irregular availability and quality of seeds for LCC species is often mentioned by farmers, and in communities where the use of *Tithonia* in biomass transfer systems has become popular, its availability also becomes problematic.

In general, replenishing soil fertility remains problematic without understanding farmers' problems. Addressing these problems requires research at the farm level, including natural and man-made heterogeneity at plot and subplot levels (Braun et al., 1997; Kanté 2001). By working through progressively reduced scales, from region to district and then to farm, and through focusing on successively finer detail, understanding of production conditions and constraints can be increased (Carter et al. 1994). Similarly, gender and other intrahousehold differences play a role in resource control, resource use, and decisionmaking that will not necessarily become apparent if the only consultations are with the "household head." Technologies are not neutral in their impacts, and some individuals or groups will benefit more than others. The use of *Tithonia* on kales in western Kenya, for example, has led to increased productivity, but at the same time it has been observed that although women continue to grow kale for home consumption, men are beginning to commercialize plots of kale to increase their own personal incomes.