Chapter 16

Strategies for Sustainable Land Management in the East African Highlands: Conclusions and Implications

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The studies in this book sought to understand the factors affecting rural households' choice of income strategies and land management practices and the implications of these decisions and of policy- and program-relevant factors for agricultural production, household welfare, and land degradation. We noted at the outset that the factors influencing these decisions and outcomes are many and complex and that their effects may be very context-dependent in a region as diverse as the East African highlands. The findings in the preceding chapters amply support this hypothesis.

The material presented in Chapters 3–15 of this book provides a rich and diverse set of findings. It is impossible to summarize all of these findings in a few sentences or provide a simple prescription to solve all of the problems of rural people in the East African highlands based on these results. Because the problems are complex and situations are diverse, the solutions to the problems are also likely to be complex and diverse. Still, in this chapter we seek to synthesize what has been learned from these studies as briefly as possible, relate these findings to the broader literature on determinants and effects of livelihoods and land management, and draw implications for policy makers, development agencies, researchers, and others seeking to address these problems in East Africa and elsewhere.

Synthesis of Research Findings

The qualitative findings of Chapters 3–15 are summarized in Table 16.1. We organize the discussion according to the factors about which hypotheses were developed in Chapter 2, including the effects of factors determining local comparative advantages (agricultural potential, access to markets and infrastructure, and population pressure), income strategies, land management practices, and other policy-relevant factors (irrigation, agricultural technical assistance, credit, other programs and organizations, land tenure institutions, education, and gender). We will discuss the empirical relationships observed in these studies as "associations" rather than as "effects" because causality is difficult to prove in any empirical study.[1] In some cases, the findings are based on results of bioeconomic modeling; such findings are discussed as "predictions" rather than "conclusions," although these models are based on empirical data collected in the study locations.

Agricultural Potential

Agricultural potential is clearly important in influencing rural households' choice of livelihood strategies in the East African highlands. In more humid areas having bimodal rainfall patterns and sufficiently good soils, production of perennial cash crops such as coffee is common, as in the highlands of central Kenya (Chapter 8), the Lake Victoria region and the eastern highlands of Uganda (Chapter 7), and much of southwestern Ethiopia. Perennial food crops are also common in such areas, but annual food crops (especially maize) are also important in many such areas. Dairy production and woodlots are also more common in higher-rainfall areas (Chapter 3), though these also depend on sufficient market access (Chapters 3, 8, and 14).

In less humid environments, cereals and livestock are more dominant in the farming system, as in northern Ethiopia (Chapters 4–6 and 9) and in parts of southwestern and much of northern and eastern Uganda (Chapter 7). Differences in rainfall, altitude, and other agro-ecological factors influence the choice of cereals and livestock within the cereal–livestock system. However, other factors besides agricultural potential also influence the mixed cereal–livestock system. For example, maize–livestock production is the dominant farming system in western Kenya, even though soil and climatic conditions are suitable for production of higher-value cash crops in this region (Chapter 8). Lack of access to the large Nairobi market and to market institutions (e.g., cooperatives) is one of the key differences between western Kenya and the much more prosperous region of central Kenya (Chapter 8).

Land management practices differ between areas of high and low agricultural potential in complex ways. Several intensive practices are more common in higher-potential areas (HPAs) where rainfall and soils are more favorable (Chapters 4 and

9). This is probably because the productivity effects of soil fertility management practices such as inorganic fertilizer and leguminous cover crops (LCC) are often greater in HPAs (Chapters 9 and 13). However, this is not always the case. For example, fertilizer use is less common on more fertile soils in Uganda (Chapter 11), probably because it has less influence on productivity on such soils.

As expected, incomes and other welfare indicators are often better in areas of higher agricultural potential (Chapters 3, 4, and 8). However, the risk of land degradation can be greater in such areas as well, especially in steeply sloping highlands as in Uganda (Chapter 7).

Market Access

Because of its favorable market access as well as its high agricultural potential, central Kenya stands out as a fairly anomalous success story in the East African highlands. Livelihoods of smallholders in this region are highly diversified, including cash crops, dairy production, and high levels of nonfarm income (Chapter 8). These different livelihoods complement each other, with cash and credit from cash crop production helping to facilitate demand for and investments in other income strategies such as dairy production and nonfarm activities, and vice versa. As a result of production of higher-value commodities and greater liquidity, farmers in central Kenya are able to adopt much higher levels of use of fertilizer and land improvements than elsewhere and attain higher productivity and more perceived improvement in soil conditions. This suggests that a virtuous circle of land improvement and higher productivity and incomes is possible in areas with sufficiently favorable agricultural potential and sufficient access to markets and market institutions to promote high-value commodity production and nonfarm activities.

The effects of better access to markets on income strategies in Kenya are demonstrated in Chapter 3 by Place et al., who showed that maize is less common and cash crops are more common closer to urban areas. Similarly, Kruseman et al. (Chapter 4) found that *teff* production (an important cash crop in northern Ethiopia) is more common, and sorghum and various livestock are less common, closer to urban markets in Tigray. Place et al. (Chapter 3) also found that woodlots are more common closer to urban areas in Kenya, consistent with the prediction by Holden et al. (Chapter 14), based on their bioeconomic model, of large potential income gains from increased tree-planting activities in northern Ethiopia close to roads and markets. In these regions, better market access is associated with income-enhancing strategies and, not surprisingly, with indicators of better welfare outcomes (e.g., better housing quality) (Chapters 3 and 4).

However, there may be trade-offs between improved income and some natural resource conditions resulting from better market access. In Kenya, better market

Table 16.1 Summary of qualitative findings of Chapters 3–15

Characteristics of development domains	Income strategies/assets	Labor intensity	Land management practices	Value of crop production per hectare	Land degradation	Income/cap welfare
Higher agricultural potential	+ higher-value cash crops (3,7,8) +/– cereals (4) + ox ownership (4) – improved livestock (6) + dairy production (3) + woodlots (3)		Mixed impacts *In higher rainfall areas:* + gully checks, drainage, compost (4), reduced tillage, contour plowing, manure, household refuse (9) – terraces, manure, tree planting (4) *On better soils:* + gully checks, drainage, soil bunds, tree planting (4) – Fertilizer (4, 11), reduced tillage, crop residues (9, 11)	+ in high-potential eastern highlands of Uganda (7) + productivity impact of fertilizer in higher-potential areas (9, 13) + productivity impact of leguminous cover crops in HPA[a] (13)	+ erosion in high potential Highlands of Uganda (7)	+ (3,4,8)
Higher market/road access	+ cash crops (3,4,8) – subsistence food crops (3,4,8) – oxen, cows, beehives (4) + oxen, goats (5) + dairy (8) – improved livestock (6) + woodlots (3, 14)	+ (5) – in HPA (9) – collective woodlot management (10)	*Closer to urban centers, towns:* + fertilizer use (4,8), oxen power (5), land investment (8), reduced tillage, contour plowing (9) – contour plowing (5), crop rotation, crop residues (9, 11), mulch (11), tree planting in community woodlots (10), guards and penalties in grazing land management (10) *Closer to roads:* + fertilizer use (4,5), burning (5), crop rotation (9) – reduced tillage, contour plowing (9)	+ (5) – in HPA (9) (road access)	– tree cover (3) + erosion in highlands (7) – perceived land degradation in C. Kenya (8) – tree survival in woodlots (10)	+ (3,4,8)
Higher population pressure	– barley, maize (4) + cattle density (3) – oxen, sheep ownership per household (4) – cattle ownership (6)	+ (5) + woodlot management at moderate population	+ fertilizer (4,5), oxen power (5), intercropping (5), crop residues (9), improved seed in LPA (9) – fallow (4), reduced tillage (9), contour plowing (9), fertilizer use in LPA (9),	– (9) (in structural model)	– tree cover (3) – availability and quality of grazing land (6) + erosion in highlands (7)	+ (3, 4)

	+ improved livestock (6) + beehives (4) + woodlots (3)	density (10)	– improved fallow (13) ∩ more tree planting density in woodlots at moderate population density (10)[b] ∩ more hiring of guards to protect grazing lands and ∪ fewer violations of grazing restrictions at moderate population level of community (10)			
Irrigation	+ barley (4)	+ (5) + in HPA (9)	+ drainage, stone terraces, tree planting (4), improved seed, reduced tillage (5), ox power in LPA (9), seed in HPA (9), private pastures (6), household refuse (9) – compost (4), fertilizer (9), improved seed in LPA (9)	+ in LPA (9)		
Government agricultural extension	– goats (4)		+ fertilizer (9, 11), contour plowing in HPA (9), crop residues in LPA (9), manure and mulch (11) – ox power (5) – community contribution to protection of community woodlots and grazing areas (10)	+ in lowlands (7) + in HPA (9)	+ erosion in highlands (7) – tree survival in woodlots (10)	
NGO agricultural technical assistance			+ fertilizer (11) – manure (11)	+ in highlands (7) – in lowlands (7)	– erosion in lowlands and highlands (7)	
Cooperatives	+ maize, oxen ownership (4) – barley (4)	+ in HPA, input coop. (9) – in LPA, mktg. coop. (9)	+ irrigation canals (4), seeds (5) – burning (5) *Input cooperatives:* + reduced tillage (9), improved seed in HPA (9), ox power in HPA (9) – crop rotation in LPA manure, household refuse (9) *Marketing cooperatives:* + crop rotation in LPA (9) – reduced tillage (9)	+ (5) Input coops: + in HPA (9) – in LPA (9)		+ (4,5)

(*continued*)

Table 16.1 (continued)

Characteristics of development domains	Income strategies/assets	Labor intensity	Land management practices	Value of crop production per hectare	Land degradation	Income/cap welfare
Local organizations (in general)			+ household contributions to protect restricted grazing lands (10)			
Food-for-work (FFW)			+ soil and water conservation (SWC) investment if FFW used to promote SWC (14) – SWC if FFW not used to promote SWC (14)	– if FFW not used to promote SWC on farm (14)	– erosion if FFW promotes SWC, + erosion if not (14)	+ (14)
Credit	+ Maize prod. (4) + Dairy, cash crops in C. Kenya (8) – Cattle ownership (ACSI credit) (9) + Oxen ownership, improved livestock (other NGO credit) (9) + in LPA (9)	+ in LPA (9) – in HPA (9) Limited effect of credit only (14)	+ drainage ditches, tree planting (4), fertilizer (5,8), fertilizer in HPA (9), improved seeds (5), stall feeding (6), reduced tillage (9), crop residues in HPA (9) – improved seed in LPA (9), manure (11) Limited effect of credit only on SWC investment (14) and fertilizer use (15)	+ in LPA (9) Limited effect of credit only (14, 15)	Limited effect of credit only (14, 15)	Limited effect of credit only (14, 15)
Income strategies (cf. food crops)	Cash crops	+ (5)	+ improved seeds, reduced tillage (5) – burning (5)	+ (7,9)		+ in central Kenya (8)
	Livestock	– (5)	– ox power, burning (5)	+ (7)		+ due to dairy in C. Kenya (8)
	Nonfarm/off farm	– (5,14)	+ fertilizer, improved seeds, reduced tillage (5) – manure/compost, ox power (5), SWC investment (14)	+ (7) – (14)	+ erosion (14)	+ (14)
	Food aid/other asst.	– (5)	– manure/compost, burning, intercropping, ox power (5)	+ (5)		
	Forestry/woodlots			– (7)	+ tree cover (3)	+ (3, 14)

Household endowments	Land/farm size		+ reduced tillage (5), contour plowing and improved seed in LPA (9), fertilizer in HPA (9), mulch (11) – fertilizer (5,11), manure (11)	– (7) – in LPA (9)		
	Labor	+ (5)	+ reduced tillage, crop residues (9), improved seed in HPA, crop rotation in HPA (9), manure (11), fertilizer (11) – manure, household refuse (9)		+ erosion (7)	– (5)
	Education	+ (5)	+ improved seed in HPA (9), crop residues (11) – reduced tillage (9), crop rotation and crop residues in HPA (9), manure (11)		+ availability of grazing land (6) + erosion (7)	+ (5)
	Gender: female head	– (5) – in LPA (9)	+ reduced tillage (5,9), fertilizer (11) – manure/compost (5), ox power (5), contour plowing (5), crop residue incorporation (9)	– (5) – in HPA (9)		– (5)
	Livestock: oxen	+ (5) – in HPA (9)	+ ox power (5), manure/compost (5), contour plowing (5), reduced tillage (9), fertilizer in HPA (9), crop residues in LPA (9) – reduced tillage (5), crop rotation in LPA (9), household refuse (9)	+ in HPA (9)		
	Livestock: other	– (5)	+ crop rotation, manure, household refuse (9) – ox power, burning, intercropping (5), reduced tillage (9), fertilizer in HPA (9), crop residues in LPA (9)	+ (5,7)		+ (5, 12)
Land tenure/rights						
– Land redistribution	+ household ownership of up to two oxen (6) – ownership of more than two oxen (6) + ownership of other livestock, improved breeds (6)		+ crop residue incorporation in HPA (9), use of stall feeding, crop residues as a feed source (6) – ox power, contour plowing, crop rotation and crop residue incorporation in LPA (9); fertilizer use in HPA (9)	+ (9) (in structural model)	– quality of grazing land (6)	

(*continued*)

Table 16.1 (continued)

Characteristics of development domains	Income strategies/assets	Labor intensity	Land management practices	Value of crop production per hectare	Land degradation	Income/cap welfare
– Tenure security			+ manure use (9), ox power in LPA (9) – fertilizer and crop residue incorporation in HPA (9)	+ (9)		
– Mode of land acquisition (owner-operated versus other)		+ on owner-operated in HPA (9)	– manure (9), improved seeds in HPA (9); ox power, contour plowing and seeds in LPA on owner-operated plots (9)	– owner–operated plots in LPA (9) + purchased versus inherited plots (7)		
– Land rights system			+ crop residue incorporation and mulching on *mailo* versus freehold plots (11) – fertilizer use on customary versus freehold plots (11)		– erosion on *mailo* versus freehold plots (7)	
– Village level management of grazing lands					+ grazing land availability and quality (6)	
Land management						
– Investments		+association of stone terraces with labor use in LPA (9), fences with labor use (5,9)	+ association of stone terraces with fertilizer use (5,9) and contour plowing (5,9) – association of stone terraces with household refuse (9) + association of fences with manure (5,9), contour plowing (9), household refuse (9), ox power in HPA (9), seed use in LPA (9) – association of live fences with reduced tillage (9), crop residue incorporation in LPA (9)	+ impact of stone terraces in LPA (5,9) + impact of live fences and drainage ditches in HPA (9)		
– Fertilizer				+ (5) + in HPA (9, 13)		

– Agronomic practices		– reduced labor requirement of reduced tillage (with herbicides) (12) + increased labor requirement for leguminous cover crops and biomass transfer (13)			+ ox power in LPA (5,9), seed use (5,9) + improved seed in HPA (9) + reduced tillage (5) + reduced burning (5) – crop residues in LPA (9) + leguminous cover crops and *tithonia* biomass transfer (13) Limited productivity impacts of most soil fertility practices in eastern Uganda (15)	+ reduced/zero tillage reduces erosion, increases carbon sequestration, increases soil moisture (12) + grazing enclosures reduce erosion, increase biodiversity (12) + leguminous cover crops improve nitrogen balance (13) +/– biomass transfer improves nutrient balance in recipient areas, depletes source areas (13)	+ reduced tillage by promoting higher-value livestock (12) + area enclosures (12) Limited income impacts of most soil fertility practices in eastern Uganda (13, 15)

Note: Chapter numbers in parentheses.

[a]HPA = higher-potential areas; LPA = lower-potential areas.

[b]U = U-shaped relationship (e.g., lower at moderate population density); ∩ = inverted U-shaped relationship.

access is associated with less tree cover (Chapter 3), and in Tigray better market access is associated with lower tree survival rates in community woodlots (Chapter 10). These findings are consistent with others showing that road development is associated with many indicators of improved welfare, but also with deforestation, in Uganda (Pender et al. 2004a), as in many other developing countries (e.g., Chomitz and Gray 1996; Mertens and Lambin 1997; Nelson and Hellerstein 1997).

Market access also influences access to nonfarm opportunities. In the highlands of central and western Kenya, nonfarm income accounts for nearly 40 percent of total household income (Chapter 8). The similar share of nonfarm income in these two regions, despite large differences in total household income between these regions, suggests that nonfarm activities do not hinder agricultural income in the more prosperous central highlands. Households in central Uganda close to Kampala earn a similar share of income from nonfarm activities (Ehui and Pender 2003), but nonfarm income generally accounts for a much smaller share of income elsewhere in Uganda (Ehui and Pender 2003) and in the northern Ethiopian highlands (Pender 2004), where access to urban centers is much less. This is similar to findings of other literature showing that nonfarm activities and off-farm income tend to be higher in areas close to urban markets and roads in Africa (Haggblade, Hazell, and Brown 1989; Reardon 1997; Barrett, Reardon, and Webb 2001).

As expected, market access and high-value crop production contribute to intensification in use of fertilizer and many other inputs in central Kenya (Chapter 8). Market access also contributes to use of fertilizer and other inputs in Tigray (Chapters 4 and 5). However, better market access sometimes reduces adoption of labor-intensive land management practices by increasing the opportunity costs of labor (Chapters 5, 9, and 11).

Market access also influences collective land management decisions. Gebremedhin et al. (Chapter 10) found that communities with better access to markets contribute less labor and plant fewer trees on community woodlots (and have lower survival rates of the trees planted, as mentioned above), probably because of higher opportunity costs of labor in such areas and/or because market access increases people's ability to avoid sanctions for not participating in collective action (Bardhan 1993). Communities with better market access are also less likely to establish penalties for violations of grazing restrictions or to pay a guard to monitor their restricted grazing areas (Chapter 10). Thus, better market access does not assure better management of natural resources.

Population Pressure

Population pressure also affects households' income strategies. In Kenya, higher population density is associated with higher cattle density and more woodlots (Chapter 3). Livestock and tree-planting activities thus appear to be intensification responses to population pressure. However, although population pressure appears to contribute to higher livestock density per hectare in Kenya, it is associated with fewer large animals owned per household in northern Ethiopia (Chapters 4 and 6). Adoption of improved livestock breeds (Chapter 6) and beekeeping (Chapter 4) are also associated with population pressure in Ethiopia, suggesting that these are intensification responses to declining availability of land for extensive livestock production.

Population pressure contributes to more intensive land management practices, as hypothesized by Boserup (1965) and many others. Higher population density is associated with less use of fallow (Chapter 4), higher labor and oxen intensity in crop production (Chapter 5), more use of fertilizer (Chapters 4, 5, and 11), and with use of some labor intensive land management practices (Chapters 5, 9, and 11). However, high population density in much of the East African highlands likely limits the use of leguminous cover crops in improved fallows because land scarcity limits farmers' ability to fallow land, even for only one season (Chapter 13). This argument is supported by other research findings showing that larger farms are more likely to adopt improved fallows in western Kenya (Place et al. 2002a, 2004) and Malawi (Gladwin et al. 2002). Population pressure also limits use of terraces by small farms, because these occupy scarce land (Chapter 14).

Moderate population pressure is associated with more effective collective action to manage communal resources than low or high levels (Chapter 10). This may be because the benefits of collective action to manage resources are too low relative to the fixed cost of organizing it at low population density, whereas the variable costs of achieving effective collective action and the incentives to violate collective agreements become too high at high population density (Olson 1965; Ostrom 1990; Sandler 1992; Pender 2001).

Population pressure indirectly affects agricultural production by leading to smaller farm sizes. Pender et al. (Chapter 7) found that smaller farms achieve higher crop yields in Uganda, as did Benin (Chapter 9) in lower-rainfall areas of the Amhara region in northern Ethiopia. These findings are consistent with a large body of literature showing an inverse relationship between farm size and agricultural productivity in developing countries (e.g., Chayanov 1966; Sen 1975; Berry and Cline 1979; Carter 1984; Barrett 1996; Heltberg 1998).

Population pressure is associated with better indicators of some aspects of welfare but worsening of natural resource conditions in some parts of the East African highlands. For example, housing quality (indicated by houses with metal roofs) is better in more densely populated areas of Kenya and northern Ethiopia (Chapters 3 and 4). On the other hand, tree cover is lower in more densely populated areas of

Kenya (Chapter 3), there has been more decline in grazing land availability and quality in communities where population growth has been more rapid in the Amhara region of Ethiopia (Chapter 6), and soil erosion is higher in more densely populated areas of the highlands of Uganda (Chapter 7). These findings are consistent with those of Pender et al. (2001a), who found that more rapid population growth was associated with many worsening resource conditions in northern Ethiopia, and Grepperud (1996), who found greater land degradation in more densely populated areas of the Ethiopian highlands. They are not consistent with the more optimistic "more-people, less-erosion" hypothesis that Tiffen, Mortimore, and Gichuki (1994) found in the Machakos district of Kenya. However, access to urban markets and technical assistance may have been more responsible than rural population growth for improved land management in the Machakos district, consistent with the findings of Chapter 8 of improved land management in central Kenya as a result of these advantages.

Income Strategies

In central Kenya, cash crop production is associated with investments in land improvement and with greater use of fertilizer and other inputs, resulting in higher value of crop production, higher incomes, and perceived improvements in land quality (Chapter 8). In Uganda, bananas, coffee, and horticultural crop production are also associated with adoption of various intensive land management practices and higher value of production (Chapter 7; Nkonya et al. 2004). These findings are consistent with those of Pender et al. (2004a) and Pender et al. (2001a), who found, based on community surveys in Uganda and Ethiopia, that perennial crops were associated with more use of several resource conservation practices and more improvement in several indicators of productivity, human welfare, and natural resource conditions. Horticultural crops are associated with more use of improved seeds in Tigray (Chapter 5), although no significant difference in the value of crop production or income as a result of horticultural production was found there. Thus, cash crop production contributes to intensification and improved outcomes in many cases, but not everywhere.

Livestock production is associated with higher value of crop production and incomes in much of the East African highlands. Dairy production is associated with higher incomes and better housing quality in Kenya (Chapters 3 and 8). In Uganda, livestock are associated with more use of manure in crop production (Chapter 11), higher value of crop production (Chapter 7), and higher household income (Nkonya et al. 2004). Livestock ownership (especially oxen and other cattle) is also associated with intensification of crop production in northern Ethiopia (Chapters 5 and 9) and with higher incomes in Tigray (Chapter 5).

Tree planting also can contribute to higher incomes and welfare and improved resource conditions in suitable areas of the East African highlands. In Kenya, Place et al. (Chapter 3) find that woodlots are associated with better housing quality and more tree cover. Holden et al. (Chapter 14) predict that eucalyptus tree planting on degraded lands could substantially increase incomes in their study site in northern Ethiopia, with limited effects on soil and water conservation or erosion of croplands. These findings are consistent with those of several other studies of the economic and ecological impacts of woodlots in Ethiopia (Okumu et al. 2002; Gebremedhin, Pender, and Tesfay 2003; Getahun 2003; Jagger and Pender 2003). Tree crops are also important sources of income, especially coffee and tea in suitable areas, but fruits and nuts also can be important. For example, macadamia trees are an important source of income in central Kenya (Chapter 8).

Nonfarm activities and off-farm employment can have mixed impacts on agricultural production, reducing labor intensity but increasing farmers' ability to purchase inputs. For example, these activities are associated with less labor-intensive crop production in Tigray but more use of improved seeds (Chapter 5). The net effect on crop production is insignificant, but household involvement in nonfarm activities and off-farm employment increase household incomes (Chapter 5). Holden et al. (Chapter 14) predict that increased off-farm employment opportunities in the northern Shewa zone of the Amhara region would substantially increase household incomes but would also reduce investment in soil and water conservation (SWC) measures and crop production and increase soil erosion unless off-farm employment is targeted to promote SWC investment, for example, through food for work (FFW) programs. These findings indicate potential trade-offs between promoting increased incomes, increased agricultural production, and reduced land degradation via income diversification into nonfarm activities. Such trade-offs appear to be dependent on the context and type of land degradation considered, however. In Uganda, for example, nonfarm activities are associated with higher value of crop production (Chapter 7) and less soil nutrient depletion (Nkonya et al. 2004).

Land Management Practices

Investments in stone terraces were found to have substantial positive influences on crop production in lower-rainfall areas of the northern Ethiopian highlands (Chapters 5 and 9) but not in higher-rainfall areas (Chapter 9). This suggests that the short-term yield benefits of these investments are largely through conservation of soil moisture. Pender and Gebremedhin (Chapter 5) estimate that the rate of return of investments in stone terraces in Tigray averages close to 50 percent, similar to the rate of return from such investments estimated by Gebremedhin, Swinton, and Tilahun (1999) based on experiments conducted in Tigray. In earlier research, Herweg (1993a,b) also noted greater yield effects of soil and water conservation measures in lower-rainfall environments in the Ethiopian highlands. In higher-rainfall areas of the Amhara region, Benin (Chapter 9) found that investments in drainage ditches and live fences have significant positive effects on crop yields, suggesting that management of excess water and livestock are of more concern for crop production in higher-rainfall environments.

By increasing the availability of soil moisture, SWC investments can increase the profitability and reduce the risks associated with use of inputs such as inorganic fertilizer (Hengsdijk, Meijerink, and Mosugu 2005). Consistent with this, Pender and Gebremedhin (Chapter 5) and Benin (Chapter 9) find greater use of inorganic fertilizer on plots where stone terraces have been constructed. Some organic land management practices such as manuring are more common on plots where fences have been constructed (Chapters 5 and 9), possibly because such plots are where livestock are kept. Exploiting such complementarities can substantially enhance the profitability and sustainability of land management approaches.

Inorganic fertilizer can contribute to higher productivity, especially in more favorable environments with sufficient rainfall and good access to markets. Use of inorganic fertilizer is yielding high returns in the high-potential highlands of central Kenya, especially on higher-value crops (Chapter 8). It is also contributing to substantially higher yields in the higher-potential parts of the Amhara region in Ethiopia, increasing average cereal yields by more than 50 percent (Chapter 9). Improved seeds are having a similarly large effect in this favorable environment (Chapter 9).

However, in less favorable environments, inorganic fertilizer use is much less profitable and is risky. In drought-prone areas of the northern Ethiopian highlands, inorganic fertilizer use is not profitable on average (Chapters 5 and 9). A recent study by Kruseman (2004) confirms the low profitability and high risk of using inorganic fertilizer in the drought-prone environment of eastern Tigray, predicting with a bioeconomic model that fertilizer prices would have to be about 50 percent lower to induce sufficient adoption of fertilizer to stem soil fertility decline. The results of Holden et al. (Chapter 14) also imply relatively low returns to use of inorganic fertilizer in their study community in North Shewa. Inorganic fertilizer is also not very profitable in much of Uganda (Chapter 7; Pender et al. 2004c; Nkonya et al. 2005b), in part because of low yield response and in part because of high fertilizer prices relative to commodity prices (Chapter 15). Woelcke et al. (Chapter 15) predict using their bioeconomic model that fertilizer prices would have to fall by more than 90 percent before substantial adoption would be profitable in maize production in their study villages in eastern Uganda. Inorganic fertilizer will thus not likely be a panacea for soil fertility depletion and low productivity in much of the East African highlands.

Organic approaches to soil fertility management also have context-dependent effects. Manure and compost use are associated with higher crop yields in Tigray, as are reduced tillage and reduced burning (Chapter 5). However, in the Amhara region and in Uganda, organic practices have statistically insignificant or negative associations with crop yields (Chapters 7 and 9). The apparently better response of soils in Tigray to organic inputs may be because of the extremely low organic matter content of soils in this region, where over 90 percent of the soils are very low in organic carbon (Haile, Gebremedhin, and Belay 2003) and where soil moisture is a severe constraint. In drier environments, the benefits of soil organic matter often result more from its effects on soil moisture infiltration and retention than on nitrogen availability (Giller et al. 1997). Where soil moisture and organic matter are less constraining, application of organic materials may be less immediately beneficial and can actually reduce yields in the near term if the carbon-to-nitrogen ratio or lignin content of the organic matter is too high because such organic materials can immobilize available nitrogen (Giller et al. 1997; Chapter 13). The quality of manure and other organic materials can vary greatly as a result of differences in animal type and feed sources, soil fertility, how the material is stored, and other factors (Giller et al. 1997). Such variations may contribute to the low returns to organic inputs in many cases.

Reduced tillage has more favorable effects on crop productivity in the Tigray region (Chapter 5) than in the Amhara region (Chapter 9). As with application of organic inputs, reduced tillage helps to conserve soil organic matter (Chapter 12; Giller et al. 1997) and improve soil moisture retention, which are critical needs in Tigray. Aune et al. (Chapter 12) report somewhat higher maize yields on demonstration plots using reduced tillage than on plots using normal tillage in higher-potential areas of the Amhara and Oromiya regions of Ethiopia. Whether such yield advantages exist under farmers' normal practices in higher-potential areas, when herbicides are rarely used, is not clear, however. Nevertheless, even if farmers are able to obtain similar yields with reduced tillage, its use may still be advantageous by helping to reduce tillage costs and land degradation, providing an option to oxen-poor households, and promoting more remunerative investment in other kinds of livestock besides oxen (Chapter 12).

Transfer of high-quality biomass sources of nitrogen and phosphorus, such as *Tithonia diversifolia,* a common shrub in western Kenya and eastern Uganda, has shown promising effects in increasing maize yields (Chapter 13). However, using nonleguminous plants such as *Tithonia* for biomass transfer only redistributes soil nutrients within the landscape, increasing fertility in one place by decreasing it in another, and is limited by the high labor costs involved (Chapter 13).

Planting leguminous cover crops, shrubs, or trees as part of an improved fallow also shows significant potential to increase crop yields in parts of the East African highlands (Chapter 13). However, such yield increases are often insufficient to compensate for the loss of at least one season of production and the additional management and labor costs (Chapter 13). Thus, such improved fallow technologies are less suited to areas of high population density, where land scarcity is extreme and fallowing is uncommon (Chapter 13), as in much of the East African highlands, except in spatial niches such as field boundaries or by farmers who have relatively large farms (Place et al. 2004). These technologies are also more suited to areas of higher agricultural potential because the productivity of these leguminous crops is higher in areas of higher agricultural potential (Place et al. 2004; Chapter 13).

The results in this subsection highlight the context dependence of the effects of land management technologies. Inorganic fertilizer is most profitable in areas of high agricultural potential and market access, and vegetative practices such as improved fallows also appear better suited to areas of high agricultural potential but intermediate population density. By contrast, some soil and water conservation investments, organic inputs, and reduced tillage appear to be more profitable in lower-rainfall areas where their effects on soil moisture retention appear to be more beneficial.

Effects of Other Factors

The studies in this book also shed light on the effects of several policy-relevant factors, including irrigation, technical assistance, and credit programs, presence of and participation in various types of organizations, education, gender, and land tenure issues. We consider the findings related to these issues in this subsection.

Irrigation

Not surprisingly, irrigation is associated with increased intensity of crop production in northern Ethiopia (Chapters 4, 5, and 9). Despite this, Pender and Gebremedhin (Chapter 5) find insignificant effects of irrigation on the value of crop production and household income in Tigray, controlling for use of inputs, land quality, household characteristics, and other factors. These findings are consistent with those of Amacher et al. (2006), who also studied effects of irrigation dams in Tigray. That study and others also found that access to irrigation dams contributes to increased incidence of diseases such as malaria and schistosomiasis (Tedros et al. 1999; Amacher et al. 2006). Such costs should be borne in mind in efforts to promote irrigation or other water-harvesting methods (especially at lower elevations). Nevertheless, where irrigation is profitable, households may be willing to pay for mosquito nets and other preventive measures (Lampietti et al. 1999).

Part of the reason for low returns to irrigation in Tigray is that farmers' traditional methods of irrigation use water inefficiently and obtain significantly lower yields than is possible (Mintesinot et al. 2004). Irrigation dams in Tigray are also beset by problems of sedimentation because of inadequate conservation of the catchment areas, salinity buildup from seepage and lack of adequate drainage, and biological contamination of the reservoirs (Mintesinot and Mitiku 2003). In addition, several institutional and market problems also appear to be limiting the beneficial economic effect of irrigation investments, including lack of skilled manpower to ensure proper design of the dams (Egziabher 2003); lower actual than nominal irrigation capacity of the dams (Hagos, Pender, and Gebreselassie 1999); separation of organizational responsibilities for constructing the dams, conserving the catchment, and maintaining the irrigation structures (Hagos, Pender, and Gebreselassie 1999); lack of farmer experience with irrigation or with production and marketing of higher-value perishable crops (Hagos, Pender, and Gebreselassie 1999); lack of development of marketing facilities and institutions for such crops (Hagos, Pender, and Gebreselassie 1999); lack of clarity about water rights and their relationship to land access rights (Tesfay et al. 2000); and lack of a comprehensive irrigation policy addressing issues of water rights, cost recovery, and other issues (Tesfay et al. 2000).

Benin (Chapter 9) found positive effects of irrigation on crop production in drought-prone areas of the Amhara region but not in high-potential areas. As in Tigray, the positive effects of irrigation on crop yields appear to be related to increased intensity in use of inputs (especially draft power). The effects of irrigation on crop production may be year specific as well as location specific: there was a major drought affecting the survey year in Amhara but not in Tigray, which may account for larger effects of irrigation in drought-prone areas of Amhara than in Tigray.

Irrigation is also associated with more intensive livestock production, including greater use of improved breeds, animal health services, and private pastures (Chapter 6). These associations may result from indirect influences. For example, irrigation may increase farmers' income and ability to finance purchase of improved breeds and to provide feed and health care for improved animals. It may also increase the scarcity of land available for common pasture, thus contributing to privatization of pastures.

Agricultural Technical Assistance Programs

Access to government agricultural extension contributed to adoption of inorganic fertilizer and contour plowing in the Amhara region and to higher crop yields in higher rainfall areas of this region (Chapter 9). However, extension has small and statistically insignificant effects on production in lower rainfall areas of Amhara and Tigray (Chapters 5 and 9). Hagos (2003) also found statistically insignificant effects of agricultural extension on income in Tigray, and Demeke and Egziabher (2003) even found negative effects of the extension and credit program on production and income in marginal agricultural areas of Tigray. This is because the technologies most promoted by the extension program in Ethiopia during the period studied, inorganic fertilizers and improved seeds for cereals, are profitable mainly in the high-rainfall areas but less profitable and risky in low-rainfall areas, as noted earlier.

Involvement of the Bureau of Agriculture's development agents in promoting establishment of community woodlots in Tigray also tended to undermine collective action in managing these resources (Chapter 10). Thus, agricultural extension and regulatory efforts of agricultural bureaus in low-rainfall areas of northern Ethiopia appear to have been of limited benefit to farmers during the period studied.

In Uganda, Jagger and Pender (Chapter 11) find a positive association of government agricultural extension with adoption of several land management practices, including use of fertilizer, pesticides, manure, and mulching. Extension and training programs also are associated with increased value of crop production (Chapter 7), especially in the lower-elevation areas. However, agricultural extension is also associated with greater soil erosion in the higlands of Uganda (Chapter 7), and in eastern Uganda, extension contributes to soil nutrient depletion by promoting adoption of higher-yielding varieties without sufficient adoption of soil fertility management practices (Nkonya et al. 2004). Thus, agricultural extension may lead to trade-offs between production and sustainability objectives unless the extension program provides a sufficiently intensive effort to promote improved land management practices.

Agricultural technical assistance programs of nongovernmental organizations (NGOs) also appear to have significant effects on agricultural production in Uganda, but these are also context dependent. Such organizations are associated with increased use of fertilizer and pesticides (Chapter 11), with higher crop production in highland areas, and with lower erosion in general (Chapter 7).

In Kenya, Place et al. (Chapter 8) argue that differences in access to technical assistance cannot account for the large differences in technology adoption and productivity between the central and western highlands. Although Chapter 8 does not statistically test the effects of technical assistance, their argument is supported by findings of Gautam and Anderson (1999), who found statistically insignificant effects of the agricultural training and visit extension system in Kenya. Thus, the effects of extension may not be uniformly positive even in areas of high agricultural potential and favorable market access.

Credit Programs

The availability of credit appears to have had important positive effects on the extent of agricultural commercialization, diversification, and intensification in central Kenya (Chapter 8). In Ethiopia, we see less positive influence of credit. In Tigray, formal credit use is associated with greater use of improved seeds and fertilizer but has little effect on crop production and income because of limited influences of these technologies in this environment (Chapter 5; Hagos 2003; Demeke and Egziabher 2003). Holden et al. (Chapter 14) also predict limited effect of fertilizer credit on crop production and income in their study community because of the limited profitability of fertilizer use.

Credit programs also appear to have had relatively limited effect on land management and crop production in Uganda (Chapters 7, 11, and 15; Nkonya et al. 2004). Unless profitable technologies are available that can be financed by credit, there is little reason to expect credit to have a major influence on agricultural production.

Credit can also affect livestock ownership and management. Availability of credit from the Amhara Credit and Savings Institution is associated with declining livestock ownership, perhaps because of forced livestock sales to repay fertilizer loans during a drought (Chapter 6). By contrast, other NGO sources of credit are associated with increased ownership of oxen and improved cattle breeds, increased stall-feeding, and reduced feeding of crop residues (Chapter 6). The effects of credit thus appear to depend greatly on the focus of the credit program, with programs oriented toward livestock development having more positive effect on livestock ownership and management.

Local Organizations

Cooperatives and other local organizations appear to have important effects in some circumstances. In Tigray, cooperatives are associated with more use of irrigation (Chapter 4), more use of seeds and less burning (Chapter 5), higher value of crop production and income (Chapter 5), and better housing quality (Chapter 4). In Amhara, the effects of cooperatives are more mixed (Chapter 9). Input cooperatives are associated with greater use of improved seeds and some other inputs but have mixed effects on yields in Amhara (Chapter 9). Such cooperatives appear to be promoting use of purchased inputs as a substitute for other inputs in this case.

Local organizations also can influence collective action to manage community resources. Gebremedhin et al. (Chapter 10) found that communities that have more local organizations were more likely to establish a penalty system to protect restricted grazing lands, contributed more per household to protect the grazing land, and had fewer violations of restrictions. Social capital is thus an important asset contributing to collective as well as private natural resource management, as emphasized in much of the literature on collective action and common property resource management (e.g., Wade 1988; Ostrom 1990; Rasmussen and Meinzen-Dick 1995; White and Runge 1995; Baland and Platteau 1996; Agrawal 2001; McCay 2002; Pender and Scherr 2002).

Education

Education can influence agricultural production and household income in complex ways. In western Kenya, the level of education is strongly correlated with use of chemical fertilizer and higher off-farm income (Chapter 8). In Tigray, primary education of the household head is associated with more intensive labor use (Chapter 5), and in Amhara, education is associated with more use of improved seeds in HPAs but less use of reduced tillage, crop rotation, or incorporation of crop residues (Chapter 9). In Uganda, education is associated with less use of manure (Chapter 11). However, formal education has little association with the value of crop production per hectare or income in northern Ethiopia (Chapters 5 and 9), probably because of the generally low level of education of rural households. In Uganda, education is associated with higher value of crop production in the highlands but lower production in the lowlands, perhaps because of greater off-farm opportunities available to more educated people in lowland areas close to the main urban centers of Kampala and Jinja (Chapter 7). Nevertheless, education contributes substantially to higher incomes in rural Uganda (Appleton 2001; Deininger and Okidi 2001; Nkonya et al. 2004).

Gender

Gender also influences household income strategies, agricultural and land management practices, and outcomes. In western Kenya, female-headed households plant fewer crops in general and fewer high-value crops and use less fertilizer (Chapter 8). In northern Ethiopia, female-headed households use less labor and oxen power, reflecting a cultural taboo against women plowing (Chapters 5 and 9). As a result, female-headed households in northern Ethiopia obtain substantially lower crop yields and incomes than male-headed households (Chapters 5 and 9). In Uganda, female-headed households are more likely than male-headed households to use fertilizer, and households with more men use more of some labor-intensive land management practices (Chapter 11). Nevertheless, the difference in crop production between male- and female-headed households is insignificant in Uganda (Chapter 7). Thus, in Uganda female-headed households appear able to overcome labor shortages in agricultural production by using other inputs.

Land Tenure

Land tenure also influences land management and productivity in mixed and context-specific ways. In the Amhara region of Ethiopia, productivity is higher in villages where land redistribution has occurred since 1991, even though use of several inputs and management practices was lower (Chapter 9). This finding is consistent with findings of Benin and Pender (2001), based on community-level data for the Amhara region, and suggests that an important short-term effect of land redistribution is to enable land-poor households who are able to use land productively to access land.

This does not prove that redistribution increases productivity in the longer term because this may be undermined by lack of investment in soil and water conservation or in soil fertility improvements caused by tenure insecurity related to expected future land redistributions. For example, other findings in Chapter 9 show that expected tenure insecurity is associated with less use of manure but more of inorganic fertilizer, probably reflecting incentives to use inputs that yield short-term benefits where tenure is insecure. In another study in Ethiopia, Deininger et al. (2003) found that land redistributions are associated with less investment in terraces, and expectations of future redistributions are associated with less investment in both terraces and tree planting.[2] Several other studies have also found negative effects of perceived tenure insecurity on land investments in Ethiopia (Alemu 1999; Gebremedhin and Swinton 2003a; Gebremedhin, Pender, and Ehui 2003). However, other studies have found insignificant associations of tenure security with land investments in Ethiopia (Shiferaw and Holden 1998; Holden and Yohannes 2002; Yesuf 2004; Hagos and Holden 2005), so the evidence is not fully clear.

Land redistribution can also influence livestock ownership and management. Benin et al. (Chapter 6) find that land redistribution was associated with reduced household ownership of more than two oxen but an increase in ownership of fewer oxen and in ownership of other livestock. Land redistribution is also associated with increased adoption of improved animal breeds, stall feeding, and use of animal health services (Chapter 6). Nevertheless, land redistribution is associated with more degradation of grazing land quality, probably because it contributes to increased livestock numbers overall (Chapter 6). Other effects of land redistribution can include changes in intrafamily relationships (e.g., dependence of children on their parents for access to land), conflicts over land access, reduction in social differentiation and economic mobility, changes in poverty and destitution, effects on migration, and others (Bauer 1987; Amare 1994; Abate 1995; Amare 2003), though these were not examined in the studies in this book.

Studies in this book found mixed effects of the mode of land acquisition. In Amhara, Benin (Chapter 9) found that use of several inputs and land management practices is lower on owner-operated plots than on leased in (mostly through sharecropping) or borrowed plots and that yields were also lower on owner-operated plots in low-rainfall areas. This is contrary to predictions of inefficiency of sharecropping (Shaban 1987; Otsuka and Hayami 1988) and findings from studies elsewhere in Ethiopia, which find that productivity is either lower (Ahmed et al. 2002; Pender and Gebremedhin 2004) or insignificantly different on sharecropped than on owner-operated plots (Gavian and Ehui 1999; Pender and Fafchamps 2005). Benin's finding of lower productivity on owner-operated plots was not robust when a household-fixed effects model was estimated, however, so not too much should be inferred from this anomalous result.

Land tenure also has mixed effects in Uganda. Ugandan farmers are less likely to use fertilizer on customary than freehold plots but are more likely to incorporate crop residues and use mulching on *mailo* than freehold plots (Chapter 11). Farmers with freehold plots appear to be more oriented toward using cash inputs than other farmers, whereas *mailo* holders use more labor-intensive methods. Nevertheless, Pender et al. (Chapter 7) do not find statistically significant differences between the value of crop production on plots of different tenure, though they do find lower erosion on *mailo* plots, probably because of greater production of less erosive perennial crops on *mailo* land. The limited productivity effect of freehold land tenure in Uganda is similar to findings of several other studies of the effects of land titling in Africa (e.g., Atwood 1990; Barrows and Roth 1990; Migot-Adholla et al. 1991; Place and Hazell 1993; Platteau 1996). Interestingly, the value of crop production is greater on purchased than inherited plots in Uganda, suggesting that farmers adopt a more commercial and intensive approach to use of purchased plots in order to justify their investment (Chapter 7).

Summary of Findings

As hypothesized, many of the factors considered have complex and context-specific associations with households' income strategies, land management practices, agricultural productivity, household income, and land degradation. Among the more general and robust findings are the findings that:

- Agricultural productivity, household incomes, and welfare indicators tend to be greater in areas of higher agricultural potential and better market access.

- Adoption of purchased inputs such as inorganic fertilizer tends to be greater in areas of better market access.

- Population pressure and smaller farm sizes are associated with intensification of agricultural production, but also with land degradation, in many cases.

- Cash crop production is associated with adoption of purchased inputs and higher value of crop production per hectare.

- Nonfarm activities are associated with increased adoption of purchased inputs and household income but also with lower labor intensity in agricultural production.

- SWC investments and some organic measures have more immediate effect on productivity in moisture-stressed environments, whereas inorganic fertilizer and some vegetative agronomic practices are more effective in HPAs.

- Access to credit has limited influence on technology adoption and outcomes unless the market environment and the profitability of technologies is adequate.

The effects of other factors, such as irrigation, agricultural technical assistance, local organizations, education, and land tenure systems appear to be more context dependent. Further research efforts could usefully focus on such context-dependent effects, investigating what about the context leads to better land management and outcomes in some circumstances and less so in others, and how to devise more effective strategies for sustainable land management taking such contextual factors into account.

Although further research on effects of specific factors in specific domains is still needed, several implications for policies and programs can be suggested based on the findings of this book.

Policy and Program Implications

The research findings discussed above imply that no single policy strategy or program will be able to solve the problems of land degradation, low agricultural productivity, and poverty throughout the East African highlands. To achieve positive and sustainable effects, policies and programs must account for the diversity and complexity of situations in the East African highlands. A broad portfolio of investments by both public and private sectors in physical, human, natural, financial, and social capital will be needed to achieve sustainable effects, but the socially profitable mix of those investments will vary as a result of differences in comparative advantages of different livelihood and land management options in different contexts, as influenced by differences in agricultural potential, access to markets, population density, and other factors. In this section we suggest strategies for different development domains in the East African highlands, followed by consideration of more general lessons relating to some specific policy and program issues, drawing on the broader literature as well as the findings in this book.

Although we seek to account for the heterogeneous environments in the East African highlands, it is not practical to develop strategies for every possible situation. The conceptual framework and research findings in this book can be helpful to target strategies to the most important domains in the highlands. For simplicity, we consider options for only three broad domains: (1) areas with high agricultural potential and favorable market access, (2) areas with high agricultural potential but less favorable market access, and (3) areas with lower agricultural potential. We consider variations in other dimensions, such as population pressure, where relevant to the discussion.

Areas of High Agricultural Potential and Favorable Market Access

In areas of high agricultural potential and favorable access to large urban markets, a virtuous circle is possible, involving increased production of high-value commodities and increased nonfarm activities, all contributing to higher incomes and increased ability and incentive of farmers to invest in land-improving and productivity-enhancing technologies, helping to increase production of high-value commodities. In central Kenya, this virtuous circle was stimulated by the availability of the large and growing market in Nairobi, the development of infrastructure and proximity of processing facilities, and the presence of cooperatives providing credit and market outlets for high-value products (Chapter 8). It also built on the presence of a local merchant class with considerable international trading experience and development of long-term relationships between Kenyan exporters and overseas buyers and distributors (Jaffee 1995).

These advantages are not present to the same extent elsewhere in the East African highlands, though government policies and government and NGO programs can help to develop some of these advantages. For example, cooperative development in Ethiopia and Uganda has been set back by the politicization and poor performance of cooperatives in these countries during the tenures of the Marxist Derg regime in Ethiopia and of Idi Amin and Milton Obote in Uganda. Cooperatives are again developing in these countries. For example, dairy cooperatives are being promoted in periurban areas around Addis Ababa, though their coverage is still quite limited (Holloway et al. 2000). It will take significant investment capital and a supportive policy environment (e.g., avoidance of politicization or excessive government regulation and taxation) to help nurture the development of such organizations. Development of infrastructure in periurban areas, including roads, electricity, and communications, is also needed to promote such private sector development.

Where such investments in high-value commodities are taking place, small farmers' opportunities to profitably use purchased inputs such as fertilizer, improved seeds, pesticides, and animal feed will be increasing. In this context, provision of agricultural technical assistance and credit promoting adoption of such high-value commodities and inputs can yield high returns, as seen in central Kenya. The potential to adopt labor-intensive land management practices such as use of manure, compost, and biomass transfer is also likely to increase, both because of higher return to labor inputs in high-value commodity production and because of increased availability of manure as a result of dairy and other intensive livestock development. Technical assistance and credit programs should be designed with these opportunities in mind.

In some areas of high agricultural potential and favorable market access, such as in central Uganda, pest and disease pressure are severe constraints to intensive livestock and high-value crop production because of the lower elevation and more humid climate in this region. Efforts to address these pest and disease problems (for example, tsetse fly eradication or control efforts) are important public goods that are required before substantial realization of the potential will be possible. Even when pest control can be done privately, such as using pour-on insecticides, the degree of collective cooperation in such efforts is critical to their success (Swallow et al. 2002). Thus, factors affecting the ability to attain cooperation, such as distance to treatment centers, ethnic heterogeneity, and the nature of local governments, should be taken into account in designing programs for pest and disease control.

Areas of High Agricultural Potential but Less Favorable Market Access

In areas of relatively high agricultural potential but more remote from major markets, such as the highlands of western Kenya, eastern and western Uganda and much of the southern and western highlands of Ethiopia, the comparative advantage is likely more in nonperishable and readily transportable commodities such as coffee and cereals (coffee in more humid areas, cereals in less humid areas) and livestock (more in live animals and skins than dairy). These areas have been suffering from low world prices of both cereals and coffee in recent years, which, together with elimination of input subsidies, liberalization of foreign exchange markets, and regional trade restrictions (especially affecting livestock), has reduced the profitability of using inputs in agricultural production. Pests and diseases are also serious problems for these commodities in many areas and reduce the expected return and increase the risks of expenditures on inputs. As a result, use of such inputs is not very profitable in many of these areas, and efforts to promote their use through extension and credit are unlikely to be very successful without major changes in the market environment.

In such environments, promotion of improved technologies can lead to increased soil nutrient mining as farmers adopt improved seeds (which are often profitable) without adequate use of fertilizer or other soil fertility management practices (which are often unprofitable in the near term) to restore the nutrients, thus increasing depletion of soil nutrients through increased harvest. Identifying and disseminating profitable technologies for restoring and maintaining soil fertility are critical in such circumstances. Positive results have been demonstrated for some agroforestry practices such as improved fallows and biomass transfer, but widespread adoption has been limited by land and labor constraints as well as by limited awareness of these technologies in much of the East African highlands. These technologies have shown sufficient promise that broader efforts to disseminate them are warranted, but the importance of land and labor constraints implies that these practices are unlikely to be widely adopted everywhere, even when they are capable of increasing crop yields substantially. Thus, efforts to develop suitable and profitable technologies consistent with the constraints faced by small farmers in these environments are still urgently needed.

Agroforestry and other vegetative approaches to livelihood diversification, provision of fodder and fuel supplies, and soil fertility improvement also may be constrained by free grazing of livestock, as is common in the Ethiopian highlands (Amede 2003). Development and enforcement of local community bylaws regulating this practice may be necessary to attain the potential of such technologies (Amede 2003). Given the long-standing tradition of the free grazing system and its importance to the livelihoods of rural households in Ethiopia, such changes should not be imposed by governments or widely promoted without adequate understanding of the implications of such changes. Any changes in such long-standing institutions are likely to fail unless they are initiated and owned by local communities themselves and brought about through processes that are perceived as fair by all stakeholders at the local level.

Although not profitable in all areas, some use of inorganic fertilizer is usually necessary to address deficiencies of some plant nutrients (such as phosphorus). This is profitable (often in combination with other technologies) in many higher-potential areas of the highlands, such as in western Amhara in Ethiopia and in parts of the eastern highlands of Uganda and western highlands of Kenya. The potential value of inorganic fertilizer in such areas should not be discounted simply because farmers face cash constraints. Such constraints can be addressed through fertilizer credit programs, as has occurred in Ethiopia, which are effective where fertilizer use is profitable. The problem then becomes the potential for successful adoption of fertilizer and improved seeds to cause a collapse in output prices as a result of poorly developed infrastructure, markets, storage, and marketing credit systems, as occurred in high-potential maize-producing areas of Ethiopia in 2001 and 2002.

Development of market infrastructure and institutions, such as roads, transportation and storage facilities, grades and standards, a market information system, and marketing credit (e.g., through a warehouse receipts system) is critical to help avoid such price collapses (Gabre-Madhin and Amha 2003) and can help to make use of fertilizer and other inputs more profitable in general. Local purchasing of grains for food aid and emergency reserve needs can also help to prevent dramatic declines in prices that undermine farmers', consumers', and traders' confidence in the market, though care should be exercised to avoid the opposite problem of causing sharp price rises that contribute to food insecurity. Beyond this, promoting development of an intensive livestock industry (e.g., poultry, pigs, beef fattening, dairy) in areas close to urban markets can stimulate the demand for maize and other feed grains from outlying areas having comparative advantage to supply this demand, providing a source of longer-term growth as well as helping to dampen price variability because of the higher elasticity of demand for feed supplies than for food supplies.

Improvements in markets for coffee are also needed in high-agricultural-potential areas. Although East African producers have limited ability to change world market prices, they can focus on earning higher returns for their coffee by investing in quality improvement and promoting coffee production for high-value specialty markets (e.g., for organic coffee, shade-grown coffee, fair trade coffee, appellation zones) (You and Bolwig 2003). Much of the coffee produced in East Africa is grown using organic methods and under shade conditions; thus, qualifying for certification should be feasible, though it is costly and subject to numerous requirements. Development of cooperatives can help to meet the requirements and reduce transaction costs per farmer of compliance. For example, the Kawacom Organic Coffee Project in Uganda has organized 14,000 farmers in farmer groups and is exporting about 1,000 tons of organic coffee annually (Parrott and van Elzakker 2003), and in Ethiopia there are about 23,000 farmers involved in organic coffee production through 35 cooperatives (Parrott and Kalibwani 2005). Organizations in several East African countries (Uganda, Kenya, and Tanzania) are pursuing development of accredited certification bodies and standards, which will help to reduce the costs of certification in the future (EPOPA 2004).

Although there is potential for increased value from specialty coffees, this potential should not be oversold, as the market for these coffees is thin, and many countries are trying to exploit these opportunities, so the price advantages of producing these are likely to be bid down as more producers enter these markets. Improvements in the technology and marketing systems of more standard coffee varieties should also be pursued and may benefit more coffee producers in the East African highlands. Among the more promising options include development and dissemination of disease-resistant and higher-yielding varieties, improved regulation of coffee quality, investments in improved infrastructure and transportation, development of institutions to reduce traders' risk, such as a forward auction (Schluter 2003), and establishment of a warehouse receipts system (being considered in Ethiopia) to facilitate provision of marketing credit (Ehui and Pender 2003). The market potential may be greater for *arabica* (produced in highland areas of Ethiopia, Kenya, and Uganda) than for *robusta* coffee (most common in Uganda at lower elevations) because of heavy competition from low-cost *robusta* production from Brazil and Vietnam (You and Bolwig 2003).

Improvements in food production are likely complementary to increasing coffee or other high-value cash crop production. In densely populated remote areas such as in much of southwestern Ethiopia, small and declining farm sizes and high transportation costs may cause farmers to reduce production of coffee in order to produce sufficient food for subsistence (Technical Committee on Agroforestry in Ethiopia 1990; Westlake 1998). Increasing productivity of food crops may therefore help farmers save land for cash crop production, whereas cash crop production enables farmers to be able to afford to purchase inputs for intensive food crop production. Such complementarities between cash and food crop production should be recognized by technical assistance programs.

Woodlots can be highly profitable in densely populated higher-potential areas and can help to reduce pressure on natural forests and depletion of soils caused by burning of dung and crop residues, as is common in Ethiopia. Provision of nurseries and technical assistance helps to promote these. Policies that undermine woodlot development, such as excessive regulation of community woodlots and prohibition of tree planting in arable areas, as exist in the Tigray region of Ethiopia, should be reconsidered.

Areas with Lower Agricultural Potential

In lower-potential areas, as in the highlands of eastern Amhara and Tigray in Ethiopia, the comparative advantage is not in coffee production, and in most cases also not in intensive cereal production using high levels of inputs. We have seen that the profitability of inputs such as fertilizer and improved seeds is low in these areas, and as a result, agricultural extension and credit promoting them have had limited influence. Investments in some soil and water conservation practices and use of some land management practices such as reduced tillage and use of manure and compost have shown more promise as a result of low organic matter and soil moisture–holding capacity of the soils of these areas. Targeted use of costly inputs such as fertilizer and improved seeds in combination with soil and water conservation or water-harvesting measures to ensure adequate soil moisture to enhance the effectiveness of such inputs is likely to be more effective than blanket use of inputs. Agricultural technical assistance programs are likely to be more effective if they take such potential synergies into account.

Livestock are very important in the livelihood strategies of most households in the lower-rainfall highlands, as in much of the higher-rainfall highlands. Cattle (both oxen and other cattle) contribute to higher value of crop production, both directly through use of ox traction and indirectly through increased availability of manure. However, the potential to increase incomes through cattle ownership appears to be greater for cows than for oxen in parts of northern Ethiopia, consistent with the promising effects of reduced tillage found in this environment. Opportunities to promote a shift away from dependence on oxen where reduced tillage is profitable should be explored, as this can enable increased emphasis on more profitable livestock, provide better opportunities to female-headed households and oxen-poor households, and reduce degradation of grazing lands (Chapter 12). Other livestock (e.g., small ruminants and poultry) can also yield relatively high returns in this environment, though livestock are a risky asset in drought-prone areas because they are susceptible to substantial losses during drought years as a result of feed shortages and price collapses resulting from herd liquidation. Thus, efforts to develop rural financial institutions, providing farmers remunerative and less risky savings alternatives to holding livestock as a store of wealth, could be helpful.

Efforts to improve water, feed, and fodder availability and quality are needed to achieve the potential contribution of livestock in such environments. Investments in small-scale irrigation and water harvesting, as are being promoted in drought-prone areas of Ethiopia, can have benefits for livestock as well as for crop production (Sileshi, Tegegne, and Tsadik 2003), though most emphasis has been on crop production. Improved management of communal grazing lands is also needed. Although many communities in northern Ethiopia are protecting some of their grazing lands (Chapter 10), there is little investment in planting fodder trees, shrubs, or grasses in most such areas. Without investments in increased biomass productivity of such areas, the productivity of livestock will continue to be limited by the productivity of the natural vegetation growing in communal areas and the limited availability of crop residues. Availability of appropriate technical assistance, credit, and health facilities oriented toward improved livestock production can also be very helpful, as suggested by the positive effects of some NGO programs on livestock development in the Amhara region (Chapter 6). Continued efforts to provide vaccination and animal health services are also needed.

Improved management of communal lands can also contribute to increased income from forestry and related activities, such as beekeeping. Tree planting is one of the most potentially profitable investments available to communities in these less-favored environments and can contribute to increased agricultural production and improved land management by reducing the need to burn dung and crop residues for fuel, enabling more of these materials to be recycled to the soil (Jagger and Pender 2003). However, the effectiveness of collective action to manage community woodlots in northern Ethiopia has been undermined by a regulatory approach that has limited communities' sense of empowerment to harvest poles and other materials from the woodlots. Devolution of real authority over community woodlots to local communities, groups, or households is needed to achieve their potential (Jagger, Pender, and Gebremedhin 2005). There is also potential to promote tree planting through allocation of degraded communal lands for private tree-planting activities, as is being promoted in Tigray and Amhara. Such efforts have shown promise of achieving higher survival rates of trees and higher economic returns with less intensive labor input than on community woodlots, though it is still too early to be sure of their effects (Jagger, Pender, and Gebremedhin 2005). Even on these privately managed woodlots, most households still require permission to be able to harvest poles, which may undermine their incentive and ability to manage these woodlots profitably.

Beyond relaxing such regulations, governments should also reconsider other policies that restrict tree planting, such as the provisions of Tigray's 1997 land policy proclamation banning planting of eucalyptus trees or prickly pear cactus on cultivable land. The economic returns to tree planting can be much higher than the returns to crop production, tree planting can increase a household's food security by providing a source of income in a drought or other calamity, it frees labor that may be used more profitably in off-farm activities or other pursuits, and the environmental effects (though often hotly debated) are not clearly negative relative to annual crop production (Getahun 2003; Jagger and Pender 2003). Where there is serious concern about the effect of eucalyptus or other trees in arable lands on neighboring farmers or water sources (e.g., negative effects on availability of water, nutrients, or sunlight), local communities may find better ways to address this concern than an outright ban, such as by regulating tree planting to be a minimum distance from neighbors' fields or water sources. Continued promotion of tree planting through technical assistance and provision of nurseries is also important.

Investments in irrigation are also needed where this is feasible and profitable, especially in drought-prone environments. We have seen that small-scale irrigation can have large positive effects on production in such environments (Chapter 9), but this is not always the case (Chapter 5). Careful study is needed to better understand the extent to which small-scale irrigation is succeeding or failing in these contexts and the main factors contributing to success or failure. Policies and investments to address the problems discussed earlier, such as inefficient traditional irrigation practices, lack of trained manpower to design irrigation structures, lack of coordination between organizations promoting irrigation development and those responsible for maintenance of irrigation structures and watershed conservation, and the need for technical assistance, credit, infrastructure, and institutions to facilitate production and marketing of higher-value irrigated crops could be very helpful in attempts to ensure that irrigation investments achieve their full potential. The problems limiting the effectiveness of microdams and other small-scale irrigation investments, and the negative health effects of these investments, should raise a cautionary flag concerning efforts to rapidly promote other water-harvesting approaches such as the small ponds for supplementary irrigation that are now being widely promoted in Ethiopia. There is a need to assess the problems and constraints that may lead to worse than anticipated results of these investments before they are adopted on a massive scale. Targeting such investments to areas where the benefits are substantial and the health and other risks are low (e.g., higher elevations), or making these investments in combination with other investments in necessary health measures (e.g., mosquito nets), may be a more effective approach.

Regardless of what is done to promote improved agricultural production in less-favored areas of the East African highlands, these areas are likely to remain food-deficit areas and dependent to a significant degree on off-farm income for the foreseeable future. Food-for-work programs account for a substantial share of household income in drought-prone areas such as Tigray and eastern Amhara (Pender 2004), acting as employment guarantee schemes and an important means of preventing droughts from causing major famines. Efforts to promote development of the nonfarm economy in these regions will continue to be important, for example, through public investments in infrastructure, education and vocational training, and attraction of private investment in industry. Until such efforts have succeeded in bringing much broader development of the nonfarm economy, employment guarantee schemes through food-for-work or other mechanisms will continue to be needed as a safety net in these areas to prevent famines and the downward spiral of asset liquidation, declining production, increasing poverty, and land degradation that such famines can trigger (Amare 2003). However, this should be done in a way that minimizes disincentives to pursue productive alternative livelihood strategies or make productive investments.

Policy and Program Lessons

A primary lesson of the studies in this book is the critical importance of identifying and promoting profitable income strategies and land management practices in different biophysical and socioeconomic contexts. This lesson appears obvious but needs to be emphasized because technical assistance and credit programs sometimes attempt to promote activities and technologies that are not profitable in many contexts. The ineffectiveness of agricultural extension and credit focusing on promoting fertilizer and improved seeds in drought-prone areas of northern Ethiopia is a clear example, but there are many others highlighted in the case studies of this book.

Profitability depends not only on the price of outputs and purchased inputs but also on the opportunity costs of nonpurchased inputs such as land and family labor. Despite impressive effects of many organic technologies on crop yields in many settings, these technologies often entail high land or labor costs that make the technologies unattractive to farmers, as argued by Delve and Ramisch in Chapter 13. Such costs must be taken into account in efforts to promote technologies. Identification of what domains and for what types of households such costs and constraints are likely to be prohibitive can help in targeting technical assistance efforts. For example, improved fallow technologies are not likely to be widely adopted in very densely populated areas, except in niches such as along field boundaries or on degraded plots; and highly labor-intensive technologies are less likely to be adopted by extremely labor-constrained households, such as female-headed households and HIV-affected households.

Technical assistance programs are more likely to be successful in identifying and promoting profitable technologies if they take a farmer-centered, demand-led approach and provide farmers with a broad menu of options rather than a very narrow package of technologies. Top-down, target-driven approaches to technical assistance are likely to fail, as shown in this book and in numerous other studies. Farmers need information about the potential profitability of alternative livelihood and land management options in different contexts, and not just blanket recommendations to maximize yield or minimize soil erosion, which are unlikely to be their primary objectives. Farmers also need information about postharvest and marketing technologies, prices and marketing options, especially for newer commodities with which they are less familiar.

The profitability of land management practices can be increased in several ways. Where high-value crops are agronomically and economically feasible, the return to applying labor and other inputs intensively is generally higher for such crops. Thus, promotion of cash crops, where feasible, together with suitable land management practices can help to promote more profitable and sustainable land management. Development of improved technologies, such as drought-tolerant or more fertilizer-responsive crop varieties can also help increase the profitability and reduce the risks associated with fertilizer or other inputs. Continued applied research and dissemination of improved land management options, such as agroforestry, improved forages, and other promising technologies for specific recommendation domains, are also needed. Investments in infrastructure and market institutions can help to increase the profitability and reduce the market risk of producing high-value crops as well as other commodities. However, it is important to have realistic expectations about how much can be accomplished by such investments and where they will have the most near-term influence. Where such investments can enable expansion of what is already a highly profitable enterprise, such as dairy production in periurban areas, they will likely yield high returns in the near term. By contrast, investments in road building in remote areas will likely not have major effects on agricultural production or household incomes in the near term. Being a two-hour walk to the nearest all-weather road or town instead of three hours likely makes little difference in terms of farmers' current livelihood or land management options. Nevertheless, construction of roads and other infrastructure is an important step toward longer-term rural development, and its importance should not be discounted even if it does not show immediate effects. Such investments are part of the long-term development process.

Development of farmer organizations, such as cooperatives, can be very helpful where there are potentially profitable commodities for such organizations to promote, by reducing transactions costs in acquiring inputs or marketing outputs, and providing access to credit and technical assistance. However, as with most interventions, such organizations are not a panacea, and we have seen examples where these are not associated with higher production or incomes. Further research is needed to identify what circumstances favor the success of such organizations, but certainly the profitability of the commodities that they deal with is one of the primary factors.

In addition to expected profitability, risk is also, of course, important to farmers in the East African highlands. For farmers in high-potential areas, weather risk is often less important than market risk, and addressing this requires development of market infrastructure and institutions, as discussed previously. Problems of pest and diseases are also a major concern, especially (but not only) in humid environments, and investments in appropriate infrastructure, collective action, research, inputs, and technical assistance are critical to addressing these concerns (e.g., vaccination campaigns, tsetse eradication efforts, human and animal health facilities, development of disease- and pest-resistant varieties, training in integrated pest management).

In drought-prone environments, weather risk is usually the primary concern. Coping with risk is of necessity a constant preoccupation of poor households in these environments. Livelihood and commodity diversification is one common strategy that households pursue to address risk as well as for other reasons (e.g., to more fully utilize labor and other household resources or to exploit economies of scope among different activities) (Barrett, Reardon, and Webb 2001). Education, technical assistance, and credit programs should recognize the importance and potential of the variety of income strategies that households may pursue, facilitating options and not focusing too narrowly on a particular commodity or set of land management technologies.

Irrigation, other water-harvesting technologies, and soil and water conservation measures can help to reduce risk and increase profitability of agricultural production, especially in drought-prone environments. However, such efforts must be carefully designed and implemented (especially if done on a large scale) to address the technical, institutional, and market problems such as have been discussed in the context of Tigray (but which are likely not limited to Tigray). This need appears to be at odds sometimes with the desires of policymakers and program managers, who may feel pressure to rapidly scale up such efforts and achieve broad consequences. In some cases, the availability of food aid or other assistance or the goal of providing employment may contribute to the desire to implement public works projects rapidly and on a large scale, even if production or conservation objectives may not be adequately served (Bantirgu 2003). Because irrigation and water-harvesting projects can have substantial negative health and environmental effects as well as being costly to implement and maintain, it is advisable for policymakers and development agencies to resist such pressures and take a more careful approach to ensure that such negative effects can be minimized, while the economic and social benefits of such projects are maximized.

Education can contribute substantially to households' livelihood options and to household income, although these occur only in the long-term. In some cases, this will also contribute to improved land management. However, this will not always be the case, as more educated households are sometimes less prone to adopt labor-intensive land management practices. This is not an argument not to invest in education, but it suggests that the potential trade-offs of improved education for land management should be recognized and addressed. For example, incorporating teaching about the principles of sustainable land management into educational curricula could help to improve farmers' capacity to innovate and adapt technologies to their particular circumstances.

Even when profitable and risk-reducing technologies are available, they may not be adopted by households because of the constraints that they face. For example, fertilizer and improved seed use are often constrained by farmers' lack of access to cash and credit, even where they would be profitable. Improved fallows are constrained because of farmers' lack of land. Application of organic materials is often limited by scarcity and competing uses for these materials and by labor constraints. Knowledge constraints may also limit adoption of many natural resource management technologies (e.g., integrated pest management, integrated soil fertility management) that require adequate understanding of local conditions and the principles underlying the technologies to adapt them to local conditions. Many of these constraints may be binding for smallholders in the East African highlands; thus, an integrated approach that accounts for and addresses multiple constraints is needed.

Special attention is needed to address the constraints of women farmers. As we have seen, in some places they are disadvantaged by cultural norms. They often face much tighter labor constraints than male farmers and male-headed households, and women are sometimes inhibited from making decisions about land investments and land management practices while their husbands are away, as seen in western Kenya. Addressing these problems requires special attention in agricultural research, technical assistance, education, training, and credit programs to provide livelihood and land management options that are suitable to the circumstances of women farmers. Households affected by HIV/AIDS and other diseases also require special consideration, particularly when labor-intensive methods are being promoted.

Land tenure policies and traditions also sometimes discriminate against women farmers. For example, households that move away from their village in northern Ethiopia for more than two years lose access to their land; this restriction may be very limiting to a widow who is not able to farm productively but is prevented from moving to town where she may have better employment opportunities. Addressing such problems requires changes in social attitudes as well as policies.

Land tenure issues have implications beyond the effects on female farmers, especially regarding the means of acquiring land. In Ethiopia, where land sales are prohibited, alternative means of land transfer can have important effects on land management and productivity. We have seen that government land redistribution can increase farming intensity and productivity in the near term but may also undermine productivity in the long term by reducing tenure security. Land lease markets in many areas appear to function relatively efficiently, though this is not always the case, as seen in Tigray. This may be a result of government regulation of land lease markets in Tigray (Pender and Gebremedhin 2004) and argues for avoiding such restrictions.

We do not see significant productivity advantages of freehold tenure over customary or other tenure systems in Uganda, consistent with findings of other studies from Kenya and elsewhere in Sub-Saharan Africa. Thus, there is little argument for broad-based land titling efforts, although there may still be advantages of land titling in some socioeconomic contexts (e.g., in periurban areas where the demand for land titles to facilitate sales and access to credit may be high). This is consistent with the general theme of this book that such interventions should be targeted to the development domains where they can yield high returns.

Population pressure was found in several studies to contribute to intensification of agriculture, as argued by Boserup (1965) and her followers. However, rural population pressure is associated with land degradation in some studies, and we have seen that population pressure and small farm sizes inhibit adoption of some improved land management practices, such as improved fallows. Reducing population pressure in densely populated highland areas thus may help to improve some aspects of land management and reduce land degradation. However, it is clear that population pressure is not the most important factor contributing to land degradation in the East African highlands, as demonstrated by the favorable land management outcomes in the densely populated highlands of central Kenya.

Research Implications

A great deal has been learned from the research studies included in this book. Still, these studies have not been able to cover all of the important research issues related to achieving improved livelihoods and sustainable land management in the East African highlands; many important information gaps remain to be investigated.

Despite the primary importance of profitability of livelihood and land management options, there is still a dearth of information about this. The studies in this book have shed light on the profitability of some options in some circumstances, but much more needs to be known in order to develop effective targeted interventions. There is little systematic and reliable information collected on a regular basis about the profitability of different crop, livestock, or forestry activities in the different domains of the highlands or the profitability of land management practices linked to these different livelihood activities. Beyond estimating private profitability, information on the social profitability of alternative activities in different domains is also needed, taking into account externalities, market price distortions, nonmarketed inputs and outputs, and other factors.

The social profitability of alternative public programs and investments also needs to be better understood, to help guide development investors and governments as to where the highest returns can be expected. For example, there is limited information on the social costs and benefits of investments in small-scale irrigation and other water-harvesting measures, as mentioned previously. The returns, costs, risks, and social and environmental effects of other public investments, such as investments in infrastructure, education, agricultural research and extension, and others are also not well quantified. Several of the chapters in this book provide a solid basis to build on in addressing this information need, but more research is needed to estimate the costs, risks, and social and environmental effects.

To better assess such effects, more long-term research with panel data sets and dynamic models is needed to better understand the dynamic relationships between policy and program interventions; among local institutions and endowments of physical, human, natural, financial, and social capital; between community and household responses in terms of collective action, livelihood strategies, and land management practices; among changes in production, income, land degradation, and other outcomes; and the feedback effects of these responses and outcomes on interventions, local institutions and endowments, and future responses. It is difficult to know the extent to which communities and households are trapped in a downward spiral, stagnation, a virtuous upward spiral, or another kind of dynamic development path, or what the most effective interventions will be to promote sustainable development, without better understanding of the dynamic situations that are occurring and the key causal factors and feedback relationships that are driving them.

For example, some communities may be falling deeper into poverty and depleting all of their endowments as a result of a lack of sufficiently profitable investment opportunities for any type of capital. Unless profitable investments of some kind can be identified, a sustainable development solution may not be possible without promoting large-scale emigration out of such areas. In other cases, communities and households may be depleting their natural capital but investing in other forms of capital that are yielding higher returns (Pender 1998). Such a development path may be sustainable as long as households are aware of the depletion of natural capital and will eventually address it adequately as the returns to investing in natural capital increase relative to the returns to investing in other types of capital (Pender 1998). Alternatively, they may not be sufficiently aware of the depletion, may not have adequate incentive or ability to address it because of externalities or other market failures (e.g., absence of credit, land tenure insecurity), or may be crossing a threshold into a poverty-degradation trap in which the costs are too high or the marginal returns too low to maintain or restore the natural capital stock (Pender 1998; Barrett et al. 2002).

It matters a great deal for the appropriate policy or program response which situation householders are in. If there is sufficient awareness and no major market failure, the problem is likely to take care of itself as the relative returns to investment in different types of capital adjust (Pender 1998). If there is insufficient awareness of the degradation problem, educational and technical assistance approaches may be sufficient to solve it. If the problem is caused by market failures or a degradation trap, more intervention will be necessary to address these causes. Without more information to diagnose what kind of dynamic situations communities and households are facing, it will be difficult to prescribe effective remedies.

Even before such dynamic information becomes available, however, it would be very useful to identify areas and household types for whom profitable livelihoods and land management practices are feasible but are not being pursued. Where such untapped potentials exist, it is useful to investigate the reasons why and identify the extent to which policies, public investments, and programs could facilitate fulfillment of these potentials. The research in this book has identified some examples of such potentials, such as production of high-value commodities in high-potential areas close to urban markets and tree-planting activities in many other areas. The research has also provided some insights into the reasons why such potentials are not being more widely exploited; these include the lack of development of cooperatives in Ethiopia and Uganda, in part because of politicization and poor performance of these in the past, and overregulation of tree-planting activities in northern Ethiopia. Further case study research into these and other promising livelihood and land management options could yield valuable insights.

More historical case study research investigating the dynamics of changes in income strategies, land use, land management, land degradation, productivity, and welfare outcomes, such as the influential case study of Machakos by Tiffen, Mortimore, and Gichuki (1994), would also be valuable. Such long-term historical studies can yield a wealth of insights into the processes of land degradation or improvement and into key driving forces and responses that are not possible to achieve using only cross-sectional surveys of the type emphasized by many of the studies in this book. However, the conclusions of such a well-focused case study can easily be overgeneralized. Similar studies are needed in different development domains and different historical, political, and social contexts to draw more robust and generalizable conclusions about the dynamics of land degradation, causes, and responses in the East African highlands. A combination of quantitative survey and qualitative case study research methods, building on the strengths and addressing the weaknesses of each approach, is more likely to produce clear and robust conclusions than reliance on any single approach.

The scale of interventions and their effects also need to be better understood and have been addressed only in a limited fashion in this book. Interventions that are able to increase production and household income when pursued on a small scale may lead to quite different effects when implemented on a large scale. The negative effects of rapid adoption of improved maize varieties and fertilizer on maize prices in high-potential areas of Ethiopia have been cited, but other examples of such scale-dependent effects could be found. Research tracing effects across scales is needed, from assessing influences of policy and program interventions on adoption decisions at the plot and household scale and their implications for local natural resource conditions to the effects on prices and other outcomes at the community, national, and regional scales. The feedback effects occurring between these scales must be better understood and accounted for in planning interventions if the benefits of such interventions are to be maximized and unintended negative effects are to be minimized. The use of bioeconomic models at household, community, and higher scales are likely to be essential for an understanding of these effects.

Notes

1. However, substantial efforts were made in the chapters to base the empirical specification on sound theoretical models and to control for threats to causal interpretation such as nonrandom selection of cases, omitted variables, and endogenous explanatory variables. Thus, although causality cannot be proven, the studies have addressed many of the usual reasons why the relationships between explanatory and dependent variables may fail to be causal ones.

2. Interestingly, Deininger et al. (2003) also found that past land redistributions were associated with more tree-planting investments. They argued that this may be because tree planting increases tenure security, but it may simply have been the result of young households planting trees around newly constructed houses on land acquired through redistribution, as trees are commonly planted around the homestead in Ethiopia.