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Resource degradation, low agricultural productivity, and poverty in sub-Saharan Africa: pathways out of the spiral

Simeon Ehui*, John Pender**

Abstract

Sub-Saharan Africa (SSA) has the lowest agricultural productivity in the world, while almost half of the population lives below US$1 per day. The biggest development policy challenge is to find appropriate solutions to end hunger and poverty in the region. Building on several years of empirical research conducted in East Africa, this paper identifies potential strategies for sustainable development in this region. In general, the empirical evidence reviewed confirms that different strategies are needed in different development domains of SSA. Nevertheless, some elements will be common to all successful strategies, including assurance of peace and security, a stable macroeconomic environment, provision of incentives through markets where markets function, development of market institutions where they do not, and public and private investment in an appropriate mix of physical, human, natural, and social capital. The differences in strategies across these domains mainly reflect differences in the mix of those investments as influenced by different comparative advantages.

JEL classification: Q01, Q16, Q24, Q38

Keywords: resource degradation; agricultural productivity; policy options; development domains

1. Introduction

About two thirds of the 627 million people living in sub-Saharan Africa (SSA) depend on agriculture for their livelihoods. Almost half of them live on less than US$1 per day. Most of the poor live in rural areas, and it is estimated that there are 236 million agricultural poor representing 60% of the agricultural population and 80% of the total number of poor in the region (Dixon et al., 2001). Therefore, agriculture continues to remain important, and indicators of rural well-being are closely related with agricultural performance.

While agricultural output is growing, productivity is not. Food production per capita has declined by 17% in SSA from an already low level since 1970, the most of any major region of the world (Figure 1). Cereal yields have remained stagnant since the mid-1970s, while yields have doubled in other regions of the developing world, and now average only one third of yields in other developing regions (Figure 2). Yields of other food crops and livestock have also declined since the 1970s (World Bank, 2000a). Beef yields have decreased by 10% since 1970 (Figure 3). Low productivity has eroded the competitiveness of African agriculture in the world market; as a result most countries in the region have become net importers of food commodities.

Many factors have been suggested as causes, with some emphasizing the Malthusian link between rapid population growth, low agricultural productivity, and resource degradation (World Commission on Environment and Development, 1987; Cleaver and Schreiber, 1994), and others market failures (Holden and Binswanger, 1998), or government and institutional failures (World Bank, 1994). Clearly, there is no shortage of reasons to explain the failure to initiate sustainable development. What are needed are effective strategies to reverse the downward spiral.

In this paper it is argued that no single strategy will work for SSA. The key is to identify and implement

* *The World Bank, Washington, DC, USA.*
** *The International Food Policy Research Institute, Washington, DC, USA.*

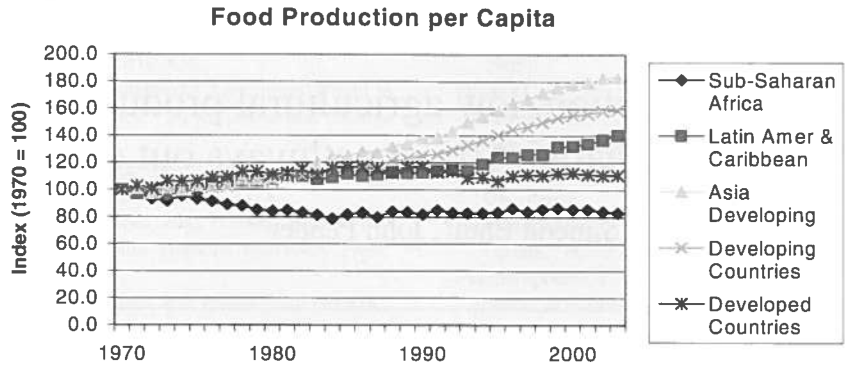

Figure 1. Food production per capita. *Source:* FAOSTAT 2004.

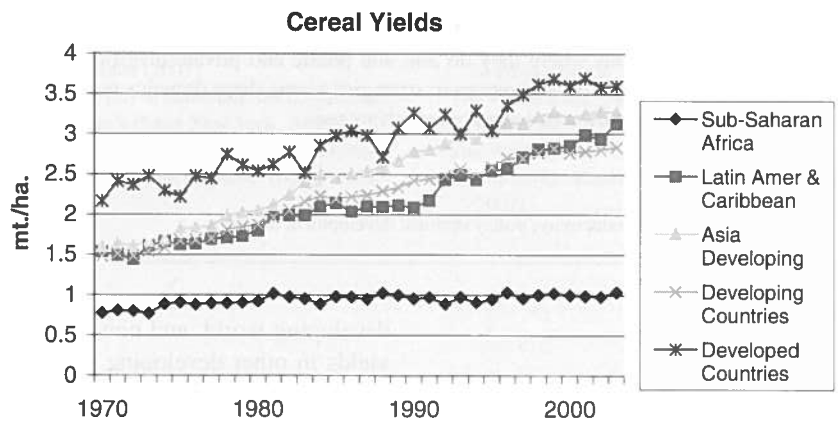

Figure 2. Cereal yields. *Source:* FAOSTAT 2004.

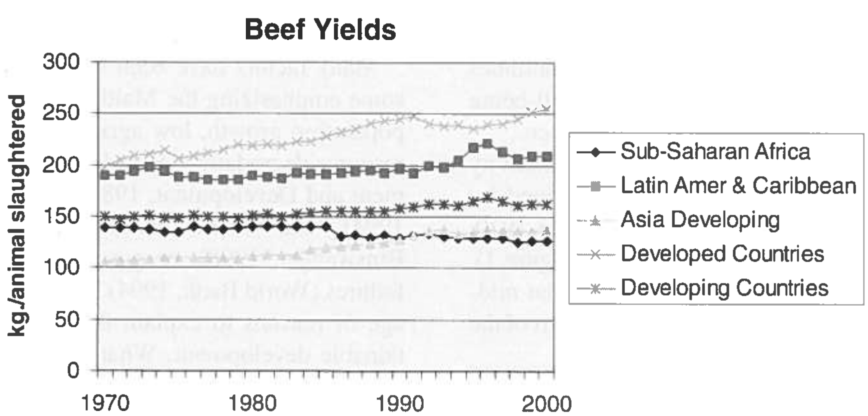

Figure 3. Beef yields. *Source:* FAOSTAT, 2004.

effective policies and strategies for different circumstances in the region. Essential to such strategies will be investment in an appropriate portfolio of physical, human, natural, and social capital, which will differ from one place to another depending on potential comparative advantage. The argument draws on the results of several years of empirical research conducted in East Africa where an attempt has been made to identify strategies for sustainable development based on comparative advantage. The lessons learned can serve as a basis for similar analyses in other regions of the subcontinent.

2. Explaining SSA's poor agricultural performance

Socioeconomic, policy, biophysical constraints, and unsustainable land management practices have been identified as major causes of low food productivity, soil fertility decline, and degradation of the agricultural land resource in SSA. The region has also been afflicted with poor resource endowments (including climate extremes, poor land quality, and endemic livestock and human diseases), and poor policies, including low public investments that have consistently undermined agriculture and the infrastructure and institutions that serve it (Binswanger and Townsend, 2000; Rosegrant et al., 2001).

2.1. Poor resource endowments

Adverse endowments and biophysical conditions have contributed to SSA's poor agricultural development. Although land is abundant, more than half of the region lies within the arid and semi-arid zones. High temperatures accelerate the degradation of organic matter, thus severely reducing the water-holding capacity of the soils and making them deficient in nitrogen and phosphorus. Only 6% of the land is of high agricultural potential, considering climate and soil constraints (Tegene and Wiebe, 2003). The soils in most of SSA are more marginal and less responsive to inputs that in Green Revolution areas of Asia (Voortman et al., 2000). Superimposed on these inherently fragile resources is the continuous removal through cropping of plant nutrients in quantities greater than those being returned by mineral or organic fertilizers. Average rates of nutrient depletion during the past 30 years indicated losses of about 660 kg/ha of nitrogen, 75 kg/ha of phosphorous, and 450 kg/ha of potassium per year (Smaling et al., 1997). The situation is even more desperate in the arid zone, where the soils are shallow, calcerous, and saline.

The continuous decline in the stock of soil nutrients is linked to soil fertility management practices that are not properly aligned to continuous cultivation under increasing population pressure. Many Asian countries were able to achieve dramatic increases in crop yield through high rates of adoption of inorganic fertilizers on irrigated lands in conjunction with the high-yielding varieties of rice and wheat. Use of inorganic fertilizer in SSA averages less than 10 kg per cultivated hectare, less than 10% of the average intensity of fertilizer use in other developing regions of the world (Figure 4). Application of organic materials such as manure and compost, and use of nitrogen-fixing leguminous plants to restore soil fertility are also limited (Barrett et al., 2002; Nkonya et al., 2004; Place et al., 2003a).

Other natural factors that hinder agriculture include geography, the risk of drought, low-quality feed for livestock, and endemic livestock and human disease. Many countries are landlocked, and the resulting high transportation costs lead to high prices of imported inputs relative to local output prices (especially for export commodities). Uncertain rainfall is a major risk, especially in the dryland areas, also contributing to low adoption of fertilizer and other inputs in crop production. In the humid and sub-humid zones, where crop production is relatively less risky, trypanosomiasis reduces cattle and milk off-take by up to 30% and 40%, respectively, and reduces the work performance of draught animals by up to 30% (ILRI, 1998). Among the human diseases, malaria, tuberculosis and, more recently, HIV/AIDS have had a devastating impact on human lives and on agricultural performance. In 2000, about 70% of the people estimated to have AIDS worldwide were found in SSA, with 16 countries having more than 10% of their adult population affected (FAO, 2001).

2.2. Poor policy environments

Low producer prices for crops and livestock have discouraged farmers from investing in agriculture and

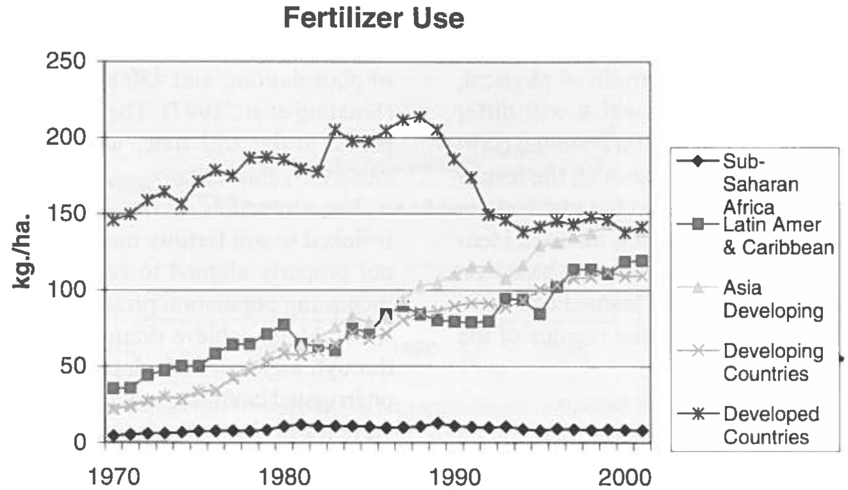

Figure 4. Use of inorganic fertilizer. *Source:* FAOSTAT 2004.

natural resource conservation measures. Disincentives were created by overvalued exchange rates in the 1970s and 1980s that resulted in loss of competitiveness in many countries. Agricultural marketing and input supply systems were dominated by the public sector, inhibiting the development of private traders and farmer cooperatives.

Despite high tax levels, there was little investment in rural public services and infrastructure. Urban bias favored investments that benefit more politically powerful urban elites (Lipton, 1993). Less than 10% of public spending has gone to agriculture (World Bank, 2000b). In addition, subsidies for fertilizer and credit usually benefited larger, export-oriented farmers (Binswanger and Townsend, 2000). While governments in East and South Asia encouraged the adoption of productivity-enhancing technologies through significant investments in the rural infrastructure necessary to enable the commercialization of smallholder agriculture, SSA's road and communication infrastructure remains undeveloped and inadequate (Rosegrant et al., 2001).

In part because of poor infrastructure, input markets have been poorly developed and inefficient, limiting long-term planning by farmers, while government policies have contributed to the poor performance of input markets. Fertilizer policy in SSA has generally been disastrous, with costly subsidies distorting markets during the 1970s and 1980s. Elimination of subsidies and liberalization of exchange rates through structural adjustment programmes in the 1980s and 1990s resulted in higher fertilizer prices and diminishing use. Benin et al. (2003a, 2003b) argue that the low adoption and consumption of inorganic fertilizers is due mostly to high cost, lack of credit, delivery delays, lack of irrigation, low variable returns, and policy deficiencies. The current policy environment in SSA, which is generally opposed to efforts to stabilize commodity prices or subsidize fertilizer, other inputs, or credit, is less favorable to the adoption of Green Revolution technologies than the policies existing in countries where and when the Green Revolution occurred (Dorward et al., 2004). As a result of such limitations, organic sources of nutrients are often proposed as an alternative to inorganic fertilizers (Reijntjes et al., 1992). However, many organic methods are at best only a buffer to the system, do not redress nutrient depletion (Palm et al., 1997), may be limited in supply, and are difficult to use in sufficient quantities to restore soil nutrients due to the low concentration of nutrients in organic materials, especially phosphorus (Palm et al., 1997; Larson and Frisvold, 1996).

Output markets are also poorly developed and inefficient. High transport costs; high costs of vehicles, spare parts, and fuel; and poorly coordinated marketing chains depress farm prices. Lack of marketing institutions and infrastructure, such as appropriate grades and standards, price information systems, quality regulation, contract enforcement, storage facilities, and marketing credit all contribute further to high transaction costs (Gabre-Madhin and Amha, 2003). Heavy regulation of markets severely undermined the development of private markets in the 1970s and 1980s. Although markets have been liberalized, private investment is still often undermined by unpredictable food aid imports or other trade interventions, high taxes and fees on market activity, corruption, and other problems.

Complementary investment in irrigation systems has also been limited. Although irrigation potential is high, less than 4% of the total arable land has been irrigated since 1965. In 1965, there were more tractors per hectare of arable in SSA than in South and Southeast Asia, but by 1995, there were more than four times as many tractors per hectare of arable land in South and Southeast Asia. Public spending on agricultural research and development, despite their high returns (Alston et al., 2000), has also been poor, as they remain a low priority. Only 0.7% of agricultural GDP was spent on agricultural research in SSA in 1991, compared to 2.4% in developed countries (Alston et al., 2001).

3. Policies and strategies to reverse the downward spiral

The appropriate strategies will depend upon the potential comparative advantage of a particular location. Many factors combine to determine comparative advantage and the appropriate response to it, including agricultural potential, access to markets and infrastructure, and population density (Pender et al., 1999).

Agricultural potential determines the absolute advantage (technical efficiency) of producing agricultural commodities in different locations. Access to markets and infrastructure greatly influences which commodities have a comparative advantage in a particular location, given its agricultural potential. For example, a community may have absolute advantage in producing perishable vegetables, due to rainfall and soil conditions, but may not have a comparative advantage if it is located far from the market. Population pressure determines the labor intensity of farming (Boserup, 1965).

These factors interact with each other. For example, people tend to migrate to or stay in places with higher agricultural potential or market access, resulting in higher population densities in such areas. Conversely, population density can affect the development of markets and provision of infrastructure and rural services, or affect agricultural potential by affecting land degradation or improvement. Where population densities are high, per capita costs of investment in infrastructure and services are lower and transportation and transaction costs are generally lower, thus facilitating competitive markets for both outputs and inputs. In sparsely populated areas there is also little demand for credit and the supply of credit is limited by lack of diversification and absence of suitable collateral, as land has little value (Binswanger and Townsend, 2000). The resulting high transaction costs and absence of credit markets in sparsely populated areas inhibits technology adoption and sustainable management of the resource base.

The next section discusses as a case study the development strategies for the East African Highlands with a focus on Ethiopia, Kenya, and Uganda. The highlands, which are within the semi-arid, humid, and sub-humid zones and are primarily found in East Africa, cover only 5% of the total area, but contain about 14% of the population of the subcontinent due to the relatively favorable climate and soil conditions.

3.1. Development strategies for the East African highlands

The East African highlands—areas above 1,200 meters above sea level in Burundi, Ethiopia, Kenya, Rwanda, northern Tanzania, and Uganda—are home to 53% of the population of these countries (Place, 2000). Rural population densities are the highest in Africa; well above 500 people per square kilometer in some areas. Consequently, farm sizes are small, averaging around 1 hectare. Most of the highlands have favorable rainfall, averaging over 1,000 mm per year, and many sites have two growing seasons. There are a variety of soil types, though most are clayey with relatively good stability. Therefore, most of the area has high potential, although potential varies greatly and much farming takes place on steeply sloping land.

A wide range of agricultural crops is found, especially in the bimodal rainfall highlands, where high-value commodities such as tea, coffee, dairy, sugar organization—the Dairy Development Enterprise (DDE)—acts as a guaranteed buyer of fluid milk at set prices. Due to the high perishability of milk and limited development of transport and marketing facilities, most fresh milk is supplied through informal market channels by producers in or close to the city, or by producers within a few kilometers of a DDE collection center (Ahmed et al., 2003b; Holloway et al., 2000). In a few places, "cooperatives" have been established by a dairy development project, but their coverage is limited. Most farmers who produce a surplus of milk process it themselves into butter or cheese to sell in local markets (Holloway et al., 2000).

High transaction costs have limited the development of dairy marketing, while low administered prices and an overvalued exchange rate have also reduced profitability (Staal and Shapiro, 1996). Farmers' poverty and lack of credit for purchasing dairy animals have also limited the adoption of higher-yielding crossbred cows (Freeman et al., 1999), despite evidence that such animals are profitable (Ahmed et al., 2003a; Holloway and Ehui, 2002). Concerns about susceptibility of crossbred cattle to local diseases are also a constraint on widespread adoption (Holloway and Ehui, 2002). Severe shortages, low quality, and seasonal unavailability of feed similarly remain as major constraints to livestock production in Ethiopia (Ahmed et al., 2003b). The net result has been to limit the development of dairy production, despite evidence that Ethiopia could be efficient in peri-urban production (Staal and Shapiro, 1996). These constraints need to be addressed and technological change should be promoted in order to increase milk production.

Planting of eucalyptus trees is also profitable, especially in areas of good market access, adequate rainfall, and moderate temperatures, as a result of the extreme scarcity of fuelwood and the high value of the poles for construction, ploughing materials, and other purposes (Jagger and Pender, 2003). Holden et al. (2003) predict that allowing farmers to plant eucalyptus on land unsuitable for crop production in a community in North Shewa could increase household incomes by at least 30%, with little impact on soil conservation incentives or erosion of farmland. Okumu et al. (2002) predict that allowing eucalyptus planting on uncultivated slopes in a watershed close to Addis Ababa, along with other technological interventions focusing on improved vertisol management, could increase household cash incomes substantially and reduce soil erosion, even if eucalyptus prices were to fall substantially.

Intensification of cereal crop (especially maize) production is occurring in the central Ethiopian highlands, using high levels of fertilizer and improved seeds, stimulated by the government's agricultural extension and credit program. This program succeeded in increasing cereal production to near record levels in 2000/2001 (together with favorable weather), though the effect on farmers' incomes was less positive because of the fall in cereal prices that ensued. Many farmers' reaction to the price crash was to reduce use of inputs in cereal production in 2002, which was a possible contributing factor to the 2003 famine (Thurow, 2003). This problem resulted from limitations of the marketing and credit system, including the absence of credit for marketing, the fact that credit for inputs must be repaid at harvest, the high costs of transporting cereals from surplus to deficit regions or for export, limited storage facilities, absence of grades and standards or an effective market price information system, the limited use of the cereals as feed for livestock, and other factors leading to high transactions costs and inelastic demand for cereals (Amha and Gabre-Madhin, 2003; Gabre-Madhin and Amha, 2003).

Intensified cereal production, if it can be sustained, is complementary to dairy production and other intensive livestock operations in peri-urban areas, and development of such livestock operations can increase cereal prices and reduce their variability, as well as provide a source of manure that can be used in intensive crop production. Nevertheless, development of this potential remains low, probably in part because of the high variability of cereal supplies and prices, but also because of the need to develop markets, market institutions, and farmers' and traders' technical, financial, and managerial capacity. Concentration of supply chains, transaction costs, and economies of scale in production or marketing may limit the potential of smallholders in particular, to benefit from opportunities to produce intensive livestock and other high-value products (Delgado and Minot, 2003). The evidence cited earlier of smallholder participation in dairy and horticulture production in Kenya suggests that such barriers are surmountable, given the right economic and policy environment.

3.1.2. High-potential areas with poor market access

3.1.2.1. Western Kenya. In areas with high agricultural potential that have less favorable access to a large urban market (or to export markets), as in western Kenya, some of the options available in areas of better market access will be less feasible. Commercial production of high-value perishable commodities such as milk and horticultural crops is less likely the further away from a major market one is located. For example, Staal et al. (2002) estimate that being 10 km further away from Nairobi reduces the probability of Kenyan households using improved dairy cattle (crossbred or exotic breeds) by 0.7%. As a result, dairy production in the western highlands is much less intensive than in the central highlands. Besides the impact of market access, dairy production may also be limited by the high population density in the western highlands, which raises the opportunity cost of devoting land to feed production (Place et al., 2003c). However, both Staal et al. (2002) and Place et al. (2003b) found that market access is a more important factor than population density in determining differences between central and western Kenya in dairy production.

A wide variety of crops are grown in the western highlands, with maize and beans the dominant crops. The share of land allocated to horticultural crops is lower than the central highlands and the share of crop revenue is much lower (Owuor, 1999). Traditional industrial cash crops such as coffee and tea are also grown, though they also account for a substantially smaller share of land and revenue than in the central highlands (Owuor, 1999). Lower access to markets, processing facilities, and credit appear to be the main reasons for differences between central and western Kenya in the adoption of such high-value commodities, since agro-ecological potential, access to technical assistance, and land tenure security are similar in these two regions (Place et al., 2003a).

Private woodlots are common, much more than in the central highlands (Place et al., 2003a), largely because the returns to such investments are not sufficiently high to compete with the high-value perishable commodities in the central highlands, but are still profitable and necessary as sources of scarce fuelwood and construction materials in densely populated areas further from markets. Consistent with this explanation, Place et al. (2003b) found that the allocation of land to woodlots in Kenya is positively associated with higher population density, but not significantly affected by distance to an urban market. As a result, woodlots appear to have a comparative advantage in densely populated areas more distant from a major urban center. Rainfall and altitude also matter; woodlots are more common at higher elevation and where rainfall is higher.

Because of the small farm sizes, rapid population growth, and limited development of high-value agricultural production, many people (especially men) migrate out of the western highlands. Nearly 40% of household income comes from nonfarm income, due in part to such migration (Place et al., 2003a). While this income benefits the household, temporary migration is also associated with problems such as increased prevalence of HIV/AIDS. Thus, despite high population density, there is often a scarcity of labor for agriculture, which can undermine the ability of farmers to use labor-intensive soil conservation methods (Place et al., 2003c). Furthermore, the temporary absence of male household heads may undermine decisions about land management, as there is wide variation in the extent to which women are allowed to make such decisions.

Due to the limited production of cash crops and the relatively low use of hybrid maize, use of fertilizer is relatively low in the western highlands. Only one fifth of the farmers in two survey sites in western Kenya used fertilizer (Place et al., 2003c), and the average amount of fertilizer used is only about one fifth of that used in the central highlands (Owuor, 1999). Cash constraints are a major reason for the low use of purchased inputs (Place et al., 2003c).

Organic soil nutrient replenishment approaches are being promoted by nongovernmental organizations (NGOs), contributing to significant adoption: over 70% of households apply manure and 40% apply compost in the study sites, while 10% to 30% of households have adopted agro-forestry practices where they are being promoted (Place et al., 2003c). Such technologies (e.g., leguminous cover crops in an improved fallow rotation, biomass transfer, manure use) have shown good potential to increase agricultural production in western Kenya and eastern Uganda, but are not attractive to farmers in many circumstances. Where land is scarce, farmers are reluctant to give up crop production on a field for even one season of improved fallow, even if total production over two seasons would be significantly increased (Delve and Ramisch, 2003). High labor requirements also limit the adoption of such practices, especially by labor-scarce households, such as female-headed households. Thus, adoption of such practices remains low except where they have been intensively promoted, despite their potential to increase food production and reduce land degradation. The downward spiral of declining fertility, productivity, and income is thus not likely to be broken by the availability of such technologies, unless maize prices improve relative to input costs or farmers shift to higher-value crops, and demand-driven technical assistance responsive to the opportunities and constraints of farmers in diverse settings becomes broadly available.

3.1.2.2. Highlands of Uganda. In the highlands of eastern Uganda, the dominant livelihoods are production of coffee (high value arabica), cereals (primarily maize), and bananas (Pender et al., 2001b). The comparative advantage of the region in high-value coffee production is due to the high potential of the volcanic soils and the climate. Bananas are produced primarily for subsistence, while maize is both consumed and sold. Cattle raising is important as a secondary occupation, while other annual crops (including vegetables) are of tertiary importance. In the southwest highlands, the dominant activities are banana and cereal production, while other storable annuals, coffee, root crops, and cattle are important secondary or tertiary activities. Perishable horticultural crops and dairy production are somewhat more important in parts of the eastern highlands than in the southwest, probably due to better access to markets (in Kenya). Nonfarm activities are less important than in Kenya, accounting for less than 10% of household income in the eastern highlands and little over 20% of household income in the southwestern highlands (unpublished IFPRI data), probably due to more limited market access in the Uganda highlands.

Adoption of improved land management technologies is even lower than in western Kenya, despite similar high agricultural potential in these regions. Only about one tenth of households use fertilizer in these regions (Pender et al., 2001b). Adoption of improved seeds is much higher than fertilizer adoption, contributing to more rapid soil nutrient depletion as improved seeds increase yields without adequate nutrient replenishment. Soil erosion also contributes substantially to soil nutrient depletion and to diminishing soil depth (Nkonya et al., 2004). Contributing to erosion problems is cultivation of steep slopes with limited investment in soil and water conservation measures, especially in annual crop systems. The most common measure used is grass strips (used by about one fourth of the farmers surveyed in the southwest highland and one third of those surveyed in the eastern highlands), which are used mainly in perennial systems (Nkonya et al., 2002). Mulching, composting, and manuring are also common, but are also used more for perennials.

The major causes of low adoption of fertilizer in Uganda include low profitability of fertilizer in many places, limited development and coverage of technical assistance programs, cash constraints, and limited availability of credit. The low profitability results from limited impacts of fertilizer on crop production in many environments (Kaizzi et al., 2002; Nkonya et al., 2002; Woelcke, 2003), as well as high transport costs and the limited size and development of the market for fertilizer. Nevertheless, fertilizer is profitable in maize production in higher potential areas of the eastern highlands (Kaizzi, 2002). Such places should be priority for technical assistance and credit focused on promoting fertilizer and complementary soil and water conservation measures. Thus, land degradation and declining agricultural productivity are likely to continue without expansion of participatory technical assistance efforts, improvements in market development, and/or a shift toward higher-value crops. Developing this potential in the highlands may thus represent a "win–win" strategy, increasing production while reducing land degradation.

Livestock production is also increasing in the eastern highlands, including some use of crossbred cows for intensive dairy production (Pender et al., 2001b). Development of livestock production is associated with higher crop production—reflecting complementarities between crop and livestock production—reduced soil nutrient depletion, and higher household incomes (Nkonya et al., 2004). Promotion of livestock development thus offers a potential pathway out of poverty, low agricultural productivity, and land degradation in the highlands of Uganda.

3.1.2.3. Southern, Western, and Central Ethiopia. A large share of the Ethiopian highlands can be considered as high agricultural potential with poor market access. For example, the average walking time to the nearest all-weather road from rural communities in higher rainfall areas of the highlands of Amhara region is nearly three hours, and walking time to the nearest bus service is more than three hours (Pender, 2001).

High-potential agricultural zones in the Ethiopian highlands (having growing periods of more than 180 days) have been classified into the humid high-potential perennials (HPP) zone, mainly in the southern and western highlands (mostly within Oromiya regional state), and the sub-humid high-potential cereals (HPC) zone, mainly in the central and northwestern highlands (within Oromiya and the western part of Amhara regional state) (Technical Committee for Agroforestry in Ethiopia, 1990). The soils are generally of good potential for agriculture, though significant areas of vertisols (heavy clay soils, more common in the HPC zone) face special management problems as they are difficult to plough and prone to waterlogging in the rainy season and cracking in the dry season. Average population density is about 100 persons per square kilometer in these regions, with average farm sizes of less than 2 hectares.

Mixed crop–livestock farming systems are dominant in both zones. In the HPP zone, the dominant crops are coffee, enset (a perennial tuber crop), and cereals, while in the HPC zone, cereals (mainly barley, wheat, maize, teff, and sorghum) dominate. In the HPP zone, enset and coffee are commonly grown near the homestead, while cereals are grown in more distant fields. In the HPC zone, eucalyptus trees are commonly planted in homestead plots. Livestock (local breeds only) are kept as a source of draft power, manure, wealth, and food in these systems.

The primary comparative advantage in the HPP zone has long been in high-quality arabica coffee. However, this advantage has been eroded because of declining world market prices. Many farmers are increasingly growing chat (a tree crop used as a stimulant), due to its relatively high profitability and lower susceptibility to diseases. Nevertheless, coffee will remain the dominant cash crop for the foreseeable future. There is also increasing pressure on coffee production from population growth, leading to increased needs for food production. Given the high costs of transporting food, as well as farmers' lack of access to consumption credit, subsistence food production is important for smallholder coffee producers, implying that land scarcity and increasing food needs are likely to constrain and may even reduce the area devoted to coffee production. The emphasis of the agricultural extension system on promoting food production may have contributed to the tension between food and coffee production (Westlake, 1998). Significant expansion in the area planted with coffee seems unlikely, especially if world coffee prices remain low.

Smallholders produce more than 80% of Ethiopian coffee in forest, semi-forest, and garden systems. Few coffee farmers use purchased inputs (fertilizer or pesticides). Under shade conditions, coffee production is not very responsive to fertilizer, so the potential for adoption is limited. Given low and uncertain prices, a shift to higher input systems is risky and unlikely. There is more potential to increase production through introduction of higher-yielding improved cultivars resistant to coffee berry disease (CBD), a risk faced by more than half of the coffee planted in Ethiopia. Resistant cultivars have been developed and disseminated that have two to three times the yield potential of traditional varieties. The extent of area replanted with these cultivars and their impacts on coffee yield is not certain, but it has been estimated to have increased national production by perhaps 10% by the late 1990s (Westlake, 1998). Continued development and dissemination of improved cultivars is likely to be the main avenue to increasing coffee yields in the near future.

Development in coffee-producing areas is also affected by management of coffee quality and the efficiency of the marketing system. Despite stringent quality regulation by the Coffee and Tea Authority (CTA), quality problems resulting from farmers picking berries at the wrong time, drying the berries on bare ground, or other problems in handling and storage, are common, and reduce the value of the product (Westlake, 1998). These problems, together with high transaction costs, limited finance, and high risks faced by coffee traders lead to high marketing margins. Although margins declined after liberalization, with reduction of export taxes starting in 1992 (LMC International, 2000), margins remain relatively high, with farm-level prices only about 50–60% of export prices in 2000 and 2001. Marketing costs are higher in Ethiopia than in most other exporting countries, reflecting higher transaction costs and risks in the system. Improvements in infrastructure and transportation, and the development of institutions to reduce traders' risks, such as a forward auction for coffee could help to reduce marketing margins (Schluter, 2003). Improving traders' and farmers' access to marketing credit by the establishment of a warehouse receipts system could also help improve efficiency and reduce margins.

Intensification of food crop production could help to alleviate the tension between food production and coffee production in densely populated areas of the HPP zone. Thus, the agricultural extension program focus on promoting improved seed and fertilizer use in food production can be complementary to the promotion of coffee or other cash crops, while options for improving cash crops, intercropping, and other opportunities to increase the complementarity between food and cash crops should also be identified and promoted.

In the HPC zone, substantial increases in cereal yields have been achieved because of the extension and credit package focusing on improved seeds and fertilizer (Benin, 2003). However, the benefit of this improvement has been limited by limitations in the cereal marketing system, resulting in low cereal prices in 2001 and 2002. Improvements in infrastructure and market institutions, facilitation of cereal exports, and development of new sources of domestic cereal demand, are needed to achieve sustainable development. Development of dairy, other intensive livestock production, and agro-processing industries in areas closer to urban markets will be an important complementary strategy. Given the substantial potential to increase cereal yields further (e.g., maize yields averaged only about 2 tons per hectare in western Amhara in 1999–2000 [IFPRI/ILRI, unpublished data], much less than the potential), this zone could become the breadbasket of East Africa, if development of market institutions and market demand keep pace with technology impacts.

3.1.3. Low-potential areas

3.1.3.1. Northern and Eastern Ethiopia. In areas with lower agricultural potential due, for example, to low and uncertain rainfall and thin soils, as in much of the northern and eastern highlands of Ethiopia, the potential for intensive production of food or cash crops using fertilizer and improved seeds is more limited, except where investments in irrigation, water harvesting, or soil and water conservation enable farmers to overcome soil moisture constraints. In Tigray and eastern Amhara, for example, substantial efforts have been made by the extension program to promote fertilizer and improved seed use, but these have not been very profitable to farmers in rainfed areas (Benin, 2003; Pender and Gebremedhin, 2004). Therefore, the agricultural extension and credit program has not had much positive impact on farm incomes in these regions.

Investments in small-scale irrigation offer the potential to increase productivity and promote a shift to higher-value crop production. There has been substantial investment in such irrigation schemes in recent years. Irrigation was found to contribute to greater use of fertilizer and labor in crop production, contributing to an average 26% increase in the value of crop production per hectare, controlling for plot quality and other factors (Pender and Gebremedhin, 2004). Problems resulting from limited farmer experience with irrigation, irrigated production of low-value crops such as maize, limited availability of irrigation water when needed, and salinization due to inadequate drainage may have contributed to the limited impact of irrigation (Haile et al., 2002a; Tesfay et al., 2000). Larger productivity impacts of small-scale irrigation were found in the eastern Amhara region (Benin, 2003).

Farmers' private investments in soil and water conservation structures can yield high returns in semi-arid environments by increasing the availability of soil moisture (Herweg, 1993; Shapiro and Sanders, 2001). Econometric analysis of survey data from Tigray indicates that stone terraces increase the value of crop production by 17% on average, implying an average rate of return of 34% (Pender and Gebremedhin, 2004). Using on-farm experimental results, Gebremedhin et al. (1999), estimated even higher rates of return to stone terraces. Clearly, there are substantial economic returns to such investments, in addition to their beneficial impact on controlling soil erosion, which explains their widespread adoption.

Pender and Gebremedhin (2004) also found significant returns to other land management practices, including reduced tillage, reduced burning, and application of manure or compost. The positive impact of reduced tillage is supported by recent experimental evidence from Ethiopia, showing that higher yields are possible with reduced labor use using zero tillage (Aune et al., 2003). This technology could be of great benefit to female-headed households, who face a cultural taboo against ploughing in Ethiopia, and other poor households that lack access to oxen. It could also lessen dependence on oxen, enabling households to raise more profitable dairy animals (especially in areas closer to urban markets), and reducing pressure on grazing lands. In addition, reduced tillage reduces soil erosion and depletion of soil organic matter, contributing to soil fertility and global carbon sequestration (Aune et al., 2003). Reduced burning and application of manure or compost also help improve soil organic matter content (Haile et al., 2002b).

Ownership of cattle also contributes to higher crop productivity in Tigray, due in part to the benefits of manure (Pender and Gebremedhin, 2004). Cattle also contribute substantially to household income, earning an estimated marginal rate of return on investment of 36% (Pender et al., 2002a). Investments in chickens and beehives also earn relatively high returns (over 30%), while returns to sheep and goats are lower (Pender et al., 2002a).

The potential of realizing the benefits of improved livestock production and greater recycling of manure to the soil depends on improved management of communal lands. Because of increasing population pressure, grazing lands are increasingly scarce and degraded in the northern Ethiopian highlands (Pender et al., 2001a). Grazing lands and croplands after harvest are often unregulated open access resources, though many communities have established access restrictions, which are helping to reduce the degradation (Gebremedhin et al., 2002). Econometric evidence from Gebremedhin et al. (2002) suggests that establishment and effectiveness of restrictions is induced by population pressure, but it is not clear whether these responses are optimal. Investments in improving grazing lands (e.g., planting fodder trees and grasses) are also needed, but are rare. In some parts of Tigray, access to grazing lands has been privatized (using social fencing), and this appears to be contributing to better management. Such institutional changes in the free grazing system are becoming increasingly necessary as resource scarcity increases.

Improved management of forests, community woodlots, and degraded lands is also necessary. Farmers in the Ethiopian highlands increasingly burn animal dung and crop residues as fuel sources, due to the limited availability of fuelwood, reducing the recycling of nutrients and organic matter to the soil, and contributing to human health problems. Community woodlots and area "enclosures" (protected areas left to regenerate naturally) have been established in many communities. These have not succeeded in addressing the shortage of fuelwood and poles because households have not been allowed to cut trees or collect fuelwood, even from older woodlots (Gebremedhin et al., 2003). Part of the problem is lack of clarity in the regulations of the regional government: although the government claims that communities are free to use woodlots however they wish, most communities believe that they must have permission from the regional Bureau of Agriculture to cut trees. Empowerment of local communities to decide when and how to use such woodlots could greatly increase the benefits, which could be quite substantial because of the high value of the trees in these woodlots (Gebremedhin et al., 2003). This would, in turn, increase community members' incentive to manage woodlots sustainably.

One way to empower communities and households is to allow allocation of unused degraded land for private tree planting or other economic uses. In the early 1990s, a village in eastern Tigray (Echmare) decided to allocate part of a degraded hillside in very small parcels for private tree planting. All households received an allocation, and were expected to manage the parcels intensively in order to ensure tree survival. The penalty for failing to do so was to lose access to the parcel and to future allocations of such parcels. The results were remarkable: households cleared stones and built stone walls around each parcel and hand-watered the seedlings from a stream one kilometer or more away, resulting in significantly higher survival rates than in most community woodlots (Jagger and Pender, 2003). The regional government was so impressed with the results that it established a pilot program allowing selected communities to allocate degraded lands for private tree planting, and has since established this as a general policy. Results of a recent survey of these and other communities show that tree survival rates are (slightly) higher for private woodlots or village-managed woodlots than for woodlots managed at a higher administrative level, despite much lower labor inputs on the private or village woodlots (Jagger et al., 2003). These results indicate that labor is used more effectively to ensure tree survival when management is at a more local level. The economic benefits of these woodlots have yet to be determined, but could be quite substantial, given the value of poles, fuelwood, and other products. Jagger and Pender (2003) estimated potential internal rates of return from community and private woodlots ranging from about 20% to over 100%, depending upon the access to markets, the growth rate of the trees (determined by agro-climatic factors), and the opportunity cost of land used for the woodlots.

Nonfarm activities are also important in the low potential highlands, accounting for more than one fourth of average household income in the highlands of Tigray in 1998–1999 (unpublished IFPRI/ILRI data). Some nonfarm activities, such as participation in Food for Work (FFW) projects, are more important further from towns (Pender et al., 2002a). This reflects the importance of such projects as sources of employment in food-deficit areas, and their decisions to locate activities away from towns. FFW and cash for work projects accounted for a sizable portion (about 40%) of average nonfarm income in Tigray in 1998–1999, and more than 10% of average total household income (unpublished IFPRI/ILRI data). Further, participants in such projects earned higher incomes than other households (Pender et al., 2002a).

Investments in education are likely to be key for long-term development in low-potential areas, and are a high priority, as evidenced by the rapid increase in school access and participation (Pender et al., 2002b). Education was found to be associated with higher per capita income and increased value of crop production (Pender et al., 2002a). Membership in marketing cooperatives also was found to increase the value of production and incomes substantially (Pender et al., 2002a).

The results of this subsection indicate that profitable investments exist that can increase agricultural production, income, and reduce land degradation in low-potential highland areas. The comparative advantage of such areas is not in intensive food crop production using high levels of fertilizer and improved seeds, as these inputs are risky and not very profitable in this environment, as long as soil moisture is the key limiting factor in production. The government of Ethiopia has recognized this fact in its own agricultural extension program, and is now promoting a broader package of interventions for such areas, including a new emphasis on water harvesting. Other opportunities to increase food crop production without large reliance on purchased inputs include promotion of sustainable land management practices such as reduced tillage, reduced burning, manuring, and composting. Yet the comparative advantage of the low-potential highlands is more in livestock production and tree planting.

4. Conclusion

Despite the fact that two thirds of the 627 million people living in SSA depend on agriculture or agriculture-related activities for their livelihoods, the region has the lowest agricultural productivity in the world. Soil fertility is the principal biophysical constraint for sustaining agricultural production in the region. With rapid population growth, soil nutrient stocks are being mined due to reduction in fallow lengths, cultivation of fragile lands, and limited use of inorganic or organic sources of fertility, lowering agricultural productivity and increasing poverty. Poor policies combined with low public investment have also undermined agricultural growth.

Building on several years of empirical research conducted in East Africa this paper has identified potential strategies for sustainable development in this region. In general, the empirical evidence reviewed confirms that different strategies are needed in different development domains of SSA. Nevertheless, some elements will be common to all successful strategies, including assurance of peace and security, a stable macroeconomic environment, provision of incentives through markets, where markets function, development of market institutions, where they do not, and public and private investment in an appropriate mix of physical, human, natural, and social capital. The differences in strategies across these domains mainly reflect differences in the mix of those investments as influenced by different comparative advantages.

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