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Promoting Farm Investment for Sustainable Intensification of African Agriculture

by

Thomas Reardon, Eric Crawford, Valerie Kelly, and Bocar Diagana

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EXECUTIVE SUMMARY

For African agricultural productivity to improve, governments and donors must invest in programs and policies that will improve the incentives and capacity of farmers to make investments that increase farm productivity and soil fertility while protecting the environment. With rapid population growth, agriculture must rapidly intensify if African farmers are to meet the rapid growth in the demand for food and fiber.

Recent case studies demonstrate that incentives and capacity to invest in more intensive cropping technologies have declined during the last decade:

- Cuts in subsidies and government-run input distribution programs reduced farmers' incentive to use fertilizer, improved seed, and animal traction.

- The reduction or elimination of agricultural credit programs has severely reduced the capacity of farmers to invest in the above technologies.

- Despite the increasing need for conservation investments, it often does not yet pay farmers to invest. Existing incentives do not incorporate the net social benefit of these measures.

Good macroeconomic policies ("getting prices right") are <u>necessary but not sufficient</u>. Even after overvalued currencies are devalued and markets are liberalized, there remain major policy and structural constraints to farmer investment.

Identifying cost-effective ways to increase the farmer's incentive and capacity to use chemical fertilizer, organic matter, improved seed, and equipment is crucial. Addressing this need will require:

- reliable and efficient agricultural support services (input supply, credit, extension, output marketing). Cutting these services without a strong and quick alternative puts African farming back at "square one";

- reduction of high input transportation costs;

- farmers to earn more cash crop income, nonfarm enterprise income, and credit to finance investments;

- "complementary public investments" to remove bottlenecks that limit private-sector participation and increase the costs of input and output marketing;

- reexamining the taboo subject of selective subsidies for fertilizer and even soil conservation investments that are a net benefit to society;

- a hard look at agricultural researcher, asking what technologies farmers can use and are attractive <u>relative</u> to off-farm opportunities.

Recent case studies of input use and investment patterns examine successes and failures, and suggest how governments and donors can improve farmers' incentives and capacity for agricultural productivity and resource conservation investments. Key findings and implications are as follows.

● Farmers are much more likely to invest in both productivity and land protection when they can produce cash crops (food or non-food). Vertically-integrated cash cropping systems (1) often have surer markets for output and inputs, (2) have a credit program built in, (3) pay well, and pay in cash, (4) come with extension, and (5) are often linked to, or benefit food production. Trying to persuade farmers to make investments or adopt new labor-intensive practices without these five elements is an uphill battle — even if the investments would be good for the farmers or society in the long run.

● Livestock husbandry is a boon to farm investments. Livestock provide (1) cash income, (2) manure, and (3) an insurance policy. Mixed farming helps. Pastures are waning however, under population pressure and there is the need to intensify livestock husbandry through the use of stabling and corralling. Relief-to-development efforts should include building stables and corrals.

● Making farmers lives more stable and predictable is crucial. Land tenure insecurity, political instability, policy caprice, and wildly fluctuating farm prices dissuade investment. Land security is a complex and subtle need, as it does not necessarily require land titling.

● Complementary infrastructure. Often built by villages or national governments, is crucial. Wells to keep windbreaks and horticulture alive, culverts to make bunds and fertilizer use practicable, and roads to make farm commercialization and input access possible are all examples of critical, modest investments that governments and donors need to make that will relieve key bottlenecks that are holding up farm investments in rural areas.

● Rural nonfarm businesses are a crucial source of funds for farm investments, especially since the dismantlement of public credit programs. Promotion of these businesses is critical — and can be realized in such a way that there is maximum spillover to the farm. One example would be to promote animal traction equipment manufacture and repair where there is effective demand — a situation more prevalent in cash cropping schemes. Credit programs that help nonfarm enterprise may be as, or more, helpful to farm investment than credit targeted to farming per se.

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1. INTRODUCTION

1.1. Background

Due to the rapid growth of population and slow growth of agricultural productivity, many countries in Africa have passed from land abundance to land scarcity. Farmers are less able to meet growing food and fiber demand by "extensifying" (cultivating new land). Increasingly, farmers must "intensify" by using more labor and nonlabor variable inputs (e.g., fertilizer), and quasi-fixed capital (e.g., animal traction equipment, bunds) to raise yields on a given land area.

Boserup (1965) maintained that as population density increased and arable land per- capita declined, fallow periods must be shortened, and technologies must be adopted that are intensive in factors that substitute for land. Intensification to date in Africa has meant the use of more labor, shorter fallow times, and denser planting — often without accompanying investments in land conservation and soil fertility. Without sufficient use of fertilizer and organic matter, intensification of land use causes soil erosion and loss of fertility.

To break this vicious circle, African farmers need to pursue "sustainable intensification." This means using inputs and capital which provide net gains in productivity, but which also protect land and water, and enhance soil fertility over time. Specifically, farmers need to increase the use of fertilizer, lime, mulch, manure, and, in some areas, animal traction combined with tied ridging. They will need to adopt soil conservation investments such as alley cropping, bunds, windbreaks, and terraces. Introduction of perennial crops or integration of forestry/fruit trees/livestock with cropping are other ways of ensuring that intensive farming is sustainable.[1]

Unfortunately, African farmers' ability to purchase variable inputs and make capital investments has, generally, declined during the last 15 years. MSU productivity research has shown that the use of fertilizer, animal traction, and, in some cases, organic matter has declined in its study countries.[2] Policy reform to improve the fiscal and trade balances has often included cuts in agricultural input subsidies, public input delivery networks, and credit programs. Government investment in rural infrastructure (e.g., roads and markets) has also been curtailed. Fertilizer and equipment have thus become more expensive, undermining their use from the supply side. Risk and poverty further undermine input use from the demand side. Those hurt the most are the many farmers whose capacity to purchase higher-priced inputs is constrained by their lack of access to cash income and credit.

[1] These inputs and practices were identified in the MSU synthesis paper on determinants of agricultural productivity in Africa (Reardon et al. 1994c).

[2] There is variation in this trend. Lowenberg-DeBoer et al. (1992) and Abdoulaye et al. (1992) showed for example, in Maradi, Niger that there has been an increased use of organic matter and animal traction.

1.2. Objectives

This report is targeted to policy analysts, policymakers, and agricultural researchers. It aims to: (1) identify factors that stimulate farmers' investments in sustainable intensification; (2) review recent evidence regarding how the relative strength of these factors varies from one setting to another; and (3) recommend policy and program initiatives likely to encourage investment. This report focuses on input use and capital investment at the farm level, and leaves to subsequent work an exploration of input supply issues.

We draw primarily on recent MSU studies, funded by AID Africa Bureau, SD/PSGE/FSP.[3] The research has focused on agricultural productivity trends and determinants in Burkina Faso, Senegal, Rwanda, and Zimbabwe (see references). A review of other recent productivity studies has been used to supplement the MSU findings.

The report proceeds as follows. Section 2 lays out a conceptual framework used primarily for organizing the review of the findings on incentives and capacity, and understanding differences between productivity and conservation investments. Section 3 discusses incentives for investment, and Section 4 discusses the capacity for investment. In both sections 3 and 4 we present key findings and discuss external factors (policies, institutions, and technologies) that condition the determinants of investment. Section 5 concludes with general strategic implications and specific program recommendations.

[3] The Sustainable Development Office, Productive Sector Growth and Environment Division, Food Security and Productivity Unit.

2. CONCEPTUAL FRAMEWORK AND HYPOTHESES

2.1. General Framework

Here we lay out a conceptual framework for the determinants of farm investment. By "farm investments," we mean expenditures on both production inputs (e.g., fertilizer) and durable capital goods (e.g., animal traction equipment). We present the framework as a way of organizing the subsequent discussion of findings.[4]

Farm investment is a direct function of two categories of variables:

- incentive to invest
- capacity to invest

Incentive and capacity are, in turn, influenced by "external conditioners," such as technologies, institutions, and policies.[5]

2.1.1. Incentive to Invest

Incentives to invest include: (a) environmental factors; (b) net returns; (c) relative returns; (d) riskiness; and (e) the household-specific discount rate.

The Physical Environment. Soils, rainfall, temperature, diseases and pests determine the technical feasibility of investments, affecting their profitability and riskiness. Land degradation is a function of past production and investment decisions, but it also influences future input use, crop choices, and soil conservation investments.

Net Returns. Net returns of the given investment depend on the yields and input requirements per-unit-of-output, and the prices of inputs and outputs. In general, leaving aside the question of capacity constraints, the better the net return of a potential investment, the greater the probability of farmers' investing.

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[4] The main features of the framework are drawn from the literature on firm-level investment theory. On input use models, see Jorgenson and Lau (1974), Lau (1976), and Shumway (1983). On capital investment models, see Christensen (1989) and Feder et al. (1985) and (1992). An example of simulation models of African farm input use and investment is Crawford and Milligan (1982).

[5] The way in which external conditioners affect incentives and capacity to invest is reflected in the "effective factor price." Constraints on access to land, labor and capital, influenced by external conditioners and household characteristics, determine the effective factor price facing the household. Thus, the market price for a factor might not be the one the household actually faces. For example, the market interest rate may be well below the cost the household would have to pay to borrow money because of their difficult access to the credit market.

Relative Returns. A given investment may be profitable, yet not sufficiently attractive relative to alternative farm and nonfarm investments to motivate the farmer to invest.

Riskiness (absolute and relative). Risks include price and yield variability, political and policy instability, insecure land tenure, etc. The greater the risk, the lower the probability of investment (Newbery and Stiglitz 1981).

The Household-Specific "Discount Rate." This is also called the "time value of money," and reflects how much a household values income received now versus later. It is influenced by household characteristics that raise the importance of immediate survival and return on investment. For example, the poorer the household, the more the household values immediate income. A resource conservation investment such as agroforestry typically has delayed payoffs, and a household with a high discount rate might be less inclined to make this type of investment.

2.1.2. Capacity to Invest

Capacity to invest depends on the household's (a) landholdings, (b) physical and financial capital, and (c) labor availability. Clearly, while the incentives to invest might be quite strong, the capacity to invest might be weak.

Landholdings. The quantity and quality of land affect the types of investments which are technically feasible and profitable. Land is therefore a critical factor influencing net returns.

Nevertheless, one can only formulate an ambiguous hypothesis regarding how farm size affects farm investment, as its effects are complex. On the one hand, small farmers can have strong incentives for intensification investments, but not always have the capacity to do so. Land-enhancing investments are especially suitable for small farms because their owners depend more on their small landholdings, they usually have a lower share of land under fallow, and organic input use and soil conservation investments can substitute for fallowing. However, small farmers also often face stiff constraints to obtaining credit and physical capital, as shown for example in Kenya by Carter and Wiebe (1990), and in Rwanda by Clay et al. (1995). The very smallness of their farms and (often) the riskiness of their environment mean that small farmers want to diversify their incomes off-farm to manage income risk. Yet the off-farm income can help pay for investments (discussed in Section 4).

On the other hand, large farmers may have less incentive to intensify, but their wealth means that they can afford the investments. Larger farmers can rely on more extensive techniques and set aside land for fallow, pasture, and woodlots. This means they have less need of intensification investments. Yet large farmers are sometimes in schemes or regions where private or public input delivery schemes make the inputs and equipment cheaper for them than for small farmers outside the schemes.[6]

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[6] Examples include the "paysannat" schemes for coffee in Eastern Rwanda (see Clay et al. 1995), the large cotton/rice farms of the northern Ivory Coast (Adesina et al. 1994), and the large-scale commercial maize

Capital. Capital consists of not only cash and liquefiable assets (e.g., livestock) that can be used to finance an investment, but also equipment, structures, land improvements, etc., which support production.

Crop and livestock sales and nonfarm activities are the main cash sources for investment. There is substantial evidence that outside of cash crop credit programs, informal and formal credit markets are used very little for input purchases in Africa (Christensen 1989). One's own sources of cash are crucial when the credit market is underdeveloped or absent — as it is in much of Africa.

The effect of nonfarm income on farm investment is especially interesting, because of the importance of nonfarm income in African rural households shown by farm household surveys in the 1970s and 1980s.[7] An important agricultural productivity and food security issue, then, is how to encourage farm households to invest their nonfarm earnings into farm input acquisitions and capital formation. The literature, and the case studies we discuss in section 4.3., present a mixed picture concerning the investment of nonfarm income in farm capital. In some areas, especially where agriculture is profitable and not too risky, there is a complementary relationship; in areas where agriculture is risky and poor, the two sectors compete.

Moreover, farm-level physical capital (animal traction, infrastructure such as terraces or bunds to reduce erosion and runoff of fertilizer, windbreaks, wells, etc.) reinforce and enhance the use of seasonal production inputs.

Labor Availability. Labor supply in quantity and quality terms (family size and composition, health, education), is critically important. The "quantity" aspect of labor is important when considering labor as an input used in the labor-intensive production of on-farm infrastructure (e.g., building and maintaining irrigation canals, terraces, anti-erosion ditches, alley cropping). Farm households frequently do not have an adequate supply of labor to carry out improved farm practices. Household demographics (e.g., worker/consumer ratio) affect the quantity of labor available for such practices.

All else being equal, cheaper (more available) labor drives farmers to substitute labor for land or capital, (choosing labor-using technology). In some cases, however, farmers with off-farm labor opportunities actually want labor-saving technologies so as to free labor for off-farm work.[8]

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farmers
in Zimbabwe (Jayne et al. 1995).

[7] Reardon et al. (1994a) reviewed West African evidence, for example, and found that the share of nonfarm income in total household income ranged (over zone averages) from 20 to 80 percent, with an average of 50 percent in rural areas. This contrasts with the conventional image of rural African households deriving their "food entitlement" almost exclusively from their own land. See also Matlon (1979), Collier and Lal (1986), Low (1986), Reardon et al. (1988), and Haggblade et al. (1989).

[8] See Low (1989) for an illustration from Botswana.

The "quality" of labor ― human capital ― includes the worker's education, training, technical knowledge, and health. These are important to the farmer's ability to make appropriate investment decisions, and manage improved production or conservation technologies.

2.1.3. Conditioners of Incentive and Capacity Variables

Conditioners external to the farm household include: (a) technologies; (b) agricultural and macroeconomic policies; (c) institutional environment and physical infrastructure; and (d) political stability.

Technologies. Production and input- or output-processing technologies affect the set of available investments and their profitability and riskiness.

A technology can be characterized by its "factor bias," that is, whether it uses land and saves labor, or uses capital and saves land, and so on. The relationship between the factor bias and factor scarcity determines the "appropriateness" of the technology.[9] For example, if it is difficult for farmers to obtain capital and dry season labor, but the available conservation technology requires these to build bunds in the dry season or to use a tied-ridger in the rainy season, then the technology may not be "appropriate."

Agricultural and Macroeconomic Policies. Macro and sectoral policies directly and indirectly affect output and input prices, and hence net and relative returns to investments.

The stability ― or lack thereof ― of government policies can affect farm investments. If price and credit policies are changing dramatically and frequently, farmers do not know how to plan and shy away from on-farm investment.

The Institutional Environment and Physical Infrastructure. The legal system, markets, extension services, and the transportation and communication infrastructure determine the availability of information, access to markets, and costs and returns of investments. The quality and quantity of roads affect transaction costs, risk and price fluctuations, and nonfarm activities. Watershed management infrastructures (such as dams, culverts, and farm-level bunds) are key complementary investments. Wells help ensure the survival of live windbreaks during dry seasons, and cattle that supply manure, meat, and milk. Institutions and infrastructure affect household strategies (e.g., how much of their food needs they meet from farming versus buying food), and the relative profitability of farm and nonfarm activities.

Political Instability. This disrupts input distribution and output marketing, leading farmers to keep their savings in liquid assets such as jewels or livestock rather than investing it in land improvements and perennial crops.

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[9] We do not use "appropriate" to refer to only low-input technologies — rather, it can be used for any situation in which there is a match between what is needed and what is available.

2.2. Differences Between Productivity and Conservation Investments

During the past three decades, a large amount of literature was developed on determinants of developing country farmer adoption of productivity-enhancing green revolution technologies such as improved seeds and fertilizer, especially in Asia and Latin America (Feder et al. 1985). It is not obvious, however, what part of the adoption literature applies to new questions regarding farmer and community investments in resource conservation (such as bunds and terraces). How do the determinants of investment differ between conservation and productivity investments? Should policy approaches to promote conservation investments differ from traditional approaches used in promoting "Green Revolution" productivity investments?

Reardon and Vosti (1992, 1996) addressed the above questions. They classified investments by yield and environmental effects into a continuum from "mainly productivity-enhancing" (e.g., fertilizer use) to "mainly conservation-enhancing" (e.g., agroforestry). The two types of investments differ in several ways in their content and specific requirements, and how they are perceived by farmers, delineated below.[10]

Risk and Delayed Return. Conservation investments (e.g., agroforestry) might be seen as riskier, and the return more delayed, compared to investments that have an immediate impact on productivity (e.g., fertilizer or animal traction). Planning for cash and labor to invest in conservation measures may require a longer planning horizon than is typical of poor farm households in risky, fragile areas.[11]

Timing and Competition. Conservation investments often need to be made in the dry season (e.g., building or maintaining bunds), and so compete with migration and local off-farm activities. If they require labor during the rainy season (e.g., alley cropping), they compete with the labor needed for fertilizer application or weeding.

Externalities. For example, if one farmer constructs bunds but his neighbor does not, the runoff from the second farmer's land could overwhelm the conservation measures of the first farmer.[12]

Equipment Requirements. Some conservation investments require specific equipment for which there is no market (e.g., the case of animal traction equipment modified to produce tied-ridges). Even if it is available, it can be expensive.

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[10] There is, of course, inherent ambiguity in such categories. For example, a bund can stop topsoil removal and immediately raise yields on a plot; another conservation investment, agroforestry, may have more delayed and less easily observed productivity effects. Moreover, sustaining the resource base means that base will continue to be productive, or will lose productivity at a slower rate.

[11] See Reardon et al. (1992c); Kerr and Sanghi (1992); and Lowenberg-DeBoer et al. (1994).

[12] Moreover, watershed management investments by a given farmer might obstruct soil deposition efforts by another. For an example from India, see Kerr and Sanghi (1992).

Lumpy Expenditures. Many conservation investments require substantial "lumpy" expenditures of labor or cash, or both (especially for bunds, anti-erosion ditches, and terraces). The labor and cash available to a given household may not suffice, and the household may need to hire outside help or borrow money. It is sometimes hard to find laborers to hire, and often hard to borrow for such investments (see Section 4.4.).

3. INCENTIVES FOR FARM INVESTMENT

This section is organized around the incentive variables and hypotheses discussed in Section 2. We summarize MSU case study findings for each variable, and selectively review other recent empirical studies.

3.1. Environmental Factors

Land degradation and decline in fallow can drive input use and soil conservation investments to compensate for it.[13] Box 1 illustrates this point for Senegal, and Box 2 for Rwanda.

3.2. Net Returns and Relative Returns Affect Farm Investment

Net Returns. In general we find that African farmers are sensitive to net returns to their investment choices.

Box 3 shows that withdrawal of agricultural support services and input subsidies increased input costs, reduced net returns, and led to a decrease in the use of agricultural inputs. By contrast, Box 4 shows that profitable and low-risk cash crops (commercialized food crops and cotton), and associated programs, facilitate access to inputs and increase farm investments. The lower risk comes from surer markets facilitated by government policy and parastatal marketing.[14]

However, even when macroeconomic incentives improve (for example, with *devaluation,* a key macroeconomic policy in Africa today), it is not *a priori* evident that net returns to intensification investments improve. Specifically, overvalued exchange rates mean that export crops earn too little, and imported inputs are too cheap (relative to "equilibrium levels"). Devaluation can increase farmers' gross incomes from export crops and lead to more farm investments.[15] This will not necessarily occur, however, if devaluation increases the cost of imported inputs and equipment enough to outweigh the output price increases. In addition, "stabilization policies" that accompany devaluation may include cuts in subsidies and input delivery systems, thus increasing the cost of inputs. Box 5 illustrates this scenario from post-devaluation Senegal.

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[13] Decline in fallow has attained more importance as an issue as population density has increased in many countries, most obviously in the African highland tropics (Getahun 1992; Clay and Lewis 1990), but also in the semi-arid tropics (Matlon 1987). Tiffen et al. (1994) presented similar findings for Kenya.

[14] Lele et al. (1989) made this point for cotton in French-speaking West Africa.

[15] The gains from devaluation or decreased tariffs are not always fully passed along to farmers (reflected in farmgate prices). Sometimes the gain is absorbed at the government level to offset preexisting deficits.

Box 1 Soil Degradation and Peanut Seeding Rates in Senegal

In Senegal, decades of continuous peanut/millet cultivation, with limited use of fallow, organic matter, and chemical fertilizers, has increased soil degradation through erosion and nutrient loss. Following the sharp drop in fertilizer usage during the 1980s (due to changes in subsidy and credit policies), soil degradation accelerated. Farmers began increasing peanut seeding densities to compensate for the declining soil quality, which they believed was slowing down the growth of peanut ground cover and, therefore, increasing weed problems. The practice has become widespread; survey data show that many farmers are using more than two times the recommended quantity of seed per-hectare. Although this appears to be a logical short-term solution which increases yields and net returns (Kelly et al. 1995), agronomic research suggests that it is not a sustainable practice (Gaye and Sene 1994). Without supplementary fertilizer and organic matter, increasing seeding densities will not only lead to further soil mining, but also have negative repercussions on seed quality.

Box 2 Land Degradation and Land Improvements in Rwanda

In Rwanda, Clay et al. (1995) found that steeper slopes, which are more susceptible to erosion (particularly where rainfall is high), increase the incentive to invest in soil protection and adopt less erosive forms of land use. Without such investment, steepness discourages the use of fertilizer and organic matter because of runoff. The issue of field slope has become more important with the increased population density. The steepest areas have been reserved traditionally for pasture, woodlots, and minor crops; frequent fallow periods were commonly required. At the very outer rings of cultivation, toward the base of the slope and in the swampy valleys, crops were grown along ridges built for water drainage. Increasing land scarcity has obliged many farmers in recent decades to depart from this traditional system, which has, in turn, increased soil conservation investments. Declining fallow as a share of farmland, and declining periods of fallow, can also drive input use and soil conservation investments, which are partial substitutes for fallow. Another consequence of increased population pressure — and farmers' desire to decrease risk — is farm "fragmentation," or geographic dispersion of plots. This tends to have a negative effect on farm investments, as the transaction costs increase with walking distance from the household compound to the plot.

Box 3 Agricultural Support Services and Subsidies Provide Needed Incentives for Intensification

Fertilizer use declined substantially in three MSU case study countries — Senegal, Burkina Faso, and Zimbabwe — when subsidies were removed and/or access to credit was made more difficult (Kelly et al. 1995; Savadogo et al. 1994; and Jayne et al. 1994).

For Senegal, Gaye (1992) showed that farmers' demand for fertilizer was more sensitive to changes in input/output price ratios than to net returns. Sharp declines in the ratio in the mid-1980s led to drastic reductions in the fertilizer used by farmers in the Peanut Basin, despite economic analyses showing that fertilizer remained profitable in the southern Peanut Basin with average value/cost ratios of greater than 5 (Kelly 1988).

Farmers' reliance on fertilizer input/output price ratios can be explained by the difficulty of estimating net returns for this input, which exhibits highly variable interannual yield responses. Where farmers' reliance on input/output price ratios does not foster input use decisions that maximize net returns over time, policy interventions may be required to improve the farmgate appeal.

Relative Returns. African farmers are sensitive to their returns on investments in cropping relative to returns in the nonfarm sector. Returns can be high for capital and labor used in rural nonfarm businesses and wage employment relative to farming.[16]

Farm and nonfarm sectors compete for farmer investments: Christensen (1989) found in northern Burkina Faso that better returns off-farm decreased on-farm investments. The competition is more apparent in risky, drier zones, where farmers diversify activities to manage risk. Off-farm activities often occur in the dry season, when conservation measures such as bund or terrace building and maintenance are done.

The two sectors can be complementary, however, especially in the more favorable agroclimatic zones, where agricultural payoffs are higher. Farmers in these areas also diversify to take advantage of off-farm opportunities. This is discussed further in Section 4.3.

[16] See, for example, Fall (1991), Lowenberg et al. (1994), and Reardon et al. (1992).

Box 4 Cash Cropping Provides Incentive for Farm Investment

In the MSU case studies we find that farmers usually apply the bulk of productivity-enhancing inputs and resource conservation investments to cash crops, either because profitability is higher for these crops than for subsistence crops, or because there is credit or input provision in cash crop schemes (Reardon et al. 1994c).

- In Burkina, Faso, Savadogo et al. (1994 and 1996) found that the payoff, in terms of the marginal value product use of animal traction, manure, and fertilizer was much higher for cash crops (cotton and maize) than for semi-subsistence food grains (millet and sorghum). Farmers were much more likely to use capital and inputs for cash crops.

- In Rwanda, Clay et al. (1995) found that farmers were much more likely to make land conservation investments and use fertilizer when farming was more profitable. Substantially more fertilizer was used on cash crops (white potatoes and coffee), since the payoff was much higher than on subsistence food crops.

Moreover, farmers produce more of the more profitable (cash) crop if they can. In the Senegalese Peanut Basin, where peanuts and millet are cultivated in rotation, farmers tend to allocate a larger share of land to the crop with the higher net returns to land and labor — in most zones, this is peanuts. When the producer price of peanuts changes significantly, thus making the crop more or less profitable compared to millet, time series data show a shift toward increased cultivation of the crop with improving profitability (Kelly et al. 1995).

3.3. Risk Undermines Farm Investment

3.3.1. Instability in Politics

The MSU case studies provided evidence of the critical role of political stability to farm investment.

A poignant example is Rwanda's recent civil wars, which have depleted livestock herds and caused neglect of perennial crops, in addition to the massive loss of human life and destruction of economic and social institutions (Clay et al. 1995).

Box 5 A Post-Devaluation View of the Lack of Incentive for Sustainable Intensification in Senegal

The January 1994 devaluation of the franc CFA (that doubled the number of francs one pays per dollar) has added fuel to the process of increase of peanut seed density and degradation that was described in Box 1 for pre-devaluation Senegal. Diagana (1995) modeled the optimal response of Peanut Basin farmers to the increase of 71 percent in the peanut farmgate price and the increase of 45 percent the peanut seed price and 3 percent of the peanut fertilizer price. Diagana found that peanut production became more profitable than competing crops (millet, maize, cotton, cowpeas), which explains why area to peanuts increased 21 percent after devaluation. Nevertheless, no agricultural intensification module based on chemical fertilizer was optimal. And the high peanut seed density module was optimal. This spells a post-devaluation confirmation of the pre-devaluation problem of lack of fertilizer use and excessive density of seeding — both of which lead to soil exhaustion and further decline of yields.

Moreover, net incentives declined for River Basin rice, an "intensification crop" (BAME 1995). To protect consumers, the rice farmgate price post-devaluation was only allowed to rise 6-11 percent. But production costs rose 53 percent (a rise of 146 percent in the price of certified seed, 58 percent for the price of herbicides, and 89-135 percent in the price of rice fertilizer); profit margins dipped 44 percent. This can be contrasted to a rise in the profitability of Malian irrigated rice, the output price of which was allowed to rise faster than input costs.

Senegal provides an example of how election year politics thwarted a program to foster private sector competition in peanut seed production and marketing activities. To reward the rural sector for their overwhelming support during the 1993 elections, the government pressured the parastatal seed marketing firm to distribute peanut seed on extremely liberal credit terms for the 1993/94 campaign. The fledgling private sector firm had no option but to distribute seed on the same terms. The end result was a disastrous credit reimbursement rate (about 35 percent) for both the parastatal and the private company.

3.3.2. Uncertainty in Markets and Prices

Output Markets. Uncertainty in output market outlets for crops has plagued several promising crop/technology combinations; for example, cowpeas in northern Senegal (Kelly et al. 1993) and maize in Mali (Boughton et al. 1994). Output market uncertainty and high transaction costs reduce farmers' incentives to market their crops (de Janvry et al. 1991).

This becomes a vicious circle; it produces a thinner market where prices are more volatile, which makes farmers less willing to make risky farm investments, which then decreases productivity and makes the market even thinner. The thinner market also reduces the participation of merchants, which leads to higher transaction costs.

MSU studies show that where markets are less risky, farmers are more willing to invest in fertilizer and new grain varieties. For Zimbabwe, Jayne et al. (1994, using zone-level data) and Rohrbach (1989, using farm-level data) found that government construction of grain depots increased the use of fertilizer and the marketed surplus rate. In Senegal, Goetz (1990) showed that increased availability of grain helped farmers adopt cash cropping. Dione (1989) found that for Mali, cash cropping increased the ability of farmers to buy inputs for food cropping, thus setting off a "virtuous circle."[17]

Moreover, where the foodgrain market is risky, farmers will continue subsistence grain farming even while they underinvest in new cash-cropping opportunities (von Braun and Kennedy 1994).

Macroeconomic policies such as devaluation can increase the average return to investment (if the farmgate price increase outweighs the increase in cost due to more expensive imported inputs, see Box 5), but would not alone reduce the variability of returns due to rainfall instability, and hence reduce the risk of investment. Thus the expected increase in farm investment may not occur. Devaluation could even increase risk by increasing transportation costs, so that prices in production areas will be determined locally and thus be more unstable (Reardon et al. 1992b; and Barrett and Carter 1994).

Input Markets. The riskiness of input markets can also reduce investment and input use. In Rwanda, Clay et al. (1995) found that farmers were unsure of fertilizer availability in markets, except when provided through donor projects.[18]

[17] For Madagascar, Barrett (1994) found that price risk reduced marketed surplus and affected input use and productivity more severely among smaller farms than among larger farms.

[18] von Braun and Puetz (1987) found that the policy failure related to fertilizer imports — delays and shifts in donor-assisted fertilizer deliveries — decreased farmer fertilizer use in the Gambia by 64 percent, with the result that output dropped 10 percent; mainly the richer farmers were able to obtain the fertilizer that did arrive. They noted that there is extreme variability in such donor-assisted fertilizer deliveries in Africa: between 1980 and 1984, for example, bilateral and multilateral assistance in fertilizer supply varied between 16 and 328 million dollars per year.

3.3.3. Security of Land Tenure

In general, one would expect farmers to make fewer longer-term land improvements such as bunds and terraces on land with short-term and/or uncertain use rights, because such holding arrangements are risky. Landowners can take back the land, or the land might not be available from one year to the next.

In general, studies show that the perception of long-term use rights (whether from formal title or traditional right) can be important for investments.[19] The empirical evidence is mixed, however, and several factors condition the effects.

The Perception of the Security of Traditional Use Rights. There is evidence that at times traditional use rights may be perceived by farmers to be secure, even though farmers do not have a legal title to the land.[20]

The Kind of Investment Matters. The effect of land tenure insecurity depends on the kind of investment. MSU research in Rwanda (Clay et al. 1995) showed that the use of inputs with short-term effects, such as chemical fertilizer, are not affected by whether the land is rented. However, Clay et al. also found that insecure tenure undermines longer- term investments such as soil conservation and organic matter use.

Intra-Household Factors Matter. Kelly et al. (1995) showed that in Senegal, dependents of the household head (in general, women and unmarried men) invest less in their private plots because of uncertainty about access to the same plot from year to year, although the household has security of land use (cf. the point from Golan, above). Resolution of this issue is not easy because the household needs to rotate fields between the cereal fields managed by the head of the household and the individual fields controlled by the dependents, on which peanuts are often grown.

Hence, the importance of the issue and the straightforwardness of the solution vary considerably by country, so that no general statement can be made (see Dommen 1994; Place and Hazell 1993; Blarel 1989).

[19] Cook and Grut (1989) found that rented holdings in Rwanda tended to be used for annual crop production, rather than for more protective perennial crops and woodlots whose value is realized over a longer time period. Migot-Adholla et al. (1990) showed that for Ghana, plots owned or under long-term use rights were more likely to be improved (fertilized, mulched, irrigated, or have trees planted on them) than those under short-term use rights, such as rental. For Rwanda (in three prefectures: Butare, Gitarama, and Ruhengeri), Place and Hazell (1993) found that farmers tended to invest less in rented land.

[20] Various studies (e.g. Migot-Adholla et al. 1990; and Pinckney and Kimuyu 1994) showed that titling does not necessarily confer more certainty regarding land tenure. In Senegal, Golan (1990) tested whether farmers who held title to land invest differently than those with only customary land use rights, and found no statistical difference between the two situations. Migot-Adholla et al. (1990) found for Kenya that the relationship between tenure and land improvements was weak, because farmers felt secure about being able to continuously cultivate rented plots.

4. CAPACITY FOR FARM INVESTMENT

This section is organized around the capacity variables discussed in Section 2. We summarize MSU case study findings for each variable, and selectively review other recent empirical studies.

4.1. Landholdings

The MSU case study findings reflect the ambiguity discussed in the hypothesis concerning farm size in Section 2.

For example, in Rwanda, Clay et al. (1995) found that small farmers invested more per- hectare in soil conservation measures (anti-erosion ditches, terraces, windbreaks, grasslines) than larger farmers. Smaller farms are more likely to use organic matter, while larger farms are more likely to use more expensive inputs such as fertilizer and lime. But small farmers often face stiff constraints to obtaining credit and cash to buy the latter. Larger farms[21] can rely on more extensive farming and less use per-hectare of improved inputs and conservation investments. An exception to this, however, is larger farms in the "paysannat" scheme for coffee in Eastern Rwanda (see Clay et al. 1995).

4.2. Cash Cropping Creates Capacity for Farm Investment

In Sections 4.2. and 4.3. we focused on cash cropping and nonfarm income as the major sources of cash available to farmers to buy inputs. Neither formal nor informal credit markets are major sources of credit for agricultural investments, including input use (Christensen 1989), and credit markets in many areas are quite underdeveloped, with high interest rates and limited access for smallholders (Binswanger 1986). Structural adjustment has further reduced credit access by dismantling many public sector credit institutions in rural areas.

We noted in Section 3.1. that cash cropping provides incentives for farm investments. It also provides capacity for African farmers to make investments.[22] Box 6 provides an illustration of this for animal traction investments in the peanut zones of Senegal. Dione (1989) showed that for Mali, cotton farming (in a vertically-integrated system) provided the cash and the institutional platform to have access to the formal credit market that allowed farmers to buy animal traction equipment, which in turn increased productivity of cotton and maize.

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[21] "Larger" farms in Rwanda are still small compared to the African average; but note that the largest quartile of farms is, on average, seven times larger than the smallest quartile.

[22] von Braun and Kennedy (1994) also showed the positive income, consumption, and nutrition effects of agricultural commercialization in a number of case studies in Africa and elsewhere.

Box 6 Cash Cropping Increases Farmers' Capacity to Make Animal Traction Investments in Senegal

From 1960 through 1980 a liberal credit program encouraged farmers in Senegal's Peanut Basin to invest in animal traction equipment. The equipment credit program was supported by other input policies (fertilizer and seed subsidies and input distribution programs) and output marketing programs (guaranteed prices and markets) that helped farmers earn the level of net returns necessary to reimburse the equipment credit. Adoption was very high during this period, so that virtually every farmer in the Peanut Basin now uses some form of animal traction.

The current dilemma is that the credit program was halted in the early 1980s and then replaced by a program which made access to credit much more difficult. At the same time, there was substantial inflation in the cost of factory-made equipment. This fostered the production of traction equipment by local blacksmiths, who sold their products at a fraction of the price demanded for industrial-quality equipment. The extent to which artisanal production of traction equipment can provide a sustainable solution in the long term needs to be examined quickly, as the current stock of factory-made equipment is, on the average, more than 20 years old — well beyond the 10-15 year lifetime used in most depreciation calculations.

4.3. Links Between Nonfarm Income and Farm Investment[23]

MSU productivity, investment, and income diversification studies have examined the interactions between farm and nonfarm income in the farm household economy, asking in particular whether households with more nonfarm income use more or better cropping inputs and invest more in agriculture.

The evidence shows both positive and negative links between nonfarm activities and farm investments. The direction of the link is influenced by the opportunities in farming, as well as the nature of the financial, insurance, and savings markets. In the more favorable agroclimatic zones, farmers reinvest nonfarm profits in the farm. Box 7 lays out the evidence from MSU studies of the positive effects of nonfarm activities on farm investments and discusses the conditions for this. In more fragile environments, farmers are more likely to diversify away from the farm in order to manage income risk.

[23] This section draws heavily from Reardon et al. (1994b).

Box 7 Reinvesting Nonfarm Income in Crop Production

In the Guinean zone of southern Burkina Faso, where agroclimatic conditions are good, Savadogo et al. (1994 and 1996) showed that nonfarm earnings were reinvested in expensive animal traction packages. Nonfarm income and farm size were important determinants of adoption of animal traction. Nonfarm income (controlling for farm size) was particularly important in this zone because credit was not generally available for these purchases so the household's own liquidity ─ mainly from nonfarm income ─ was crucial to the animal traction investment.

Also in Burkina Faso, Reardon and Kelly (1989) showed that fertilizer use was positively related to nonfarm income in the Sudanian zone ─ but not in the Guinean zone where the presence of SOFITEX (the cotton parastatal) made fertilizer available to farmers regardless of their village location or household cash sources.

In Rwanda, Clay et al. (1995) showed that more nonfarm income increased soil conservation investments mainly through financing labor hiring and materials. Nonfarm income also increased use of purchased inputs among larger farmers. Nonfarm income was also important to smaller farmers because it enabled them to maintain traditional extensive practices (fallowing, etc.), and purchase food when necessary (Clay and Reardon 1995).

In Senegal, Kelly et al. (1995) showed that nonfarm income was used to purchase tools and occasionally fertilizer, repair animal traction equipment, and obtain peanut seed. The source of nonfarm income appeared to influence the method of peanut seed acquisition. Those with large shares of livestock income tended to use the income for downpayments to obtain peanut seed credit. Credit permitted these farmers to keep more of their capital assets in livestock during the cropping season, rather than turning it all into seed. This spread the risk across different farm activities. Those with large shares of nonfarm income were more likely to purchase peanut seeds for cash, by-passing the deferred payment option associated with credit, because the peak period for nonfarm liquidity is at the end of the dry season rather than at the end of the rainy season.

We are worried, however, because in many parts of Africa, participation in nonfarm activities is inequitably distributed ─ poorer households depend more on their farms and are thus vulnerable to the vicissitudes of weather, while richer households have much more diversified incomes. The poor must content themselves with labor-intensive jobs that have low capital entry barriers. Richer households can start relatively capital-intensive nonfarm enterprises, because they are less bound by cash and credit constraints. Hence, policies and programs that increase the poor's ability to start nonfarm enterprises and obtain off-farm employment will promote food security. Structural adjustment has added importance to households' own-cash sources to finance farm input purchases by reducing agricultural credit programs (Reardon et al. 1994a).

4.4. Credit Issues Particular to Conservation Investments

We noted above that there is a dearth of credit (apart from cash crop schemes) for input acquisition. There appear to be particular problems in the credit market for conservation investments. Reardon and Vosti (1992, 1996) noted the following.

Loan Size. Financing large items, such as bunds, terraces, and orchards, might exceed the capacity of local creditors or even village credit groups, especially if many households require loans at once.[24]

Externalities. Problems of externalities and "free riding" can undermine a farmer's ability to get credit for such investments.

Short-Term Payoff. Creditors may not perceive (and indeed there may not be) a clear short-term return to conservation investments. Hence, the risk of default may appear greater.

Collateral. Productivity investments often require, but also create, loan collateral (e.g., animal traction equipment). This is generally not so with conservation investments (e.g., creditors cannot reclaim bunds!).

4.5. Human Capital/Labor Supply

Labor Supply. A plentiful supply of labor is crucial for construction of soil conservation infrastructures. In Rwanda, households with more adults (all else being equal) constructed more land improvements than households with fewer adults (Clay et al. 1995). Households without abundant family labor, however, may still be able to hire the necessary labor if they have cash sources.

Education. The quality of the available labor (education and training) is also important. Evidence from Kenya and Tanzania (Pinckney 1994) suggested that general education increased productivity and use of improved technologies.

Extension Services. Extension services are frequently tied to cash cropping programs and thus access to inputs, so it is difficult to separate the effects on input use of extension versus cash cropping programs. Especially where it conveys new knowledge, extension programs have an effect on soil conservation and improved input use in Rwanda (Clay et al. 1995). Extension services promote adoption, and cut the cost of using new technologies. Unfortunately, access to

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[24] For example, some tree-cropping schemes require mass production of seedlings, and few banks are willing to lend for such activities (Ohm and Nagy 1985).

extension services (as well as credit and other input access) is often greater for farmers with more political clout and larger landholdings (e.g., in Senegal, see Jammeh 1987).

4.6. Farm- and Village-level Complementary Investments

On-Farm Investments. Some on-farm investments increase the returns to other farm investments and use of purchased inputs. For example, soil conservation investments made prior to the use of organic matter and fertilizer can be crucial in protecting against runoff and leaching of nutrients (Ehui et al. 1992; Matlon and Adesina 1992; Clay et al. 1995; Sanders et al. 1995). Other farm investments, for example in livestock, reduce the cost of soil-fertility enhancing investments. Owning livestock reduces the transaction costs for using animal traction, and it increases the availability of manure; livestock are a key form of savings, and an important source of cash for both investments and starting nonfarm activities.

Moreover, whether neighbors build conservation infrastructure can affect a given farmer's investment choice.[25]

Public Village-Level Investments. The existence of complementary (public) investments in the watershed or community can be very important in determining whether a given farmer invests. For example, the presence of a public culvert next to a farmer's field affects the maintenance costs of a bund on that field. Or, a public well can determine whether the live windbreaks of nearby farmers will survive the first dry seasons. A nearby road can make cropping investments more profitable (Reardon 1995).

[25] Kerr and Sanghi (1992), in an analysis of watershed management in India, noted that whether others uphill in the watershed were investing in contour bunds could affect a given downhill farmer's decision to so invest — if the chain of bunds is broken by one or more farmers not building or maintaining bunds, the water will break through and erode fields of neighbors downhill who invested in bunds.

5. IMPLICATIONS

5.1. General Policy and Strategic Implications

Growing constraints in, and degradation of, arable land in Africa, coupled with soaring demands for food and fiber, driven by economic and population growth, point to a great need for sustainable intensification of agriculture ─ in agroclimatic zones where intensification is physically possible and economically attractive.

There are limits to merely intensifying cropping by intensifying labor use, increasing crop densities, and shortening fallow periods. These practices will exhaust the soil in short order. Farmers need to invest in soil and water conserving technologies to control erosion and improve soil moisture (such as bunds, windbreaks, drainage tiles), and soil fertility- enhancing inputs (such as fertilizer and manure). The conservation investments will increase the profitability of the fertilizer and manure use. In some areas, investments in animal traction equipment will be especially important.

In Reardon et al. (1994c) we showed that these investments have important farm productivity effects. Yet in many countries, farm investment has stagnated, or even fallen, due to constraints on input demand and supply. In the present report we focus on the determinants of farm-level input demands and investment. Our study points to three general conclusions.

5.1.1. There Is a Pressing Need to Improve Access to Inputs and Incentives to Use Them.

Input use has been historically promoted in ways that are not economically sound or fiscally sustainable in the long run. Yet the reduction of government programs and subsidies that are associated with structural adjustment appears to have discouraged the use of modern inputs (improved seed, fertilizer, animal traction), by raising their cost and reducing their availability.

The result has been that farm input costs must be reduced without returning to fiscally unsustainable and generalized subsidies. We advocate a "middle path" between fiscally unsustainable government outlays and complete government withdrawal from support to agriculture. This middle path implies substantial public and private investment in agricultural research, human capital, and production and market infrastructures. In certain situations, where it is fiscally possible and justified by risk considerations and potential net benefits to farmers and society, the reinstitution of selected subsidies for fertilizer use and soil conservation investments should be considered.

Complementary public infrastructure (roads, wells, culverts, agricultural research institutions) to make investments attractive and affordable is crucial. Resource, technology, and market constraints on agricultural growth must be addressed directly by allocating government and donor resources to overcome them. Public investments should be such that they complement and spur private investments by farmers and villages in on-farm infrastructure and input use, and by merchants in input distribution systems and primary product processing. It is essential that governments and donors invest in understanding how to promote the economic use of the tools of sustainable intensification — fertilizer, animal traction, organic inputs, and soil conservation measures.

Thus the debate should be reopened on identifying cost-effective ways of increasing access to inputs, through improving the delivery of inputs and enabling farmers to acquire the means to pay for them. This effort is especially appropriate in countries whose macroeconomic environment has become more favorable through structural adjustment.

5.1.2. Macroeconomic Policies Are Not Enough.

To improve the incentives for farmers to invest, improved political stability and macroeconomic conditions — "getting prices right" — the two foci of policy attention in the last decade, are necessary but not sufficient to induce the crucial farm investments outlined above and spur higher agricultural productivity. Governments are wrestling with policy changes associated with structural adjustment, which is usually a mixed bag of new incentives and disincentives from the farmers' perspective. But a long-term policy perspective is needed by governments in order to promote rural capital formation over the long term. A strategic vision to promote investment will require greater coordination of agricultural, employment, and industrial policies.

Impacts from the prices of both outputs and inputs must be considered in tandem. If more investment in sustainable intensification is the goal, policymakers must ensure that devaluation does not make "extensive" cultivation more profitable than intensive cultivation. There is a strong risk of this as "modern" inputs tend to be imported and prices rise with devaluation. Innovations that aim at decreasing risk and increasing affordability of the investments, and the incentive and capacity of farmers to undertake them are important, especially in the domains of infrastructure, credit, and institutional policy.

5.1.3. Improving Farmers' Capacity to Invest is Crucial.

Nonfarm income and cash cropping can play important roles as sources of cash, particularly in the common situation where the informal credit market is underdeveloped and the formal credit market dismantled or inaccessible. Whether farmers reinvest profits from nonfarm activities and cash cropping back into agriculture is a crucial issue for agricultural transformation. Agricultural research strategies should be formulated, bearing in mind that farmers will evaluate both the input requirements and the returns to cropping and land conservation investments in relation to those of nonfarm investments.

5.2. Program Implications

Our case studies suggest several new approaches to increase the incentives and capacity for farmers to invest. We suggest that policymakers examine these broad recommendations in the context of their country's situation. Our case studies were in the semi-arid tropics and tropical highlands; thus individual countries will find some suggestions relevant and others irrelevant. For those that are relevant, the next step is to design a program and perform a cost/benefit analysis, comparing the pros and cons of different approaches and their potential impact on agricultural productivity, food security, and the government budget.

Below we note areas of critical importance to sustainable intensification, and review key recommendations from our case studies.

5.2.1. Soil Fertility

Ensuring adequate soil fertility is a *sine qua non* of sustainable intensification. The availability and affordability of the following three sources of fertility need special attention:

Chemical Fertilizer. Reduction of the fertilizer subsidy in various study countries (Burkina, Senegal, Zimbabwe) coincided with a decrease in its use during the 1980s. Because fiscal constraints prohibit a return to the days of large fertilizer subsidies, programs and policies are needed to get cheaper fertilizer to farmers in a more cost-effective manner.

A key way to do this is to reduce transportation costs and improve the quantity and quality of rural infrastructures. For example, a study by the Prime Minister's Office (1993) of the potential impacts of devaluation in Burkina Faso showed that fertilizer costs could be greatly lowered by improving the transportation system and infrastructure.[26]

Moreover, country-specific studies of selective fertilizer subsidies are needed (a taboo subject in the 1980s, but a debate that needs to be revisited now). Agronomic research on fertilizer response (particularly the possibility of using locally-produced phosphates) needs to be updated for current soil conditions. Cost/benefit analyses are needed for the subsidy levels that would be required to increase fertilizer use to more agronomically and economically appropriate levels. Both the agronomic and economic analyses should take into account the risk associated with fertilizer use, so as to avoid overestimating the beneficial effects.

Study and promotion of the *fertilizer/lime subsector* are needed. The focus should be on constraints to private sector production and marketing of inputs. Government regulations and licensing requirements that inhibit fertilizer imports should be examined and, if necessary, eased or eliminated.

Manure. There is a critical need for manure use in the semiarid and hillside zones of Africa. Manure is an important complement to fertilizer for restoring soil fertility in areas undergoing intensification.

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[26] These costs are extremely high in Sub-Saharan Africa (Ahmed and Rustagi 1987). Spencer and Badiane (1994) showed that high transportation and other infrastructure costs are major obstacles to increased fertilizer use in much of Africa, including the humid zones.

In our tropical highlands case study (Rwanda), we recommended more emphasis on livestock production, and a shift from extensive to intensive livestock husbandry. Losses from four years of civil war, plus disease and loss of pasture, have rapidly decreased herds, thus decreasing manure availability. Intensified production techniques, such as stabling and disease control, are areas where extension services and projects could have a major impact on productivity in hillside areas. Also, by Asian standards, integration of fodder and food crop production is poorly developed in our case study countries. Its promotion would increase manure availability.

For the semi-arid regions, Powell and Williams (1993) and McIntire et al. (1992) noted that corralling livestock on cropland could have major soil fertility payoffs. In both types of regions, better integration in mixed crop-livestock systems is essential. Examples might be combining fodder, green manuring, and livestock husbandry intensification programs, or intensification of intercropping and mixed cropping techniques that increase output but protect the soil. More technical agricultural research is needed on these possibilities.

Organic Matter Apart From Manure. We noted that Rwanda has underinvested in the use of *green manuring* (an agroforestry practice using perennials or herbaceous annuals) and other agroforestry practices, despite successful on-farm trials. Research in Africa has, in general, shown the merits of green manure and fodder crops. The inclusion of forage legumes in crop-livestock production systems will promote a better integration of crop-livestock activities in several ways. The forage legumes will fix atmospheric nitrogen and, at the same time, provide feed for livestock. Animals within the mixed system will provide an additional source of income (Powell and Williams (1993)). Research on green manure has been ahead of its time in the sense that it was conducted before land and soil quality constraints became pressing. It is now time to look at these results again.

Animal Traction Programs. Animal traction is very important in our semiarid case study areas (Burkina Faso and Senegal) because of its value in reducing on-field labor requirements, allowing area expansion, increasing yields, pursuing intensification, and facilitating incorporation of manure and fertilizer (illustrated in the MSU productivity study in Burkina Faso, Savadogo et al. (1994 and 1996).

As discussed in Box 6 (see Page 17) for the case of Senegal, there is a need to reexamine the state of animal traction equipment and repair in areas that had successful programs in the 1970s. There is also a need for new local manufacture and repair capacity, which can be tied into small enterprise and rural employment programs.

5.2.2. Risk Reduction

Secure Land Tenure. Our work shows that farmers need secure land tenure in order to have confidence that they will benefit from long-term farm investments. The importance and application of this idea will vary greatly over countries and types of investments. Some evidence points to the assurance of long-term use rights (land tenure) as important for long-term land protection investments such as bunds and agroforestry, although in many cases it is shown to be less important for short-term soil fertility management.

The issue is not necessarily giving title so land can be used as collateral for credit (as many propose); evidence from Senegal suggests that farmers are leery of this. The issue is that legislation/custom must make farmers feel that they will be able to reap the benefits of land improvements that do not have immediate payoffs. There is substantial evidence that this does not necessarily require land titling; in some cases, land policies are even impeding this process. In Rwanda, for example, we recommended revision of traditional practices and land policies (such as laws prohibiting land sales) that impede land transactions and limit productivity increases.

Risk Can Undermine Conservation Investments. Risk is especially important in unfavorable zones, where investments in cropping — let alone in soil conservation — may have low, risky returns. When farmers are poor and risk averse, and conservation investments appear to have only long-term payoffs that are perceived as more uncertain than productivity or income diversification investments, resource conservation measures may be ranked quite low in the farmers' priorities.

Policymakers and program designers should not count on programs that promote resource conservation investments in fragile, risky areas to appear to farmers as automatically in their interest or feasible for them, given their short-term planning horizons and immediate survival needs. It may be necessary to have complementary programs that help them overcome capital constraints (such as trucks to haul laterite pieces for bunds) or generate alternative income sources that will reduce the risk of investment. We discuss this further in the credit section below.

5.2.3. Cash Sources

Farmers need cash to buy materials, animals, and hire labor for productivity and conservation investments. In practice, the three major sources of cash are nonfarm activities, cash cropping, and credit. One's own sources of cash have become critical after the dismantlement of many public credit programs in the rural areas of Africa in the 1980s.

Nonfarm Activities. Promotion of small, rural nonfarm enterprises is important for several reasons. First, such enterprises provide rural employment; they can also provide farm inputs. Second, nonfarm activities increase the demand for crops through downstream production linkages. Third, the income provided by nonfarm activities reduces pressure on the land by relieving households of the need to earn a livelihood entirely from farming. Fourth, nonfarm income can be an important source of cash for farm investments.

Unfortunately, nonfarm income is poorly distributed, and the poor need help to start off-farm businesses or find off-farm employment. Industrial location and small enterprise promotion policies should focus on providing greater nonfarm income-earning opportunities to the poor, and in fragile zones experiencing severe land constraints and soil degradation. In agroclimatically more favorable zones where agriculture is more dynamic, such policies could promote nonfarm enterprises linked to agriculture. For example, in Senegal we recommended programs promoting animal traction equipment manufacture and repair, processing of peanuts and cotton, and livestock feeding enterprises that sell manure and hides for local processing. Input delivery could also be improved by supporting microenterprises that provide inputs and services (e.g., repair services for animal traction).

Cash Cropping. We found in our case studies that cash cropping (of food and non-food crops) is crucial to both the incentives and capacity of farmers to make productivity and conservation investments in both cash crop and food staple production.

In Burkina Faso, Savadogo et al. (1994 and 1996) showed that the main cash crop (cotton) and the most productive food crop (maize) were complements, not competitors. With appropriate technologies (animal traction) and incentives (guaranteed markets for cotton), farmers in southwest Burkina have expanded their cultivation of both cotton and maize.

Moreover, credit programs organized by cash crop schemes, and cash income from cash cropping, allowed farmers to: (1) acquire fertilizer in Burkina Faso through cotton cropping; (2) acquire animal traction equipment in Mali through cotton cropping; (3) acquire equipment in Senegal through peanut cropping; and (4) acquire fertilizer through coffee production in Rwanda. These inputs also raised the yields of grains and tubers grown on the cash cropping farms (Dione 1989; Clay et al. 1995; Savadogo et al. (1994 and 1996).

Credit. Innovative credit programs are needed. Improving capital/credit markets will increase access to farm and nonfarm activity inputs for the poor.

To take advantage of farm/nonfarm linkages in areas where nonfarm income is reinvested in the farm, credit could be provided for nonfarm activities. This is especially attractive given that experience has shown it is difficult to design economically viable financial institutions to directly fund agricultural projects; the covariate risk problem is at the heart of this difficulty.[27] Note, however, that the success of a credit program for a specific crop depends on the returns, risk, and sustainability of the market for that crop. Crops with strong demand and profitability (e.g. cotton, horticultural crops) have had successful credit programs.

Credit programs that help cushion farmers from risk (e.g., by allowing variable interest rates or rescheduling after bad harvests) should also be investigated.

An innovative approach would be to *link input use and natural resource management programs*, perhaps with the help of extension services. For example, one could tie fertilizer credit to evidence of proper natural resource management practices, such as composting.

[27] von Pischke et al. (1983) and Carter et al. (1995) explored the difficulties of agriculture-specific credit programs.

5.2.4. Public Investments in Complementary Infrastructure

Need for Complementary Public Investments. Complementary investments by villages, Non-Governmental Organizations, national governments, and donors in physical infrastructure at the village or regional level can be crucial in facilitating profitable on-farm investments. Examples are roads, culverts, and wells. Investment bottlenecks due to lack of such infrastructure need to be identified and addressed (Reardon 1995).

Public interventions that demonstrate to farmers the practical payoffs of conservation investments are critical to reduce the perception of riskiness (Swindale 1988). Moreover, community institutional arrangements to reduce the problem of externalities undermining private incentives to investment are also important.[28]

Some new practices that are not, strictly-speaking, capital investments at the farm level (say integrated pest management) may be relatively cheap for the farmer in terms of cash outlays, but only if there are prior outlays by the community or state for extension programs and other "soft infrastructure" development, and possibly substantial increases in own-labor outlay on the farm (Reardon et al. 1992c).

Caveat on the "Local Participation" Approach. Community "social capital" is nowadays often the focus of donor and NGO activities. Collective action or "local participation" programs that are now in favor can be useful and successful if they address underlying infrastructure and economic constraints that households and communities face in pursuing their primary objectives — attaining food security and avoiding income shortfalls — especially when these farmers are poor and do not have much "margin of maneuver." If not, these programs will fail, even if they are aimed at objectives that can benefit local communities and the outside world in the long run.

Relief-to-Development. Combining programs that meet immediate food security goals with construction of complementary investments is key: a case in point are local *food-for-work* projects if the community lacks sufficient resources (von Braun et al. 1992). Relief programs could be designed to provide farm inputs and complementary infrastructure rather than just food aid. In Rwanda, we recommended that foreign assistance and government programs after the war assist in building the base of productive assets whose stocks have been reduced by conflict and neglect (e.g., perennial crops and livestock). This would help increase mulch and manure availability, and, in the case of bananas and coffee, protect against erosion. Disaster relief could also be used to rebuild herds, prevent or treat animal diseases, and improve livestock stabling facilities.

5.2.5. Extension and Research

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[28] Chopra and Rao (1992) described one such action in a community in India where the State "sweetened" and facilitated the action with complementary infrastructure investments.

Extension for Productivity. Farmers need knowledge of productivity and land conservation practices. We show that extension services have been, and can be, an effective tool for technology dissemination. In Senegal, we recommended extension programs on the use of fungicides, and encouraged the extension service to synthesize and diffuse information generated through recent research on ways of combining fertilizer, manure, and composting for soil fertility management. In Rwanda we noted that extension programs were needed to promote the use of fertilizer and lime on food, and not just cash crops.

Extension for Conservation. There is a need for improved extension services associated with conservation practices. But extension programs are costly. There are hard choices to make regarding the best use for shrinking resources: should an extension agent devote his time to showing farmers how to build bunds and terraces? Or how to apply fertilizer? Or how to space plants? If there are cash and labor constraints to the bigger projects (bunds and terraces), agents may choose to focus on the simpler techniques of plant spacing, timing of activities, and fertilizer selection.

This means that the state may need a special cadre of "sustainability extension agents" for the larger conservation investments, and couple this with credit programs. Farmers can be effective participants in, and purveyors of, this extension program ─ witness OXFAM's program in Burkina Faso of farmer-to-farmer diffusion of bund technology (Wright 1985). Such extension services can pay off, especially when the techniques are new and promise to be more appropriate to the local conditions than prior "recommended" conservation practices, as we found in Rwanda.

Research to Bring Down Investment Costs. Research (private and public) has a large task ahead of it to seek appropriate, <u>affordable</u> soil conservation measures, especially those which would reduce the cost of large, lumpy investments such as tied ridgers, bunds, and drainage infrastructure. Many technologies and practices are "on the shelf," but need to be adapted to the needs of the farmers both in form and cost (Matlon and Adesina 1992; Matlon 1985).

5.2.6. Seed

In many African countries, and in most grain and tuber zones, access to seed is not yet a critical constraint. The few areas using improved maize, or relying on peanut seed, are exceptions. Our Senegal case study treated the latter, and we discuss its implications here to point to what will be important issues in a broader area a few decades hence.

In Senegal, a critical constraint on productivity is poor access to peanut seed, and a decline in peanut seed quality. Improving farmers' access to seed requires both supply- and demand-side interventions.

On the supply side, programs are needed to promote the sale of certified seed. Possible strategies for accomplishing this are: marketing campaigns; sales of certified seed at weekly markets (instead of only at peanut collection points); sales in smaller, more affordable quantities (rather than at the present minimum of a 50-kilogram sack); sales throughout the year (rather than only for a month or two before planting); and increased competition in seed production and marketing.

On the demand side, farmers need the ability to pay for this seed. The needs are to (1) make seed more affordable by getting the price down, and (2) improve the farmers' cash flow through nonfarm income and credit so they can afford seed.

While the quantity of the available seed is a less important problem for cotton and maize, seed quality remains an important issue in many countries, as shown in part by the MSU studies of agricultural research impact (Crawford 1993).

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