MSU International Development Papers

Determinants of Farm Productivity in Africa: A Synthesis of Four Case Studies

by

Thomas Reardon, Valerie Kelly, Eric Crawford,
Thomas Jayne, Kimseyinga Savadogo, and Daniel Clay

MSU International
Development Paper No. 22
1996

Department of Agricultural Economics
Department of Economics
MICHIGAN STATE UNIVERSITY
East Lansing, Michigan 48824

MSU INTERNATIONAL DEVELOPMENT PAPERS

Carl Liedholm and Michael T. Weber

Editors

The MSU International Development Paper series is designed to further the comparative analysis of international development activities in Africa, Latin America, Asia, and the Near East. The papers report research findings on historical, as well as contemporary, international development problems. The series includes papers on a wide range of topics, such as alternative rural development strategies; nonfarm employment and small scale industry; housing and construction; farming and marketing systems; food and nutrition policy analysis; economics of rice production in West Africa; technological change, employment, and income distribution; computer techniques for farm and marketing surveys; farming systems and food security research.

The papers are aimed at teachers, researchers, policy makers, donor agencies, and international development practitioners. Selected papers will be translated into French, Spanish, or other languages.

Individuals and institutions in Third World countries may receive single copies of papers published since 1993 free of charge. Requests for copies and for information on available papers may be sent to:

MSU International Development Papers
Department of Agricultural Economics
219 Agriculture Hall
Michigan State University
East Lansing, Michigan 48824-1039
U.S.A.

Information concerning how to purchase MSU International Development Papers is included in the back of this publication and requests should be sent to:

MSU Bulletin Office
10-B Agriculture Hall
Michigan State University
East Lansing, Michigan 48824-1039
U.S.A.

DETERMINANTS OF FARM PRODUCTIVITY IN AFRICA: A SYNTHESIS OF FOUR CASE STUDIES

by

Thomas Reardon, Valerie Kelly, Eric Crawford,
Thomas Jayne, Kimseyinga Savadogo, and Daniel Clay

July 1996

This paper is published by the Department of Agricultural Economics and the Department of Economics, Michigan State University (MSU). Funding for this research was provided by the Food Security II Cooperative Agreement (AEP-5459-A-00-2041-00) between Michigan State University and the United States Agency for International Development, through the Office of Agriculture and Food Security in the Economic Growth Center of the Global Bureau (G/EG/AFS). Supplemental funding for this research was also provided to the FS II Cooperative Agreement by the Africa Bureau, through the Food Security and Productivity Unit of the Sustainable Development Division, Productive Sector, Growth and Environment (AFR/SD/PSGE/FSP).

Thomas Reardon is Associate Professor, Valerie Kelly is Visiting Assistant Professor, Eric Crawford is Professor, and Thomas Jayne is Visiting Associate Professor in the Department of Agricultural Economics, MSU. Daniel Clay is Professor in the Institute for International Agriculture, MSU. Kimseyinga Savadogo is Professor, FASEG, Université de Ouagadougou, Burkina Faso.

ISSN 0731-3438

Published by the Department of Agricultural Economics and the Department of Economics, Michigan State University, East Lansing, Michigan 48824-1039, U.S.A.

ACKNOWLEDGMENTS

This report is the final version of the document submitted November 1994 to USAID Africa Bureau: Reardon, T., V. Kelly, E. Crawford, K. Savadogo, and T. Jayne, "Raising Farm Productivity in Africa to Sustain Long-Term Food Security," MSU Staff Paper No. 94-77.

Collaborators in the case studies upon which this synthesis is based include: F. Byiringiro (MSU and Ministry of Agriculture, Rwanda), D. Clay (MSU), B. Diagana (MSU and Senegalese Agricultural Research Institute (ISRA)), A.A. Fall (ISRA), M. Gaye (ISRA), J. Kangasniemi (MSU), K. Pietola (MSU and Agricultural Economics Research Institute, Helsinki), K. Savadogo (FASEG, University of Ouagadougou, Burkina Faso), B. Sibomana (Ministry of Agriculture, Rwanda), L. Uwamariya (posthumous, Ministry of Agriculture, Rwanda), and David Tardif-Douglin (DAI).

We thank the United States Agency for International Development (AFR/SD/PSGE/FSP and USAID/Rwanda) for funding this work under the Michigan State University Food Security II Cooperative Agreement managed by the AID/Global Bureau, Office of Agriculture and Food Security.

We are grateful to Simeon Ehui (International Livestock Research Institute) and John Sanders (Purdue University) for their useful external reviews of this report. We also thank the following for useful comments: Jock Anderson, David Attwood, Roy Black, Arthur Dommen, George Gardner, Jeff Hill, Glenn Johnson, James Oehmke, Thomas Olson, and Michael Weber.

We are grateful for comments from participants in seminars where the results of this work have been presented: AID Africa Bureau seminars, February 1994, November 1994, May 1995, December 1995, March 1996; Hunger Briefing, World Hunger Program, Brown University, April 1995; African Studies Association Meetings in Orlando, Florida, November 1995; USAID/Mali, July 1995; ASSA meetings, January 1994; Conference on Technology Development and Transfer sponsored by USAID Africa Bureau, in Harare, Zimbabwe, July 1995; Conference for ANRDO/PSOs sponsored by USAID Africa Bureau in Annapolis, July 1995.

We also thank ICRISAT for provision of Burkina Faso data, ISRA and IFPRI for Senegal data, DSA/MINAGRI for Rwanda data, and Colin Thirtle and the Central Statistics Office of the Government of Zimbabwe for provision of Zimbabwe data.

EXECUTIVE SUMMARY

BACKGROUND: Over the past two decades, many cropping systems in Africa have been in a major transition--from land-abundant to land-constrained. Pressure to produce more from less and lower quality land has increased soil degradation. Yields of many major staple crops have fallen or stagnated. Rural households have diversified incomes into noncropping activities, and farming has become increasingly linked to the market economy. Structural adjustment programs have cut fertilizer subsidies and farm-support services, but have increased incentives for export crop production.

OBJECTIVES: The bulk of studies on farm productivity were done in the 1960s and 1970s before land became constraining. Our understanding of African farm productivity needs to be updated to see how farmers are responding to recent policy, economic, and environmental changes. We aim in this report to "dig below" aggregate trends to uncover differences in patterns and determinants of productivity over agroclimatic zones, types of technology, degrees of environmental degradation, and levels of improved inputs. The report synthesizes studies in four countries. The Burkina Faso, Rwanda, and Senegal studies use detailed farm-survey data from the past decade. The Zimbabwe study uses aggregate data from the past two decades which is stratified by farm type (commercial and smallholder).

FINDINGS

I. Productivity Patterns

Rates of growth in yields (output per hectare) and returns per labor day were generally low in the four study countries but differed by crop, zone, technology, and farm size, providing some success stories.

a. Yields increased for government-promoted cash crops in Burkina Faso (cotton and maize) and in Rwanda (maize, wheat, and soybeans). Total factor productivity of smallholder maize in Zimbabwe grew over 1980-1986, then fell when government support was cut.

b. By contrast, yields were stagnant or declined for many subsistence staples, such as millet in Burkina Faso and Senegal or tubers in Rwanda.

c. Yields in more favorable agroclimatic zones were 2 to 3 times greater than those in poorer zones.

d. Large swings in yields occurred between years of good and bad rainfall in the semi-arid zones, making farming very risky and analysis of longitudinal trends very sensitive to years covered.

II. Productivity Determinants

1. Fertilizer

a. Farmer-managed trials in Senegal show physical response and profitability (but also riskiness) of fertilizer use. Survey data from Burkina Faso show positive fertilizer impacts on crop output.

b. Observed fertilizer use varied widely by zone and crop (from under 10 to over 110 kg/ha, compared with an African average of 8 kg/ha). Greatest use was in higher rainfall areas, on cash crops, where parastatal agencies handled distribution, credit, marketing and credit recovery , and where households had more noncropping income.

c. The elimination of credit and fertilizer subsidies and a switch from government to private-sector distribution (reducing the area served) reduced fertilizer use in the study countries. In Senegal, fertilizer use on peanuts went from 38,000 t in 1976 to 3,000 t in 1988. Overall consumption of fertilizer went from 75,000 tons in 1980/81 (roughly its average in the 1970s) to 27,100 tons in 1985/86, 19,900 in 1986/87, and 22,400 in 1987/88. Farmers used much of the fertilizer on cotton, irrigated rice, and vegetables, i.e., where subsidies and credit remain (cotton) or where water is controlled (rice, vegetables). In Zimbabwe, elimination of fertilizer credit/subsidy in the mid 1980s caused a decline in fertilizer use on hybrid maize by small farmers.

2. Seed

a. The case studies in Senegal and Zimbabwe point to seed as an important determinant of productivity.

b. Plant-breeding programs have developed improved cultivars that have increased productivity (hybrid maize in Zimbabwe) or maintained productivity in the face of worsening environmental conditions (short-cycle peanuts in Senegal).

c. For seed to make its full contribution to productivity, public and private sector institutions must assure seed quality, availability, and affordability, through both research and supportive policies.

d. In Senegal the government seed distribution and credit programs have been cut back and seed prices increased by structural adjustment programs. In Senegal, the result was limited access to seeds, a marked drop in use of peanut seed, and a substantial acreage shift from peanuts to millet (hence less nitrogen fixation by peanuts).

e. Given previous constraints on the development of private sector input supply networks and rural financial markets, seed distribution in Africa has tended to work better when a single organization (1) provides seeds on credit in conjunction with complementary inputs and (2) recovers credit by controlling output marketing (e.g., cotton and confectionery peanuts in

Senegal, and cotton in Burkina Faso). This approach has tended to deal more effectively with the problems of coordinating input delivery, credit, and output markets than more decentralized and unintegrated networks found in much of Africa. The integrated approach has also tended to work better for cash crops than for food crops, which have scattered, small marketing outlets.

3. Animal traction

a. The main effect of animal traction shown in Africa to date has been to reduce field labor inputs and facilitate area expansion (especially on light soils), rather than to increase yields.

b. However, our case study in Burkina Faso showed strong positive farm-level impacts of animal traction on land productivity and labor returns in cotton in the favorable agroclimates as well as on supply responsiveness, efficiency of resource allocation, and manure use.

c. Investment in animal traction is more likely for households that have access to more land, earn more noncropping income, and grow cash crops.

4. Organic inputs and conservation investments

a. Practices that add organic matter to soil, conserve soil (prevent erosion) and help water retention (e.g., bunds, tied ridges, terraces) increase productivity by increasing soil moisture and the effect of fertilizer. Conservation investments are complementary with improved inputs and organic matter. The effects can be dramatic on the farms of the poor who are struggling to survive in fragile environments. In Rwanda, increasing soil conservation investments (moving from "low" to "high") increased yields by 25 percent. By contrast, moving from low to high erosion decreased yields by 35 percent.

b. Investment in soil conservation is more likely for farmers with smaller holdings (hence have less ability to fallow), earn more noncropping income, and grow cash crops.

5. Farm size and land tenure

a. In Rwanda, land rental (as compared to ownership) discourages use of fertilizer, organic matter, and soil conservation.

b. Smaller Rwandan farms, which had much higher land productivity than did larger farms, tended to have surplus labor. They also made more soil conservation investments, though they had similar levels of improved inputs per hectare compared to larger farms.

c. Commercial farms in Zimbabwe tended to have higher yields than smallholders, mainly because of better access to improved inputs and better land.

6. Noncropping income

a. Noncropping income is an important indirect determinant of productivity via its effect on farm input acquisition and investments.

b. Noncropping income can increase purchased inputs or capital investments where credit is unavailable or costly to use, or where other sources of cash income for loan repayment are lacking.

c. Noncropping income helps pay for soil conservation investments, for which credit is rarely available. Noncropping activities reduce household income instability and help to reduce risk by diversifying income sources.

d. The poor tend to have less access to noncropping jobs and less ability to start small businesses. This is worrisome because unequal access to noncropping income translates into unequal access to farm inputs in the face of limited credit access.

e. Noncropping income generally is correlated with improved input use (fertilizer and animal traction in Burkina Faso and Senegal, peanut seed in Senegal, and conservation investments and fertilizer in Rwanda). Yet in some areas, more noncropping activity is related to poorer farm performance, with the latter pushing the former.

7. Well-functioning input and output markets

a. Markets are also an indirect determinant of farm productivity as they affect profitability of farming, outlets, and input access.

b. Well-functioning markets help farmers acquire and use improved inputs and profitably sell outputs by reducing transaction costs and risks (e.g., from imperfect information, or price volatility due to a thin market). They also assure that more benefits from improved productivity will be passed on to consumers.

c. Parastatals assured vertical integration and coordination functions (input supply, credit, output marketing) for cotton (Senegal, Burkina Faso), maize (Senegal), and coffee (Rwanda). In Zimbabwe, government marketing depots and loans helped spur adoption of hybrid maize and use of fertilizer. The costs of these programs were high, however. Higher consumer prices were increased due to grain movement controls that forced the bulk of marketed grain output into the State marketing channels and onward into private large-scale milling (that tends to make grain more expensive to consumers than do alternative channels).

d. Nevertheless, in situations with poor farming conditions, market proximity can act to pull rural people out of farming and provide them alternatives.

POLICY IMPLICATIONS AND RECOMMENDATIONS

Case study reports provide specific recommendations per country. The general findings are as follows.

1. To improve long-term food security in Africa, farmers must be able to pursue sustainable intensification of farm production by use of improved inputs. Use of fertilizer, organic inputs, animal traction, and conservation investments needs to rise dramatically.

2. Strategies will need to differ, however, between favorable and unfavorable agroclimatic zones. With proper conditions, increased productivity can be expected in the favorable zones. Expectations for cropping intensification are more modest for the agroclimatically unfavorable and fragile zones where attention will need to be paid to alternative income sources off-farm. This will promote food security in the agroclimatically unfavorable zones and increase effective demand for farm products from favorable zones.

3. The environment and the farm productivity agendas are linked. Degradation and pressure on marginal lands cannot be halted without raising farm productivity. Intensification of already-cultivated land reduces pressure to crop fragile marginal lands. Yet interventions to improve farm productivity must be accompanied by conservation investments.

4. Noncropping employment and the farm productivity agendas are linked. In many areas, noncropping income is a critical means to pay for farm inputs and investments and achieve food security. Moreover, much noncropping activity is linked to the farm sector (downstream or upstream). Micro-enterprise promotion programs that provide rural employment while reducing the cost of farm inputs and increasing the off-farm multipliers from farm output growth are desirable.

The flip-side of this argument is that new cropping technology proposed for farmer adoption must not only be financially and economically profitable, but also attractive relative to alternative uses of household resources outside of cropping.

5. Cash-cropping programs spur productivity by providing cash for improved inputs. Depending on how they are organized, they can increase access (from the supply side) to improved inputs and to low-risk output marketing.

6. Promotion of improved inputs will need to be innovative to be consistent with widespread fiscal constraints and the goals of structural adjustment. Input use has traditionally been promoted in ways that are not economically sustainable. Yet the reduction of government programs and subsidies associated with structural adjustment appears to have discouraged the use of fertilizer and improved seed by raising costs and reducing access.

The upshot is that farm input costs must be reduced without returning to generalized subsidies. We advocate a “middle path” between fiscally unsustainable government outlays and complete government withdrawal from support to agriculture. Policy reform (exchange and interest rate policy, market liberalization) is **necessary but not sufficient** to spur higher farm productivity. The “middle path” addresses long-term structural problems via substantial public and private investment in agricultural research, human capital, and production and market infrastructure. Governments and donors need to invest in understanding how to promote the economic use of the tools of sustainable intensification--fertilizer, animal traction, organic inputs, water, and soil conservation.

Public investment should complement and spur private investment on-farm, in the input distribution system, and in primary product processing and distribution.

Thus the debate should be reopened on identifying cost-effective ways of increasing access to inputs, improving the delivery of inputs, and helping farmers find ways to earn cash income to pay for them. This effort is especially appropriate in countries whose macroeconomic environment has become more favorable through structural adjustment. This should be a priority policy issue in Africa in the 21st century.

CONTENTS

LIST OF BOXES

1. INTRODUCTION

In each of our four case-study countries (Burkina Faso, Rwanda, Senegal, and Zimbabwe), and in many other countries in Africa, governments view increasing and sustaining agricultural productivity as a means to overall growth, poverty reduction, and promotion of food security. We seek here to assist policy makers in pursuing that goal by informing them of research results concerning the determinants of farm productivity. What increases it? What constrains it? What are the policy, institutional, and technological approaches that can be taken to improve it?

Current study of agricultural productivity must build on the considerable edifice of studies on farm management, farming systems, and rural economy in the 1960s and 1970s that advanced our understanding of the determinants of productivity in African agriculture and the behavior of the rural household.[1] That work shows the benefits of using improved management practices and inputs such as fertilizer, animal traction, and manure, and points to connections between the farm and noncropping sectors, and the cropping and livestock economies.

The physical, economic, and policy context of the studies done in the 1960s and 1970s differed from the present. Most rural Africans were subsistence farmers producing for their own consumption and using few, if any, purchased inputs. The exception was in cash crop "pockets" such as the cotton zone in Burkina Faso, the coffee areas in Rwanda, and the peanut zone in Senegal. Input access was facilitated by these schemes, and input prices kept low by direct or indirect subsidy and public investment. African agriculture was viewed as land-abundant and labor-constrained, so the focus was on raising labor-yields and expanding cultivated area, and on promoting a shift from subsistence to commercial agriculture.

In the 1980s and 1990s, however, there have been fundamental changes in the rural economy and in the economic, political, and social context of the rural areas. These changes are important to our study of productivity. We briefly discuss these changes as follows.

1. *Intensification:* Land constraints have increased in many areas of Africa formerly thought to be land-abundant. Population density has risen, and fallow periods have decreased. Approximately a third of Sub-Saharan African countries can be ranked as land-constrained (e.g., Rwanda, Malawi), a third in transition (e.g., Burkina Faso, Senegal, Zimbabwe), and a third still land-abundant (e.g., Zaire).[2]

2. *Land degradation*: Farmland, commons, and open-access areas have been degraded by water and wind erosion, and nutrient loss through soil fatigue from too much farming of the same land without nutrient replacement. Bush and tree cover in the commons and open-access areas has been reduced by farmers and loggers.

---

[1] See Eicher and Baker (1982) for a review of this work.

[2] Pingali and Binswanger (1984); Binswanger (1986); and Binswanger and Pingali (1988).

3. *Income diversification*: Noncropping activity (in wage employment and self-employment, both locally and in migration) by farm households appears to have substantially increased[3]. African smallholders are no longer "only farmers," but rather multisectoral firms.

4. *Agricultural commercialization*: Cash cropping[4] has increased. Although many rural households still rely on home production for a large share of their staple food supply, most now participate in the monetized economy by selling crops and other home-produced goods, by buying more food and nonfood products in the market, and by earning a substantial share of their income from noncropping activities.

5. *Urbanization*: The share of the population in urban areas (not just in capitals and/or large coastal cities, but in small towns in rural areas) has greatly increased.

6. *Farm capital formation embodying technological change*: Investment in animal traction equipment has occurred, mainly in zones with rapidly commercializing agriculture (Sanders, Shapiro, and Ramaswamy (1996). However, farmers have made little investment in small-scale irrigation and tubewells. To our knowledge, no systematic information is available on whether farmers have increased their soil conservation infrastructure; however, some case studies show increases in these investments to counter growing degradation. (For example, for Burkina Faso, see Wright (1985) or Sanders, Shapiro, and Ramaswamy (1996).)

7. *Structural Adjustment Programs (SAPs)*: External debt, rapidly increasing food imports, and fiscal deficits in the 1970s led to macroeconomic and agricultural sector policy reforms in the 1980s and 1990s in most African countries (including our case study countries). The SAPs included: (a) devaluation of currencies; (b) cuts in or privatization of rural-service parastatals; (c) cuts in fertilizer and food subsidies; (d) cuts in programs for provision of credit, farm equipment, seed, and fertilizer; and (e) liberalization of markets. These policies had mixed effects on agriculture. On the one hand, by correcting "policy distortions" that undermined the profitability of tradeable crops, the reforms improved incentives. On the other hand, it appears that the private sector did not quickly fill the breach in input provision. When input costs rose, input access declined in our study countries.

Collectively, however, the above changes do not appear to be having a positive impact on the agricultural sector. The rate of growth in farm land-yields in many areas is below population growth rates (see Section 4). In some countries, agricultural growth has stagnated and in others it is even negative; fertilizer use is stagnant or declining in many areas. Average yields for the mainly-*subsistence grains* (with marketed surplus rates of around 10 percent, such as millet and sorghum) have stagnated. Population growth rate now exceeds the overall growth and the food output growth throughout much of the continent. Many countries now import substantial

[3] Reardon et al. (1994b).

[4] Cash cropping means that most of the crop output is sold; "crops" include food and nonfood crops.

quantities of staple foods.[5] Moreover, Africa has seen few Green Revolutions, particularly in food crops. Exceptions include relatively short-lived successes in hybrid maize in Zimbabwe in the 1960s for largeholders and in the first half of the 1980s for smallholders, in Kenya in the 1960s, and in Malawi, Zambia, Zimbabwe, Nigeria, and Ghana in the 1980s to 1990s, cocoa in Ivory Coast and Ghana, and cotton in French-speaking West Africa (Lele, van de Walle, and Gbetibouo 1989; Eicher 1995).

Yet the picture has not been purely gloomy. The study countries, for example, experienced *growth in yields of cash crops* (of cotton and, to some extent, of maize and peanuts). Some countries have developed high-value nontraditional export crops such as horticultural products in East Africa (see Jaffee and Morton 1995).

Nevertheless, sweeping statements about agricultural productivity based primarily on aggregate national crop production statistics are not enough to adequately inform policy makers about the state of African agricultural productivity or what policies, institutions, and technologies are needed to improve it. The transfer of attention to structural adjustment programs and to improvement in macro-economic indicators during the 1980s was accompanied by an emphasis in research on macro issues and away from the detailed farm management studies typical of the 1960s and 1970s. Consequently, much of the recent analysis of agricultural productivity relies on aggregate statistics. A necessary complement to that aggregate work is "digging below" the aggregate surface to examine how farm productivity is determined -- how policies, technologies, and institutions affect it, and how it varies over crops, zones, farm types. These insights will indicate where there are successes and what led to the success, and what might be replicable elsewhere.

We use available household data to add a micro dimension to our understanding of factors that are either increasing or constraining agricultural productivity across a broad spectrum of crops, agroclimatic zones, and types of households. We then draw implications for policy to increase food security via increasing farm productivity. This study focuses on farm-level productivity. Outside of our scope is the issue of how changes in farm-level productivity (and changes in policy to effect them) affect the rest of the economy.

The present document synthesizes results on patterns and determinants of agricultural productivity from four African case studies based mainly on primary data collected by the authors and collaborators. The case studies were undertaken in collaboration between MSU and African research institutions to strengthen the policy research capacity of those institutions. Study results have been the object of a series of outreach and policy discussions in the study countries and in regional fora (listed in the preface). Details of the methods and country-specific results are reported in the case study documents available under separate cover, and included in the references to this report.

---

[5] See Matlon (1990); Agcaoili and Rosegrant (1994).

The report proceeds as follows. Section 2 discusses definitions and methods. Section 3 describes the case study contexts and the data used. Section 4 presents patterns in average factor productivity in the study countries. Section 5 discusses findings concerning the key physical determinants of productivity (seed, fertilizer, land, labor, and animal traction) and conditioning factors (markets, credit, noncropping income, farm size) in the four case-study countries. Section 6 concludes with strategic, policy, and program implications.

2. CONCEPTS AND METHODS

"Input[6] productivity" is the output derived from the use of a standard unit of an input. This ratio is conditioned by the technology and quantity and quality of all inputs used. Farm productivity measures can be defined with one to all crops in the numerator. When there is more than one input, input quantities are aggregated using prices as weights (e.g., with a Divisia index). When all crops of the farm are in the numerator and all inputs in the denominator, one has an index of "total factor productivity" (TFP). When a single input is used (with one or more outputs) one has "partial factor productivity." TFP calculation in many areas of Africa is constrained by missing input prices (from missing markets), especially for land and manure and to a lesser extent for labor (Kelly et al. 1995).

"Yield" is the average product of an input. Land-yield (labor-yield, or average return to labor) is the average output per unit of land (labor) used. "Marginal input productivity" is the additional output (at the margin) produced by an extra unit of input used (e.g., how much millet an additional hectare of land will produce, say beyond the average land used), conditioned by the quality and quantity of inputs used.

To compare input productivities across goods or to aggregate over goods, productivities are commonly valued at the output price. For example, the marginal product of land, multiplied by the price of the good produced, is the "marginal value product of land," or land MVP.

In theory, if the producer is economically rational, and there is no constraint on the use of or access to inputs, the MVP of the input should equal the pecuniary factor price (which is termed "allocative efficiency"). If, however, the farmers' access to the labor market is constrained, or the farmers lack complementary inputs, the MVP of labor can be below the wage, indicating excess use of labor. Labor may be "bottled up" on the farm. Or, if the MVP of seed is above its price (because of constraints in access to seed), that means that farmers could efficiently use more seed. If the constraint were removed, farmers would use more seed and the MVP of seed would decline until it equaled the seed price.

Moreover, with the same conditions of economic rationality and lack of constraints on inputs, the MVPs of a given input should be equal across crops on a given farm. If they are not equal, it could be because farmers have input-access constraints (e.g., limits to the type or quality of land on which the farmer can grow cotton), or have nonoptimal behavior due to presence of risk (e.g., safety-first behavior), or have an agronomic constraint (such as a rotation requirement). Then, for example, farmers might find that they could earn more on each additional hectare if they could put the land under maize or cotton. But they cannot because of limits on availability to the proper quality or type of land for cultivation of these crops. So farmers have to put the extra land under millet and sorghum.

---

[6] We use "input" rather than "factor" for simplicity.

Calculation of marginal productivities requires estimation of production functions or profit functions. The production function shows output as a function of variable inputs (labor, manure, fertilizer) and quasi-fixed and fixed inputs (tools, equipment, land), and conditioning factors such as rainfall and soil quality. Given an estimate from the function of the marginal effect, e.g., labor on millet output, one can examine how this marginal impact changes as conditioning factors and input levels change. For example, how much more productive is labor when fertilizer or animal traction (AT) are used, or land quality is lower?

One can, in turn, ask what determines the input use levels. The determinants can be context variables such as policies, technologies, and institutions, or other household characteristics such as education or participation in the noncropping sector. For example, in Burkina Faso we studied what determined the adoption of animal traction, then split the sample into traction users and nonusers. Then we examined how their land and labor productivity differed by estimating production functions for each group. Thus, through the production function and input use functions, we traced how price and nonprice variables, themselves influenceable in part by policy, determine productivity levels.

3. DATA, COUNTRIES, AND ZONES

Of the four case studies, three were in the semi-arid tropics (Burkina Faso, Senegal, and Zimbabwe) and one is in the highland tropics (Rwanda). In the Burkina Faso, Rwanda, and Senegal studies, we used farm-level panel data, with four, three, and two years of data, respectively. In the Zimbabwe study, we used aggregate data (for smallholder and largeholder groups), with 20 years of data. All the studies covered the main agroclimatic zones in the countries.

The authors and collaborators collected the farm-level data that constitute some of the most detailed panel data sets in Africa. Data were collected frequently (weekly, fortnightly, or monthly depending on the variable and the survey) during the study years. The surveys covered incomes (from farm and noncropping activities), production, prices, transactions, input use, and other variables. The data go beyond the usual farm management data set that is confined to farm production. The detail permits us to address questions that are rarely examined (e.g., the impacts of soil erosion and soil conservation investments on productivity, or of noncropping activity on farm investments, and in turn on yields). The Zimbabwe data set is rare in Africa, because few long-term studies distinguish between smallholders and largeholders.

1. Burkina Faso

The Burkina Faso study[7] is based on a survey undertaken by ICRISAT (in collaboration with IFPRI and the World Bank). The data cover five growing seasons from 1981 to 1985, which include two severe droughts and three relatively good rainfall years. The sample includes 150 households spread over three agroecological zones (50 each, in two villages of 25 each). The choice of sample zones and villages was reasoned, and the choice of households was random.[8] The zones are as follows.

The first zone, the Sahelian zone, is in northern Burkina Faso. The zone is very poor agroclimatically, with rainfall variable and low on average (480 mm/year in the long-term, and 410 mm/year during the study period, with a coefficient of variation in the study period of .60). Farmers mainly produce coarse grains for home consumption and livestock for sale. These farmers make little use of animal traction or fertilizer, and they do not use irrigation. Households have (relative to other zones) substantial livestock holdings. Population density on farm land is .92 hectares per adult equivalent. Soils are degraded and commons are disappearing due to bush removal and erosion.

The second zone is the Sudanian zone in the center of Burkina Faso. The zone is poor agroclimatically, with rainfall moderately variable and low on average (724 mm/year in the long-term, and 563 mm/year during the study period, with a coefficient of variation in the study period

[7] Presented in Savadogo et al. (1994a), (1994b), (1995a), (1995b), (1996a), and (forthcoming).

[8] See Matlon (1988) for details of the survey methods.

of .36). Other aspects are similar to the northern zone, except that some animal traction is used (14 percent of farms) and some fertilizer is applied (11 kgs per hectare). Population density on farmland is .58 ha per adult equivalent.

The third zone is the Guinean zone, in the south. The zone is medium-to-good agroclimatically, with low variability and higher rainfall (952 mm/year in the long-term, and 779 mm/year during the study period, with a coefficient of variation in the study period of .14). Farms produce coarse grains, cotton (an important cash crop) and pulses. They make moderate use of animal traction (19 percent of farmers) and fertilizer (average level of use is 31 per hectare). The farmers do not irrigate. Household livestock holdings are small on average, but vary considerably. The land constraint is less advanced than in the Sudanian zone (.65 hectares per adult equivalent). Soils are not very degraded, and common bushlands are still available and in good shape.

In all zones non-cropping income as a share of total household income is substantial: 37 percent in the Sahelian zone, 20 percent in the Sudanian, and 40 percent in the Guinean (Reardon, Delgado, and Matlon 1992).

The analyses undertaken include: (1) estimation of land, labor, and fertilizer productivities (average and marginal); (2) production function estimation; (3) profit function estimation and derivation of output supply and input demand functions; (4) endogenous stratification of (2) and (3) by animal traction adoption; the latter was estimated as a function of noncropping income, landholdings, and other farm and individual characteristics; and (5) analysis of composition and distribution of farm household incomes across sectors.

2. Senegal

The Senegal study[9] is based on a survey undertaken by Institut Senegalais de Recherches Agricoles (ISRA) and International Food Policy Research Institute (IFPRI). The data cover crop production, incomes, and expenditures for 1988/89 and 1989/90. The first year rainfall was below-average, the second year was above-average. The sample consists of 140 households spread over the following five zones of the Senegalese Peanut Basin. The choice of the zones and villages was reasoned, and the choice of households, random.

The north region of the Peanut Basin is represented by one study zone, the “North,” in the Sahelian agroclimatic zone, with rainfall of 300 to 500 mm and sandy soils. Its rural economy is much more diversified into noncropping and migration activities than the other zones; livestock is important. Kelly et al. (1993) show the share of noncropping income in total income (for the same sample) to be 64 percent. Farmland is very degraded due to low (but intra-seasonally and interseasonally highly variable) rainfall, loss of tree cover, and erosion.

---

[9] Presented in Kelly et al. (1995) and (1996); Diagana (1994) and Diagana et al. (1995); Gaye (1994), Gaye and Sene (1994), Gaye and Kelly (1996) and Gaye, Sene, and Kelly (1996).

The center region of the Peanut Basin is represented by two study zones, the Center-west and the Central Peanut Basin. The Center-west, in the Sudano-Sahelian agroclimatic zone, has rainfall of 500 to 700 mm, sandy soils, and land constraints. The Center zone, also in the Sudano-Sahelian zone, has rainfall of 500 to 700 mm and sandy soils. In these study zones, cropping income and total household income vary greatly over years. Households are not as fully diversified away from crop production as in the north and have more difficulty covering income shortfalls when crops fail. Kelly et al. (1993) show that the share of noncropping income in total income is 24 percent. The Central Peanut Basin is densely populated by Senegalese standards (70 to 85 people per square kilometer), making it increasingly difficult to earn a living from either cropping or animal husbandry.

The southern region is represented by two study zones. The Southwest, in the Sudano-Guinean agroclimatic zone, has rainfall of 700-1000 mm, sandy soils, and land constraints. The Southeast, also in the Sudano-Guinean zone, has rainfall of 700-1000 mm, and rocky and clay soils. The two southern zones have better soils, better rainfall, and proximity to the Gambia. The latter provided (at least before the 1994 devaluation of the franc CFA) a source of cheaper inputs (fertilizer, for example) and food products (rice, sugar, and tea in particular), and increased options for households to earn noncropping income through cross-border commercial activities, at least before the Franc CFA devaluation in 1994. The share of non-cropping income in total income is 43 percent. While the southwestern zone is facing land constraints (32 people per square kilometer), this is not true in the southeast (7 people per square kilometer). Pastures are also relatively abundant in the east, making animal husbandry a major income source.

Peanuts and millet (and sorghum in the southeast) are the principal crops in all zones. Farmers in the southeast also produce a little cotton and maize. Cowpeas are becoming important in the north and the center, but still constitute a very small share of land cultivated.

Transportation and market infrastructure are relatively good throughout the Peanut Basin. However, the lower population density in the southeast means that the population in this zone generally needs to travel farther to get to paved roads and markets.

The analyses undertaken include: (1) estimation of average and marginal land, labor, and peanut seed productivities by crop and by zone; (2) comparison of characteristics of high-productivity farms with low-productivity farms; (3) analysis of the determinants of peanut seed acquisition; and (4) estimation of production functions.

3. Rwanda

The Rwanda study[10] covers three years, 1988-1991. The data are from a farm-household survey based on a nationwide stratified-random sample of 1,240 households. The Agricultural Statistics

[10] Presented in Clay and Reardon (forthcoming), Uwamariya, Kangasniemi, and Reardon (1993), Kangasniemi and Reardon (forthcoming), Clay et al. (1995a), Byiringiro and Reardon (forthcoming), Clay, Reardon, and Kangasniemi (1995b).

Division (DSA) of the Ministry of Agriculture and Animal Husbandry (MINAGRI), in collaboration with MSU, conducted the survey. The sample is spread over the country's five agroecological zones, which are defined according to differences in altitude, rainfall, soil type, and a variety of agricultural characteristics including cropping patterns and livestock ownership (see Clay and Dejaegher 1987). The five zones lie within the tropical highlands, with rainfall ranging from 800 to 1300 mm/year.

On average, households cultivate slightly less than one hectare of land (versus 5-10 hectares of land per household in Burkina Faso and Senegal). The distribution of landholdings is more skewed than in the Sahel case studies, with a Gini coefficient of .43 versus one of .30 in Burkina Faso. Cultivated holdings are fragmented into many smaller plots. The vast majority of landholdings are owner-operated. Only 9 percent are rented.

Pulses, roots, tubers, and grains are the main food staples, and coffee and bananas are the main cash crops among sample households. Farming is labor-intensive. Hoes and machetes are the main farm tools. Farmers do not use animal traction. Most households own a few small ruminants. Less than a quarter own cattle. Livestock husbandry is integral to the farming system, but the progressive conversion of pasture into cropland has caused a reduction in livestock production in recent decades, and a decline in manure availability. Population density is among the highest in Africa (574 people per-square-kilometer of cultivable land). Virtually all arable land is used for farming. Marginal lands once set aside for pasture or left in long fallow are now coming under more intensive cultivation. Loveridge (1992), using the same sample, shows that noncropping income (from labor sales and self-employment) is 25 percent of total income, although the average varies from 10 to 38 percent over the 10 prefectures comprised by the study zones.

The analyses undertaken include: (1) production function estimation, including examination of the effects of land quality (erosion), soil conservation investments, and farm size; (2) analysis of the determinants of fertilizer and organic matter use, investment in soil conservation, and land use; (3) analysis of the determinants of crop mix; and (4) analysis of retrospective observations on changes in yields and land degradation.

4. Zimbabwe

The Zimbabwe study[11] uses two aggregate time series, one for smallholders (1975 to 1990) and one for large commercial farmers (1970 to 89), without distinction of agroclimatic zone. The largeholder data are from the Central Statistics Office and the smallholder data are from the aggregate agricultural accounts compiled for the communal sector by the Ministry of Lands, Agriculture and Water Development. The University of Reading and Michigan State University compiled the aggregated data.[12]

---

[11] Presented in Jayne et al. (1994) and (forthcoming).

[12] See Thirtle et al. (1993) for details.

Zimbabwe's agricultural structure is dualistic--with a large-scale, capital-intensive commercial sector and a small-scale, low-input smallholder sector. The commercial sector is composed of about 4,000 farmers of mainly European descent controlling 35 percent of the country's arable land, while the other 65 percent is managed by about one million African smallholder households. The largeholders account for about 70 percent of the nation's agricultural output and 80 percent of the marketed output (Thirtle et al. 1993).

Although the analysis did not distinguish agroclimatic zones, there is a rough correspondence between farm groups and zones. The zones with more than 650 mm of rainfall have only one-quarter of the smallholders. About 58 percent of the land in these regions is operated by largeholders, and 36 percent by smallholders (6 percent is composed of national parks and other public lands). Three-quarters of the smallholders live in regions with less than 650 mm rainfall, regions that are subject to frequent drought.

The analyses undertaken include: (1) the estimation of profit functions for smallholders and largeholders by crop, controlling for government grain buying stations, government loans disbursed, and rainfall; and (2) the calculation of total factor productivities for smallholders and largeholders.

4. PATTERNS IN PRODUCTIVITY: AGGREGATE VERSUS DISAGGREGATED

Below we examine aggregate patterns for the study countries over the last several decades, and then examine patterns using farm-level data. We conclude with a discussion of the need to look beyond farm productivity to full rural household productivity by adding noncropping income to the equation.

4.1. Aggregate Patterns

We use FAO data by crop to calculate growth rates in labor yields (national output per agricultural worker) and land yields (output per hectare cultivated) over 1961 to 1991 for Burkina Faso and Senegal. We fit linear functions of yields to time trends. For Burkina Faso, annual rates of growth in land yields were 1.7 percent for maize, 0.7 percent for millet/sorghum, and 3.8 percent for cotton. For labor yields, the rates were 0.1, -0.2, and -1.5, respectively. For Senegal, the land yield rates were 1.6 percent for maize, 0.6 percent for millet/sorghum, and -0.0 percent for peanuts. The labor yield rates were 0.1 percent for maize, -0.2 percent for millet/sorghum, and -1.5 percent for peanuts. In general, land yields grew more quickly than did labor yields.

In Rwanda, we used data from DSA/MINAGRI (farm-level series covering 1984 to 1991), one of the longest farm-level series in Africa, and FAO data covering 1979 to 1991. The two series differ somewhat.[13] According to the DSA data, the land yields of only three crops (maize, wheat, and soya, that together cover only 10 percent of cultivable land in 1990) increased during 1984 to 1991. Maize output grew at a rate of 2 percent (1 percent according to FAO data). Compare this gain to the population growth rate of 3.4 percent. By contrast, DSA data show land-yield stagnation or losses for nine crops (sorghum, white potatoes, sweet potatoes, coffee, cassava, dry peas, peanuts, beans, and bananas, that cover nearly 90 percent of the cultivated land in 1990).

In Zimbabwe, the FAO data over this period show a dim picture for maize, the main food crop, with land yields increasing only at 1.1 to 0.6 percent per year, and labor yields barely changing, at 0.3 percent per year. But this disguises rapid land yield growth in maize starting in 1981, and after dips in land yields from droughts from 1982 to 1984, a rise again in 1985 and 1986. Smallholder total factor productivity grew at 7 percent annually from 1975 to 1990, but tapered off since 1985. After 1985, the growth rate of maize production has been outstripped by population growth. After rising dramatically during the early 1980s, per capita maize production in the smallholder sector during 1989 to 1991 had declined to about the same level as it was at independence in 1980. Zimbabwe's smallholder maize area peaked in 1985, and has declined at an average rate of 55,000 hectares per year from 1985 to 1991. Most of the decline in the smallholder maize area appears to be in the lower-rainfall areas that are already subject to chronic food deficits. For Zimbabwe's commercial farming sector, output had grown at an annual rate of

---

[13] Clay et al. (1995a) discuss the details. FAO yield figures are substantially above those of DSA for most crops. DSA's 1989 to 1991 mean yield estimates for maize, sweet potatoes, and cassava are 23-30 percent below those of FAO, and the estimates for sorghum, coffee, and potatoes are 12-18 percent below the FAO figures. Only bean yield estimates are the same from the two sources.

over 4 percent during the 1970s, but this rate dropped to just over 2 percent during the 1980s. However, total factor productivity during the 1980s increased 3.5 percent annually, compared to 3.4 percent during the 1970s.

Thus, in general, land yields and labor yields in the four study countries were stagnant except in the cases of cotton and maize in Burkina Faso, maize, wheat, and soya in Rwanda, and maize in Zimbabwe during the first half of the 1980s. Land yields rose for commercialized, in the main, food crops (except for cotton). Farmers of these crops had benefited from market support and access (sometimes subsidized) to key inputs such as seed and fertilizer, and to loans. In general, yield growth for subsistence (or semi-subsistence) food staples stagnated or fell.

4.2. Disaggregating the Aggregate Picture

Farm-level data allow us to "dig below" the country-level data, examining differences by agroecological zone, farmer-type, and good-rainfall versus drought year. Data used for national and FAO statistics are usually broken down by administrative regions. The latter are less useful than agroclimatic zones for understanding productivity differences. The main findings are as follows.

First, large differences in farm productivity are evident over agroclimatic zones for most crops within each study country. Yields in agroclimatically unfavored zones are on average well below those in agroclimatically favored zones (which have higher and more stable rainfall).

> In Burkina Faso, for example, the ratio of favorable (Guinean) zone land-yields to those of the unfavorable (Sahelian and Sudanian) zones are 1.5 for millet, 1.5 for sorghum, 1.2 for maize, and 3 for cotton (over the study years).
>
> In Senegal, there is no statistically significant difference in peanut land yields across agroclimatic zones. This may be due to the development and extension of peanut varieties that are adapted to different rainfall regimes. Millet land yields, however, are 1.7 times higher in the southern zones (Sudano-Sahelian zones) compared to the northern zone (Sahelian zone).
>
> In Rwanda, the ratio of the land yields in the zone with the best yields to those in the worst were: 1.7 for beans, 3.1 for maize, 1.4 for sweet potatoes, 3.8 for white potatoes, 1.4 for bananas, and 2.4 for coffee. Labor yields also differ greatly over zones.

Second, annual aggregate growth rates mask large differences in land yields between years and zones. The differences are greatest where rainfall variability is highest, in the drier areas of the semi-arid regions.

> In Burkina Faso, for example, millet land-yields in the Sahelian zone in a year of good rainfall (1983) were 3.6 times those in the drought year 1984. The latter ratio is about twice the ratio of land yields between favorable and unfavorable zones in a good rainfall year (1.5). Thus, with plenty of rainfall, the zone differences are nearly erased.

Third, land yields can differ greatly over technology regimes. In Burkina Faso, millet and sorghum land yields are close between animal-traction user and nonuser households (in the Guinean and the Sudanian zones). For cotton, however, traction-user yields are 50 percent greater.

Fourth, land yields can differ by farm size. In Rwanda, the ratio of land yields of the smallest farm quartile to those of the largest farm quartile is 1.6 for bananas, 2 for white potatoes, 1.7 for sweet potatoes, 1.6 for beans, and 1.9 for coffee. In Zimbabwe, farm-level evidence shows that maize land yields on commercial farms can be 3 to 5 times those on smallholder farms.

Whether smaller farms have greater land-yields than larger farms depends on whether larger farms use nonlabor variable inputs more intensively than smaller farms (thus compensating for their lower labor/land ratios). In Rwanda they do not, but in Zimbabwe they do.

Fifth, in practice, marginal value products (MVPs) can also differ over crops on a given farm. As noted in Section 2, economic theory predicts that they should not differ where there are no constraints in land, labor, capital access or no market distortions. Nevertheless, this does not always hold in Africa because of input constraints and market distortions.

We found in Burkina Faso, for example, that land and labor MVPs were much higher for cotton and maize (cash crops) in the Guinean zone than are those of millet and sorghum, subsistence crops. In Rwanda, the value of land yields and land MVPs differ over crops, as bananas and coffee earn about twice as much per hectare as do beans and sweet potatoes (that is, cash crops earn much more than do subsistence crops). But in both countries, there are constraints on access to the type and quality of land that the higher value crops require, and on fertilizer and manure required.

Sixth, the MVP of an input can differ from the input's price, implying under use or overuse of the input, given the levels of complementary inputs (as discussed in Section 2).

> In Rwanda, we find that the MVP of land on small farms is well above the rental price of land, implying a land market constraint. Moreover, the tercile of smallest farms in Rwanda apply labor until the labor MVP is only a third of the market wage compared to two-thirds for the largest farms. This implies a “bottling-up” of labor on the smallest farms, with a lower opportunity cost of labor than that reflected in the farm labor market. This may be due to constraints to access to that labor market as well as to nonagricultural employment opportunities.
>
> In Senegal, the MVP of peanut seed exceeds its price, indicating access constraints to seed. The MVP of labor, however, is below the market wage, indicating that more than the economically optimal amount of labor is being used. These smallholders may lack access to labor market jobs.

In sum, farm-level data allow us to go “below” the surface of the aggregate data. Despite our finding a number of constraints and much evidence of stagnation, we also found that land yields increased substantially for some crops in some periods (cotton and maize in Burkina Faso or Zimbabwe), and in the favored zones in the African semi-arid tropics or in pockets of productive agriculture in the Rwandan highlands. Aggregate data hide these farm-level successes. Yet we need to know the determinants of these successes as a guide to future action.

4.3. A Broader View of the Labor Productivity of the Farm Household: Adding the Noncropping Sector

Although the rest of this report returns to the cropping-side of the farm household economy, this section presents a useful aside on the importance of the noncropping sector to the modern African farm household. Hill (1982) laments that the traditional view persists and that the typical African rural household is exclusively engaged in farming, with only very minor activity outside the farm. Early work in Nigeria by Norman (1973), Matlon (1979), and Hill (1982) showed that this is a misconception, and more recent studies confirm this.[14] African farmers substantially diversify their incomes beyond farming into noncropping activities (as noted in Section 3 for the case study countries). This is important for several reasons.

First, our observations on cropping performance *understate* the full output of the farm household, and this in a sense understates the full labor-yield (in income terms) of the farm household. A narrow focus on crop output and crop productivity neglects the important non-cropping dimension of farm household's activity, that can be nearly half of its income and output per person. Much more economic activity is taking place in rural areas in Africa than crop statistics show.

Second, the first argument reflects on the "numerator" of the land-yield measure. The flip-side of the argument touches on the "denominator" of the labor productivity measure in the crop sector. As members of the household are working part or full time in the noncropping sector, it would be inappropriate (though usual in aggregate statistics) to divide crop output by rural adults. One would have to remove from the denominator the equivalent time used off-farm, thus increasing the crop land-yield measure. We have done this in our Rwanda study.[15]

Third, below we show that the farm household's participation in the non-cropping sector affects its cropping productivity via its effect on variable input and capital acquisition.

Fourth, the success of the farm and noncropping sectors are interdependent. On the one hand, Reardon et al. (1994a) show for Burkina Faso, Niger, and Senegal that most noncropping income earned by farm households is from "production-linkage" activities (upstream and downstream from local agriculture). The latter include supplying inputs and services to the farm or using

[14] For example, in Botswana and Zambia (Low 1986), Kenya (Collier and Lal 1986), Burkina Faso (Reardon, Matlon, and Delgado 1988; Reardon, Delgado, and Matlon 1992), Senegal (Kelly et al. 1993), Niger (Hopkins and Reardon 1993), and Rwanda (Loveridge 1992).

[15] See Kelly et al. (1995) for a full discussion of the first two points.

outputs from the farm in processing and marketing. This shows how important the crop sector is for off-farm activity. On the other hand, activities in the off-farm components of the food system affect the profitability of farm investments in productivity, as well as the extent to which the gains from productivity increases are passed to consumers in urban areas.

Fifth, we find it worrying that noncropping income in Burkina Faso, Rwanda, and Senegal is inequitably distributed with both share and absolute levels much higher for richer households than for poorer households in a given zone. The poorest are most dependent directly on cropping. Inequality in access to noncropping income can translate into poorly distributed success in increasing farm productivity.

5. WHAT DETERMINES FARM PRODUCTIVITY?

This section is organized by productivity determinant. In each subsection, we first present background discussion if applicable, then key findings, and illustrations from case studies in boxes.

5.1. Fertilizer

5.1.1. Background

The role of fertilizer in increasing African agricultural productivity has become a surprisingly controversial topic. It seems self-evident to say that fertilizer increases productivity. Yet there have been many attempts to remove fertilizer from the list of key productivity-enhancing options worthy of government and donor policy support. Among the reasons given for downgrading its importance in Africa are its riskiness under conditions of low or erratic rainfall, its relatively low yield response in Africa when compared to results in Asia and Latin America, as well as its high distribution costs in a context of low effective demand and poor storage facilities and roads.

During the past decade, research and extension services have given priority to finding more cost-effective and "environmentally friendly" fertilizer recommendations for African farming systems. Part of the motivation for this research was low fertilizer use. Bumb (1988) reports an average of 8 kilos used per hectare in Africa versus 57 kilos for developing countries in general. The research was also motivated by evidence that high doses of fertilizer without reconstitution of organic matter were hurting soil quality.[16] This recent research has produced recommendations for smaller (i.e., more affordable) applications of fertilizer, larger applications of organic matter, and use of bunds or tied ridges to prevent fertilizer run-off.[17]

As land constraints increase under population pressure in the semi-arid tropics and highlands of Africa, fertilizer, in combination with organic matter, remains one of the few options available for rapidly increasing yields and arresting soil degradation through acidification, thus reducing the need to cultivate fragile, marginal lands. Using fertilizer in combination with organic matter is not, however, a panacea as there are also constraints on the availability of organic matter. Population pressure has pushed farmers onto land that was previously reserved for pasture (the center-west of Senegal's Peanut Basin, for example), making it more difficult to keep animals close to cultivated areas that need the manure. Furthermore, there are competing demands for crop residues that prevent them from being plowed back into the soil (the thriving market for peanut hay in Senegal or cowpea hay in Niger are prime examples).

Unfortunately, no one has found real alternatives to fertilizer and manure for increasing productivity. Marginal value products of labor for most case study countries and crops are

---

[16] Sarr (1981); Pieri (1989); Matlon and Spencer (1984); Kelly (1988).

[17] Matlon and Spencer (1984); Ohm and Nagy (1985); Matlon and Adesina (forthcoming).

already low (frequently below wages), indicating that increasing labor use would not be profitable. As discussed below in the Senegal seed example, increased seeding densities are not a sustainable route to better productivity. Animal traction makes an important contribution, but is at its best when combined with complementary inputs such as fertilizer and manure.

An analysis of household crop production data for Burkina Faso and a 19-year time series of aggregate-level data for Zimbabwe, plus a review of the literature on economic returns to fertilizer in Senegal, confirm that fertilizer can still play an important role in increasing land-yields and aggregate output in the higher (>700 mm) rainfall zones (see key results below).

Despite the contribution that fertilizer can make in these countries, an analysis of input use patterns for Burkina Faso, Senegal, and Zimbabwe reveals that the elimination of fertilizer credit and subsidies associated with structural adjustment programs has led to sharp reductions in fertilizer use. Case study evidence on both the productivity of fertilizer and the declining use rates is summarized in Boxes 1 and 2.

5.1.2. Our Findings

First, fertilizer is more costly and financially risky than some other variable inputs such as seed, hence constraints on farmer demand are greater. Fertilizer is bulkier, harder to store, and more costly to transport than seed, hence constraints on effective distribution are greater.

Second, data on farmer-managed trials in Senegal show evidence of physical response and profitability (but also riskiness) of fertilizer use. Survey data from Burkina Faso show evidence of fertilizer impacts on output when combined with manure and animal traction.

Third, observed fertilizer rates varied widely by zone and crop (from under 10 to over 110 kg/ha in Burkina Faso, for example, compared with an African average of 8 kg/ha). Greatest use (well above the African average) was in higher rainfall areas and on cash crops, where distribution, credit, and marketing/credit recovery were handled by a parastatal, or where households had more noncropping income.

Fourth, the elimination of credit and fertilizer subsidies and a switch from government to private sector distribution (reducing the area served), often associated with structural adjustment programs, have had a negative impact on fertilizer use.

In Senegal, fertilizer use on peanuts went from 38,000 tons in 1976 to 3,000 tons in 1988. Overall consumption of fertilizer went from 75,000 tons in 1980/81 (roughly its average in the 1970s) to 27,100 tons in 1985/86, 19,900 tons in 1986/87, and 22,400 tons in 1987/88. Much of the fertilizer use was on cotton, irrigated rice, and vegetables. This is where subsidies and credit remain (cotton) or where farmers have water control (rice, vegetables).

In Zimbabwe, smallholders rapidly adopted hybrid maize when fertilizer credit was available and output market prices were guaranteed. When fertilizer credit was eliminated in 1985, fertilizer

Box 1. Effects of Fertilizer Use in Burkina Faso

Farm-survey data are seldom used to evaluate fertilizer response because it is so difficult to obtain statistically significant coefficients when other inputs (timing of fertilizer applications and other key activities such as seeding and weeding, for example) are not controlled. Analysis of land-yields for Burkina Faso did not show a statistically significant effect of fertilizer. Analysis of crop output (using profit function estimation and deriving the supply function) did, however, show that fertilizer has a statistically significant and positive impact on the gross value of household crop production in the Guinean zone. The sample was stratified (endogenously) into animal-traction user and non-user households to capture the supply response effect of technology, price, and nonprice effects on supply response. Elasticities of supply with respect to fertilizer use were .34 and .55 for maize and cotton for traction users in the Guinean zone, and .84 for cotton for non-user farmers. The other elasticities were much lower, as the other grain crops are less responsive and less fertilizer is used on them. The elasticity for manure use was also much lower in the unfavorable zone (Sudano-Sahelian) as not much is used there and weather is unstable and poor on average. The elasticity of maize with respect to manure was around .3 for both groups in the Guinean zone.

use declined. The amount of fertilizer that could be purchased with government credit disbursed to smallholders was 44,000 metric tons in 1992 compared with 148,000 tons in 1986.

Cotton production in Burkina Faso and confectionery peanut production in Senegal have been spared from the cutbacks in agricultural support programs that have affected producers of other crops. The institutions running both of these programs provide a wide range of inputs to farmers on credit (seed, fertilizer, pesticides, herbicides). Both institutions have a virtual monopoly on purchasing the output because there is no competing local demand, and both, therefore, are relatively successful in recovering input loans. Monopoly control over output marketing, however, appears to be the key to loan repayment. When farmers have alternative means of disposing of their output, loan repayment becomes more problematic. This is the case for producers of oil peanuts in Senegal. The institution providing credit cannot count on recovering the loans at marketing time.

Nevertheless, Burkina Faso's fertilizer subsidy removal (gradually effected from 1983 to 1987) was accompanied by a reduction in fertilizer use on cotton (SOFITEX 1993). After that decline, fertilizer use rose from 1988 to 1992 apparently because of nonprice factors and increased awareness of its need in cotton production. During the whole period SOFITEX essentially subsidized input credit to cotton farmers, however, by offering credit below market rates.

In Box 1 we discuss the effects of fertilizer use on productivity in Burkina Faso. Boxes 2 and 3 contain discussions on the returns to fertilizer use in Senegal.

Box 2. Economic Returns to Fertilizer in Senegal

Although our study examined the physical relationship between fertilizer and output, it did not include analysis of the economic returns to fertilizer at the farm level. However, one study on economic returns to fertilizer in Senegal (Kelly 1988) reveals that average value/cost ratios calculated using a 20-year data set from farmer-managed trials in the southern Peanut Basin were 3 for peanuts and 6 for sorghum. This is well above the level of 2 usually thought to stimulate use. Trials used fertilizer doses recommended by extension services from 1960 to 1980. Despite the high averages, response and profits are extremely variable in this zone of relatively high rainfall (>800 mm). Peanuts, for example, had a ratio below 2 during 40 percent of the time and above 4 during 45 percent of the time. These results show that fertilizer use is profitable on average in the southern Peanut Basin, but highly risky, which suggests that greater use is unlikely to occur without some type of risk sharing or insurance program. Kelly (1988) also analyzed 15 years of data for the central Peanut Basin showing much greater risk, lower response, and lower profits than found for the southern Peanut Basin. Value cost ratios were below 2 during 70 percent of the time for peanuts and 20 percent for millet. The average value cost ratio for the entire period was 1.4 for peanuts and 3.5 for millet. Given the poor response and profitability in this zone, intensification using fertilizer makes little sense; alternative means of improving soil fertility must be sought.

Box 3. Fertilizer Use in Senegal

Because of the fiscal unsustainability of the programs, the government experimented with different fertilizer distribution, price, and credit policies during the early 1980s in an effort to eliminate direct budgetary support of input distribution and subsidy programs for the most common crops (oil peanuts, millet, and sorghum). Credit programs were virtually eliminated, subsidies were removed, and government involvement in distribution stopped, leaving a very reluctant private sector in charge. While annual fertilizer consumption in Senegal was in the range of 50 to 70 thousand metric tons during the 1970s, it fell to less than 30 thousand tons during the latter half of the 1980s. Prior to 1980, 80 percent of fertilizer was consumed in the Peanut Basin. By the end of the 1980s, only 25 percent was used in the Peanut Basin with most of the rest going to irrigated rice and horticulture. Case study survey results show that in 1989/90 not a single farmer in the sample used fertilizer on oil peanuts and fewer than 5 percent of households applied fertilizer to millet or sorghum fields. The few farmers using fertilizer on cereals purchased it for cash in The Gambia where it was sold at about half of the prevailing Senegalese price. It is not possible to trace the effect of declining fertilizer use on aggregate productivity, but ample survey evidence shows that farmers believe their soil fertility has fallen substantially since they stopped using fertilizer (Gaye 1992; Kelly 1988).

5.2. Seed

Our key findings are as follows.

First, the case studies point to seed as one of the most important determinants of productivity. MSU studies of returns to agricultural research have also showed the pivotal role of effective seed distribution (Crawford 1993).

Second, plant-breeding programs have developed improved cultivars that have increased productivity (hybrid maize in Zimbabwe) or maintained productivity in the face of worsening environmental conditions (short-cycle peanuts in Senegal).

Third, for seed to make its full contribution to productivity, seed quality, availability, and affordability must be assured by public and private sector institutions, through both research and supportive policies.

Fourth, the government has cut back seed distribution and credit programs. Seed prices have increased because of policy reforms associated with structural adjustment. In Senegal, the result has been limited access to seeds (reflected in marginal value products of seed well above seed prices), a marked drop in use of peanut seed, and a substantial acreage shift from peanuts to millet (with the consequence of less nitrogen fixation by peanuts).

Fifth, given previous constraints on the development of private-sector, input-supply networks and rural financial markets, seed distribution in Africa has tended to work better when a single organization provides seeds on credit in conjunction with complementary inputs and recovers credit by controlling output marketing (e.g., cotton and confectionery peanuts in Senegal, and cotton in Burkina Faso). This vertically integrated approach has tended to deal more effectively with the problems of coordinating input delivery, credit, and output markets than more decentralized and un-integrated networks found in much of Africa. The integrated approach has also tended to work better for cash crops with a regional, national or international market, than for semi-subsistence crops (as the latter are sold locally at a variety of outlets).

Case studies reveal two examples of successful development and adoption of new seed varieties, hybrid maize in Zimbabwe and short-cycle peanuts in Senegal. The successes were of a limited duration, however, because tight government budgets in the 1980s led to a reduction in input distribution and subsidy programs that had eased adoption. Reduction in these support programs made it difficult for farmers to obtain desired quantities of good quality seed and complementary inputs.

The productivity-enhancing potential of seed is dependent not only on the development of appropriate varieties but also on programs that multiply and market the seed in such a manner that ensures quality, availability, and affordability. The Zimbabwe and Senegal case studies provide examples of improved varieties being developed and adopted when support services were in place.

Box 4. Hybrid Maize Seed in Zimbabwe

In Zimbabwe, hybrid maize seeds were bred in programs that targeted the larger commercial farmers. In the late 1970s, the hybrid seed was made available to smallholders. Rapid adoption did not take place because smallholders did not have access to fertilizer, loans, and reliable market channels. In the first half of the 1980s, the government provided these supporting services by establishing a public loan disbursement program and a network of marketing outlets (Rohrbach 1989; Jayne et al. 1994). When the conditions were in place, the adoption of seed proceeded rapidly. In a short time all smallholders were growing some hybrid maize. In the late 1980s, however, the government reduced expenditures for the credit (particularly fertilizer credit) and marketing programs.

Payoffs to research and development (to raise productivity) require a supportive policy environment "in tandem" with the productivity-increasing measure (the hybrid seeds were "on-the-shelf" for over a decade before marketing improvements stimulated their use by smallholders). After the mid 1980s, tight government budgets and structural adjustment forced a decrease in the number of depots and a cutback in the number of loans. The independence war was also a factor impeding the distribution of inputs to rural areas. The reduction in support services and infrastructure had as a counterpart the discouragement of hybrid maize production and marketing and use of complementary inputs geared to it, and a reduction of cropped area and resource allocation to agriculture.

Box 5. Peanut Seed in Senegal

In Senegal, peanuts are the principal cash crop for most farmers. Maintaining a high-quality supply of seed at affordable prices is a key issue for all peanut-producing countries because peanut seed has a low reproduction rate. (One hectare of millet requires only 4 kilos of seed; one hectare of peanuts requires from 60 to 100 kilos of seed.) Peanut seed costs represent about 20 percent of the gross value-added by crop production for the average farm household.

The pillar of Senegal's agricultural program in the 1960s and 1970s was a parastatal-run input distribution program with liberal credit terms that guaranteed peanut seed to all farmers. The terms were usually limits of 100 kilos of seed to all men and 50 kilos to all women. The only criterion for access was that the recipients paid their taxes. These taxes were substantially below the value of the peanut seed.

Declining rainfall and repeated droughts during the 1970s spurred researchers to develop shorter-cycle peanut varieties that matured in 90 rather than 120 days. As rainfall continued to worsen, farmers became rapid adopters of the earlier maturing varieties which were distributed by the input supply parastatal in the drier zones of the Peanut Basin. The shorter-cycle variety is now the most common variety planted throughout the Peanut Basin, because few areas continue to get the 120 days of useful rain required by older varieties.

In the late 1970s, credit defaults (due primarily to repeated droughts) were high, which caused financial problems for the parastatal. Corruption in the parastatal and the cooperative movement exacerbated the situation. By the mid 1980s, the entire input distribution system was bankrupt and had to be revamped. The new program required farmers to make a hefty down-payment to get peanut seed on credit. This posed a severe liquidity constraint for most farmers. As a result, farmers store their own seed rather than purchasing better quality certified seed. Farmers do not obtain nearly the desired quantity of seed. As a result, aggregate peanut production has suffered.

Production function analysis of crop production data for 1989/90 provides supporting evidence that the seed constraint is real. The marginal value product of peanut seed is 2 to 3 times greater than the seed price, suggesting that considerably more seed could be used in an economically efficient manner. The lower-than-optimal use of peanut seed also has implications for soil fertility and productivity of cereal crops as the decrease in area planted to peanuts means that the peanut/cereal rotations, which return nitrogen to the soil, are not being maintained.

(continued on next page)

Evidence shows that the quality of seed is declining. This appears to be true for purchased seed as well as that stocked by farmers from the prior harvest. Survey results show that farmers have been increasing the peanut seeding density, despite problems of obtaining desired quantities of seed. Farmers questioned about the increased density claim that declining soil quality and a growing land constraint as well as seed quality are pushing them to higher seeding rates.[1] Recent reports by the Senegalese seed service also document problems with (1) maintaining the quality of national seed stocks, and (2) encouraging farmers to renew their own stock with certified seed every few years (Sene 1994).

Although the economic logic of farmers' current seeding density strategies is confirmed by production function results, it is a strategy conditioned by levels of complementary inputs currently used (no fertilizer or manure on peanuts) and seed quality (very little certified seed use). Increasing seeding densities *ad infinitum* is clearly not a sustainable strategy for the long-run, but from the farmers' perspective it is the only economically feasible way of increasing returns to land at the present time.

---

[1] In the case of peanuts, farmers want the crop to fill in between the rows as rapidly as possible. They believe this reduces weeding problems and helps maintain soil moisture. Now that fertilizer is no longer used and seed quality is declining, peanut plants do not fill out as rapidly, hence the decision to plant the rows closer together. In these same zones, the opposite strategy is used for cereals -- the poorer the soil the less densely the crop is planted.

5.3. Animal Traction

5.3.1. Background

Eicher and Baker (1982) review evidence from studies of animal traction in the 1960s and 1970s. Pingali, Bigot, and Binswanger (1989) review more recent evidence. In general, they find that animal traction has historically been associated with these potential benefits: (1) increase in area cultivated (as the most cited advantage); (2) (occasionally cited) increase in land-yield through improved seed bed preparation, deeper plowing, more timely planting and weeding, moisture conservation (and we would add manure transport, and manure and crop residue incorporation); (3) income generation through off-farm transportation; (4) reduction in drudgery (potentially freeing labor); and (5) facilitation of tied ridging for water retention and soil conservation (see Ohm and Nagy 1985 and Sanders, Nagy, and Ramaswamy 1990). Farmers use traction mainly for plowing, and sometimes for seeding and weeding.

Nevertheless, the long (60-year) history of animal traction programs in Africa is characterized by high expectations but mixed results and by discontinuous support. Eicher and Baker (1982) note that

> ...although these figures are impressive, similar 'waves' of animal traction have appeared in other African countries over the last 50 years only to disappear or recede during periods of drought, changes in government policies, and the failure to provide veterinary support services. In 1981, the major concentration of animal traction was in Senegal, Mali, Botswana, and to a lesser extent in Tanzania, Uganda, and northern Nigeria (p. 141).

Historical evidence on land yields and area response has been mixed. Sargent et al. (1981) reviewed 27 traction projects and found that most had not met expectations because of the high cost of animals and equipment, low acreage and land yield effects, and lack of reliable institutional support. Whitney (1981) found that traction farmers increased hectarage by 39 percent but experienced no change in land yields. Barrett et al. (1982) show that, in eastern Burkina Faso, area and land yield effects were modest, but labor inputs were reduced 20 to 25 percent per hectare.

In general, researchers have found that the economics of animal traction are problematic for farmers producing only subsistence food grains (such as millet and sorghum), but become more favorable in cash-cropping areas. Eicher and Baker (1982) note that "the presence or absence of a cash crop is a central determinant of farm-level profitability of animal traction" (using evidence from northern Nigeria, peanuts in Senegal, cotton in southern Mali, and cotton in northern Cameroon). Barrett et al. (1982) found important cash flow problems for traction adopters. Internal rates of return were positive over 10 years, but net returns for oxen-traction farms were below net returns before adoption for the first four years due to slow learning by farmers.

Because of high costs and learning requirements, farmers' cash sources or credit and veterinary services are crucial. Equipment adapted to key activities (weeding, tied ridging) is not usually available, and a persistent issue is affordability. In the 1960s to 1970s, governments and donors promoted a "total oxen cultivation package" (oxen or donkeys or horses, plus a tool bar and attachments such as plow, seeder, ridger and sometimes carts). This package can be very expensive relative to rural household incomes. An oxen traction package cost $1000 in 1977, a donkey traction package $500.[18] Compare these costs to $1500/household income in the Guinean zone of Burkina Faso in 1981-1985, of which $1140 is cash income (Reardon and Mercado-Peters 1993).

5.3.2. Our Findings

---

[18] Cited by Eicher and Baker (1982), page 145, from Zerbo and Le Moigne (1977) and Barrett et al. (1982).

First, our case study in Burkina Faso showed strong farm-level impacts of animal traction on *land* and labor productivity on cotton in the Guinean zone, and on supply responsiveness, efficiency of resource allocation, and on manure use.

Second, investment in animal traction is more likely for households that have access to more land, earn more noncropping income, and grow cash crops.

See Box 6 for a more detailed discussion.

Box 6. Animal Traction in Burkina Faso

Animal traction increased *land* and labor productivity in the farm households in our Burkina Faso study. In the Guinean zone (the favorable agroclimate), compared to non-traction households, traction households' land-yields are 44 percent higher in cotton and 98 percent higher in maize. For labor-yields, the figures are 76 percent in cotton and 91 percent in maize. Manure use per hectare is 417 percent higher in traction households than in non-traction households.

By contrast, labor use by animal traction households is close to total cropping labor by non-traction households (not taking into account animal husbandry labor associated with the traction animals). In cotton and maize, labor use per hectare is only 6 to 7 percent lower for traction households. Thus, the land-yield effect was much greater than the labor-saving effect in our case study. But for subsistence grains, traction mainly increases labor productivity.

Moreover, we found that traction households had greater supply responsiveness with respect both to price changes and to manure and fertilizer application, especially for cotton, the main cash crop. We also found that households using traction had greater allocative efficiency of labor and land, probably because animal traction allows greater timeliness of cultivation operations and gives farmers the ability to clear land for millet.

5.4. Organic Inputs and Soil Conservation Investments

5.4.1. Key Findings

First, the Rwanda case study showed that land degradation substantially undermines productivity. The direction of this effect is common sense, but the empirical importance of the effect had rarely (particularly in Africa) been examined in developing countries outside of field-station experiments.

Second, land conservation measures and organic matter incorporation help to protect the land and facilitate intensification of production. Practices that add organic matter to soil and conserve water or prevent erosion and help water retention (bunds, tied ridges, grass strips, windbreaks, terraces) increase productivity, e.g., by increasing the impact of fertilizer and increasing soil moisture. Conservation investments are complementary with the use of improved inputs and organic matter. Use of organic matter and soil conservation investments greatly increased land productivity in Rwanda.

Third, investment in soil conservation is more likely for farms that are smaller (hence have less ability to fallow, a substitute for these investments) and earn more noncropping income.

Box 7 shows results for manure use in Burkina Faso; Boxes 8 and 9 show results for the determinants and effects of use of organic matter and chemical fertilizer, as well as soil conservation investments in Rwanda.

Box 7. Manure Use in Burkina Faso

Most manure is used on cotton and maize (cash crops). Much more manure is used in the favorable Guinean zone than in the unfavorable northern zone, despite similar levels of livestock holdings. Animal traction households use much more manure than do nontraction households. In the Guinean zone, traction households use four times more manure for cotton (1776 kgs/ha vs 402 kgs./ha) and two times more manure for maize (8588 kgs/ha vs. 4350 kgs/ha). Animal traction helps farmers to carry and incorporate manure; manure use is related to animal holding. Relatively little manure is used on sorghum and millet in either zone. Our analysis shows that manure has a strong effect on maize and cotton output in the Guinean zone and a moderate effect on the cotton yield. Manure availability has declined in the middle zone (the Sudanian zone) over time because of reduction in size of herds kept in the zone. This could harm soil quality in the long term.

Box 8. Effects of Farm Size, Soil Erosion, and Soil Conservation Investments in Rwanda

Our simulation results for marginal products of land and labor, based on regression results using field survey data, show the following. Note "low" and "high" are specified in Byiringiro and Reardon (forthcoming), and are the extreme deciles of the range of current use or experience on survey sample farms.

First, farms with high investment in soil conservation have much better land productivity than average. Those with very eroded soils do much worse than average. Smaller farms are not more eroded than larger farms, but rather smaller farms have twice the soil conservation investments. When erosion increases from low to high, the land MVP decreases 30 percent. On farms with a high share of cash perennials (coffee and bananas) in total crop output, and a high share of their land fertilized (by chemical fertilizer or animal or green manure), the effect of moving from low to high erosion is only 24 percent. With a low share of cash perennials in total crop output (hence a high share of annual crops, which are more erosive), and with a low share of land fertilized, an increase in erosion (from low to high) has a large impact, 51 percent.

Second, when soil conservation investment per hectare increases from low to high, the land MVP increases by 21 percent. The farms that benefit most from soil conservation investment are those with high erosion, low share of cash perennials, and low *or* high share of land fertilized. The effect of moving from low to high soil conservation is 42 percent and 35 percent, respectively for low and high share of land fertilized. Those that benefit least are those with low erosion, high share of output in cash perennials, and low *or* high share of land fertilized. The effect of moving from low to high soil conservation investments is to increase land MVP only 15 percent for those with a high share of land fertilized, and 18 percent for low. Hence, cash perennials are an alternative to soil conservation investments for protecting the fertility and productivity of farmland.

Third, smallholder land productivity benefits substantially from perennial cash crops; and the gains to shifting to cash crops are highest for those with low erosion and high use of fertilizer and organic matter. When one moves from farms with a low share of land fertilized to those with a high share, the land MVP rises by 15 percent. On farms with high erosion and low share of cash perennials, the gain in land MVP in moving from low to high share of land fertilized can be as high as 44 percent. Hence, the need for soil amendments is greatest where land is already eroded and annual crops are intensively cropped, and thus farmers need to replace soil nutrients. When the share of cash perennials increases from low to high, the impact is quite high on land MVP (92 percent) (cash perennials pay so much more than food annuals such as beans and tubers and grain). The effect is highest where farm conditions are good -- when erosion is low and the share of land fertilized is high, and lowest (39 percent) when farm conditions are poor (high erosion, low share of land fertilized). Hence, producers of cash perennials have incentive to improve farm conditions, although producing bananas and coffee is itself a fertility-enhancing, soil-protecting measure.

Box 9. Determinants of Soil Conservation, and Organic Matter and Fertilizer Use in Rwanda

> In Rwanda, farmers mainly use organic matter on cash crops (such as bananas, coffee, and soybeans). Often this is because (1) these crops respond well agronomically to organic amendments, (2) fertilizer is used on cash crops because it complements organic inputs (their combined use is recommended by agronomists), and (3) cash cropping helps farmers buy cattle that generate manure. Moreover, there are tradeoffs between fallowing and organic input use, and between fallowing and conservation investments.
>
> Smaller farms have a smaller share of their land under fallow, but they have two times more soil conservation investments per hectare than do larger farms. Controlling for farm size, two other factors influence conservation investments and improved input use: (1) noncropping income (important as a source of cash for labor and materials and tools); cash crop input credit programs often support acquisition of fertilizer, but these programs do not financially support soil conservation investments (we do not know of any African country where they do), and (2) field slope (hence the need to control runoff).
>
> Rented land (compared to owned land) receives less organic inputs, fertilizer, and conservation investments. Farmers perceive these long-term productivity improvements as not worth making on rented land that could be reappropriated by the owners.

5.5. Farm Size and Land Tenure

5.5.1. Background

The distribution of land in the tropical highlands of East Africa is becoming a burning issue as land constraints increase and smallholders are forced to farm on tiny plots. The Gini coefficient of landholding in Rwanda (.4) shows land to be relatively unequally distributed (compared to smallholder areas in West Africa). In Zimbabwe, the land debate is at least as charged as in Rwanda, but for different reasons. Zimbabwe has a dual structure in which one million smallholders are restricted to half the arable land, with 4500 largeholders farming the other half. By contrast, the land distribution debate is not as important in the Sahel where most countries have a relatively equal land distribution (Burkina Faso's rural land Gini coefficient is only around .3) and only a smallholder sector.

The land debate in countries with unequal smallholder sectors (such as Rwanda's) or dual agricultures (such as Zimbabwe's) focuses on three issues.

First, do largeholders use scarce land as productively as do smallholders? Policy researchers debated this in Latin America and Asia, especially South Asia, with much of the productivity research in the 1960s to 1970s in those places focused on this, as well as on the concomitant issue of mechanization. In general, the Asian literature shows that land productivity is higher on smaller farms, except where land-substituting capital has made largeholders more land-productive.

Second, is labor "bottled up" (and thus in excess use) on smallholders's holding? This hypothesis, put forward in Lewis (1954), was debated in the 1950s and 1960s. This surplus could be due to small farmers not having opportunities to sell labor in the farm labor market or in the nonagricultural sector (directly, via wage-employment, or indirectly, via self-employment). The surplus could also be due to small farmers' having constrainted access to land or capital. In Kenya, for example, Carter and Wiebe (1990) show that the marginal value product of smallholder (but not largeholder) labor in the wheat sector was well below the market wage, while the marginal value product of capital on small farms is well above the capital price (indicating a capital constraint for smallholders).

Third, is secure tenure of landholding necessary to induce farmers to make short- and long-term productivity and soil conservation investments? African evidence is mixed and ambiguous. Place and Hazell (1993) (and Clay et al. 1995b) for Rwanda show tenure to be important to investment. By contrast, Golan (1990) shows that secure tenure is not necessary for investment in Senegal. In general, the literature shows that secure tenure is more necessary where investments are more long-term. Moreover, security of tenure can be by traditional arrangements and not necessarily by "land titling."[19]

5.5.2. Our Findings

First, the Rwanda results do show clear productivity patterns by farm size, with smaller farms having much higher land productivity than larger farms. These results are reported in Box 10.

Second, although we distinguish between small and large holders in Zimbabwe, our data for largeholders do not allow easy comparison with smallholders. The largeholder aggregate encompassed primarily-livestock and primarily-cropping farms that have very different crop land-yields. The smallholder aggregate encompassed farms from widely different agroclimatic zones.

Third, in Senegal, farm size and productivity are not clearly linked. Large farm size is correlated with higher peanut yields and smaller farm size with higher cereal yields. This suggests economies of size in peanut but not in millet production. Moreover, small farms may have land constraints and are intensifying their cereal production to free land for peanut production.

[19] See Dommen (1994) for a review of the evidence and debate.

Box 10. Farm Size and Input Productivity in Rwanda

The "smallest" quartile of farms in the study sample average 0.34 ha.; "middle," 0.83 ha.; and "largest," 2.38 ha. Despite its name, the "largest" tercile farms are still much smaller than farms in other agroecological regions of Africa outside the tropical highlands.

Compared to the largest farms, the smallest farms: (1) have three times higher land-yields in value terms; (2) use four times more labor per hectare; (3) have four times the number of plots per hectare (hence the farms are more fragmented); (4) have farmed the holding for fewer years; (5) have plots clustered closer to the domicile; (6) rent twice as much land (as a share of total farmland); (7) have soil that is only slightly less eroded; (8) have twice as much soil conservation investment per hectare; (9) use the same (tiny) amount of chemical fertilizer; and (10) have about the same share of land under "high valued crops" (coffee and bananas).

That the smallest farms are at present no more eroded than the largest farms may be due to the farms being newer and receiving more soil conservation investment. They are not, on average over the country, husbanded more carefully in terms of receiving more soil amendments or having more of their area planted to the land-protecting perennials, such as bananas and coffee. Nor do they have the option of fallowing as much as larger farmers do. As these smallest farms age, one can expect in the long term for them to suffer greater soil degradation -- unless this is obviated by more use of soil amendments and more land under perennials.

Regression results show a strong inverse relationship between farm size and the MVP of land, and a positive relationship between farm size and the MVP of labor. Comparing the MVPs of land and labor to the market wage and the land rental rate (as a proxy for the market price of land), respectively, we find that the farmers in the smallest-farms tercile apply labor until the labor MVP is only a third of the market wage compared to two-thirds for the largest farms. This implies a "bottling-up" of labor on the smallest farms, with a lower opportunity cost of labor than that reflected in the farm labor market. This may be due to constraints on access to that labor market as well as to nonagricultural employment opportunities. On the smallest-tercile farms, the land MVP is much higher than the land rental rate, indicating constraints on access to land. By contrast, for the largest farms, the land MVP and the rental rate come close to equality.

5.6. Noncropping Income

5.6.1. Background

Sections 3 and 4 summarize evidence concerning the importance of noncropping income in the rural economy of Burkina Faso, Senegal, and Rwanda. We also noted that noncropping income is poorly distributed, which means that positive influences of noncropping income on productivity in turn will be poorly distributed. Here we focus on the influence of noncropping income on improved input use and conservation investments.

In general, noncropping income earned by rural households is important to increasing farm input use and hence cropping productivity and intensification. Reardon and Kelly (1989) show that noncropping income is important in Burkina Faso to the purchase of fertilizer where institutional credit is not available (in the noncotton areas such as the Sudanian zone). Kelly (1988) found similar results for the Peanut Basin of Senegal. Hoffman and Heidhues (1993) show for Benin that noncropping income is treated as a substitute for land collateral in informal credit markets. This is because of the problem of covariability of harvests, hence riskiness of using land as collateral in areas of risky agriculture.

Why is noncropping income important for these farm investments? In our case study contexts, in particular Rwanda, Burkina Faso, and Senegal, formal rural credit is lacking except in cotton schemes and, to a more limited extent than formerly, in peanut schemes. Informal credit markets are also very underdeveloped. Access to noncropping income therefore tends to be crucial to farm input purchase. Moreover, capital equipment for soil conservation and water retention measures is often costly. Farmers usually find it impossible to get credit to construct bunds and terraces, or buy tied ridgers, wells, and carts. Reardon and Vosti (1993) argue that the nature of this conservation capital makes informal credit even harder to get than for traditional investments such as animal traction equipment and fertilizer. Farmers and creditors may not perceive a clear immediate payoff to these investments. Hence, the risk of default may appear greater. Investments in capital goods require but also create loan collateral (e.g., animal traction equipment). This is usually not the case with conservation investments (e.g., creditors cannot reclaim bunds).

5.6.2. Our Findings

First, noncropping income is an indirect determinant of productivity, as it can increase purchased input use or capital investments where credit is unavailable or costly to use, or where other sources of cash income for loan repayment are lacking. The Burkina Faso case study found that noncropping earnings are reinvested into expensive animal traction packages in southern Burkina Faso where agroclimatic conditions are good. We also found that noncropping income is important to peanut seed purchase in Senegal through providing cash at the end of the dry season to pay the down payment for peanut seed credit. In Rwanda, we find that farmers who have more noncropping income are able to make conservation investments and buy fertilizer.

Second, nevertheless, noncropping activities, especially in unfavorable agroclimates or where farming conditions are otherwise poor, can compete with land improvements.[20] The competition

[20] Christensen (1989) finds that households with more noncropping income invest less in farm capital. Norman (1973) found that noncropping activities in northern Nigeria compete for labor in off-season cropping.

can be for labor in the rainy season, for weeding, for plowing, or for maintenance of bunds and alley cropping systems. In parts of Senegal we found that less productive farmers sought income off-farm as a way of compensating for the poor farming conditions. This was also the case in northern Burkina Faso.

The results concerning possible competition between farm and off-farm activities should serve to caution agricultural research institutions. At issue is whether new farm technologies or soil conservation investments are perceived as more profitable or less risky than investments in off-farm activities. If they are not, then new farm technologies that are profitable in absolute terms may still not be adopted because they do not generate as high returns to cash or labor as noncropping activities.

Third, noncropping activities smooth household income and help to reduce risk by diversifying the sources of household income. As risk and desire to invest in the farm are inversely related, such diversification can increase incentive to invest.

Fourth, however, within a given agroecological zone, the poor have less access to noncropping income opportunities. Noncropping income tends to make up a smaller share of total income for poor than for rich households. Poor households are less able than rich households to participate in high-return, noncropping activities. This is worrisome because unequal access to noncropping income translates into unequal access to farm inputs in the face of limited credit access.

5.7. Output and Input Markets

5.7.1. Background

First, early studies (e.g., von Thunen, writing in 1830-40s) showed that markets and the proximity of cities influence productivity in agriculture. de Janvry, Fafchamps, and Sadoulet (1991) show that transaction costs (influenced by the efficiency of markets) affect the marketed surplus rate; how well food markets work also affects adoption of cash crops. A market might be limited because of high transaction costs caused by structural constraints such as bad roads, or inefficient marketing systems, or limited demand for the product by local consumers or trading partners.[21]

Second, a limited or poorly functioning market "bottles up" supply in a local area. Rainfall fluctuations, translated into output fluctuations, create price instability. The latter implies riskiness of investments in productivity-raising inputs. Our results (discussed above) on fertilizer use in Burkina Faso and of soil conservation investments in Rwanda show that farmers are

[21] For example, Reardon (1993) shows that demand for course grains in the Sahel is inelastic. Thus, even when a bumper harvest occurs, and prices dip, consumers do not shift in a substantial way from imported cereals such as rice and wheat toward millet/sorghum. This bids up the prices of the latter. With poorly functioning markets or limited demand, increases in production either through good rains or increased productivity can translate into price risk and big drops in crop profitability. The latter two can discourage further crop productivity investment.

sensitive to net profitability and price risk in making these decisions. Three things can reduce price fluctuation based on market limitations: (1) investments "downstream" in grain processing to improve the demand prospects for the crop (thus reducing in the longer term riskiness of cropping)[22]; (2) investments in road and other market infrastructure; and (3) opening regional and foreign markets through economic integration.

Third, by contrast, farm productivity itself affects market development potential directly via production linkages and indirectly via consumption linkages. The "growth linkages" literature (e.g., Mellor and Lele 1972) shows that increases in agricultural productivity spur local economic growth through direct (production) and indirect (consumption) linkages.

Our Senegal study shows that drops in peanut output reduce capacity utilization hence efficiency and profitability of peanut processing plants. Reardon et al. (1994b) show that nonfarm activity in the Sahel is mainly in production-linkage activities upstream (supplying inputs to farms) or downstream (using farm outputs as inputs) in local areas. How well agriculture performs affects local off-farm employment and general industrialization.

Fourth, the off-farm component of the food system affects productivity indirectly by affecting the food price. On the one hand, food price influences profitability of both the farm and nonfarm sector: Ricardo (early 1800s) noted that farm productivity affects the food price which in turn, working through the real wage bill, affects nonagricultural profits and employment. On the other hand, the efficiency of the market system affects how well the benefits of greater farm productivity are distributed to consumers (and farmers) by affecting the food price the consumer faces.

Raising farm and market productivity means driving real food prices down. Who gets access to the cheaper food depends in turn on the efficiency and structure of the market system, as well as whether consumers have sufficient employment and income. This suggests that a useful focus for research is also on the efficiency of the whole food system, from the input distribution system, to the farmer, through the market chain, to the consumer (Antle 1983). The converse of our point is that, if improvements are made in farm-level productivity but are not passed on to the urban consumer because of inefficiencies or structural rigidities "downstream," benefits to the overall economy are reduced. If "upstream" input distribution is inefficient, this forces input prices up and farm productivity down.

5.7.2. Our Findings

First, well-functioning input and output markets help farmers acquire and use productivity-increasing inputs. They reduce transactions costs and risks (e.g., from imperfect information, or price volatility due to a thin market).

---

[22] See Dibley, Boughton, and Reardon (1994) for example.

Second, vertical integration and coordination functions (input supply, credit, output marketing) were assured effectively by parastatals for cotton (Senegal, Burkina Faso), maize (Senegal), and coffee (Rwanda). Government marketing depots and loans in Zimbabwe helped spur adoption of hybrid maize and use of fertilizer. The costs of these programs were high, however. For example, higher consumer prices due to grain movement controls in Zimbabwe forced the bulk of marketed grain output into the state marketing channels and onward into private large-scale milling, making grain more expensive to consumers.

Third, where farm conditions are poor, however, proximity to markets can diminish incentives to increase agricultural productivity because the markets provide alternative employment. This was the case in the middle and northern zones of Senegal.

5.7.3. Illustration from Zimbabwe

The importance of improved markets can be illustrated by our case study findings for Zimbabwe. Since independence, Zimbabwe has received widespread international acclaim for the rapid growth in smallholder maize production. However, structural decline in production since 1985, associated with a contraction of public sector support programs, has been largely unnoticed. These programs contributed to the dramatic rise in smallholder production during the early 1980s but involved large treasury deficits. The adverse effects of this production decline on urban food security appear to have been to some extent mitigated by recent maize marketing reforms. The latter reduced distribution and milling costs of staple maize meal available to consumers.

The rise and fall of agricultural production in Zimbabwe's smallholder sector over the 1980s has mirrored an upsurge and then contraction of key public investments and expenditures to agriculture. Zimbabwe has had difficulties in “scaling-up,” i.e., managing the transition from a well-organized public research and market infrastructure system that fits the needs of a few thousand commercial farmers under Southern Rhodesia to a system that meets the needs of over a million smallholder households. This has clear implications for South Africa and other countries in the region.

The impressive growth of Zimbabwe's smallholder maize production from 1980 to 1985 was due to six major factors: (1) the ending of the war after independence; (2) an increase in the use of hybrid maize seeds from about 40 percent in 1979 to 98 percent in 1985 (Kupfuma 1994); (3) an increase in state crop buying stations serving smallholder areas, from 5 in 1980 to 148 in 1985, thus reducing the costs and risks associated with surplus maize production; (4) guaranteed state-set producer prices that were generally well above export parity prices (but below import parity); (5) an eight-fold increase in crop credit disbursed to smallholders between 1979 and 1986, which led to greater fertilizer use and maize land-yields; and (6) an associated response by private input suppliers to the increased demand for farm inputs due to the aforementioned (Rohrbach 1989).

The stagnation of Zimbabwe's smallholder revolution since the mid-1980s is due to three major factors. The most conspicuous is drought, which has affected the country three times since 1985.

Several structural factors have caused this decline in maize production. First, the improved hybrid seed varieties that stimulated smallholder productivity during 1980-85 are now almost universally adopted. A new set of technological improvements or management practices is necessary to stimulate additional gains in productivity. The national agronomic and crop breeding research institute (DR&SS) received only 75 percent of the budget it had in 1980/81 in real terms. The number of on-farm trials and sites by DR&SS has shrunk from 63 in 1987/88 to 31 in 1990/91 (Shumba 1990). The public agricultural research system is having serious staffing and budget problems (Eicher 1995). The slowed productivity of the public agricultural research system is also indicated by the continued use of hybrid seeds that were developed 15 to 20 years ago.

Second, several important features of the 1980-85 production boom (expansion of state marketing infrastructure and credit allocation, producer prices above export parity) involved large and sustained treasury outlays. The maintenance of high maize prices to sustain surplus production also put pressure on the government to cushion the impact on consumers by subsidizing the price of maize meal manufactured by large urban millers. Under mounting pressure to cut budget deficits, these public investments in support of agricultural production were progressively cut after 1985. Grain marketing board (GMB) buying stations in smallholder areas have been reduced. Even though 20 additional grain buying depots have been established since 1985, the number of rural collection points has declined from 135 in 1985 to 42 in 1989 to 9 in 1991.[23] GMB real producer prices have also declined steadily, being only 75 percent in 1991 of their 1985 level. State credit allocation to smallholders has also declined steadily since 1986. The amount of fertilizer that was available for purchase with government credit disbursed to smallholders was 44,000 metric tons in 1992 compared with 148,000 tons in 1986. Declining input use, along with relatively poor rainfall, may explain why smallholder maize land-yields, even in the relatively productive Mashonaland provinces, have exceeded their 1985 level only once.

However, important distinctions between the two sectors led to the financial unsustainability of simply “scaling-up” a marketing apparatus for a small number of large farmers to meet the needs of almost a million geographically-dispersed smallholder families (Blackie 1987). The large-scale farming areas were predominantly close to urban centers. The volume of sales per farmer were larger, and the production units were geographically concentrated and few in number. GMB marketing costs were therefore low. By contrast, the expansion of state buying stations into the smallholder areas forced the GMB to buy relatively small, variable quantities of grain from a large number of geographically-dispersed farmers. Per unit marketing costs rose dramatically in this setting, although the government normally chose not to raise the GMB's trading margin sufficient to cover these costs. This has been a major impetus for the GMB's call for further contraction unless the government agrees to underwrite its losses (Herald 1991).

[23] While part of this decline is due to reduced expected throughput because of frequent drought and lower real producer prices, it is evident that the collection point program was financially inviable (Herald 1991).

The experience with expanding crop credit to individual smallholders farming in environments prone to frequent drought has resulted in high default rates (Herald 1993). Credit allocation and the associated demand for farm inputs have failed to expand since the mid-1980s.

A rising share of state expenditure on agriculture has been used to pay subsidies, in particular to cover the operating deficits of marketing boards. In the latter half of the decade, over 40 percent of total agriculture expenditures from the State was absorbed by marketing board subsidies. For example, in 1986, state allocations for the entire agriculture budget was 8.2 percent of the total national budget. By 1990, this had decreased to 5.5 percent. With the exception of 1989, when marketing board losses were exceptionally low, the share of budget allocations to cover marketing board losses has been over 40 percent of total public expenditures on agriculture during the latter half of the 1980s. In real terms government spending on agricultural research, extension, veterinary services, and so on, had declined by 25 percent from 1980 to 1990.

6. IMPLICATIONS

Case study reports provide specific recommendations per country. The general implications are as follows.

(1) *Raising improved input use for sustainable intensification is crucial.* Given growing land constraints and soil degradation, sustainable intensification of farm production through use of improved inputs that raise and sustain increases in land productivity is essential. To get needed breakthroughs in farm productivity, farm input use needs to rise substantially. The key inputs include chemical fertilizer, organic matter, animal traction, and conservation investments.

Although the results are based on four case studies in rain fed areas of the semi-arid and highland tropics, and on review of selected recent farm productivity studies in other countries of Africa, some specific program suggestions emerge.

First, we favor promoting chemical fertilizer use especially in higher potential zones, in combination with water or soil retention (conservation) measures and organic matter application (the latter helped by animal traction programs). Measures to link access to improved inputs with adoption of soil conservation practices should be considered. In the long run, mixed farming (association of animal husbandry and cropping) will be crucial to supplying organic matter. Promotion of fodder markets and research on fodder would support this.

Second, animal traction programs are worth promoting in areas of high agronomic potential where the terrain is suitable (not too sloped). Animal traction programs have had success in some areas, especially when linked to cash cropping initiatives, but have suffered from inadequate research support and program continuity. In some countries, such as Senegal, in general, farmers in peanut and cotton areas use traction, but the equipment stock is aging and renewal programs are needed. In other countries, such as Burkina Faso, animal traction is not widespread partly because of demand-side constraints such as lack of working capital, which only some farmers have been able to overcome through noncropping activity and cash cropping.

Third, crop research is crucial to the overall competitiveness of agriculture, and to the profitability of productivity-increasing inputs such as fertilizer and animal traction.

Fourth, extension programs are needed to support conservation investments (water retention, soil retention structures) that will facilitate sustained increases in productivity, especially in high-potential areas where rapid intensification of agriculture is envisaged. In many cases this will require modest complementary infrastructure such as culverts or wells to allow watering of live windbreaks, or trucks to haul laterite for construction of bunds.

Fifth, noncropping microenterprise promotion programs, popular in USAID and other donor missions now, are important for farm productivity both to supply cash to farmers to buy farm inputs and to supply inputs (such as animal traction equipment and repairs) to farms. Microenterprises are also important to increase the production-linkage and consumption-linkage multipliers from increases in farm output. Priority types of microenterprise promotion would in general be those involved in farm input provision, food processing and marketing, and spinoffs from cash cropping.

Sixth, investments in transport and market infrastructure are needed to reduce costs within the agricultural system. Investments in transport and market infrastructure, by reducing costs within the food system, can also make it profitable for farmers to adopt new technologies or new crops that are consistent with consumer preferences and willingness to pay. To this end, a commodity sector perspective is needed to help identify important opportunities to raise productivity at levels of the food system above the farm (e.g., in processing or marketing activities, or through policy change). Knowledge of consumer or export demand is also needed to guide development of new farm production technology.

(2) *Strategies to raise farm productivity will need to differ, however, between favorable and unfavorable agroclimatic zones.* With proper conditions, increased productivity can be expected in the favorable (to cropping) zones.

Expectations for cropping intensification are more modest for the agroclimatically unfavorable (to cropping) and fragile zones, and attention will need to be paid to alternative income sources off-farm in the latter zones. This will promote food security in the agroclimatically unfavorable zones and increase effective demand for agricultural products from favorable zones.

(3) *The environment and the farm productivity agendas should be linked.* Environmental degradation and pressure on marginal lands cannot be halted without raising farm-level productivity through sustainable intensification. Yet interventions to improve farm-level productivity must be accompanied by conservation investments. One cannot go far in conserving the soil without increasing land productivity through intensification, e.g., by applying fertilizer and manure. Intensification reduces the land area needed to achieve a given output level. Intensification on land already under cultivation can reduce pressure to expand cultivation onto fragile marginal lands and thus lead to more sustainable resource use. Soil conservation measures also become more attractive when the production enterprises they support are more profitable. One cannot increase farm productivity without battling soil degradation with soil conservation measures (grass strips, anti-erosion ditches, bunds, hedgerows, terraces), supported by conservation extension and education.

African farmers can be “caught between a rock and a hard place.” Structural adjustment, by making inputs such as fertilizer more expensive due to agricultural policy reform, may hamper the ability of poor farmers to intensify production. Because of environmental policy reform, the same farmers may be unable to compensate by expanding production into marginal areas or by exploiting resources of the commons. Such contradictions often pass unperceived because the reforms are promoted by separate constituencies and monitored by different government agencies.

(4) *The off-farm employment and the farm productivity agendas should be linked.* In many areas off-farm income is a critical means to pay for farm inputs and investments. Moreover, much of the growth of noncropping activity is linked to growth of farm output. Growth in off-farm employment opportunities in rural areas is essential to achieving food security and economic transformation in Africa.

Noncropping income can increase purchased input use or capital investments (thereby increasing productivity) where credit is unavailable or costly to use, or where other sources of cash income for loan repayment are lacking. Noncropping income can be especially important in facilitating conservation investments, for which credit is rarely available. Noncropping activities smooth household income and help reduce risk by diversifying the sources of household income.

Agricultural growth in turn stimulates growth of the noncropping sector, by increasing the demand for inputs such as animal traction equipment and repair services, and by increasing the supply of crop and livestock products used as inputs for processing firms (millers, leather workers, and so on). Agricultural growth can also stimulate other rural noncropping firms since an important share of increments to farm income tends to be spent on locally produced consumer goods.

Micro-enterprise promotion programs provide rural employment while reducing the cost of farm inputs and increasing the off-farm multipliers from farm output growth.

The importance of income diversification to rural African households means that new cropping technology proposed for farmer adoption must not only be financially and economically profitable, but also attractive relative to alternative uses of household resources (e.g., livestock and noncropping production).

Policymakers should be worried about equitable access to these income sources, however, since that will affect how equitably the benefits of productivity improvements are distributed over time. We have noted that in many areas of Africa, farmers have very unequal access to noncropping income-earning activities, often because families are unable to make the necessary initial investments for lack of cash reserves or access to credit to finance them. The same equity issue can arise concerning access to high-return cash cropping schemes.

(5) *Cash cropping programs spur productivity* by providing cash to buy improved inputs, and depending how they are organized, increasing access from the supply side to improved inputs and to low-risk output marketing opportunities.

In sum, important synergies between programs raise African farm productivity, and programs promote noncropping enterprises, market development, and natural resource conservation. Harnessing these synergies will allow national governments and donors to get more for their money in terms of growth, food security, and environmental protection.

Promotion of improved input use will need to be innovative in order to be consistent with widespread fiscal constraints and the goals of structural adjustment. In the past in many cases governments have promoted input use in ways that were not economically sound, that in the long run were not fiscally sustainable. Yet the reduction of government programs and subsidies associated with structural adjustment appears to have discouraged the use of modern inputs (improved seed, fertilizer, animal traction), by raising cost and reducing availability.

The upshot is that farm input costs must be reduced without returning to fiscally unsustainable 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.

Policy reform alone (exchange and interest rate policy, market liberalization, privatization), while important, is not sufficient to spur higher agricultural productivity. Resource, technology, and market constraints on agricultural growth must be tackled directly by allocating government and donor resources to overcoming them. Three potential dilemmas are associated with the use of policy reform.

First, as with the "food price policy dilemma" described by Timmer (1994), increased prices (especially if they result from currency devaluation) can cut two ways by raising the price of output, especially export crops, but also by raising the price of key imported inputs such as fertilizer and animal traction equipment. Devaluation could also encourage the export of animals needed locally to generate manure. The result may be that net profitability of key cash crops and productivity investments does not necessarily rise with devaluation.

Second, raising average profitability without reducing price instability or income risk means that a major impediment to the attractiveness of productivity investments remains. Risk and instability are a function of climatic variation (especially in rain fed zones), high transaction costs, and other structural constraints that require infrastructural investment (e.g., irrigation, improved roads) to overcome.

Third, farm investment can be profitable in an absolute sense but not in a relative sense if noncropping investment opportunities appear to be "better bets" to rural households, or if noncropping activities are necessary in order to generate cash income. Households will not want to adopt productivity- and conservation-enhancing measures if the payback is not higher or faster than alternatives off the farm. Because capital and labor may be tied up in noncropping activities, either in the rainy season or the dry season, agricultural researchers and environmentalists should not expect farm households to adopt natural resource management practices and make conservation investments automatically. The profitability of such investments must be evaluated relative to the returns available from other farm and noncropping activities.

Public investment should be such that it complements and spurs private investment on-farm, in the input distribution system, and in primary product processing. Governments and donors must invest in understanding how to promote the *economic* use of the tools of sustainable intensification (fertilizer, animal traction, organic inputs, and soil conservation investments).

Thus the debate should be reopened on identifying cost-effective ways of increasing access to inputs, by improving the delivery of inputs and giving farmers the means to pay for them. This effort is especially appropriate in countries whose macroeconomic environment has become more favorable through structural adjustment. This should be a priority policy issue in Africa in the 1990s and beyond.

Improved food system performance will require productivity gains both at the farm level and at other levels of the system, such as processing and marketing. Which level of the food system is the highest priority for research and policy interventions will depend on circumstances in the commodity subsectors concerned. The nature of consumer demand constitutes an important parameter that determines what can and should be done to expand the volume of business within the subsector, as well as what this implies for the potential to expand farm-level production.

Land constraints are growing in many places in Africa as a result of population pressure and the slow development of successful intensification technologies. In some cases more secure land tenure is necessary for intensification investments to take place. In addition, large farmers sometimes use land less efficiently than smaller farmers. Land policy will need to take that into account.

7. REFERENCES

7.1. Productivity Project Documents Drawn on for Synthesis Report

Byiringiro, F. and T. Reardon. Forthcoming. Farm Productivity in Rwanda: Effects of Farm Size, Erosion, and Soil Conservation Investments. *Agricultural Economics.*

Clay, D., F. Byiringiro, J. Kangasniemi, T. Reardon, B. Sibomana, L. Uwamariya, and D. Tardif-Douglin. 1995a. *Promoting Food Security in Rwanda Through Sustainable Agricultural Productivity: Meeting the Challenges of Population Pressure, Land Degradation, and Poverty.* MSU International Development Paper No. 17. East Lansing: Michigan State University.

Clay, D., T. Reardon, and J. Kangasniemi. 1995b. *Sustainable Intensification in the Highland Tropics: Rwandan Farmers' Investments in Soil Conservation and Fertility.* Department of Agricultural Economics Staff Paper No. 95-21. East Lansing: Michigan State University.

Clay, D. and T. Reardon. Forthcoming. Determinants of Farm-level Conservation Investments in Rwanda. In *IAAE Occasional Paper No. 7.* Contributed Paper for IAAE 22nd Congress (International Association of Agricultural Economists) August 1994, Harare, Zimbabwe.

Diagana, B. 1994. Role du Foncier dans l'Acces au Credit Agricole et la Diversification des Revenus au Senegal: une Analyse des Opinions Paysannes. Senegal: ISRA/BAME. Mimeo.

Diagana, B., V. Kelly, and A.A. Fall. 1995. Dévaluation du franc CFA et décisions de production agricole. Paper presented at the PRISAS Regional Workshop on the Impacts of the Devaluation of the CFA franc on Income and Food Security in Africa. Mimeo.

Gaye, M. 1994. Les facteurs déterminants de l'allocation des terres dans le bassin arachidier du Senegal. Dakar: ISRA/BAME. Mimeo.

Gaye, M. and V. Kelly. 1996. *L'utilisation des terres agricoles dans le bassin arachidier du Senegal: facteurs déterminants des combinaisons culturales et des systemes de rotation.* Department of Agricultural Economics Staff Paper No. 96-32. East Lansing: Michigan State University.

Gaye, M. and M. Sene. 1994. Les fortes densités de semis de l'arachide au Senegal: motivations paysannes et interprétations agronomiques. Kaolack: ISRA. Mimeo.

Gaye, M., M. Sene, and V. Kelly. 1996. *Les pratiques paysannes face aux contraintes de productivité: cas du semis de l'arachide au Sénégal.* Department of Agricultural Economics Staff Paper No. 96-29. East Lansing: Michigan State University.

Jayne, T.S., Y. Khatri, C. Thirtle, and T. Reardon. 1994. Determinants of Productivity Change using a Profit Function Approach: Smallholder Agriculture in Zimbabwe. *American Journal of Agricultural Economics* 76(3): 613-618.

Jayne, T.S., C. Thirtle, T. Sakurai, Y. Khatri, B. Kupfuma, and T. Reardon. Forthcoming. *Sources of Agricultural Productivity Growth in Zimbabwe.* Forthcoming International Development Paper. East Lansing: Michigan State University.

Kangasniemi, J. and T. Reardon. Forthcoming. Demographic Pressure and the Sustainability of Land Use in Rwanda. In *IAAE Occasional Paper No. 7*. Contributed Paper for IAAE 22nd Congress (International Association of Agricultural Economists) August 1994, Harare, Zimbabwe.

Kelly, V., B. Diagana, and T. Reardon. 1996. Nonprice Determinants of Input Acquisition Behavior in Senegal. Select Paper, AAEA 1996 Meetings. Abstract. *American Journal of Agricultural Economics* December.

Kelly, V., B. Diagana, T. Reardon, M. Gaye, and E. Crawford. 1996. *Cash Crop and Foodgrain Productivity in Senegal: Historical View, New Survey Evidence, and Policy Implications.* International Development Paper No. 20. East Lansing: Michigan State University.

Kelly, V., J. Hopkins, T. Reardon, and E. Crawford. 1995. *Improving the Measurement and Analysis of African Agricultural Productivity: Promoting Complementarities Between Micro and Macro Data.* International Development Paper No. 16. East Lansing: Michigan State University.

Reardon, T., E. Crawford, and V. Kelly. 1995. *Promoting Farm Investment for Sustainable Intensification of African Agriculture*. International Development Paper No. 18. East Lansing: Michigan State University.

Reardon, T., V. Kelly, E. Crawford, K. Savadogo, and T. Jayne. 1994a. *Raising Farm Productivity in Africa to Sustain Long-Term Food Security.* Department of Agricultural Economics Staff Paper No. 94-77. East Lansing: Michigan State University.

Savadogo, K., T. Reardon, and K. Pietola. 1994a. *Determinants of Farm Productivity and Supply Response in Burkina Faso.* Department of Agricultural Economics Staff Paper No. 94-79. East Lansing: Michigan State University.

Savadogo, K., T. Reardon, and K. Pietola. 1994b. Farm Productivity in Burkina Faso: Effects of Animal Traction and Noncropping Income. *American Journal of Agricultural Economics* (76) 3, August: 608-612.

Savadogo, K., T. Reardon, and K. Pietola. 1995a. Mechanization and Agricultural Supply Response in the Sahel: A Farm-Level Profit Function Analysis. *Journal of African Economies* (4) 3, December: 336-377.

Savadogo, K., T. Reardon, and K. Pietola. 1995b. Mécanisation et offre agricole dans le Sahel: une analyse de la fonction de profit des exploitations agricoles. *Revue d'économie du développement* (2) June: 57-92.

Savadogo, K., T. Reardon, and K. Pietola. 1996. *Farm Capital Formation and Productivity in the WASAT: Links with Noncropping Income and Cash Crops.* Department of Agricultural Economics Staff Paper No. 96-26. East Lansing: Michigan State University.

Savadogo, K., T. Reardon, and K. Pietola. Forthcoming. *Improving Farm Productivity and Supply Response in Burkina Faso.* International Development Paper. East Lansing: Michigan State University.

Uwamariya, L., J. Kangasniemi, and T. Reardon. 1993. *Patterns in Agricultural Productivity in Rwanda*. Draft Working Paper. Rwanda: MINAGRI/DSA.

7.2. Other Documents

Agcaoili, M.C. and M.W. Rosegrant. 1994. *World production of cereals, 1966-90.* 2020 Vision Brief 3. Washington, D.C.: International Food Policy Research Institute.

Antle, J.M. 1983. Measuring Returns to Marketing Systems Investments for Agricultural Development. In ICRISAT (editor) *Agricultural Markets in the Semi-arid Tropics,* Proceedings of the international workshop, 24-28 October 1983, ICRISAT. Center, India. Patancheru: ICRISAT.

Barrett, V., G. Lassiter, D. Wilcock, D. Baker, and E. Crawford. 1982. *Animal Traction in Eastern Upper Volta: A Technical, Economic, and Institutional Analysis.* International Development Paper No. 4. East Lansing: Michigan State University.

Binswanger, H.P. 1986. Evaluating Research System Performance and Targeting Research in Land-abundant Areas of Sub-Saharan Africa. *World Development* 14 (4) April: 469-476.

Binswanger, H. and Pingali, P. 1988. Technological Priorities for Farming in Sub-Saharan Africa. *Research Observer* (1) January. Washington, D.C.: World Bank.

Blackie, M.J. 1987. The Elusive Peasant: Zimbabwean Agricultural Policy. In M. Rukuni and C. Eicher (editors) *Food Security for Southern Africa*. UZ/MSU Food Security Project, Department of Agricultural Economics and Extension, University of Zimbabwe, Harare.

Bumb, B.L. 1988. Fertilizer Supply in Sub-Saharan Africa -- an Analysis. In T.B. Tshibaka and C.A. Baanante (Editors) *Workshop Proceedings, Fertilizer Policy in Tropical Africa*, Lomé, Togo: IFDC and IFPRI.

Carter, M.R., and K.D. Wiebe. 1990. Access to Capital and its Impact on Agrarian Structure and Productivity in Kenya. *American Journal of Agricultural Economics*, December: 1146-1150.

Christensen, G. 1989. Determinants of Private Investment in Rural Burkina Faso. Ph.D. Thesis. Ithaca: Cornell University.

Clay, D.C. and Y. Dejaegher. 1987. Agro-ecological Zones: Development of a Regional Classification Scheme for Rwanda. *Tropicultura* December.

Collier, P. and D. Lal. 1986. *Labour and Poverty in Kenya 1900-1980*. Oxford: Oxford University Press.

Crawford, Eric W. 1993. *Assessment of the Economic Impact of Agricultural Research: Summary of Studies Conducted by Michigan State University*. Staff Paper 93-66. East Lansing: Michigan State University.

de Janvry, A., M. Fafchamps, and E. Sadoulet. 1991. Peasant Household Behaviour With Missing Markets: Some Paradoxes Explained. *Economic Journal*, 101(November): 1400-1417.

Dibley, D., D. Boughton, and T. Reardon. 1995. Processing and Preparation Costs for Rice and Coarse Grains in Urban Mali: Subjecting an *Ipse Dixit* to Empirical Scrutiny. *Food Policy* 20 (1).

Dommen, A.J. 1988. *Innovation in African Agriculture*. Boulder: Westview Press.

Dommen, A.J. 1994. *Land Tenure and Agricultural Production in Sub-Saharan Africa: A Market-Oriented Approach to Analyzing Their Interactions.* USDA/ERS Staff Report No. AGES-9416, June. Washington, D.C.: USDA/ERS.

Eicher, C.K. 1995. Zimbabwe's Maize-Based Green Revolution: Preconditions for Replication in Africa. *World Development* 23 (5): 805-818.

Eicher, C.K. and D. Baker. 1982. *Research on Agricultural Development in Sub-Saharan Africa: A Critical Survey*. International Development Paper No. 1. East Lansing: Michigan State University.

Gaye, M. 1992. *Les recherches sur l'économie de la production agricole dans le bassin arachidier: synthèse des acquis de 1986 à 1992*. Note. December. Secteur Centre-Sud, Kaolack: Institut Senegalais de Recherches Agricoles.

Golan, E. 1990. *Land Tenure Reform in Senegal: An Economic Study from the Peanut Basin.* Land Tenure Center Research Paper No. 101. Madison: University of Wisconsin.

Herald, The. 1991. GMB May Close Some of its Depots. Sept. 22, page 1. Harare, Zimbabwe: The Herald.

Herald, The. 1993. Farmers Owe AFC $ 555 million /Mutunhu. Sept. 10, page 1. Harare, Zimbabwe: The Herald.

Hill, P. 1982. *Dry Grain Farming Families*. Cambridge, England: Cambridge University Press.

Hoffman, B. and F. Heidhues. 1993. Credit Access in the Informal Sector: A Case Study of Two villages in the Province Oueme in Benin. In Cuevas and Benoit-Cattin (editors) *Finance and Rural Development in West Africa*. Montpellier: CIRAD.

Hopkins, J. and T. Reardon. 1993. *Agricultural Price Policy Reform Impacts and Food Aid Targeting in Niger*. Final Report submitted to USAID/Niger. Washington, D.C.: IFPRI.

Jaffe, S. and J. Morton (editors). 1995. *Marketing Africa's High-Value Foods: Comparative Experiences of an Emergent Private Sector.* Dubuque, Iowa: Kendall/Hunt Publishing Co.

Kelly, V. 1988. *Factors Affecting the Demand for Fertilizer in Senegal's Peanut Basin*. Ph.D. Thesis, Michigan State University.

Kelly, V., T. Reardon, A. A. Fall, B. Diagana, and L. McNeilly. 1993. *Final Report of IFPRI/ISRA Project on Consumption and Supply Impacts of Agricultural Price Policies in Senegal*. Washington, D.C.: ISRA.

Kupfuma, B. 1994. *The Payoff to Maize Research and Extension in Zimbabwe: An Economic and Institutional Analysis*. MS thesis, Michigan State University.

Lele, U. and S. Stone. 1989. *Population Pressure, the Environment and Agricultural Intensification: Variations on the Boserup Hypothesis*. MADIA Discussion Paper No. 4. Washington, D.C.: World Bank.

Lele, U., N. van de Walle, and M. Gbetibouo. 1989. *Cotton in Africa: An Analysis of Differences in Performance*. MADIA Working Paper. Washington, D.C.: World Bank.

Lewis, W.A. 1954. Economic Development with Unlimited Supplies of Labor. *Manchester School of Economic and Social Studies* (22): 139-191.

Loveridge, S. 1992. *Les sources de revenu des ménages agricoles rwandais, les exportations et leur impact sur la disponibilité alimentaire en milieu rural (année agricole 1990).* Publication DSA, No. 37. Kigali, Rwanda: Ministère de l'Agriculture et de l'Elevage, Division des Statistiques Agricoles.

Low, A. 1986. *Agricultural Development in Southern Africa: Farm-household Economics and the Food Crisis*. London: James Curry.

Matlon, P. 1979. *Income Distribution Among Farmers in Northern Nigeria: Empirical Results and Policy Implications*. African Rural Economy Paper No. 18. East Lansing: Michigan State University.

Matlon, P. 1988. *The ICRISAT Burkina Faso Farm-Level Studies: Survey Methods and Data Files.* Hyderabad: ICRISAT.

Matlon, P. 1990. Improving Productivity in Sorghum and Pearl Millet in Semi-Arid Africa. *Food Research Institute Studies* XXII (1).

Matlon, P. and A. Adesina. Forthcoming. Agricultural Growth and Sustainability -- Prospects for Semi-arid West Africa. In S. Vosti and T. Reardon (editors) *Sustainability, Growth, and Poverty Alleviation: Agroecological and Policy Perspectives*. Baltimore: Johns Hopkins University Press.

Matlon, P., and D.S.C. Spencer. 1984. Increasing Food Production in Sub-Saharan Africa: Environmental Problems and Inadequate Technological Solutions. *American Journal of Agricultural Economics* December.

Mellor, J. and U. Lele. 1972. *Growth Linkages of the New Foodgrain Technologies*. Occasional Paper No. 50. USAID-Employment and Income Distribution Project. Ithaca: Cornell University.

Norman, D.W. 1973. *Economic Analysis of Agricultural Production and Labor Utilization Among the Hausa in the North of Nigeria*. African Rural Employment Paper No. 4. East Lansing: Michigan State University.

Ohm, H. and J. Nagy (editors). 1985. *Appropriate Technologies for Farmers in Semi-Arid West Africa.* West Lafayette: Purdue University.

Pieri, C. 1989. *Fertilité des terres de savanes.* Paris: CIRAD.

Pingali, P. and H.P. Binswanger. 1984. *Population Density and Farming Systems: The Changing Locus of Innovations and Technical Change*. Discussion Paper No. ARU 24, Washington D.C.: The World Bank.

Pingali, P., Y. Bigot, and H.P. Binswanger. 1989. *Agricultural Mechanization and the Evolution of Farming Systems in Sub-Saharan Africa.* Washington, D.C.: World Bank.

Place, F. and P. Hazell. 1993. Productivity Effects of Indigenous Land Tenure Systems in Sub-Saharan Africa. *American Journal of Agricultural Economics.* 75 (February): 10-19.

Reardon, T. 1993. Cereal Imports in West Africa and the Potential Impacts of Sahelian Regional Protection. *World Development* 21 (1): 17-35.

Reardon, T., and V. Kelly. 1989. Impact of Liquidity Sources on Chemical Fertilizer Use in Semi-Arid West Africa. Select Paper, AAEA 1989 Meetings. Abstract. *American Journal of Agricultural Economics*. December.

Reardon, T., C. Delgado, and P. Matlon. 1992. Determinants and Effects of Income Diversification Amongst Farm Households in Burkina Faso. *Journal of Development Studies*. 28 (January): 264-296.

Reardon, T., A.A. Fall, V. Kelly, C. Delgado, P. Matlon, J. Hopkins, and O. Badiane. 1994b. Is Income Diversification Agriculture-led in the West African Semi-arid Tropics? The Nature, Causes, Effects, Distribution, and Production Linkages of Off-farm Activities. In A. Atsain, S. Wangwe, and A.G. Drabek (editors) *Economic Policy Experience in Africa: What Have We Learned?* Nairobi, Kenya: African Economic Research Consortium.

Reardon, T., P. Matlon, and C. Delgado. 1988. Coping with Household-level Food Insecurity in Drought-Affected Areas of Burkina Faso. *World Development* 16 (9):1065-1074.

Reardon, T. and M. Mercado-Peters. 1993. Self-financing of Rural Household Cash Expenditures in Burkina Faso: the Case of Net Cereal Buyers. In C. Cuevas and M. Benoit-Cattin (eds.) *Finance and Rural Development in West Africa.* Proceedings of the 12th rural economy seminar (CIRAD, Ohio State University, CNCA, CEDRES, INERA) in Ouagadougou, October 21-25, 1991. Montpellier: CIRAD.

Reardon, T. and S. Vosti. 1992. Issues in the Analysis of the Effects of Policy on Conservation and Productivity at the Household Level in Developing Countries. *Quarterly Journal of International Agriculture* (4) October-December.

Rohrbach, D.D. 1989. *The Economics of Smallholder Maize Production in Zimbabwe: Implications for Food Security*. International Development Paper No. 11. East Lansing: Michigan State University.

Sanders, J.H., J.G. Nagy, and S. Ramaswamy. 1990. Developing New Agricultural Technologies for the Sahelian Countries: the Burkina Faso Case. *Economic Development and Cultural Change* 39 (1).

Sanders, J.H., B.I. Shapiro, and S. Ramaswamy. 1996. *The Economics of Agricultural Technology in Semiarid Sub-Saharan Africa.* Baltimore: The Johns Hopkins University Press.

Sargent, M., J. Lichte, P. Matlon, and R. Bloom. 1981. *An Assessment of Animal Traction in Francophone West Africa.* African Rural Economy Working Paper No. 34. East Lansing: Michigan State University.

Sarr, P.L. 1981. *Analyse des effets induits par l'intensification des cultures sur quelques caractéristiques physico-chimiques d'un sol ferrugineux tropical du Sénégal.* Montpellier, Thèse du troisième cycle, Agronomie Pédologie, Université des sciences et techniques du Languédoc.

Shumba, E.M. 1990. Zimbabwe's Experience in Agricultural Research Priority Setting for Communal Area Households. In M. Rukuni and J.B. Wyckoff (editors) *Food Security in Southern Africa*. Harare, Zimbabwe: UZ/MSU Food Security Project.

SOFITEX. 1993. *Rapport annuel*. Burkina Faso.

Thirtle, C., J. Atkins, P. Bottomley, N. Gonese, J. Govereh, and Y. Khatri. 1993. Agricultural Productivity in Zimbabwe, 1970-89. *Economic Journal* 103 (March): 474-480.

Timmer, C. Peter. 1994. Food Prices and Agricultural Development: The Relevance of the Asian Experience to Africa. *Agriculture and Rural Development* 1 (1): 12-19.

Whitney, T.R. 1981. Changing Patterns of Labor Utilization, Productivity and Income: The Effects of Draft Animal Technology on Small Farms in Southeastern Mali. Masters thesis, Purdue University.

Wright, P. 1985. Water and Soil Conservation by Farmers. In *Appropriate Technologies for Farmers in Semi-Arid West Africa*, ed. H. Ohm and J. Nagy. Lafayette, Indiana: Purdue University.

Zerbo, D. and M. Le Moigne. 1977. *Problèmes posés par la mécanisation dans les pays membres du CILSS.* Montpellier: CEEMAT.

MSU International Development Papers

How to order from the MSU Bulletin Office:

All domestic orders under $100 must be prepaid either by check or credit card. Make checks payable to MICHIGAN STATE UNIVERSITY. Charges against credit cards (VISA and MasterCard) must be accompanied by the card's full number and expiration date and the cardholder's signature and daytime business/home phone number. Orders totaling $100 or more can be billed by MSU. Institutions and firms should use their official purchase order.

All foreign orders must be prepaid only in U.S. dollars by American Express Money Order, International Money Order, U.S.A. Postal Money Order, U.S. Dollar World Money Order, or check, which must be drawn on a United States bank.

For foreign orders, include an additional 15 percent for surface postage. For air mail orders, please call for the appropriate amount due.

Please do not send cash. Payment must be included with orders. All sales are final. When ordering from the Bulletin Office by mail, you will need each item's complete identification number and price. Be sure to print your complete address, including ZIP code.

Fill out and send the order form provided to:

MSU Bulletin Office
10-B Agriculture Hall
Michigan State University
East Lansing, MI 48824-1039
Fax: (517)353-7168
Tel: (517)355-0240
E-mail: bulk.dist@msuces.canr.msu.edu

Selected copies are available free of charge to individuals in developing countries, although supplies of these are limited. If free copies are no longer available, MSU will send you order information. USAID officials may obtain free copies through A.I.D.'s Development Information System (CDIE) or single copies are available free of charge by writing to the above address at Michigan State University.

Available from the MSU Bulletin Office

MSU INTERNATIONAL DEVELOPMENT PAPERS

IDP 13 .... *Sources and Effects of Instability in the World Rice Market* by T. S. Jayne. 1993. 104 pp. $11.00 **(CDIE reference PN-ABJ-359)**

IDP 14 .... *The Impact of Agricultural Technology in Sub-Saharan Africa: A Synthesis of Symposium Findings* by James F. Oehmke and Eric C. Crawford. 1993. 33 pp. $7.00 **(CDIE reference PN-ABP-321)**

IDP 14F .... *L'Impact de la technologie agricole en Afrique subsaharienne: Synthese des conclusions du colloque* par James F. Oehmke and Eric W. Crawford. 1993. 34 pp. $7.00 **(CDIE reference PN-ABQ-056)**

IDP 15 .... *Market-Oriented Strategies to Improve Household Access to Food: Experience from Sub-Saharan Africa* by T.S. Jayne, D.L. Tschirley, John M. Staatz, James D. Shaffer, Michael T. Weber, Munhamo Chisvo, and Mulinge Mukumbu.* 1994. 61 pp. $9.00 **(CDIE reference PN-ABS-755)**

IDP 16 .... *Improving the Measurement and Analysis of African Agricultural Productivity: Promoting Complementarities between Micro and Macro Data* by Valerie Kelly, Jane Hopkins, Thomas Reardon, and Eric Crawford. 1995. 44 pp. $7.00 **(CDIE reference pending)**

IDP 17 .... *Promoting Food Security in Rwanda Through Sustainable Agricultural Productivity: Meeting the Challenges of Population Pressure, Land Degradation, and Poverty* by Daniel C. Clay, Fidele Byiringiro, Jaakko Kangasniemi, Thomas Reardon, Bosco Sibomana, Laurence Uwamariya, and David Tardif-Douglin. 1995. 115 pp. $11.00 **(CDIE reference PN-ABX-501)**

IDP 18 .... *Promoting Farm Investment for Sustainable Intensification of African Agriculture* by Thomas Reardon, Eric Crawford, and Valerie Kelly. 1995. 37 pp. $7.00 **(CDIE reference PN-ABX-753)**

IDP 19 .... *Effects of Market Reform on Access to Food by Low-Income Households: Evidence from Four Countries in Eastern and Southern Africa* by T.S. Jayne, L. Rubey, D. Tschirley, M. Mukumbu, M. Chisvo, A. Santos, M. Weber, and P. Diskin. 1995. 83 pp. $9.00. **(CDIE reference PN-ABX-754)**

IDP 20 .... *Cash Crop and Foodgrain Productivity in Senegal: Historical View, New Survey Evidence, and Policy Implications* by Valerie Kelly, Bocar Diagana, Thomas Reardon, Matar Gaye, and Eric Crawford. 1996. 140 pp. $13.00 **(CDIE reference PN-ABY-173)**

IDP 22 .... *Determinants of Farm Productivity in Africa: A Synthesis of Four Case Studies* by Thomas Reardon, Valerie Kelly, Eric Crawford, Thomas Jayne, Kimseyinga Savadogo, and Daniel Clay. 1996. 50 pp. $7.00 **(CDIE reference pending)**

WORKING PAPERS

IDWP 39/1 ..... *The Impact of Investments in Maize Research and Dissemination in Zambia. Part I: Main Report.* Julie Howard with George Chitalu and Sylvester Kalonge. 1993. 112 pp. $11.00 **(CDIE reference PN-ABS-724)**

IDWP 39/2 ..... *The Impact of Investments in maize Research and Dissemination in Zambia. Part II: Annexes.* Julie Howard with George Chitalu and Sylvester Kalonge. 1993. 81 pp. $9.00 **(CDIE reference PN-ABS-727)**

IDWP 40 .... *An Economic Analysis of Research and Technology Transfer of Millet, Sorghum, and Cowpeas in Niger* by Valentina Mazzucato and Samba Ly. 1994. 104 pp. $11.00. **(CDIE reference PN-ABT-283 or PN-ABS-728)**

IDWP 41 .... *Agricultural Research Impact Assessment: The Case of Maize Technology Adoption in Southern Mali* by Duncan Boughton and Bruno Henry de Frahan. 1994. 95 pp. $11.00 **(CDIE reference PN-ABS-729)**

IDWP 42 .... *The Rate of Return to Agricultural Research in Uganda: The Case of Oilseeds and Maize* by Rita Laker-Ojok. 1994. 56 pp. $7.00 **(CDIE reference PN-ABS-730)**

IDWP 43 .... *Assessing the Impact of Cowpea and Sorghum Research and Extension in Northern Cameroon* by James A. Sterns and Richard H. Bernsten. 1994. 48 pp. $7.00 **(CDIE reference PN-ABS-731)**

IDWP 44 .... *Food Security II Cooperative Agreement: Project Fact Sheets (1994 Version)* by MSU Food Security II Research Team. 1994. 104 pp. $11.00 **(CDIE reference PN-ABW-277)**

IDWP 45 .... *The Potential Returns to Oilseeds Research in Uganda: The Case of Groundnuts and Sesame* by Rita Laker-Ojok. 1994. 50 pp. $7.00 **(CDIE reference pending)**

IDWP 46 .... Understanding Linkages among Food Availability, Access, Consumption, and Nutrition in Africa: Empirical Findings and Issues from the Literature by Patrick Diskin.* 1994. 47 pp. $7.00 **(CDIE reference PN-ABS-732)**

IDWP 47 .... *Targeting Assistance to the Poor and Food Insecure: A Review of the Literature* by Mattias Lundberg and Patrick Diskin.* 1994. 56 pp. $7.00 **(CDIE reference PN-ABS-733)**

IDWP 48 .... *Interactions Between Food Market Reform and Regional Trade in Zimbabwe and South Africa: Implications for Food Security* by T.S. Jayne, T. Takavarasha, and Johan van Zyl. 1994. 39 pp. $7.00 **(CDIE reference pending)**

IDWP 49 .... *A Strategic Approach to Agricultural Research Program Planning in Sub-Saharan Africa*, by Duncan Boughton, Eric Crawford, Julie Howard, James Oehmke, James Shaffer, and John Staatz. 1995. 59 pp. $9.00 **(CDIE reference PN-ABU-948)**

IDWP 50 .... *An Analysis of Alternative Maize Marketing Policies in South Africa*, by T.S. Jayne, Milan Hajek and Johan van Zyl. 1995. 51 pp. $7.00 **(CDIE reference PN-ABW-091)**

IDWP 51 .... *Confronting the Silent Challenge of Hunger: A Conference Synthesis,* by T.S. Jayne, David Tschirley, Lawrence Rubey, Thomas Reardon, John M. Staatz, and Michael Weber. 1995. 37 pp. $7.00 **(CDIE reference PN-ABW-276)**

IDWP 52 .... *An Ex-Ante Evaluation of Farming Systems Research in Northeastern Mali: Implications for Research and Extension Policy,* by Bruno Henry de Frahan. 1995. 82 pp. $9.00 **(CDIE reference pending)**

IDWP 53 .... *Who Eats Yellow Maize? Preliminary Results of a Survey of Consumer Maize Preferences in Maputo, Mozambique,* by David L. Tschirley and Ana Paula Santos. 1995. 16 pp. $7.00 **(CDIE reference PN-ABX-988)**

IDWP 54 .... *Food Security II Cooperative Agreement: Project Fact Sheets (1995/96 Version),* compiled by MSU Food Security II Research Team. 1996. 151 pp. $13.00. **(CDIE reference PN-ABY-072)**

IDWP 55 .... *Trends in Real Food Prices in Six Sub-Saharan African Countries*, by T.S. Jayne, et al. 1996. 70 pp. $9.00 **(CDIE reference PN-ABY-172)**

IDWP 56 .... *Food Marketing and Pricing Policy in Eastern and Southern Africa: Lessons for Increasing Agricultural Productivity and Access to Food*, by T.S. Jayne and Stephen Jones. 1996. 40 pp. $7.00 **(CDIE reference PN-ABY-547)**

IDWP 57 .... *An Economic and Institutional Analysis of Maize Research in Kenya*, by Daniel David Karanja. 1996. 24 pp. $7.00 **(CDIE reference PN-ABY-548)**

IDWP 58 .... *Fighting an Uphill Battle: Population Pressure and Declining Land Productivity in Rwanda* by Daniel C. Clay. 1996. 26 pp. $7.00 **(CDIE reference PN-ABM-627)**

IDWP 59 .... *Finding the Balance Between Agricultural and Trade Policy: Rwanda Coffee Policy in Flux* by David Tardif-Douglin, Jean-Léonard Ngirumwami, Jim Shaffer, Anastase Murekezi, Théobald Kampayana. 1996. 14 pp. $7.00 **(CDIE reference PN-ABY-802)**

IDWP 60 .... *Agriculture R&D and Economic Growth* by Elias Dinopoulos. 1996. 25 pp. $7.00 **(CDIE reference pending)**

IDWP 61 .... *Zambia's Stop-And-Go Revolution: The Impact of Policies and Organizations on the Development and Spread of Maize Technology* by Julie A. Howard and Catherine Mungoma. 1996. 39 pp. $7.00 **(CDIE reference PN-ABY-803)**

IDWP 62 .... *Intrahousehold Allocations: A Review of Theories, Empirical Evidence and Policy Issues by* John Strauss and Kathleen Beegle. 1996. 60 pp. $9.00 **(CDIE reference PN-ABY-848)**

IDWP 63 .... *Transforming Poultry Production and Marketing in Developing Countries: Lessons Learned with Implications for Sub-Saharan Africa* by Laura L. Farrelly. 1996. 46 pp. $7.00 **(CDIE reference PN-ABY-849)**

.... * Also published by A.I.D./Washington

Mail your marked form
(via mail or fax) to:

MSU Bulletin Office

10-B Agriculture Hall

Michigan State University

East Lansing, MI 48824-1039

Fax: (517) 353-7168

Phone: (517) 355-0240

E-mail:
bulk.dist@msuces.canr.msu.edu

ORDER FORM for Papers Available from MSU

Required with all charge card orders:

Check one: ______ VISA ______ MasterCard

Card number: ____________________

Signature: ____________________

Expiration Date: __________ Daytime Phone Number: (   ) __________

SHIP TO:

Name: ____________________

Address: ____________________

____

____

____

____

Domestic orders totaling $100 or more can be billed by MSU. Institutions and firms should use their official purchase order. All other orders, including foreign orders, must be pre-paid.

Mark each choice with the quantity needed and enter total charges.

____ IDP 13 $11.00	____ IDWP 42 $7.00	____ IDWP 56 $7.00
____ IDP 14 $7.00	____ IDWP 43 $7.00	____ IDWP 57 $7.00
____ IDP 14F $7.00	____ IDWP 44 $11.00	____ IDWP 58 $7.00
____ IDP 15 $9.00	____ IDWP 45 $7.00	____ IDWP 59 $7.00
____ IDP 16 $7.00	____ IDWP 46 $7.00	____ IDWP 60 $7.00
____ IDP 17 $11.00	____ IDWP 47 $7.00	____ IDWP 61 $7.00
____ IDP 18 $7.00	____ IDWP 48 $7.00	____ IDWP 62 $9.00
____ IDP 19 $9.00	____ IDWP 49 $9.00	____ IDWP 63 $7.00
____ IDP 20 $13.00	____ IDWP 50 $7.00	
____ IDP 22 $7.00	____ IDWP 51 $7.00	
____ IDWP 39/1 $11.00	____ IDWP 52 $9.00	
____ IDWP 39/2 $9.00	____ IDWP 53 $13.00	
____ IDWP 40 $11.00	____ IDWP 54 $13.00	
____ IDWP 41 $11.00	____ IDWP 55 $9.00	

Sub-Total	$ ______
20% (foreign orders, surface mail)	$ ______
International Airmail postage (call or e-mail for rates)	______$
Total Amount	$ ______

The MSU International Development Papers published before 1993 (IDP numbers 1-11, IDWP numbers 1-38, and RP numbers 1-31) may be obtained through A.I.D.'s Development Information System (CDIE) and are not available from the MSU Bulletin Office.

How to Order
MSU International Development Papers
from USAID:

The MSU International Development Papers published before 1993 (IDP numbers 1-11, IDWP numbers 1-38, and RP numbers 1-31) may be obtained **only** through A.I.D.'s Development Information System (CDIE).

The CDIE reference numbers are shown on the following list. They are also available in A.I.D.'s Development Information System CD-ROM Database (CD-DIS), which is available to USAID missions and to USAID/W offices free of charge and to the public for an annual subscription fee.

USAID's Internet Gopher address: GOPHER.INFO.USAID.GOV. Citations (including abstracts) to USAID documents can be found under the Gopher main menu item "Reports and Publications." Document identification necessary to order the full document in paper or microfiche form from the Development Information Services Clearinghouse (DISC) is included with the citations.

If you would like to order any of the pre-1993 IDP's, IDWP's or RP's, please do not request them from MSU, but send your request--with the correct CDIE reference number--directly to the DISC:

Mail: Development Information Services Clearinghouse

1500 Wilson Blvd., Suite 1010

Arlington, VA 22209-2404

Telephone: 703-351-4006

Fax: 703-351-4039

Telex: 703-351-4038

Internet e-mail address: AIDDISC@CAPCON.NET

If you cannot provide the CDIE reference number for the publication you wish to order, contact the A.I.D. Development Information Center Reference Librarian, who will supply you with the complete order information:

Telephone: 703-875-4818
Fax: 703-875-5269

Prices
Documents are provided to AID employees without charge. Others are required to pay reproduction and mailing/handling costs. Current prices may be obtained by contacting the Document Distribution Unit. A limited number of microfiche copies are provided without charge to LDC institutions.

Exchange programs
CDIE has established reciprocal agreements with selected development organizations who provide documents or other information resources to CDIE in exchange for distribution of CDIE documents or information. The materials received as a result of these exchange agreements are located in CDIE.

Deposit accounts
Deposit accounts may be established by USAID contractors and other users to facilitate the payment for documents ordered.

Available in A.I.D.'s Development Information System (CDIE)

MSU INTERNATIONAL DEVELOPMENT PAPERS

IDP 1 *Research on Agricultural Development in Sub-Saharan Africa: A Critical Survey* by Carl K. Eicher and Doyle C. Baker. 1982. 346 pp. **(CDIE reference PN-AAL-692)**

IDP 1F *Etude Critique de la Recherche sur la Developpement Agricole en Afrique Subsaharienne* par Carl K. Eicher et Doyle C. Baker. 1982. 345 pp. **(CDIE reference PN-ABA-840)**

IDP 2 *A Simulation Study of Constraints on Traditional Farming Systems in Northern Nigeria* by Eric W. Crawford. 1982. 136 pp. **(CDIE reference PN-AAP-677)**

IDP 3 *Farming Systems Research in Eastern Africa: The Experience of CIMMYT and Some National Agricultural Research Services, 1976-81* by M.P. Collinson. 1982. 67 pp. **(CDIE reference PN-AAM-826)**

IDP 4 *Animal Traction in Eastern Upper Volta: A Technical, Economic and Institutional Analysis* by Vincent Barrett, Gregory Lassiter, David Wilcock, Doyle Baker, and Eric Crawford. 1982. 132 pp. **(CDIE reference PN-AAM-262)**

IDP 5 *Socio-Economic Determinants of Food Consumption and Production in Rural Sierra Leone: Application of an Agricultural Household Model with Several Commodities* by John Strauss. 1983. 91 pp. **(CDIE reference PN-AAM-031)**

IDP 6 *Applications of Decision Theory and the Measurement of Attitudes Towards Risk in Farm Management Research in Industrialized and Third World Settings* by Beverly Fleisher and Lindon J. Robison. 1985. 105 pp. **(CDIE reference PN-AAU-740)**

IDP 7 *Private Decisions and Public Policy: The Price Dilemma in Food Systems in Developing Countries* by Peter Timmer. 1986. 58 pp. **(CDIE reference PN-AAZ-091)**

IDP 8 *Rice Marketing in Senegal River Valley: Research Findings and Policy Reform Options* by Michael L. Morris. 1987. 89 pp. **(CDIE reference PN-AAZ-092)**

IDP 9 *Small Scale Industries in Developing Countries: Empirical Evidence and Policy Implications* by Carl Liedholm and Donald Mead. 1987. 141 pp. **(CDIE reference PN-AAX-734)**

IDP 10 *Maintaining the Momentum in Post-Green Revolution Agriculture: A Micro-Level Perspective from Asia* by Derek Byerlee. 1987. 57 pp. **(CDIE reference PN-AAZ-093)**

IDP 11 *The Economics of Smallholder Maize Production in Zimbabwe: Implications for Food Security* by David D. Rohrbach. 1989. 100 pp. **(CDIE reference PN-ABD-549)**

WORKING PAPERS

IDWP 1 *Farming Systems Research (FSR) in Honduras, 1977-81: A Case Study* by Daniel Galt, Alvaro Diaz, Mario Contreras, Frank Peairs, Joshua Posner, and Franklin Rosales. 1982. 48 pp. **(CDIE reference PN-AAM-827)**

IDWP 2 *Credit Agricole et Credit Informal dans la Region Orientale de Haute-Volta: Analyse Economique, Performance Institutionnelle et Implications en Matiere de Politique de Developpement Agricole* by Edouard K. Tapsoba. 1982. 125 pp. **(CDIE reference PN-AAZ-527)**

IDWP 3 *Employment and Construction: Multicountry Estimates of Costs and Substitutions Elasticities for Small Dwellings* by W.P. Strassmann. 1982. 42 pp. **(CDIE reference PN-AAM-455)**

IDWP 4 *Sub-Contracting in Rural Areas of Thailand* by Donald C. Mead. 1982. 53 pp. **(CDIE reference PN-AAN-192)**

IDWP 5 *Microcomputers and Programmable Calculators for Agricultural Research in Developing Countries* by Michael T. Weber, James Pease, Warren Vincent, Eric W. Crawford, and Thomas Stilwell. 1983. 113 pp. **(CDIE reference PN-AAN-441)**

IDWP 6 *Periodicals for Microcomputers: An Annotated Bibliography* by Thomas Stilwell. 1983. 70 pp. **(CDIE reference PN-AAN-443)**

IDWP 7 *Employment and Housing in Lima, Peru* by Paul Strassmann. 1983. 96 pp. **(CDIE reference PN-AAN-396)**

IDWP 8 *Faire Face a la Crise Alimentaire de l'Afrique* by Carl K. Eicher. 1983. 29 pp. **(CDIE reference PN-AAN-444)**

IDWP 9 *Software Directories for Microcomputers: An Annotated Bibliography* by Thomas C. Stilwell. 1983. 14 pp. **(CDIE reference PN-AAN-442)**

IDWP 10 *Instructional Aids for Teaching How to Use the TI-59 Programmable Calculator* by Ralph E. Hepp. 1983. 133 pp. **(CDIE reference PN-AAP-133)**

IDWP 11 *Programmable Calculator (TI-59) Programs for Marketing and Price Analysis in Third World Countries* by Michael L. Morris and Michael T. Weber. 1983. 105 pp. **(CDIE reference PN-AAP-134)**

IDWP 12 *An Annotated Directory of Statistical and Related Microcomputer Software for Socioeconomic Data Analysis* by Valerie Kelly, Robert D. Stevens, Thomas Stilwell and Michael T. Weber. 1983. 165 pp. **(CDIE reference PN-AAP-135)**

IDWP 13 *Guidelines for Selection of Microcomputer Hardware* by Chris Wolf. 1983. 90 pp. **(CDIE reference PN-AAR-106)**

IDWP 14 *User's Guide to BENCOS A SuperCalc Template for Benefit-Cost Analysis* by Eric W. Crawford, Ting-Ing Ho and A. Allan Schmid. 1984. 35 pp. **(CDIE reference PN-AAQ-682)**

IDWP 15 *An Evaluation of Selected Microcomputer Statistical Programs* by James W. Pease and Raoul Lepage with Valerie Kelly, Rita Laker-Ojok, Brian Thelen, and Paul Wolberg. 1984. 187 pp. **(CDIE reference PN-AAQ-683)**

IDWP 16 *Small Enterprises in Egypt: A study of Two Governorates* by Stephen Davies, James Seale, Donald C. Mead, Mahmoud Badr, Nadia El Sheikh and Abdel Rahman Saidi. 1984. 187 pp. **(CDIE reference PN-AAU-610)**

IDWP 17 *Microcomputer Statistical Packages for Agricultural Research* by Thomas C. Stilwell. 1984. 23 pp. **(CDIE reference PN-AAZ-516)**

IDWP 18 *An Annotated Directory of Citation Database, Educational, System Diagnostics and Other Miscellaneous Microcomputer Software of Potential Use to Agricultural Scientists in Developing Countries* by Thomas C. Stilwell and P. Jordan Smith. 1984. 34 pp. **(CDIE reference PN-AAZ-523)**

IDWP 19 *Irrigation in Southern Africa: An Annotated Bibliography* by Amalia Rinaldi. 1985. 60 pp. **(CDIE reference PN-AAZ-524)**

IDWP 20 *A Microcomputer Based Planning and Budgeting System for Agricultural Research Programs* by Daniel C. Goodman, Jr., Thomas C. Stilwell and P. Jordan Smith. 1985. 75 pp. **(CDIE reference PN-AAZ-525)**

IDWP 21 *Periodicals for Microcomputers: An Annotated Bibliography, Second Edition* by Thomas C. Stilwell. 1985. 89 pp. **(CDIE reference PN-AAZ-526)**

IDWP 22 *Software Directories for Microcomputers: An Annotated Bibliography, Second Edition* by Thomas C. Stilwell. 1985. 21 pp. **(CDIE reference PN-AAZ-528)**

IDWP 23 *A diagnostic Perspective Assessment of the Production and Marketing System for Mangoes in the Eastern Caribbean* by Alan Hrapsky with Michael Weber and Harold Riley. 1985. 106 pp. **(CDIE reference PN-AAZ-529)**

IDWP 24 *Subcontracting Systems and Assistance Programs: Opportunities for Intervention* by Donald C. Mead. 1985. 32 pp. **(CDIE reference PN-AAZ-943)**

IDWP 25 *Small Scale Enterprise Credit Schemes: Administrative Costs and the Role of Inventory Norms* by Carl Liedholm. 1985. 23 pp. **(CDIE reference PN-AAU-615)**

IDWP 26 *Subsector Analysis: Its Nature, Conduct and Potential Contribution to Small Enterprise Development* by James J. Boomgard, Stephen P. Davies, Steve Haggblade and Donald Mead. 1986. 57 pp. **(CDIE reference PN-AAZ-101)**

IDWP 27 *The Effect of Policy and Policy Reforms on Non-Agricultural Enterprises and Employment in Developing Countries: A Review of Past Experiences* by Steve Haggblade, Carl Liedholm, and Donald C. Mead. 1986. 133 pp. **(CDIE reference PN-AAV-001)**

IDWP 28 *Rural Small Scale Enterprises in Zambia: Results of a 1985 Country-Wide Survey* by John T. Milimo and Yacob Fisseha. 1986. 76 pp. **(CDIE reference PN-AAZ-102)**

IDWP 29 *Fundamentals of Price Analysis in Developing Countries' Food Systems: A Training Manual to Accompany the Microcomputer Software Program 'MSTAT'* by Stephen Goetz and Michael T. Weber. 1986. 148 pp. **(CDIE reference PN-AAZ-103)**

IDWP 30 *Rapid Reconnaissance Guidelines for Agricultural Marketing and Food System Research in Developing Countries* by John S. Holtzman. 1986. 75 pp. **(CDIE reference PN-AAZ-104)**

IDWP 31 *Contract Farming and Its Effect on Small Farmers in Less Developed Countries* by Nicholas William Minot. 1986. 86 pp. **(CDIE reference PN-AAZ-105)**

IDWP 32 *Food Security Policy and the Competitiveness of Agriculture in the Sahel: A Summary of the "Beyond Mindelo" Seminar* by Thomas S. Jayne and Nicholas Minot. 1989. 27 pp. **(CDIE reference PN-ABF-570)**IDWP 33. ..*Small Scale Manufacturing Growth in Africa: Initial Evidence* by Carl Liedholm and Joan Parket. 1989. 18 pp. **(CDIE reference PN-ABB-945)**

IDWP 34 *Food Security and Economic Growth in the Sahel: A Summary of the September 1989 Cereals Workshop* by Victoire C. D'Agostino and John M. Staatz. 1989. 44 pp. **(CDIE reference PN-ABD-956)**

IDWP 35 *User's Manual for the SADCC Cereals Trade Database Compiled by the University of Zimbabwe and Michigan State University* by David Kingsbury. 1989. 44 pp. **(CDIE reference PN-ABF-378)**

IDWP 36 *Managing Food Security Action Programs in Botswana* by Sisay Asefa. 1989. 36 pp. **(CDIE reference PN-ABF-377)**

IDWP 37 *User's Guide to BENCOS Lotus 1-2-3 Templates for Benefit-Cost Analysis* by Eric Crawford and A. Allan Schmid. 1990. 23 pp. **(CDIE reference PN-ABF-530)**

IDWP 38 *Research Methods in the MSU Food Security in Africa Project: Conceptualizing and Implementing Policy Relevant Studies* by James F. Tefft with Michael T. Weber and John M. Staatz. 1990. 128 pp. **(CDIE reference pending)**

REPRINT PAPERS

RP 1 *The Private Sector Connection to Development* by Carl Liedholm. 1986. 19 pp. **(CDIE reference PN-AAW-353)**

RP 2 *Influencing the Design of Marketing Systems to Promote Development in Third World Countries* by James D. Shaffer with Michael Weber, Harold Riley and John Staatz. 1987. 21 pp. **(CDIE reference PN-AAV-230)**

RP 3 *Famine Prevention in Africa: The Long View* by Carl K. Eicher. 1987. 18 pp. **(CDIE reference PN-AAZ-119)**

RP 4 *Cereals Marketing in the Senegal River Valley* by Michael L. Morris. 1987. 126 pp. **(CDIE reference PN-AAZ-120)**

RP 5 *The Food Security Equation in Southern Africa* by Mandivamba Rukuni and Carl K. Eicher. 1987. 32 pp. **(CDIE reference PN-AAZ-121)**

RP 6 *Economic Analysis of Agronomic Trials for the Formulation of Farmer Recommendations* by Eric Crawford and Mulumba Kamuanga. 1988. 41 pp. **(CDIE reference PN-AAZ-370)**

RP 6F *L'Analyse Economiques des Essais Agronomiques pour la Formulation des Recommandations aux Paysans* par Eric Crawford et Mulumba Kamuanga. 1987. 33 pp. **(CDIE reference PN-AAZ-122)**

RP 7 *Economic Analysis of Livestock Trials* by Eric Crawford. 1987. 36 pp. **(CDIE reference PN-AAZ-371)**

RP 7F *L'Analyse Economique des Essais Zootechniques* par Eric Crawford. 1987. 36 pp. **(CDIE reference PN-AAZ-123)**

RP 8 *A Field Study of Fertilizer Distribution and Use in Senegal, 1984: Summary Report* by Eric Crawford and Valerie Kelly. 1987. 32 pp. **(CDIE reference PN-AAZ-124)**

RP 8F *Enquete sur la Distribution et l'Utilisation de l'Engrais au Sénégal, 1984: Résumé Analytique* par Eric Crawford et Valerie Kelly. 1988. 43 pp. **(CDIE reference PN-ABC-173)**

RP 9 *Improving Food Marketing Systems in Developing Countries: Experiences from Latin America* by Kelly Harrison, Donald Henley, Harold Riley and James Shaffer. 1987. 135 pp. **(CDIE reference PN-AAZ-125)**

RP 10 *Policy Relevant Research on the Food and Agricultural System in Senegal* by Mark Newman, Eric Crawford and Jacques Faye. 1987. 30 pp. **(CDIE reference PN-AAZ-126)**

RP 10F *Orientations et Programmes de Recherche Macro-Economiques sur le Systeme Agro-Alimentaire Sénégalais* par Mark Newman, Eric Crawford et Jacques Faye. 1987. 37 pp. **(CDIE reference PN-AAZ-127)**

RP 11 *A Field Study of Fertilizer Distribution and Use in Senegal, 1984: Final Report* by Eric Crawford, Curtis Jolly, Valerie Kelly, Philippe Lambrecht, Makhona Mbaye, and Matar Gaye. 1987. 106 pp. **(CDIE reference PN-AAZ-128)**

RP 11F *Enquête sur la Distribution et l'Utilisation de l'Engrais au Sénégal, 1984: Rapport Final* par Eric Crawford, Curtis Jolly, Valerie Kelly, Philippe Lambrecht, Makhona Mbaye, et Matar Gaye. 1987. 106 pp. **(CDIE reference pending)**

RP 12 *Private and Public Sectors in Developing Country Grain Markets: Organization Issues and Options in Senegal* by Mark D. Newman, P. Alassane Sow, and Ousseynou NDoye. 1987. 14 pp. **(CDIE reference PN-AAZ-129)**

RP 13 *Agricultural Research and Extension in Francophone West Africa: The Senegal Experience* by R. James Bingen and Jacques Faye. 1987. 23 pp. **(CDIE reference PN-AAV-929)**

RP 13F *La Liaison Recherche-Developpement en Afrique de l'Ouest Francophone: L'Experience du Sénégal* par James Bingen et Jacques Faye. 1987. 32 pp. **(CDIE reference PN-AAZ-130)**

RP 14 *Grain Marketing in Senegal's Peanut Basin: 1984/85 Situation and Issues* by Mark D. Newman. 1987. 16 pp. **(CDIE reference PN-AAZ-131)**

RP 15 *Tradeoffs between Domestic and Imported Cereals in Senegal: A Marketing Systems Perspective* by Mark D. Newman, Ousseynou NDoye, and P. Alassane Sow. 1987. 41 pp. **(CDIE reference PN-AAZ-372)**

RP 15F *Céréales Locales et Céréales Importées au Sénégal: La Politique Alimentaire a Partier Systemes de Commercialisation* par Mark D. Newman, Ousseynou NDoye, et P. Alassane Sow. 1987. 48 pp. **(CDIE reference PN-ABC-326)**

RP 16 *An Orientation to Production Systems Research in Senegal* by R. James Bingen. 1987. 88 pp. **(CDIE reference PN-AAZ-373)**

RP 16F *Orientation de la Recherche sur les Systemes de Productions au Sénégal* par R. James Bingen. 1987. 94 pp. **(CDIE reference PN-AAZ-374)**

RP 17 *A Contribution to Agronomic Knowledge of the Lower Casamance (Bibliographical Synthesis)* by J.L. Posner. 1988. 47 pp. **(CDIE reference PN-AAZ-375)**

RP 17F *Contribution a la Connaissance Agronomique de la Basse Casamance (Synthese Biblographique)* par J.L. Posner. 1988. 47 pp. **(CDIE reference PN-ABC-167)**

RP 18 *Acquisition and Use of Agricultural Inputs in the Context of Senegal's New Agricultural Policy: The Implications of Farmers' Attitudes and Input Purchasing Behavior for the Design of Agricultural Policy and Research Programs* by Valerie Auserehl Kelly. 1988. 30 pp. **(CDIE reference PN-AAZ-376)**

RP 18F *Acquisition et Utilisation d'Intrants Agricoles dans le Context de la Nouvelle Politique Agricole du Sénégal: Implications des Attitudes et du Comportement d'Achat d'Intrants des Exploitants pour l'Elaboration d'une Politique Agricole et de Programmes de Recherches* par Valerie Auserehl Kelly. 1988. 35 pp. **(CDIE reference PN-AAZ-377)**

RP 19 *Farmers' Demand for Fertilizer in the Context of Senegal's New Agricultural Policy: A Study of Factors Influencing Farmers' Fertilizer Purchasing Decisions* by Valerie Auserehl Kelly. 1988. 47 pp. **(CDIE reference PN-AAZ-378)**

RP 19F *Demande d'Engrais de la Part des Exploitants dans les Contexte de la Nouvelle Politique Agricole au Sénégal: Une Etude des Facteurs Influencant les Decisions d'Achat d'Engrais Prises par les Exploitants* par Valerie Auserehl Kelly. 1988. 58 pp. **(CDIE reference PN-AAZ-379)**

RP 20 *Production Systems in the Lower Casamance and Farmer Strategies in Response to Rainfall Deficits* by J.L. Posner, M. Kamuanga, and S. Sall. 1988. 33 pp. **(CDIE reference PN-ABC-162)**

RP 20F *Les Systemes de Production en Basse Casamance et les Stratégies Paysannes Face du Deficit Pluviométrique* par J.L. Posner, M. Kamuanga, et S. Sall. 1988. 33 pp. **(CDIE reference PN-ABC-163)**

RP 21 *Informing Food Security Decisions in Africa: Empirical Analysis and Policy Dialogue* by Michael T. Weber, John M. Staatz, John S. Holtzman, Eric W. Crawford, and Richard H. Bernsten. 1989. 11 pp. **(CDIE reference PN-ABE-627)**

RP 21F *Comment Informer les Decisions Traitant de la Sécurité Alimentaire en Afrique: Analyses Empiriques et Dialogue Politique* par Michael T. Weber, John M. Staatz, John S. Holtzman, Eric W. Crawford, et Richard H. Bernsten. 1989. 13 pp. **(CDIE reference PN-ABD-104)**

RP 22 *The Creation and Establishment of Production Systems Research in a National Agricultural Research Institute: The Senegal Experience* by Jacques Faye, James Bingen, and Etienne Landais. 1988. 25 pp. **(CDIE reference PN-ABC-161)**

RP 23 *Foreign Trade of Agricultural Products and Inputs in Senegal from 1975 to 1984* by Frederic Martin and Alioune Dieng. 1988. 45 pp. **(CDIE reference PN-ABC-164)**

RP 23F *Le Commerce Exterieur de Produits et d'Intrants Agricoles du Sénégal de 1975 a 1984* par Frederic Martin et Alioune Dieng. 1990. 45 pp. **(CDIE reference PN-ABF-529)**

RP 24 *Regulatory Uncertainty and Government Objectives for the Organization and Performance of Cereal Markets: The Case of Senegal* by Mark D. Newman, P. Alassane Sow, and Ousseynou NDoye. 1988. 24 pp. **(CDIE reference PN-ABC-159)**

RP 24F *Incertitude Réglementaire, Objectifs Gouvernementaux, Organisation et Performances des Marchés Céréaliers: Le Cas du Sénégal* par Mark D. Newman, P. Alassane Sow, and Ousseynou NDoye. 1988. 24 pp. **(CDIE reference PN-ABC-160)**

RP 25F *Etude sur la Commercialisation des Céréales dans la Région du Fleuve Sénégal: Méthodologie* par Michael Morris. 1988. 48 pp. **(CDIE reference PN-ABC-172)**

RP 26 *The Regulation and Organization of Cereal Markets in Senegal: Report on the Marketing Campaigns of 1983/84 and 1984/85* by P. Alassane Sow and Mark D. Newman. 1988. 29 pp. **(CDIE reference PN-ABC-165)**

RP 26F *La Réglementation et l'Organisation des Marchés Céréaliers au Sénégal: Situation des Campagnes des Commercialisation 1983/84 et 1984/85* par P. Alassane Sow et Mark D. Newman. 1988. 35 pp. **(CDIE reference PN-ABC-166)**

RP 27 *Farm Level Cereal Situation in Lower Casamance: Results of a Field Study* by C.M. Jolly, M. Kamuanga, S. Sall, and J.L. Posner. 1988. 35 pp. **(CDIE reference PN-ABC-157)**

RP 27F *Situation Céréaliere en Milieu Paysan en Basse Casamance: Résultats d'une Enquête de Terrain* par C.M. Jolly, M. Kamuanga, S. Sall, et J.L. Posner. 1988. 41 pp. **(CDIE reference PN-ABC-158)**

Annexe 1 Budgets de Culture et Analyse des Marges dans le Bassin Arachidier. 1988. 134 pp. **(CDIE reference PN-ABC-169)**

Annexe 2 Budgets de Culture et Analyse des Marges au Sénégal Oriental et en Casamance. 1988. 204 pp. **(CDIE reference PN-ABC-170)**

Annexe 3 Budgets de Culture et Analyse des Marges dans la Vallée du Fleuve Sénégal. 1988. 214 pp. **(CDIE reference PN-ABC-171)**

RP 29 *Agricultural Development and Policy in Senegal: Annotated Bibliography of Recent Studies, 1983-89* by Eric Crawford, R. James Bingen, and Malcolm Versel. 1990. 254 pp. **(CDIE reference PN-ABE-271)**

RP 30 *Lowland Cropping Systems in the Lower Casamance of Senegal: Results of Four Years of Agronomic Research (1982-1985)* by Joshua Posner, Mulumba Kamuanga, and Mamadou Lo. 1990. 130 pp. **(CDIE reference pending)**

RP 31 *Farming Systems Research in Southern Senegal: The Djibelor Experience (1982-1986)* by Mulumba Kamuanga and Joshua L. Posner. 1992. 57 pp. **(CDIE reference pending)**