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Raising Farm Productivity in Africa to Sustain Long-Term Food Security

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Raising Farm Productivity in Africa to Sustain Long-Term Food Security

Executive Summary

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INTRODUCTION

The physical, policy, and economic context in Africa has changed radically from the 1960s-1970s (when the bulk of farm management studies were done) to the 1980s-1990s there has been rapid population growth, soil and natural resource degradation, declining rainfall in the semi-arid tropics, growing land constraints in semi-arid and tropical highland areas, structural adjustment programs, increased market involvement by farmers, diversification of farm household incomes into nonfarm activities, and varied success of technology development and transfer

Moreover, **there has been recent widespread concern for African agriculture** based on perceptions of low or declining agricultural productivity

The above changes and concerns point to the **need to update our understanding of farm productivity in Africa** To this end, and to support Development Fund for Africa objectives, AID/AFR/SD/PSGE/FSP has funded several studies of agricultural productivity, including one conducted by Michigan State University under its Food Security II Cooperative Agreement with AID

Our aim has been to **"dig below" aggregate trends to uncover farm-level determinants of agricultural productivity**, and examine how these determinants may vary by crop, agroecological zone, farm type, technology, and institutional/policy setting An important goal of the project was also to strengthen African research capacity through **collaborative research and joint policy outreach**

The **present document synthesizes findings from our four country studies** (in Burkina Faso, Rwanda, Senegal, and Zimbabwe), focusing on **patterns in and determinants of farm productivity change, and their implications for strategy, policy, and programs** to promote agricultural productivity in Africa

DATA AND METHODS

The three farm-level studies used detailed household survey data covering both farm and nonfarm activities of households the **Burkina Faso** study used a panel of four years of farm-level data, the **Rwanda** study, three years, and the **Senegal** study one year The **Zimbabwe study used aggregate data**, and used an 18-year series for each of two groups -- smallholders and large commercial farmers

The study examined patterns in and determinants of crop productivity differences -- total and partial factor productivity, including average and marginal measures -- over groups of farms, zones, and years The factors examined were primarily physical production inputs (e g , fertilizer) and management practices (e g , soil conservation), as well as conditioning variables such as agroclimatic zone, household characteristics (e g , nonfarm income earned), supporting institutions and services (input supply infrastructure and credit access)

We also examined the broader measure of productivity of farm households -- total net income per person from farm and nonfarm sectors, and the composition of income from these sectors, so as to take into account African farm households interest beyond just crop production, their attempt to maximize overall income from many sources including livestock and nonfarm production and wage labor, to assure food security

The study's mandate is a focus 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 In practice, these economy-wide effects can be complex -- for example, government support programs can spur peanut farmers' adoption of inputs that raise yields, which can in turn increase the efficiency of downstream markets and processing plants, but subsidy outlays to spur input use can increase fiscal deficits and general price levels The effects are indeterminate *a priori* and are thus an empirical knowledge gap to address elsewhere

MAJOR FINDINGS

Productivity Patterns

Growth in average land product (output per hectare) and average labor product (output per agricultural worker) was slow in the four study countries for most crops In general, average land product grew more quickly than average labor product, indicating increasing population density This coincides with FAO analysis (Higgins et al , 1982) showing that **land constraints are generally increasing** in African agriculture, especially in the semi-arid and highland tropics (our study areas)

Disaggregating the analysis in our study countries by using farm-level data showed **substantial variability** in average land products and average labor products by (a) crop, (b) agroecological zone, (c) type of year, (d) type of technology used, and (e) and farm size

(a) **By crop Average land products increased for government-promoted cash crops** such as cotton and maize in Burkina Faso, maize, wheat, and soybeans in Rwanda, and maize in Zimbabwe (total factor productivity growth for maize among Zimbabwe smallholders grew from 1980-1986 then fell thereafter) **Average land products were stagnant or declined for many subsistence or semi-commercialized food staples**, such as for millet in the Sahel or tubers in Rwanda

(b) **By agroecological zone** Average land products in **more favorable** zones of Burkina Faso tended to be 1 5-3 0 times **higher than those in less favorable zones**, in Rwanda, that range is also 2-3 times In Zimbabwe, among smallholders, maize average land product in the more favorable agroclimatic zones grew from 1 to 1 5 tons/ha over 1980-86 while maize average land product was stagnant for smallholders in the less favored agroclimatic zones

(c) **By type of year Large swings in average land products occur between years of good rainfall and bad** For example, in northern Burkina, millet average land products changed sixfold between the good year of 1983 and the drought year of 1984 In Zimbabwe, maize average land products in the good year 1981 were threefold average land products in the drought year 1983 for the smallholder sector This result points to the **notorious riskiness of agriculture** in many areas, and to the **sensitivity to beginning and ending points of longitudinal productivity analysis in Africa**

(d) **By type of technology used** In Burkina, cotton average land products on **animal traction** farms were 1 5 times those on manual farms

(e) **By farm size** The findings are conditioned by the capital intensity of the larger farms In Rwanda, average land products on small farms were 1 6-2 0 times the average land products on larger farms, except where larger farmers were in special cashcropping programs In Zimbabwe, micro evidence shows that maize average land products on commercial farms can be 3-5 times those on communal smallholder farms

General findings regarding determinants

• Our results **reemphasized the importance of traditionally identified determinants of productivity in farm management studies in Africa**

- **improved seed**
- **fertilizer**
- **animal traction**

as well as land and labor But actual productivity effects varied substantially by location and farm household type

• Our studies **identified constraints on availability of seed, fertilizer, equipment, operating capital, and good quality land** The studies also showed **unequal access to these inputs**, and hence an unequal distribution of benefits from improved input use, partly because of unequal access to cash income (especially from nonfarm activities) and to credit

• Our studies **highlighted several determinants of productivity that have not traditionally been emphasized in Africa**, that we believe are linked to the changes in the economic and physical context over the last few decades (discussed above)

- **Nonfarm income** generation often plays a key role in facilitating acquisition and use of productivity-enhancing inputs
- **Natural resource conservation** improves farm-level productivity Conversely, improving farm productivity helps conserve resources
- **Market infrastructure** is important to acquisition of inputs that drive productivity change

Discussion of results for specific determinants

Seed

- The case studies point to **seed as one of the most important determinants of productivity** (MSU studies of returns to agricultural research (Oehmke and Crawford, 1993) have also showed the pivotal role of effective seed distribution)
- **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)
- 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**
- **Government seed distribution and credit programs have been cut back and seed prices increased** by policy reforms associated with structural adjustment In Senegal, the **result was 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)
- 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 than for food crops, which have more than one marketing outlet

Fertilizer

- Availability and affordability issues apply to fertilizer as well as to seed, fertilizer differs from seed in that

  •• fertilizer is more costly and financially risky than 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

- 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 average land product when combined with manure and animal traction

- **Observed fertilizer rates 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 (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 nonfarm income**

- **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 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 1985/6, 19,900 in 1986/7, and 22,400 in 1987/8, much of the fertilizer use was on cotton, irrigated rice, and vegetables -- either where subsidies and credit remains (cotton) or where there is water control (rice, vegetables)

  •• in Zimbabwe, recent elimination of fertilizer credit caused a decline in fertilizer use on hybrid maize by small farmers and a decline in hybrid maize area

Animal traction

- 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 average land products

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

- **Investment in animal traction is more likely for households that have access to more land, earn more nonfarm income, and grow cash crops**

Organic inputs use and conservation investments

- **Practices that add organic matter to soil and conserve water or prevent erosion and help water retention (e g , bunds, tied ridges, 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** -- conservation investments on low degradation farms increased the land marginal value product by 27%, for moderately and very degraded farms, the increase was 28-34% and 42%, respectively

•• investment in soil conservation investments is more likely for farms that are smaller (hence have less ability to fallow, a substitute for these investments), earn more nonfarm income, and grow cash crops**

Land and labor

- Size and quality of land matter for productivity, **land constraints are increasingly common due to population pressure**

  •• in **Rwanda, land rental (as compared to ownership) discourages use of organic matter and soil conservation investments,** small farms had much higher land productivity than did larger farms But on smaller farms, marginal value products of labor were very low relative to wage rates This implies lower opportunity cost of labor on smallholder farms than that reflected in the agricultural wage probably because of constraints to access to that labor market as well as to nonagricultural employment opportunities By contrast, marginal value products of land were much higher for the smaller farms than land rental rates, indicating constraints on access to land

Nonfarm income

- **Nonfarm income 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

- **Nonfarm income can play a role in facilitating conservation investments,** for which credit appears to be rarely available

- Nonfarm activities smooth household income and **help to reduce risk** by diversifying the sources of household income

  •• within a given agroecological zone, **the poor have less access to nonfarm income opportunities -- nonfarm 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 nonfarm activities This is worrisome because unequal access to nonfarm income translates into unequal access to farm inputs in the face of limited credit access

  •• there is generally a **positive relationship between nonfarm income and improved input use** (fertilizer and animal traction in Burkina Faso and Senegal, peanut seed in Senegal, conservation practices and fertilizer in Rwanda)

Markets

- **Well-functioning input and output markets help farmers acquire and use productivity-increasing inputs** by reducing transactions costs and risks (e g , from imperfect information, or price volatility due to a thin market)

  •• 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, including higher consumer prices due to grain movement controls that force 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)

IMPLICATIONS

1 **Sustainable intensification of farm production through use of improved inputs that raise and sustain increases in land productivity is a major food security issue in Africa, given growing land constraints and soil degradation To get needed breakthroughs in farm productivity, farm input use -- such as fertilizer, organic inputs, animal traction, and conservation investments -- needs to rise substantially**

2 **Strategies to raise farm productivity will need to differ, however, between favorable and unfavorable agroclimatic zones** With proper conditions, **much increased productivity can be expected in the favorable zones** Expectations for cropping intensification are **more modest for the agroclimatically unfavorable 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 are linked Environmental degradation and pressure on marginal lands cannot be halted without raising farm-level productivity -- yet interventions to improve farm-level productivity must be accompanied by conservation investments Intensification on land already under cultivation can reduce pressure to expand cultivation onto fragile marginal lands and thus lead to more sustainable resource use**

4 **Off-farm employment and the farm productivity agendas are linked** In many areas off-farm income is a critical means to pay for farm inputs and investments Moreover, much of the growth of nonfarm 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

The upshot is that 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

Moreover, 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 nonfarm production)

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

6 **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 input use has been promoted in ways that are not economically sound, that in the long run are 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 infrastructure 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

Public investment should be such that it complements and spurs private investment on-farm, in the input distribution system, and in primary product processing It is essential that governments and donors invest in understanding how to promote the economic use of the tools of sustainable intensification -- fertilizer, animal traction, organic inputs, and soil conservation 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

Raising Farm Productivity in Africa to Sustain Long-Term Food Security

1 INTRODUCTION

1 1 Background

This study builds on the considerable edifice of farm management, farming systems, and rural economy studies in the 1960s and 1970s by Abalu, Barrett, Benoit-Cattin, Byerlee, Charreau, Chuta, Cleave, Collinson, Delgado, Falusi, Faye, Flinn, Liedholm, Massell, Matlon, McIntire, Norman, Nweke, Olayide, Ruthenberg, Shapiro, Spencer, Tourte, Upton, Wolgin, and others, who advanced our understanding of the determinants of productivity in African agriculture and the behavior of the rural household Their work showed the benefits of using improved management practices and inputs such as fertilizer, animal traction, and manure, and pointed to connections between the farm and nonfarm, and the cropping and livestock economies

In the 1960s and 1970s, most rural Africans were subsistence farmers producing for their own consumption and using few, if any, purchased inputs African agriculture was viewed as land-abundant and labor-constrained, so the focus was on raising average labor product and expanding cultivated area, and on promoting a shift from subsistence to commercial agriculture

During the last 20-30 years there have been radical changes in the physical, social, and economic environment in rural Africa Rainfall has declined on average and a series of major droughts have underscored the severe risk of rainfed agriculture in Africa, soils have degraded, and land constraints are growing Lele and Stone (1989) Population growth and urbanization have accelerated, to the point where the population growth rate now exceeds the overall growth and the food output growth rates throughout much of the continent Many countries now import substantial quantities of staple foods

Although research in the 1960s and 1970s showed the potential for increasing crop productivity with 'modern' inputs, Africa has seen few Green Revolutions, particularly in food crops Exceptions include relatively short-lived successes in hybrid maize in Zimbabwe and Kenya in the 1960's and in Malawi, Zambia, Zimbabwe, Nigeria, and Ghana in the 1980s-1990s, cocoa in Ivory Coast and Ghana, and cotton in Francophone West Africa

In the face of these physical environment and demographic changes, both rural households and governments changed their economic strategies during the last two decades Farm households have become much more involved in the larger economy, while governments have recently been withdrawing from direct involvement in the farm economy 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, and by earning a substantial share of their income from nonfarm activities Agriculture alone no longer provides an adequate livelihood for most

The drive to improve farm-level productivity was thwarted to a certain extent by macro-economic crises and adjustments during the 1980s and 1990s External debt, rapidly increasing food imports, and fiscal deficits led to devaluation of currencies, and cutbacks in or elimination of rural-service parastatals, farm input and consumer subsidies cut, and farm equipment, seed, and fertilizer programs It does not appear that the private sector quickly filled the breach, so it has become increasingly difficult for farmers in many countries to obtain the productivity-enhancing inputs that they were encouraged to adopt in the 1960s and 1970s

Collectively, these changes in the physical, social, and economic environment do not appear to be having a positive impact on the agricultural sector The rate of growth in farm average land products 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

We feel, however, that 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 last decade 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 the work of "digging below" the aggregate surface to examine how productivity and incomes are evolving at the household level and how they vary by zone, type of household or type of production technology used

Fortunately, some recent studies collected detailed data on crop production activities and other facets of rural household income and expenditure behavior The key objective of our study is to use the 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

1 2 Scope

The Development Fund for Africa addresses the mutually-dependent goals of raising agricultural productivity and promoting long-term sustainability of natural resources as a means of improving economic growth and food security The Food Security II Cooperative Agreement of Michigan State University has a policy research agenda aimed at identifying technologies, policies, and institutions that will help attain these goals

In that context, AID/AFR/SD/PSGE/FSP has financed research on agricultural productivity by MSU, as part of Food Security II The present document is a synthesis of 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 Details of the methods and country-specific results are reported in the case study documents available under separate cover [1]

[1] The four case studies are (1) Savadogo, K , T Reardon, and K Pietola, "Raising farm productivity in Burkina Faso for sustainable long-term food security", October 1994, (2) Byiringiro, F , D Clay, J Kangasniemi, T Reardon, B Sibomana, "Raising farm productivity in Rwanda for sustainable long-term food security", November 1994, (3) Kelly, V , B Diagana, M Gaye, E Crawford, T Reardon, "Farm productivity in Senegal", November 1994, (4) Jayne, T , C Thirtle, Y Khatri, B Kupfuma, T Reardon, "Determinants of farm productivity in Zimbabwe", December 1994

The material in the case studies is broader than the issues treated here, where we concentrate on the determinants and constraints, leaving much of the discussion of methodological issues, capital formation, and mixed-cropping for other documents

The policy research objectives of the project were to (1) increase and update our understanding of the key determinants of and constraints to increased farm-level crop productivity, (2) discuss the policy and research implications of the findings To those ends, the study examines levels and determinants of productivity by agroclimatic zone, by specific crops, and by types of technology Beside examining physical input/output relationships, we also examine factors that indirectly influence crop productivity (for example, other farm and nonfarm activities the changing physical environment, and the evolution of agricultural policy)

1 3 Layout of the report

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, nonfarm income, farm size) in the four case study countries Section 6 concludes with strategic policy, and program implications

2 CONCEPTS and METHODS

2 1 Concepts

The study's mandate is a focus 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 In practice, these economy-wide effects can be complex -- for example government support programs can spur peanut farmers' adoption of inputs that raise yields, which can in turn increase the efficiency of downstream markets and processing plants, but subsidy outlays to spur input use can increase fiscal deficits and general price levels The effects are indeterminate *a priori* and are thus an empirical knowledge gap to address elsewhere

Here we define "productivity" as the output derived from a standard unit of input It shows how efficient is the producer's use of the input That efficiency is conditioned or determined by the technology, the level of use of the input, and levels of use of complementary inputs For example, average land productivity is the average output per unit of land used, and is conditioned by the amount and type of land used, and the farmer's use of fertilizer and animal traction It is also conditioned by other characteristics of the farmer and her/his milieu -- education, rainfall, soil quality, and so on

"Average input productivity" is thus the output divided by the input level (e g total millet output divided by total land used for millet) "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 same set of conditioners as noted above

To compare across goods, to compare with factor prices, or to aggregate over goods, productivities are commonly valued at the output price The marginal product of land, multiplied by the price of the good produced by that additional unit of land, is the "marginal value product of land"

Farm productivity measures can be defined with any number of crops in the numerator -- from one to all When there are more than one they are aggregated using prices as weights Likewise, there can be one or more inputs in the denominator, again summed (weighted by their prices) When all crops of the farm are in the numerator and all inputs in the denominator, one has an index of "total factor productivity" When a single input is used (with one or more outputs) one has "partial factor productivity"

If the producer is economically rational and there is no constraint to the use of an input, in theory the marginal value product should equal the pecuniary factor price If, however, for example, there is a constraint in the farmer's access to the labor market, it is possible that the marginal value product of labor would be below the wage, indicating a kind of excess of labor Or, if the marginal value product of for example seed is above its price, that means that farmers could efficiently use more seed (as marginal return falls until marginal value equals the seed price), but for some reason (such as credit limits) the farmers are constrained in their access to seed

Moreover, if a given input is allocated efficiently, the marginal value product of an input for one crop should equal the same for any other crop a farmer grows If they are not equal, there is some factor access constraint (e g there are limits to the type or quality of land on which she can grow cotton) or non-optimal behavior due to presence of risk (say safety-first behavior), or a rotation constraint Then, for example, the farmer might find herself in the situation where she could earn more on each additional acre if she could put the land under maize or cotton, but cannot, because of limits on availability to the proper quality or type of land for cultivation of these crops, so she has to put the extra land under millet and sorghum

In this report we work with all the above concepts and measures, but choose applicable measures somewhat differently by case study, with emphasis on single crop productivity measures in the farm-level case studies (Burkina, Rwanda, Senegal) so that allocation efficiency can be examined and because specific input-to-crop allocation data are available Total factor productivity determinants are more interesting in the case of longer time series and more aggregate data (when large exogenous changes such as research and development can be charted), and are thus used in the Zimbabwe study There is a tradeoff here given data constraints -- the farm-level data sets are usually short time series but have rich intercrop and inter-farm-type information The meso and macro level data sets are usually longer time series but lack detail to determine crop specific factor average land products

2 2 Methods

Average productivities are simply calculated using average output divided by input used by farms of a given type (say animal traction-using farms in the Guinean zone of Burkina Faso) By contrast, calculation of marginal productivities requires estimation of production functions or profit functions

The production function is output explained by use of variable inputs (labor, land, fertilizer) and capital inputs (land, equipment), and other conditioning factors such as rainfall Given an estimate from the function of the marginal effect of e g labor on millet output, one can and we did examine how this marginal impact changes when there are different levels of the conditioning factors (such as how much more productive is an extra unit of labor when fertilizer use is higher)

One can then ask what determines use of inputs and conditioning variables -- including policy and other household-level determinants like nonfarm income For example, in Burkina Faso we studied what determined the adoption of animal traction, and then split the sample into traction users and manual households, and then asked how their productivity differed by estimating production functions for the groups Thus, through the production function and input use functions, one traces how price and non-price variables, themselves influenceable in part by policy, determine productivity levels

3 DATA/COUNTRIES/ZONES

Three sets of farm-level, and one set of aggregate (group) data were used The first two farm-level sets are for the two semi-arid tropics case studies in the Sahel, Burkina Faso and Senegal, the third is a tropical highlands case study, Rwanda The fourth study uses aggregate time series for smallholders and commercial largeholders in Zimbabwe The case studies focus on two agroecological zones that cover much of the African population the semi-arid tropics and the highland tropics

The farm-level data were collected by the authors and collaborators, and constitute some of the richest panel data sets in Africa -- detailed data collected fortnightly or monthly during the study years, on incomes (from farm and nonfarm activities), production, prices, transactions, input use, and other variables Hence they go beyond the usual farm management data set that focuses mainly on crop production The richness of the data contributes to our being able to introduce topics that have been relatively neglected in other productivity analyses, such as the impacts of conservation investments and the role of nonfarm income The Zimbabwe data set is similarly rare in Africa, as there are few long time series that distinguish small- and large-holders for a given country Below are more details on each case study

(1) Burkina Faso the survey data cover five growing seasons from 1981-1985, a period of two severe droughts and three relatively good-rainfall years [2] The survey sample was 150 households spread over three agroecological zones (50 each, in two villages of 25 each)

(i) Sahelian zone, in the north The zone is very poor agroclimatically, with extremely variable rainfall over years Farms produce mainly coarse grains and livestock There is little use of animal traction or fertilizer Irrigation is not used Households have (relative to other

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[2] See Matlon (1988) for details concerning the survey method and coverage

zones) substantial livestock holdings There is only moderate population density Soils are degraded and the commons are disappearing due to bush removal and erosion

(ii) Sudanian zone, in the center The zone is poor agroclimatically, with moderately variable rainfall Farms produced mainly coarse grains and livestock There is little use of animal traction or fertilizer, and no irrigation Households have only small livestock holdings, due to lack of pasture and to destocking over recurrent droughts There is a land constraint given high population density on arable land Soils are degraded and the commons are disappearing due to bush removal and erosion

(iii) Guinean zone, in the south The zone is medium-to-good agroclimatically, with low variability of rainfall Farms produce coarse grains, cotton (an important cash crop) and pulses There is moderate use of animal traction and fertilizer Irrigation is not used Household livestock holdings are small on average, but vary considerably The land constraint is less advanced than in the Sudanian zone Soils are not very degraded, and common bushlands are still available and in good shape

In all zones nonfarm income as a share of total household income -- income diversification -- is substantial The shares for nonfarm income in total income in Burkina (Reardon et al 1992) for our case study was 37 percent in the Sahelian zone 20 percent in the Sudanian, and 40 percent in the Guinean

(2) The Senegal study analyzes crop production data for the 1989/90 growing season, a year of above-average rainfall These data are supplemented with income and expenditure data covering two years (October 1988 through September 1989) The sample consists of 140 households spread over the following five zones of the Senegalese Peanut Basin (1) North, in the Sahelian agroclimatic zone, with rainfall of 300-500 mm, and sandy soils, (2) Center-west, in the Sudano-sahelian agroclimatic zone, with rainfall of 500-700 mm, sandy soils, and land constraints, (3) Center, also in the Sudano-sahelian zone, with rainfall of 500-700 mm, and sandy soils, (4) Southwest, in the Sudano-guinean agroclimatic zone, with rainfall of 700-1000 mm, sandy soils, and land constraints, (5) and the Southeast, also in the Sudano-guinean zone, with rainfall of 700-1000 mm, and rocky and clay soils

The northern zone is much more diversified into nonfarm and migration activities than the others and livestock is important, Kelly et al (1993) show the share of nonfarm income in total income for the same sample to be 64 percent The agricultural base is extremely degraded due to low rainfall, loss of tree cover, and erosion

In the central zones, cropping income and total household income are subject to extreme fluctuations, 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 nonfarm income in total is 24 percent The central Peanut Basin is densely populated by Senegalese standards (70-85 persons per square kilometer), making it increasingly difficult to earn a living from either cropping or animal husbandry

The two southern zones benefit from better soils, better rainfall, and proximity to the Gambia The latter provides a source of less expensive inputs (fertilizer, for example) and food products (rice, sugar, and tea in particular), and increases options for households to earn nonfarm income through cross-border commercial activities The share of nonfarm income in total income is 43 percent While the southwestern zone is facing land constraints (32 persons per square kilometer), this is not true in the southeast (7 persons per square kilometer) Pasture land is also relatively abundant in the east, making animal husbandry a major income source in this zone

Peanuts and millet (and sorghum in the southeast) are the principal crops in all zones The southeast also produces some cotton and maize, but the number of fields was so small that we have not done any detailed analysis of these data Cowpeas are becoming increasingly important in the north and the center, but they still represent a very small share of land cultivated and crop income in these areas

Transportation and market infrastructure is relatively good (by African standards) throughout the Peanut Basin, however, the lower population density in the southeast means that the population in this zone generally needs to travel longer distances to get to paved roads and markets

(3) The Rwanda study covers three growing seasons, 1988-1991 The data are from a farm-household survey based on a nationwide stratified-random sample of 1,240 households The survey was undertaken by the Agricultural Statistics Division (DSA) of the Ministry of Agriculture and Animal Husbandry (MINAGRI) in collaboration with MSU The sample is spread over the country's five agro-ecological zones The distribution of households across zones is as follows 192 in the Northwest zone, 192 in the Southwest, 288 in the North-Central, 256 in the South Central, and 312 in the Eastern zone Agro-ecological zones 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) These all 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, the distribution of landholdings is inequitable by the standards of African smallholder agriculture (with a seven-fold difference in land per person between highest and lowest landholder quartiles) The Gini coefficient for distribution of land per person is about 43 (versus 2- 3 in the WASAT)

Pulses, roots, tubers, and grains are the main food staples, and coffee and tea are important cash crops Farming is labor-intensive Hoes and machetes are the basic farm implements, animal traction is not used 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 parallel decline in the amount of manure available for improving soil fertility Rwanda's average population density is among the highest in Africa Virtually all arable land is now used for agriculture, marginal lands once set aside for pasture or left in long fallow are now coming under more intensive cultivation Rural informal and formal credit is quite underdeveloped with access low Loveridge (1992) finds that nonfarm income (from wage labor sales and independent enterprise) is 25 percent of total income for the sample, although the average varies from 10 to 38 percent over 10 prefectures Cultivated holdings are very small, and are fragmented into many smaller plots The vast majority of landholdings are owner-operated, only 9 percent are rented Most households own a few small ruminants, less than a quarter own cattle

(4) The Zimbabwe study uses two aggregate time series, one for smallholders (1975-1990) and one for large commercial farmers (1970-89), 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 data were compiled by Thirtle, Khatri, and Jayne

Zimbabwe's agricultural structure is bi-modal, characterized by a large-scale, capital-intensive commercial sector and a small-scale, low-input smallholder farming 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 1 million African smallholder households The 4,000 or so commercial farmers normally account for about 70% of the nation's agricultural output and 80% of the marketed output (Thirtle et al, 1993)

The country is divided into five "Natural Regions" which are differentiated by rainfall and productive potential Regions I, II and III receive the highest rainfall and are most suited to agricultural production Regions IV and V receive under 650 mm of rainfall on average, and are prone to frequent and severe drought About 75 percent of all smallholder land is located in these relatively unproductive regions About 58 percent of the land in the relatively productive Regions I, II and III is commercial, 36 percent is smallholder, and the remaining 6 percent is composed of national parks and other public lands

The data used for both models was compiled by Thirtle et al and a detailed description of the basic data can be found therein

The data for the largeholder (commercial) sector are composed of yearly observations for the aggregate group, for (1) outputs, aggregated with a Divisia index into three groups, (i) food crops (maize and other grains), (ii) industrial crops (tobacco, coffee, and other export crops), and (iii) livestock and livestock products, (2) variable inputs, are also aggregated with a Divisia index, into four groups (i) hired labor, (ii) livestock-related inputs (feed, veterinary costs, purchases from the communal sector), (iii) chemical/crop-related inputs (fertilizer, other chemicals and packing), (iv) running costs (vehicle maintenance, transport, sundries, services and licenses), (3) quasi-fixed inputs (vehicles and buildings), (4) total land in the commercial sector, (5) conditioning factors (research and extension, rainfall, and world patents

The data for the smallholder (communal) sector are composed of yearly observations for the aggregate group, for (1) outputs (1) outputs, aggregated with a Divisia index into three groups, (i) maize, (ii) livestock, and (iii) other crops (cotton, peanuts, sunflower, sorghum, millets), (2) variable inputs, are also aggregated with a Divisia index, into two groups (i) livestock inputs, (ii) crop inputs, (3) fixed inputs, (i) labor (total number of people engaged in agriculture, less those employed on commercial farms) and (ii) land, (3) conditioning factors (research and development and extension expenditures, the number of Grain Marketing Board (GMB) buying stations servicing smallholder areas, the annual number of government loans disbursed to smallholders, and rainfall)

4 PATTERNS IN PRODUCTIVITY AGGREGATE VERSUS DISAGGREGATED

We begin by a brief look at aggregate patterns, then at patterns in the farm-level data, then at the need to broaden our view of farm productivity by looking beyond crops and at nonfarm income of rural households

4 1 Aggregate Patterns

For aggregate patterns, we used FAO data per crop to calculate growth rates in average product per active agricultural worker and per cultivated hectare over 1961-1991 for Burkina, Senegal, and Zimbabwe We did so by fitting linear function of average factor product to time trend For Burkina, we found annual rates for average land product (labor product) to be 1 7 (0) percent for maize, 7 (3) percent for millet/sorghum, and 3 8 (0 1) percent for cotton -- the latter being the main bright spot For Senegal, the figures were 1 6 (1) percent for maize, 6 (- 2) percent for millet/sorghum, and -0 (-1 5) percent for peanuts These results show slow or stagnant productivity growth over the period, per worker, and per hectare, for most crops in the four study countries In general, average land products grew more quickly than did average labor product, indicating increasing population density per hectare

In Rwanda, we used both the DSA/MINAGRI farm-level series covering 1984-91 (one of the longest farm-level surveys in Africa) and FAO numbers, covering 1979-1991 The two series differ somewhat [3] The land productivity of only three crops, maize, wheat, and soya (covering 10 percent of cultivable land in 1990) increased during 1984-1991 according to DSA data Maize had an annual growth rate of 2 percent according to DSA, and 1 percent measured by FAO But these growth rates are only about half the population growth rate (3 4 percent) DSA shows land productivity losses for nine crops that cover nearly 90 percent of

[3] The figures from FAO are based on data provided by the Ministry of Agriculture using past estimates, reports from local authorities, and research institute crop cut estimates, in addition to the DSA survey data FAO Production Year Books are not very explicit on how the yields are defined According to our understanding, FAO production figures are annual, and their harvested area includes fields under annual (seasonal) crops We further assume that their cycle for cassava is 18 months

With these assumptions, FAO yield figures are substantially above those of DSA for most crops DSA's 1989-91 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 the cultivated land in 1990 sorghum and potatoes (stagnant average land products according to FAO), sweet potatoes, coffee and cassava), dry peas (2 percent annual loss), peanuts, beans (a 1 percent annual loss according to DSA, a 1 percent annual average land product gain according to FAO) and bananas

In Zimbabwe, the FAO data over this long period show a dim picture for maize, the main food crop, with land productivity growing only at 1 1 to 6 percent per year, and labor productivity barely moving, at 3 percent per year But this disguises rapid average land product growth in maize starting in 1981, and after dips in average land products from droughts in 1982-4, a rise again in 1985 and 1986 Smallholder sector TFP grew at 7 percent annually from 1975 to 1990, but tapered off since 1985, when 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 1989/91 had declined to about the same level as it was at independence 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 smallholder maize area appears to be in the lower-rainfall areas that are already subject to chronic food deficits (Reasons for the decline are discussed in section 5)

For the Zimbabwe large-scale commercial farming sector, agricultural output growth had grown at an annual rate of 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, average land products and average labor product in the four study countries were more or less stagnant except in the cases of cotton and maize in Burkina, maize, wheat, and soya in Rwanda, and maize in Zimbabwe during the first half of the 1980s The situations where average land products were substantially raised were mainly cash crops (also food crops, with the exception of cotton) that received a fair amount of promotion, market support, and complementary inputs at the farm-level The failures or stagnation are mainly the subsistence or semi-commercialized food staples, with the exception of peanuts in Senegal

4 2 Disaggregating the aggregate picture

The farm-level data allow us to "dig below" the country-level data discussed in 4 1, examining differences by agroecological zone within a country, and by farmer type and good versus bad year This disaggregation is important to our understanding of the determinants of productivity change, and their policy and technology implications

First, data used for national and FAO statistics are usually broken down by administrative regions which are less useful than agroclimatic zones for understanding productivity differences Farm-level data, by contrast, are often selected with agroclimatic zones in mind There are often large differences in farm productivity over zones within a country Average land products and average labor product in agroclimatically-unfavored zones is on average well below that in agroclimatically-favored zones, which have higher and more stable rainfall

In Burkina Faso, for example, over 1981-85, the ratio of favorable (Guinean) zone land productivity to that of the unfavorable (Sahelian and Sudanian) zone is 1 5 for millet, 1 5 for sorghum, 1 2 for maize, and 3 for cotton

In Senegal, there is no statistically significant difference in peanut average land product per hectare across agroclimatic zones This may be due to the development and extension of peanut varieties that are adapted to different types of rainfall regimes For millet, however, there is a statistically significant difference in average land products between the Sahelian zone (Northern Peanut Basin) and one of the Sudano-Sahelian zone (Southwestern Peanut Basin) The better average land products in the Sudano-Sahelian zone are 1 7 times the land products in the Sahelian zone

In Rwanda, over 1989-1991, the ratio of the zone with the best productivity in a given crop to the worst was 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 Average labor products also differ greatly over zones, more or less with similar patterns

Second, annual aggregate growth rates mask large differences in average land products between years and across zones That variation is highest in the semi-arid areas with greatest rainfall variation In Burkina, for example, total factor productivity for animal traction households in the favored (Guinean) zone varied from 1 to 66 to 87 to 54 to 99 from 1981 to 1985 (with the large dips in 1982 and 1984 due to drought) In the unfavored (Sahelian/Sudanian) zone, the changes were even sharper, mirroring greater instability of rainfall 1 in 1981, then 1 1, 1 65, 56, and 1 46 in 1982-1985 Moreover, the ratio of millet average land products in the Sahelian zone in a good year to those in a bad year is 3 6 -- about twice the average difference of average land products over favorable and unfavorable zones for millet The good bad year ratio is only 1 2 for millet in the favorable (Guinean) zone -- reflecting less rainfall variability Interestingly, the ratio of average land products of millet between favorable and unfavorable zones in a good year is only 1 05 -- so with plenty of rainfall the zone differences are nearly erased

Third, average land products can differ greatly over technology regimes In Burkina, for example, millet and sorghum average land products are very close in the Guinean (and the Sudanian) zone between animal traction and manual households But for cotton, the ratio of traction to manual land average land products is 1 5 on average

Fourth, average land products can differ as a function of farm size Land is relatively equally distributed in the Sahel (e g Burkina has a land Gini of 30) while in Rwanda land is less equally distributed (a Gini of 43) In Rwanda, for example, we find that the ratio of average land products of the smallest farm quartile divided by the largest farm quartile is 1 6 for bananas, 2 for white potatoes, 1 7 for sweet potatoes, 1 6 for beans, 1 9 for coffee In Zimbabwe, micro evidence shows that maize average land products on commercial farms can be 3-5 times those on communal smallholder farms

Fifth, marginal value products can also differ over crops Economic theory predicts that they should not differ -- where there are no constraints in land, labor, or capital access or no market distortions Nevertheless, this does not always hold in Africa because of factor constraints and market distortions We found in Burkina, for example, that land and labor marginal value products were much higher for cotton and maize (cash crops) in the Guinean zone than are those of millet and sorghum, subsistence crops In Rwanda, average value products 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

Sixth, marginal value products can differ from their prices, implying under- or over-use of factors given the levels of complementary inputs For example, in Rwanda we find that the marginal value product of land use by small farmers is well above the rental price of land implying a land constraint The wage is above the labor marginal value product, implying constraints to access to the labor market (either agricultural or nonagricultural) In Senegal, the marginal value product of peanut seed exceeds its price, indicating access constraints to seed At the same time, the marginal value product of labor is below the estimated wage rate, indicating that more than the economically optimal amount of labor is being used This conclusion assumes that those working in the fields could find wage employment at the estimated wage rate, not a certainty given poorly functioning rural labor markets in Senegal

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 there are situations where there has been dramatic average land product increases in some periods (cotton and maize in Burkina or Zimbabwe), and very productive zones such as the favored zones in the southern band of the western semi-arid tropics, or pockets of very productive agriculture in the Rwandan highlands Aggregate data hide these farm-level successes Yet it is the determinants of these successes that we need to fathom, as a guide to future action

4 3 Broadening our perspective -- adding the nonagricultural sector

Hill (1982) laments that even up through the early 1980s the traditional view persisted that the typical African rural household is exclusively engaged in farming, with only very minor activity outside the agricultural sector Early work in Nigeria by Norman (1973), Matlon (1979), and Hill (1982) showed that this is a misconception More recent studies in Botswana and Zambia (Low 1986), Kenya (Collier and Lal, 1986), Burkina (Reardon et al 1988), Senegal (Kelly et al 1993), Niger (Hopkins and Reardon 1993), Loveridge (1992) and a few others (see Reardon et al 1993 for a review of this evidence for the WASAT, undertaken as part of the current productivity project) confirm that African farmers substantially diversify their incomes beyond farming into nonfarm activities, thus reversing that traditional image In general the more recent studies show that households diversify more than formerly Reardon et al (1993), reviewing evidence from the West African semi-arid tropics (WASAT) for this productivity project, found that nonfarm income varied from zone averages of 20 to 64 percent of total income (simple average of 39 percent), and non-cropping income ranged from 31 to 83 percent (simple average of 48 percent) Earlier studies found that the range was 2030 percent (Haggblade et al)

Moreover, Reardon et al (1993) show that most of total income in the rural areas of the WASAT is from "production-linkage" activities (upstream and downstream from local agriculture -- i e supplying inputs and services to the farm or using outputs from the farm in processing and marketing) for Burkina, 60 percent in the Sahelian, all in the Sudanian, and 90 percent in the Guinean zone In Senegal, the shares are 40 percent, 38 percent, and 40 percent, respectively for the three zones The other income is either from migration, or linked to local towns

Yet the nonfarm income in Burkina, Rwanda, and Senegal is poorly distributed with both share and absolute levels much higher for richer households in a given zone The poorest are most dependent directly on cropping Comparing the share of nonfarm income in total household income for the lower tercile versus the upper tercile, Reardon et al (1993) found in Burkina 19 vs 46 percent in the Sahelian zone, 14 vs 26 percent in the Sudanian, and 29 versus 51 percent in the Guinean zone The patterns are similar in Senegal 40 vs 75 percent, 28 vs 24 percent, and 29 vs 42 percent In Rwanda, Loveridge (1992) found that households in the lowest income/AE quartile earned 17 percent of income from nonfarm activities (self employment plus wage labor), while the richest quartile earned 33 percent -- the Sahel pattern

Therefore, a narrow focus on crop output and crop productivity neglects the important nonfarm dimension of farm household's activity, that can be nearly half of its income -- and output per person There is thus much more economic activity in rural areas in Africa than just crop statistics show -- and this corroborates important work on African rural microenterprises by Liedholm, Chuta, Mead, et al That Reardon et al (1993) also found that most nonfarm activity is related upstream or downstream to agriculture (in the WASAT) further strengthens the case to count the full output in both sectors of the rural household toward its "productivity" These findings complement the recent study by IFPRI sponsored by AID/AFR/SD/PSGE/FSP (Delgado et al 1994), showing the importance of consumption linkages in rural Africa

The above argument reflects on the "numerator" of the average land product 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 nonfarm sector, it would be inappropriate (though usual in aggregate statistics) to divide crop output by rural persons inside a certain age bracket One would have to remove from the denominator the equivalent in persons of the time used off-farm, thus increasing the crop average land product measure We have done this in our measures in our farm-level studies

Moreover, the nonfarm component of the rural economy and household has five important but understudied impacts on farm productivity and investment

(i) Nonfarm activities affect the product market as they include processing, transport, and marketing activities, and they affect the input market, as they include provision of inputs to farms (farm labor, animal traction implement repairs, and so on)

(ii) Nonfarm activities can be crucial sources of cash (along with cash cropping and livestock husbandry) for farmers' investments in animal traction, fertilizer, and seed, directly, and animals for manure, indirectly (This effect is treated more in section 5) Yet as nonfarm income is poorly distributed, but it is important to investments, then the poor will not be as able as richer households to adopt productivity and resource conservation measures, which will negatively affect income and asset distribution over time

(iii) Yet, particularly in unfavorable agroclimates, nonfarm activity may compete with farm investments for both time and capital Agricultural researchers, environmentalists, and policymakers who propose investments in the farm or the natural resource base in these zones may be surprised to find that investments off-farm are more attractive to farmers

(iv) Nonfarm activities can relieve pressure on the land and thus spare fragile margins

(v) Nonfarm income can be important to household food access and thus affect nutrition, which in turn can affect labor productivity (Strauss and Thomas, 1994)

5 WHAT DETERMINES PRODUCTIVITY IMPROVEMENT?

5 1 Seed

5 1 1 Our Key Findings

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

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, **government seed distribution and credit programs have been cut back and seed prices increased** by policy reforms associated with structural adjustment In Senegal, the **result was 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 than for food crops, which have more than one marketing outlet

5 1 2 Specifics from the Senegal and Zimbabwe case studies

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 facilitated 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 its quality availability, and affordability are ensured The Zimbabwe and Senegal case studies provide examples of improved varieties being developed and adopted when support services were in place Following cutbacks in input distribution systems, however, farmers sharply reduced their use of the better quality seeds and aggregate production of key crops declined dramatically

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, Jayne et al) When the conditions were in place, the adoption of seed proceeded rapidly, in a very short time all smallholders were growing some hybrid maize In the late 1980s, however, expenditures were reduced for the credit (particularly fertilizer) and marketing programs Payoffs to R & D (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 There is more discussion of the Zimbabwe case in section 5 7

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 [4] Peanut seed costs represent about 20 percent of the gross value added by crop production for the average farm household

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[4] Where one hectare of millet requires only 4 kilos of seed, one hectare of peanuts requires from 60 to 100 kilos of seed

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 -- usually 100 kilos of seed to all men and 50 to all women The only criterion for access was that the recipients paid their taxes -- an amount 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, as 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, and aggregate peanut production has suffered accordingly

Production function analysis of crop production data for 1989/90 provides supporting evidence that there is a real seed constraint 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 peanut seed constraint 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

There is also evidence 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 [5] 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

5 2 Fertilizer

5 2 1 Our Key Findings

First, similar availability and affordability issues apply to fertilizer as they did to seed But fertilizer differs from seed in that fertilizer is more costly and financially risky than 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 average land product 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, 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 nonfarm income**

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[5] 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

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 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 1985/6, 19,900 in 1986/7, and 22,400 in 1987/8, much of the fertilizer use was on cotton, irrigated rice, and vegetables -- either where subsidies and credit remains (cotton) or where there is water control (rice, vegetables) In Zimbabwe, recent elimination of fertilizer credit caused a decline in fertilizer use on hybrid maize by small farmers and a decline in hybrid maize area

5 2 2 Discussion

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 numerous attempts to remove fertilizer from the list of key productivity-enhancing options worthy of government and donor policy support Among the reasons for downgrading its importance in the African context are its riskiness under conditions of low or erratic rainfall, its relatively low average land product response when compared to results in Asia and Latin America, and its high distribution costs in an environment of low effective demand, and poor storage facilities and roads

During the last 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 demand -- 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 having a negative impact on soil quality (Sarr, 1981, Pieri, 1989, Matlon/Spencer 1984, Kelly 1988) This recent research has produced recommendations for smaller (i e , more affordable) quantities of fertilizer, larger quantities of organic matter, and use of bunds or tied ridges to prevent fertilizer run-off (Matlon and Spencer 1984, Ohm and Nagy 1985, Matlon and Adesina 1992)

As land constraints increase under population pressure in the semi-arid tropics and highlands of Africa (Pingali and Binswanger 1984 Binswanger 1986, 1988), fertilizer, in combination with organic matter, remains one of the few options available for rapidly increasing average land products per hectare 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 (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 is a prime example)

Unfortunately, there are no real alternatives to fertilizer and manure for increasing productivity Marginal value products of labor for most case study countries and crops are already low (frequently below wages), indicating that increasing labor use would not be profitable As discussed 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 meso-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 average land products and aggregate output in the higher (>700 mm) rainfall zones (see details below) Despite the contribution that fertilizer can make in these countries, an analysis of input use patterns for Burkina, 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 below

5 2 3 Case study evidence on fertilizer response and economic returns (Burkina, Senegal)

Farm survey data are seldom used to evaluate fertilizer response because it is so difficult to obtain statistically significant coefficients when other factors (timing of fertilizer applications and other key activities such as seeding and weeding, for example) are not controlled Analysis of average land products for Burkina Faso did not show a statistically significant effect of fertilizer on yields A supplementary analysis (using crop supply and input demand functions derived from restricted profit functions, that incorporated prices of outputs and inputs, and nonprice factors such as fertilizer and manure, rainfall, and household characteristics) did, however, find that fertilizer has a statistically significant and positive impact on the gross value of household crop production in the Guinean zone We segregated the sample into animal traction and manual households to capture the supply response effect of technology, and then looked at price and nonprice effects on supply response We found that the 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 manual 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

Although the above analyses looked at the physical relationship between fertilizer and output, they did not look at the economic returns to fertilizer at the farm level 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 -- well above the level of 2 usually thought to stimulate use [6] Trials used fertilizer doses recommended by extension services from 1960-1980 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, suggesting 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

[6] Reported v/c ratios are based on unsubsidized 1987 prices Using nominal prices prevailing during the 20 years covered by the data, the ratio is 5 for peanuts and 11 for sorghum

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 and alternative means of improving soil fertility must be sought [7]

5 2 4 Case study evidence on fertilizer use (Burkina, Senegal, Zimbabwe)

The Senegal and Zimbabwe case studies provide striking examples of how the elimination of input support programs under structural adjustment sharply reduced the amount of fertilizer used The cases of cotton in Burkina Faso and confectionery peanuts in Senegal show that comprehensive input support systems offered by crop marketing institutions fostered 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 distribtion 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 eighties, 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 there is ample survey evidence that farmers believe their soil fertility has fallen substantially since they stopped using fertilizer (Gaye 1992, Kelly 1988)

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[7] Work by Seyler (1993) in the central and northern Peanut Basin suggests that a program to help farmers increase the number of *Acacia albida* trees could gradually improve soil quality without any use of fertilizer

As discussed in the previous section, Zimbabwe smallholders rapidly adopted hybrid maize when fertilizer credit was available and output market prices were guaranteed When fertilizer credit was eliminated in 1985 both fertilizer use and hybrid maize production 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 -- as 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) After the period of 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

5 3 Animal traction

5 3 1 Our Key Findings

First, 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 average land products

Second, 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

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

5 3 2 Background and prior research results

Eicher and Baker (1982) review evidence from animal traction programs and studies in the 1960s and 1970s Pingali et al (1989) review more recent evidence In general, they find that animal traction has historically been associated with (i) potential increase in average land product through improved seed bed preparation, deeper plowing, more timely planting and weeding, moisture conservation (and we would add manure transport and incorporation), (b) potential increase in area cultivated, (c) income generation through off-farm transportation, (d) reduction in drudgery (potentially freeing up labor), and (e) longer-term improvement in soil fertility through application of manure from animals, deeper plowing plowing under crop residues (and we would add tied-ridging for water retention and soil conservation, see Sanders et al 1990) Traction is mainly used for plowing, as well as seeding and weeding Its use and spread is related to cash cropping, especially peanuts and cotton

Yet Eicher and Baker note that "surprisingly, although animal traction has been promoted for more than 50 years in Africa, research results on the impact of animal traction at the farm level are largely impressionistic" (p 142), and research on traction impacts has been conducted mainly on experiment stations

Historical evidence on farm-level average land products and acreage response has indeed been mixed Sargent et al (1981) reviewed 27 traction projects and found that most had not lived up to expectations because of the high cost of animals and equipment, low acreage and average land product effects, and lack of reliable institutional support Whitney (1981) found that traction farmers increased acreage by 39 percent but experienced no change in average land products Barrett et al (1982), showed that, in eastern Burkina, acreage and average land product effects were modest, but labor inputs were reduced 20-25 percent per acre

In general, researchers have found that the economics of animal traction are problematic for subsistence farmers producing only millet and sorghum, but become more favorable in cash cropping areas 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 farms were below net returns before adoption for the first four years due to a slow learning curve

Eicher and Baker found in a review of research in the 1970s 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)

Research has also shown that support services (credit and veterinary services) are crucial Equipment adapted to key activities (weeding, tied ridging) is not usually available, and there is a persistent issue of affordability In the 1960s-70s, 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 was $1000 in 1977, a donkey traction package $500 (cited by Eicher/Baker, page 145, from Zerbo and Le Moigne 1977 and Barrett et al 1982) Compare this to $1500/household income in the Guinean zone of Burkina in 1981-1985, of which $1140 is cash income (Reardon and Mercado-Peters, 1993)

Animal traction programs have been around for 50 years, and their history is characterized by high expectations but mixed results, and by discontinuous support Eicher and Baker 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)

5 3 3 Animal traction results from our Burkina Faso case study

Animal traction increases land and labor productivity in the farm households in our Burkina study In the Guinean zone, traction households have 44 percent higher land average land products than manual households in cotton, and 98 percent higher average land products in maize Traction households have 76 percent higher labor average land products than manual households in cotton, and 91 percent higher in maize Manure use per hectare is 417 percent higher in traction households than in manual households

By contrast, labor use by animal traction households is very close to total labor use on all crops by manual households In cotton and maize, labor use per ha is only 6-7% lower for traction households Thus the average land product 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 in Burkina We also found that households using traction animals 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 conservation investments

5 4 2 Our Key Findings

First, practices that add organic matter to soil and conserve water or prevent erosion and help water retention (e g , bunds, tied ridges, 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 -- conservation investments on low degradation farms increased the land marginal value product by 27%, for moderately and very degraded farms, the increase was 28-34% and 42%, respectively

Second, investment in soil conservation investments is more likely for farms that are smaller (hence have less ability to fallow, a substitute for these investments), earn more nonfarm income, and grow cash crops

5 4 2 Results Concerning Organic Inputs and Conservation Investments from Burkina and Rwanda Case Studies

In Burkina, we found that 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 zones, despite similar levels of livestock holdings between the two Animal traction households use much more manure than manual households in the Guinean zone, traction households use four times more for cotton (1776 kgs/ha vs 402 kgs /ha), and two times more for maize (8588 kgs/ha vs 4350 kgs/ha) Animal traction helps farmers to carry and incorporate manure, and 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 manure on the cotton average land product

In Rwanda, we found that conservation investments (e g grass strips, terraces, anti-erosion ditches) are crucial to stem the negative effects of degradation on productivity, through soil retention and organic matter (mulch, manure, compost) retention [8] We found, for example, that when farmers make conservation investments on low-degradation farms, the land marginal value product increases by 27 percent, for moderately degraded farms the figures are from 28 to 34 percent, for very degraded farms the figure is 42 percent These empirical results give impetus to the government policy goal of encouraging conservation investments coupled with greater use of organic inputs and fertilizer to intensify land use under severe land constraints, and to raise and to sustain productivity -- key long-term food security goals of the Rwandan Ministry of Agriculture as announced in CNA (1990)

In both Rwanda and Burkina Faso, organic matter is mainly used on cash crops (such as bananas, coffee, and soybeans in Rwanda or cotton and maize in Burkina) Often this is because (a) these crops respond well agronomically to organic amendments, (b) fertilizer is used on cash crops and it complements organic inputs (in fact their combined use is recommended by agronomists), and (c) cash cropping helps farmers buy cattle that generate manure Unfortunately, while cash crop input credit programs often support acquisition of fertilizer, in Burkina and Rwanda these programs do not support soil conservation investments, and we do not know of any African country where they do

Moreover, we found tradeoffs between fallowing and organic input use, and between fallowing and conservation investments In Rwanda, smaller farms have a smaller share of their land under fallow, and although they grow fewer perennials, crop more densely, making up for the potentially negative effect on soil quality of the greater share their land under

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[8] Water retention investments such as bunds or tied ridges have been found in other studies, (e g , Matlon and Adesina 1992) to be crucial to productivity in semi-arid regions Bunds, for example, have an important topsoil protection effect in the Sahel with short- and long-term productivity-enhancing effects This goes along with the findings of farming systems R&D projects in the Sahel (e g Ohm and Nagy 1985)

annual crops Larger farms have a greater share of their land under fallow, but also more fertilizer (because of the wealth effect and the greater share of their land under coffee) Also, the steeper the slope (hence newer land under cultivation) the less organic matter used -- but in general less-erosive plants are grown on the slopes (perennials)

Moreover, rented land (compared to owned land) receives less organic inputs (and conservation investments) as these are perceived as these long-term productivity improvements are not perceived by farmers as worth making on rented land that could be reappropriated by the owners By contrast, farmers use fertilizer on rented land because it is perceived as having only a short-term effect and thus reappropriation risk is less important

Finally, two other factors contribute to conservation investments and improved input use (1) nonfarm income (important as a source of cash since credit is rarely available for conservation investments), and (2) the profitability of agriculture In general, degradation undermines productivity, and land conservation measures and organic matter incorporation, themselves complementary, help to protect the land and facilitate intensification of production given severe land constraints Smaller farmers have a special incentive to make these investments, given their inability to rely on fallowing and extensification into fragile margins But incentive and ability do not always coincide investment requires credit which in general is not available for "sustainability investments " Farmers therefore need to rely on their own sources of cash -- mainly cash cropping and nonfarm activity

5 5 Land and Labor

5 5 1 Our Key Findings

In general, size and quality of land matter for productivity **land constraints are increasingly common due to population pressure**

In Rwanda, land rental (as compared to ownership) discourages use of organic matter and soil conservation investments, small farms had much higher land productivity than did larger farms

But on smaller farms, marginal value products of labor were very low relative to wage rates This implies lower opportunity cost of labor on smallholder farms than that reflected in the agricultural wage probably because of constraints to access to that labor market as well as to nonagricultural employment opportunities

By contrast, marginal value products of land were much higher for the smaller farms than land rental rates, indicating constraints on access to land

5 5 2 Background on the land debate

The land debate in the countries with unequal smallholder sectors or dual agricultures has three main issues The first is whether largeholders are as productive as smallholders This depends on the definition of the factor for which productivity is measured Given that countries with unequal land distribution also have problems of land constraints, the issue is mainly one of land (rather than labor) productivity This has been a long-debated topic in Latin America and Asia, especially South Asia, with much of the productivity research in the 1960s-1970s in those continents focused on this issue, as well as the concomitant issue of mechanization In general, the Asian literature shows that land productivity is higher on smaller farms except where labor-saving machinery has made largeholders more land-productive

The second issue is closely related to the issue of the relative efficiency of different farm sizes, and is the debate as to whether smallholders have "excess labor" on their holdings, driving the marginal product of labor very low This is a hypothesis put forward in 1954 by Sir Arthur Lewis and heavily debated in the 1950s and 1960s At issue in the present context is (a) whether small farmers have opportunities to use family labor in the nonagricultural sector, thus allowing them to earn cash to invest on the farm, and (b) whether small farmers are constrained in their access to capital (such as fertilizer) or land that would push up their marginal value product of capital or land relative to their prices Recently in the case of Kenya, a dual agriculture in the wheat sector, for example, Carter and Wiebe showed 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) We show below similar results for Rwanda despite its not being a truly dual agriculture

The third issue is security of land tenure The debate is whether more secure tenure of landholding is necessary to induce farmers to make short and long-term productivity and conservation investments The African evidence is mixed and ambiguous, our Rwanda results and the Rwanda results of Place and Hazell (1993) show tenure to be important to investment, but the latter's Ghana results are ambiguous, Hardy (1989) shows that secure tenure is not necessary for investment in Senegal See Dommen (1994) for a review of the evidence and debate

Part of the ambiguity in the debate is pinning down what is meant by "land tenure security" and part is properly differentiating types of investment For instance, in Rwanda we found that farmers do not invest in organic matter and conservation investments (long-term investments) on rented land, but they do use fertilizer on it

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 In Zimbabwe the land debate is at least as charged as in Rwanda but for different reasons There is a dual structure where 1 million smallholders restricted to half the arable land, with 4500 largeholders on the other half By contrast, the land size debate is not as important in the Sahel where most countries have a relatively equal land distribution (Burkina's rural land Gini coefficient is only around 3) and only a smallholder sector

5 5 3 Land and labor results from Rwanda[9]

Our Rwanda results coincide with the "Asian pattern" of greater land productivity on the part of smallholders We found that smallholders (the lowest tercile of landholders) use much more labor per hectare than do "largeholders" (the highest tercile of landholders) (1310 person-days/ha versus 191) Smallholders use much more organic inputs per ha, 482 versus 61 in Rwandan francs Smallholders average farm size is 24 ha while "largeholders" have 3 08 ha (still small by African standards), the former rent 9 percent of their land, the latter only 4 percent

[9] Although we distinguish small and large holders in Zimbabwe, our data for largeholders per year) do not allow easy comparison with smallholders because the largeholder aggregate encompassed primarily-livestock and primarily-cropping farms that have very different cropping average land products, and the smallholder aggregate encompassed farms from widely different agroclimatic zones

Moreover, larger farmers tend to have the luxury of being able to fallow a larger share of their land, and for longer periods Smaller farmers need to invest more per hectare in organic inputs and conservation measures to protect their meager land The more off-farm income the smaller farmers have (at least in fertile areas such as Rwanda), and controlling for profitability of agriculture, the more they invest in organic input and conservation investments

The upshot is that smallholders have much higher average land productivity (in Rwandan francs, 102,000 per ha versus 24,000 per ha) Smallholders' marginal value product of land is also much higher than largeholders -- 52,000 (RWF per ha) versus 33,600 By contrast, the smallholders' marginal value product of labor is much lower than largeholders 18 5 versus 36 4 These patterns are mirrored in the differences between the value of average land and labor products as well

We also found that the marginal value productivity of land among smallholders is 1 25 times the land rental price, while for largeholders it is only one-quarter the land rental price -- indicating a relative (and strong) land constraint for the smallest By contrast, the marginal value product of labor is only 3 of the wage for the smallholders and equal to the wage for the largeholders -- indicating constraints in access to the labor market (agricultural or nonagricultural) on the part of small farmers

The exception -- hence where largeholders have higher land productivity -- is where they participate in cash crop schemes where they are given preferred access to extension, inputs, and markets (for example in Eastern Rwanda with coffee, or rice growers in northern Ivory Coast (see Adesina 1994)), or commercial maize largeholders in Zimbabwe (see section 4)

5 6 Nonfarm income

5 6 1 Our Key Findings

First, nonfarm income 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 We found that there is generally a **positive relationship between nonfarm income and improved input use** (fertilizer and animal traction in Burkina Faso and Senegal, peanut seed in Senegal, conservation practices and fertilizer in Rwanda)

Second, nonfarm income can play a role in facilitating conservation investments, for which credit appears to be rarely available

Third, nonfarm activities smooth household income and **help to reduce risk** by diversifying the sources of household income

Fourth however within a given agroecological zone, **the poor have less access to nonfarm income opportunities -- nonfarm 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 nonfarm activities This is worrisome because unequal access to nonfarm income translates into unequal access to farm inputs in the face of limited credit access

5 6 2 Background on nonfarm income and its effect on productivity

Section 4 summarized evidence concerning the importance of nonfarm income in the rural economy of Burkina, Senegal, and Rwanda We also showed that nonfarm income is poorly distributed which means that positive influences of nonfarm income on productivity in turn will be poorly distributed Here we focus on the influence of nonfarm income on improved input use and conservation investments

In general, nonfarm income earning by rural households is important to increasing farm input use and hence cropping productivity and the ability to intensify production while replacing soil nutrients Reardon and Kelly 1989) show that nonfarm income is important to the purchase of fertilizer where institutional credit is not available (in the non-cotton 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 nonfarm income is treated as a substitute for land collateral in informal credit markets (because of the problem of covariability of harvests hence riskiness of using land as collateral in areas of risky agriculture)

Why is nonfarm income important for these farm investments? In most of the Rwanda and Sahel case study areas 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 nonfarm income therefore tends to be crucial to farm input purchase Moreover, capital equipment for soil conservation and water retention measures is often costly, and it is usually 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 like 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)

Our case studies here also point to the importance of nonfarm income for input use and investments on farm The Burkina Faso case study finds that nonfarm earnings are reinvested into expensive animal traction packages in southern Burkina Faso where agroclimatic conditions are good We also find that nonfarm income is important to peanut seed purchase in Senegal through providing cash at the end of the dry season to pay the downpayment for peanut seed credit In Rwanda, we find that farmers that have more nonfarm income are able to make conservation investments and buy fertilizer

Yet nonfarm activities, especially in the unfavorable zones, can compete with land improvements The competition can be for labor in the rainy season, for weeding, for plowing, for maintenance of bunds and alley cropping systems But in the Sahel most of the nonfarm income is earned in the dry season -- traditionally named the "slack season" by mistake because nearly half of household income is earned in the dry season in nonfarm activity Yet this is also the period during which environmentalists envision Sahelian farmers building and maintaining bunds, terraces and so on Whether there is labor competition depends on whether there are off-farm, opportunities (e g migration) that take labor away from the zone, and whether the dry season conservation investments are perceived to be profitable and reduce overall income risk This competition is more keenly felt in the less favorable zones For example, in northern Burkina Faso where agriculture is risky and drought-prone, Christensen (1989) finds that households with more nonfarm income invest less in farm capital Norman (1973) found that nonfarm activities in northern Nigeria compete for labor in off-season cropping

5 7 Markets/downstream/upstream/off-farm links to on-farm productivity

5 7 1 Our Key Findings

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

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, including higher consumer prices due to grain movement controls that force 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)

5 7 2 Background

First, early studies (e g , von Thunen writing in 1830-40s) showed that markets and the proximity of cities influence productivity in agriculture Recent work by de Janvry et al (1992) shows that the level of transaction costs affects the marketed surplus rate How well food markets work also affects adoption of cash crops [10]

Second, the performance of markets affects the level and variability of demand, hence price variability, hence riskiness of investments in productivity-raising inputs Our results on fertilizer use in Burkina and of conservation investments in Rwanda shows that farmers are sensitive to net profitability and price risk in making these decisions

A limited or poorly functioning market "bottles up" supply in a local area, and climatic fluctuations, translated into output fluctuations, create price instability -- risk A market might be limited because of high transaction costs because of structural constraints such as bad

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[10] For example, Goetz (1992) found in Senegal that high grain prices hurt cotton production, and Jayne (1993) found in Zimbabwe that high grain prices hurt sunflower production

roads, or inefficient marketing systems, or limited demand for the product by local consumers or trading partners [11] 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), (2) investments in road and other market infrastructure, (3) opening up regional and foreign markets through economic integration

Third, farm productivity affects market and nonfarm/industrial development potential Our Senegal study shows that drops in peanut output reduce capacity utilization hence efficiency and profitability of peanut processing plants Reardon et al 1993 on Sahel income diversification shows that most off-farm activity is earned in production-linkage activities upstream (supplying inputs to farms) or downstream (using farm outputs as inputs) in local areas How well crops do affects local off-farm employment and general industrialization

These findings are also in accord with early economic thinking, e g by Ricardo (early 1800s) who contended that farm productivity affects the food price which in turn, working through the real wage bill, affects nonagricultural profits and employment Moreover, they are in accord with "growth linkages" literature (e g Mellor and Lele 1972) which contends that increases in agricultural productivity spur local economic growth through direct (production) and indirect (consumption) linkages

Fourth, the efficiency of the market system affects how well the benefits of greater farm productivity are distributed to consumers (and farmers) This is an extension of an earlier point, getting productivity up means driving real food prices down for those that can get access to the cheaper food Who gets access depends on the efficiency and structure of the market system, not to mention whether consumers have sufficient employment and income

The above points about farm productivity and market efficiency suggest that a useful focus for future productivity work is 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) If improvements are made in the efficiency of farm-level production, but they are not

[11] For example, Reardon (1993) shows that demand for coarse grains in the Sahel is inelastic, so that 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, which would bid the prices of the latter back up In this situation of 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

passed on to the consumer because of inefficiencies or structural rigidities "downstream", the benefits are lost If "upstream" input distribution is inefficient, this forces input prices up and farm productivity down

5 7 3 Focus on Zimbabwe case study results

Since independence, Zimbabwe has received widespread international acclaim for the rapid growth in smallholder maize production However, there has been a largely unnoticed structural decline in production since 1985, associated with a contraction of public sector support programs that had 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 that have 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's difficulties in "scaling-up," i e , managing the transition from a well-organized public research and market infrastructure system that fit the needs of a few thousand commercial farmers under Southern Rhodesia, to a system that meets the needs of over a million smallholder households, 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) a eight-fold increase in crop credit disbursed to smallholders between 1979 and 1986, which led to greater fertilizer use and maize average land products, 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 Yet there are also underlying structural causes of the maize decline 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) receives 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 1994) The slowed productivity of the public agricultural research system is also indicated by the continued use of hybrid seeds that were developed 15-20 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 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 [12] 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 can be purchased with government credit disbursed to smallholders is 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 average land products, even in the relatively productive Mashonaland provinces, have exceeded their 1985 level only once

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[12]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)

However, there are important distinctions between the two sectors that 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 large, 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)

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, etc had declined by 25 percent from 1980 to 1990

6 IMPLICATIONS

Section 6 1 discusses strategic and program implications, and section 6 2, policy implications

6 1 Strategic and Program Implications

(1) Sustainable intensification of farm production through use of improved inputs that raise and sustain increases in land productivity is a major food security issue in Africa, given growing land constraints and soil degradation To get needed breakthroughs in farm productivity, **farm input use** -- such as fertilizer, organic inputs, animal traction, and conservation investments -- **needs to rise substantially**

Although the results are based on four case studies in rainfed 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**

- **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, there is generalized use of traction in peanut and cotton areas, but the equipment stock is aging and renewal programs are needed In other countries, such as Burkina Faso, use 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 nonfarm activity and cash cropping

- **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

• **Crop research is crucial** to the overall competitiveness of agriculture, and to the profitability of productivity-increasing inputs such as fertilizer and animal traction

• **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

• **Nonfarm 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

• **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, much 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 area 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 nonfarm 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

- **Nonfarm income (nonfarm 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

- nonfarm income can be especially important in facilitating conservation investments, for which credit is rarely available

- **Nonfarm activities smooth household income and help to reduce risk** by diversifying the sources of household income

- **Agricultural growth in turn stimulates growth of the nonfarm 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, etc) Agricultural growth can also stimulate other rural nonfarm firms since an important share of increments to farm income tends to be spent on locally produced consumer goods

- **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 ımportance of ıncome dıversıfıcatıon to rural Afrıcan households **means that new croppıng technology proposed for farmer adoptıon must not only be fınancıally and economıcally profıtable, but also attractıve relatıve to alternatıve uses of household resources** (e g , lıvestock and nonfarm productıon)

• **Polıcymakers should be worrıed about equıtable access to these ıncome sources,** however, sınce that wıll affect how equıtably the benefıts of productıvıty ımprovements are dıstrıbuted over tıme We have noted that ın many areas of Afrıca there ıs very unequal access to nonfarm ıncome-earnıng actıvıtıes, often because famılıes are unable to make the necessary ınıtıal ınvestments for lack of cash reserves or access to credıt to fınance them The same equıty ıssue can arıse concernıng access to hıgh-return cash croppıng schemes

(5) Cash croppıng programs spur productıvıty through provıdıng cash to buy ımproved ınputs, and dependıng how they are organızed, ıncrease access from the supply sıde to ımproved ınputs and to low-rısk output marketıng opportunıtıes

In sum, there are ımportant synergıes between programs that raıse Afrıcan farm productıvıty, and programs that promote nonfarm enterprıses, market development, and natural resource conservatıon Harnessıng these synergıes wıll allow natıonal governments and donors to get more for theır money ın terms of growth, food securıty, and envıronmental protectıon

6 2 Polıcy Implıcatıons

Promotıon of ımproved ınput use wıll need to be ınnovatıve ın order to be consıstent wıth wıdespread fıscal constraınts and the goals of structural adjustment In the past ın many cases ınput use has been promoted ın ways that are not economıcally sound, that ın the long run are not fıscally sustaınable Yet the reductıon of government programs and subsıdıes assocıated wıth structural adjustment appears to have dıscouraged the use of modern ınputs (ımproved seed, fertılızer, anımal tractıon), by raısıng cost and reducıng avaılabılıty

• 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 infrastructure**

• **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 There are three potential dilemmas associated with the use of policy reform

•• (a) As with the "food price policy dilemma" of Timmer (1990), **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

•• **(b) Raising average profitability without reducing price instability or income risk means that there is still a major impediment to the attractiveness of productivity investments** Risk and instability are a function of climatic variation (especially in rainfed zones), high transaction costs, and other structural constraints that require infrastructural investment (e g , irrigation, improved roads) to overcome

•• (c) **Farm investment can be profitable in an absolute sense but not in a relative sense if nonfarm investment opportunities appear to be "better bets" to rural households, or if nonfarm 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 nonfarm 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 conservation investments automatically The profitability of such investments must be evaluated relative to the returns available from other farm and nonfarm 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** It is essential that governments and donors invest in understanding **how to promote the economic use of the tools of sustainable intensification** -- fertilizer, animal traction, organic inputs, and soil conservation 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, and 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

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