

MSU International Development Working Papers

Fighting an Uphill Battle: Population Pressure and Declining Land Productivity in Rwanda

by

Daniel C. Clay

**MSU International
Development
Working Paper No. 58
1996**



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

MSU is an affirmative-action/equal opportunity institution.

MSU INTERNATIONAL DEVELOPMENT PAPERS

Carl Liedholm and Michael T. Weber

Editors

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

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

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

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

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

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

FIGHTING AN UPHILL BATTLE: POPULATION PRESSURE AND DECLINING LAND PRODUCTIVITY IN RWANDA

by

Daniel C. Clay

October 1996

This paper is published by the Department of Agricultural Economics and the Department of Economics, Michigan State University (MSU). Funding for this research was provided by the Food Security II Cooperative Agreement (AEP-5459-A-00-2041-00) between Michigan State University and the United States Agency for International Development, through the Office of Economic and Institutional Development in the Economic Growth Center of the Global Bureau. Supplemental funding for this research was also provided to the FS II Cooperative Agreement by the African Bureau, through the Food Security and Productivity Unit of the Division of Food, Agriculture, and Resources Analysis, the Office of Analysis, Research, and Technical Support (ARTS/FARA/FSP).

The author wishes to acknowledge Thomas Reardon and Harry Schwarzweiler for insightful comments made on an earlier draft of this paper. A revised version of this paper has been published in H.K. Schwarzweiler and T.A. Lyson (eds.) *Research in Rural Sociology and Development*, Vol. 6. Greenwich, Connecticut: JAI Press, Inc., 1995.

Daniel Clay is Associate Professor, Department of Sociology, and Visiting Associate Professor, Department of Agricultural Economics, MSU

ISSN 0731-3438

© All rights reserved by Michigan State University, 1996.

Michigan State University agrees to and does hereby grant to the United States Government a royalty-free, nonexclusive and irrevocable license throughout the world to use, duplicate, disclose, or dispose of this publication in any manner and for any purposes and to permit others to do so.

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

CONTENTS

LIST OF TABLES iv

LIST OF FIGURES iv

| <u>Section</u> | <u>Page</u> |
|--|-------------|
| 1. INTRODUCTION | 1 |
| 1.1. Focus on Rwanda | 3 |
| 2. CONCEPTUAL LINKAGES | 5 |
| 2.1. Land Tenure | 5 |
| 2.2. Size of Holdings | 6 |
| 2.3. Dispersion/Fragmentation of Holdings | 8 |
| 2.4. Cultivation of Marginal (Fragile) Lands | 9 |
| 2.5. Years of Operation | 11 |
| 3. RWANDA CASE STUDY | 13 |
| 3.1. Data and Research Procedures | 13 |
| 3.2. Findings and Discussion | 15 |
| 3.3. Conclusions and Study Implications | 21 |
| REFERENCES | 25 |

LIST OF TABLES

| <u>Table</u> | <u>Page</u> |
|--|-------------|
| 1. Farm Holdings Classified by Level of Reported Change in Productivity Reported by Farm Operators | 14 |
| 2. Conservation Investments, Land Use, and Reported Change in Soil Productivity by Structure of Landholding | 17 |
| 3. OLS Stepwise Regressions: Structure of Landholding, Land Management, and Reported Change in Land Productivity | 19 |

LIST OF FIGURES

| <u>Figure</u> | <u>Page</u> |
|---|-------------|
| 1. Conceptualizing how Population Pressure Affects Land Degradation Through Changes in the Structure of Landholding and Land Management (Land Use and Investments in Soil Conservation and Fertility) | 3 |
| 2. Improvement in Productivity by Slope and Conservation Investments | 20 |

1. INTRODUCTION

How population growth and increasing land scarcity affect the well-being of agrarian societies has been a subject of considerable debate since the time of Malthus. To this day, proponents of Malthusian doctrine assert that population pressure will eventually reduce food surpluses, arrest agricultural development and lead to environmental degradation, starvation and other “positive checks” (Dupaquier 1983). In contrast to the Malthusian position is an hypothesis articulated in the works of Boserup (1965, 1981, 1985). She posits that conditions of resource scarcity, precipitated by long term population growth, will ultimately give rise to higher standards of living through agricultural intensification and improved productivity.

Empirical studies relative to densely populated regions around the world suggest that both of these perspectives are deficient. For every example of demographically induced agricultural development, a seemingly comparable situation exists where such change has failed to occur, and where the well-being of the rural population and their environment has actually declined. These ambiguous findings derive, at least in part, from a conceptual weakness in the Malthusian and Boserupian paradigms. Neither paradigm takes account of the intervening effects of a *changing structure of landholding*—changes in the fundamental relationships between farmers and their land (Clay, Guizlo, and Wallace 1994).

The research reported here draws attention to the structure of landholding as a set of mechanisms through which demographic changes in agrarian societies can alter the natural environment. These mechanisms, I believe, are especially important, for they constitute both the predominant social, as well as bio-physical, properties that define the relationships between farmers and their land. As such, they are central to our understanding of agricultural development processes and of why some farmers succeed, and some farmers fail, in their efforts to ensure the long-term sustain ability of their land holdings.

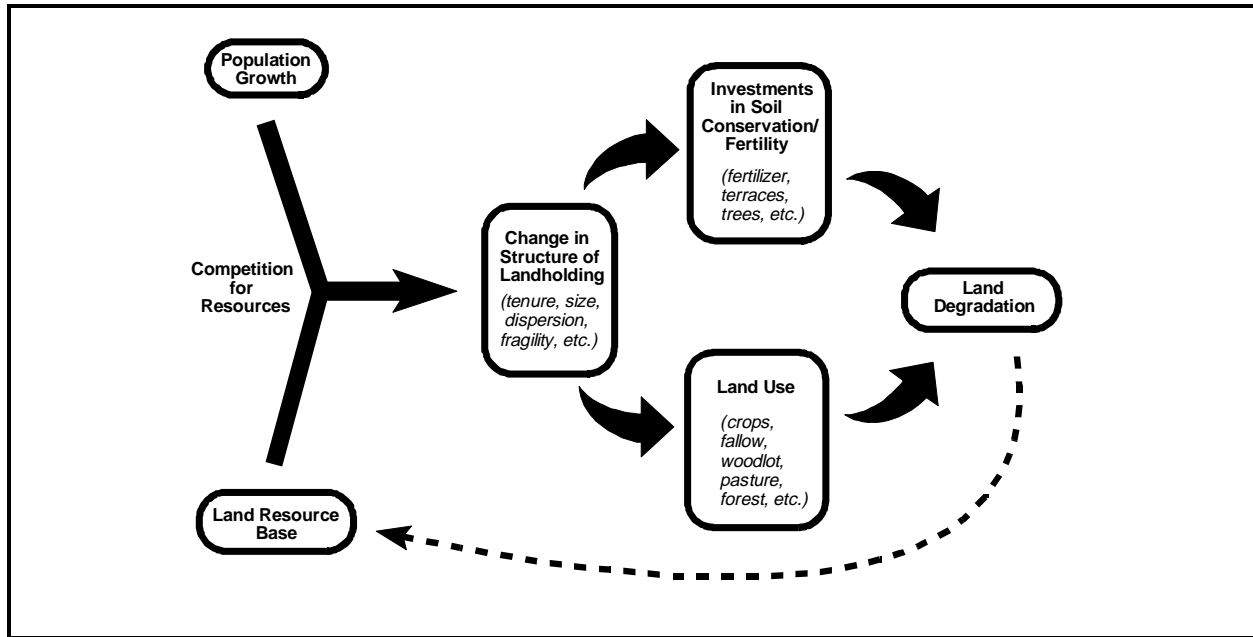
First, and perhaps the most obvious demographically-induced change in the structure of landholding, is that farm holdings generally become smaller as an ever-increasing number of households enter the agricultural work force and seek to derive their livelihood from this fixed resource base. Second, holdings tend to become more fragmented, not simply in the number of parcels operated but in the distances between parcels, as farmers look harder and farther for whatever bits and pieces of land may be available. Third, and closely tied to the second, land scarcity obliges farmers to cultivate marginal, less productive land previously held in pasture, rangeland, woodlot and forest. Fourth, many households, particularly those owning little land or with an abundance of family labor, find it necessary to expand their holdings by renting land from others. Fifth, since little new (virgin) land is brought into cultivation, the length of time under cultivation grows longer for holdings already in operation.

Thus, size of holdings, fragmentation/dispersion, fragility, and years of cultivation are among the more obvious physical attributes that differentiate one farmer's holdings from another's. Along the social dimension, land tenure (use/ownership rights) stands out above all others. Increasing population pressure and the ensuing competition for scarce resources precipitates a restructuring of these physical and social attributes of landholding. Although such demographically induced changes in the structure of landholding have drawn considerable research attention in and of themselves, my principal concern is with the impact of these changes on land degradation—notably on soil erosion and the depletion of soil fertility experienced in densely populated areas of the Third World. As shown in Figure 1, the effects of a changing structure of landholding occur indirectly through their impact on land management practices, including patterns of land use as well as investments in conservation technologies and productivity-enhancing inputs.¹

By altering the bio-physical attributes of farm holdings, the farmer's ability and willingness to invest in the long-term sustain ability of his/her land can be compromised. The application of chemical nutrients, lime, mulch and other inputs to improve soil fertility are both costly and labor intensive. The same holds true for conservation technologies (e.g., terraces and hedgerows) and land use practices (e.g., increasing perennial crops) designed to help control soil loss. Unless farmers, particularly those in developing countries, can anticipate an economic return commensurate with their level of investment they will have little incentive to adopt such practices. One cannot assume that conservation investments will be attractive to farmers simply because those practices are known to protect the resource base (Reardon and Islam 1989). As more distant, steeper (less stable) and increasingly farmed under short-term lease agreements, cost-benefit ratios of conservation technologies will become even less favorable to the individual farmer—the net result being an acceleration of land degradation.

¹ This conceptual framework linking demographic pressure and land degradation through changes in the structure of landholding and land management is developed and discussed more fully in Clay, Guizlo, and Wallace (1994). I caution that the sequence of interrelationships presented in Figure 1 is far from a full accounting of the process of land degradation in low-income, agrarian societies. Such a model would be vastly more complex and comprehensive. It would have to give attention to other factors such as class structure, market forces, the availability and affordability of purchased inputs, and variations in fundamental agroecological conditions. Rather, in line with the stated purposes of this research, Figure 1 provides a framework for conceptualizing only that subset of relationships that helps us understand the critical paths of influence between population pressure and land degradation. This research is equally restricted in geographical scope, targeting problems of land degradation faced by populations of the developing world. My intention is not to downplay the environmental impacts of population dynamics on environmental degradation in industrialized countries, or the global implications of resource use by those nations. However, I do wish to recognize the extreme conditions of declining productivity and food shortage faced by the millions of rural households living in the world's predominantly agrarian societies.

Figure 1. Conceptualizing how Population Pressure Affects Land Degradation Through Changes in the Structure of Landholding and Land Management (Land Use and Investments in Soil Conservation and Fertility)



1.1. Focus on Rwanda

Rapid population growth and declining agricultural productivity affect the livelihoods and very survival of millions of rural households throughout SubSaharan Africa. Perhaps nowhere have these effects been deeper or have they created greater hardship than among the farm population of Rwanda, where over 93 percent of the people live in rural areas and where virtually all rural households are engaged in agriculture (Rwanda 1982). Farm production in Rwanda is oriented toward subsistence; farms average slightly less than one hectare of land (Rwanda 1987). Beans and sorghum, supplemented by sweet potatoes, cassava and peas, are the principal food staples. Coffee and tea are important cash crops for some farmers and important sources of foreign exchange for the nation. Rwanda's agricultural system is labor intensive; hoes and machetes are the basic farm implements. Livestock comprise an integral part of the farming system, but the progressive conversion of pasture into cropland has caused a reduction in average household livestock production, and a parallel decline in the amount of manure available for improving soil fertility (Rwamasirabo, Clay, and Weber 1991).

The 1992 Demographic and Health Survey reports a total fertility rate (TFR) of 6.2 live births per woman, down from 8.5 a decade ago (ONAPO 1994). Consequently, the rate of population growth remains exceptionally high (above 3.0 percent annually). Small in area relative to population, Rwanda's average rural population density of 574 inhabitants per square kilometer of arable land is the highest in Africa. Virtually all arable land is used for agricultural purposes.

My research focuses on Rwanda's changing patterns of landholding and how this has contributed to the degradation (declining productivity) of agricultural lands. Steep slopes and abundant rainfall are the norm, thus the tasks of field preparation and erosion control are uncommonly difficult for the country's many small holders. Rural population growth has reduced average farm holdings in Rwanda by 12 percent over a period of just five years (DSA 1991), and increasingly farmers are finding it necessary to rent parcels of land from their neighbors.² Rwandan farmers in 1991 rented in 7.8 percent of their operational holdings compared to only 5.4 in 1983. The smallest farmers (i.e., the lowest quartile) rent proportionally 2.25 times as much land as all others.

In similar fashion, land scarcity has compelled farmers to cultivate fragile, steep-slope holdings. In Rwanda's fertile northwestern region, where the potential for agricultural productivity is high, the expansion of agriculture onto marginal lands is already resulting in serious slope failures (slumps and landslides) (Nyamulinda 1988). The increase in degradation processes acting on hill slopes will eventually lead to excessive sedimentation in the valley bottoms—conditions now reported to be common in neighboring Burundi (Mathieu 1987) and which, over time, can precipitate flood damage and the destruction of lowland crops (Clay and Lewis 1990).

In summary, population pressure and concomitant land scarcity in Rwanda have in recent decades contributed to several important changes in the structure of landholding. In turn, I believe, these landholding changes have affected the ways in which farmers manage their land and, consequently, land productivity. How, specifically, does the structure of landholding affect land management? What are the repercussions for land productivity?

My study addresses these important questions in two parts. In the first part, I examine each of the major dimensions of the structure of landholding—how they are affected by population pressure, and how they are linked to changes in land management and degradation. The focus is on research findings and conceptual issues from SubSaharan Africa as well as from other regions of the developing world. In the second part, drawing upon nationwide household survey data in Rwanda, I examine the linkages between the structure of landholding and land degradation. In the Rwanda case study, I give special attention to the intervening effects of

² Data on the proportion of parcels held under lease agreements are reported in the analysis section of this paper.

land management strategies, notably variations in farmer investments (in soil conservation and fertility) and in land use practices.

2. CONCEPTUAL LINKAGES

Changes in the structure of landholding in Rwanda and in other Third-World contexts, has affected the ways in which farm households manage their land. In some areas, farmers have adopted new technologies (irrigation, drainage, soil conservation structures, etc.) in response to declining farm size, steeper slopes, and other landholding changes. In other areas, technology substitutions (e.g., chemical fertilizers in place of fallow periods or manure) have been the more common intensification strategy. Land-use changes also result from the restructuring of landholding, and often figure prominently in farmer strategies. Fallowing practices (amount and duration), cropping patterns (types of crops grown, multiple cropping, intercropping), pastoral practices, and agroforestry, are among the more important land-use changes observed. I examine the effects of each major dimension of the structure of landholding on land management and degradation below.

2.1. Land Tenure

Long-term use rights through ownership or lease are generally regarded as a necessary precondition for prompting farmers to invest in the improvement of their operational holdings, particularly for some of the more costly soil conservation practices such as terracing and bunding. Short-term use rights discourage investment since the long-term return is not guaranteed for the farmer, and is almost never passed on to his or her heirs. Cook and Grut (1989) report that the same argument may be especially cogent for investments in agroforestry, the returns to which are generally accrued over a longer time horizon. They caution that in parts of rural Africa the tenure issue may have more to do with customary rights over how land is used than with formal laws and regulations. Thus, it is not entirely clear whether improved land-tenure arrangements would motivate farmers to invest in agroforestry technologies for soil conservation.

Migot-Adholla, Hazell, and Place (1990) report that the investment behavior of farmers in Ghana is highly dependent upon the security of land tenure. Land parcels that are operated under ownership or long-term use rights are considerably more likely to be improved than those operated under short-term use rights. This was true not only for investments in fertilizers, mulching, and irrigation, but for investments in tree crops as well. By contrast, the relationship between tenure and land improvements among farmers in Kenya was found to be rather weak—probably because Kenyan farmers feel relatively secure about their ability to cultivate rented parcels on a continuous basis.

In 1988 the World Bank in association with Rwanda's Service des Enquêtes et des Statistiques Agricoles (SESA) conducted a study on the effects of land tenure on agricultural production in three prefectures in Rwanda: Butare, Gitarama, and Ruhengeri.³ One objective was to ascertain how tenure arrangements influence farmer investments, and, in turn, how such investments affect crop yields. Consistent with the Ghana findings, Blarel (1989) found that Rwandan farmers are far more likely to invest in their own fields than in fields rented from others. Yet, despite the higher level of investment, yields on fields that farmers owned were significantly lower than on the fields they rented. One plausible interpretation is that the fields owned by farmers, though receiving inputs and physical improvements, are more seriously degraded (probably due to continuous cultivation) and thus less productive than fields over which they have use rights only. This interpretation is reexamined in the light of more recent findings presented in the following section.

Land-use patterns, like investments, often reflect the stability of use rights. Holdings operated under long-term use rights are more likely to be planted in perennial crops, used for wood production, or held in "long fallow" than is land that is shared or rented under short-term agreements. Again, if farmers are not assured of reaping the longer term benefits, they will use their holdings to maximize returns in the near-term. For example, the importance of tenure security has emerged in studies of indigenous agriculture in the Amazon region. Alcorn (1989) observes that traditionally, long-term use rights fostered a long-fallow agricultural system in the region. Newer settlers, however, have limited tenure security and thus have developed an extractive, short-term agricultural system that has resulted in rapid depletion of soil nutrients and increased erosion. Land-use controls that were important to the success of swidden systems in the region have broken down due to development policies emphasizing short-term economic growth at the expense of diversification and sustain ability (Schmink and Wood 1987).

2.2. Size of Holdings

The size of farm holdings can affect land management in numerous and sometimes inconsistent ways. Large-holders in traditional agrarian societies are generally in a better position than small-holders to maintain traditional fallowing practices and to set aside a portion of their holdings for pasture or woodlot—all land-use practices that help control soil loss and fertility depletion. Because these farmers also tend to be relatively wealthy, their liquidity enables them to invest in the kinds of inputs and improvements that will raise the productivity of their land in the long term (Grabowski 1990). Large holders are also better prepared to endure the short-term consequences of taking land out of production in order to create space for anti-

³ This study was conducted as a part of the same research initiative cited above (Migot-Adholla 1990) with reference to Ghana and Kenya.

erosion technologies such as grass strips, trees and bunds. Conversely, small farms in densely populated regions of the world are typically endowed with a relative abundance of labor which can be drawn upon for the construction and maintenance of terraces, bunds, hedgerows, drainage ditches, and other soil conservation measures that require a significant and continuing supply of labor. Moreover, those with small holdings are often in greater need of careful management and the related improvements in productivity. Their lower level of production puts them closer to the margin and thus at greater relative risk should some of their land fail to produce adequate yields.

Relating to the latter point, Boserup (1965) maintains that as population density increases and land becomes scarce (farms grow smaller), fallow periods must be shortened, and levels of investment in productive technologies must increase if populations are to avoid the hardships of migration and/or a declining standard of living. Although Boserup uses length of fallow as the key variable in defining the degree of intensification, inputs such as fertilizers, irrigation, and soil conservation are examples of technologies that substitute for long fallow periods.

Empirical support for Boserup's paradigm has been reported by Maro (1988) who describes several changes in investment and land use which have occurred in Tanzania as a result of decreased farm size. Complex networks of irrigation channels form the basis for agricultural intensification in one area, while steep slopes have been terraced and brought into production in others. Further evidence is provided by Riddell and Campbell (1986) from their work in the Mandara mountain region of Cameroon, where high population densities and small farm sizes have made the development of intensive farming systems a necessity. Over time, farmers in the region have developed a complex farming system based on soil building strategies, integration of animal husbandry with cultivation, and soil conservation. Paradoxically, as more people leave the mountains to farm on the lowlands, problems of soil degradation have begun to emerge. A decline in population density due to out migration has curtailed the amount of labor available for the soil conservation and manuring activities—labor necessary for maintaining the productivity of the system. As Riddell and Campbell (1986) note: "Traditional technology that keeps tropical soils in near continuous production requires dense populations to ensure adequate labor. The Mandara material suggests that these systems collapse as soon as population density is reduced below some critical threshold."

Farms in Rwanda are shrinking in size as farmers continue to subdivide already meager holdings equally among their sons. Though the impact of this phenomenon on the degradation of agricultural lands has received little direct attention from the local research community, bits and pieces of indirect evidence exist which, at the very least, permit us to formulate a few initial thoughts on the question. In his search for an optimal distribution of land holdings, one that would maximize crop yields, Blarel (1989) found that farm size and crop yields in Rwanda were inversely related. Small-holders, it was reasoned, intensify their farm operations through more rigorous use of available family labor, a substitution toward higher-

yielding crops, sowing seeds more densely, and growing more crops in association. While more intensive use of family labor has indeed hastened the use of terraces, living fences, mulching and other soil conservation technologies (Cook and Grut 1989), it seems unlikely that some of the other forms of intensification mentioned, particularly changes in plant densities, would be as likely to improve soil fertility. Quite to the contrary, without additional inputs or fallowing, such intensification will undoubtedly precipitate even greater depletion of the soil.

2.3. Dispersion/Fragmentation of Holdings

The World Bank Land Tenure Study also addressed the issue of land fragmentation (*morcellement*) in Rwanda and its impact on crop yields. It is important to note that fragmentation is distinct from the process by which farms become smaller over time due to the division of holdings among two or more children. I adopt the definition of land fragmentation employed by the World Bank (Blarel 1989), which emphasizes the “geographic dispersion” of land holdings. Large farms and small farms alike can be pieced together from many individual parcels. For purposes of understanding the structure of landholding in Rwanda, I am more concerned with the *distance* (time) farmers must travel on foot to work and improve their fields than with the number of parcels operated or the size of individual parcels.

Blarel reports that the dispersion of holdings has not had a negative effect on crop yields in Rwanda. Indeed, dispersed farms and parcels show higher yields overall than do consolidated farms. One suspects, however, that at least part of the reason why more distant parcels may be more productive is that, like parcels rented from other farmers (as suggested above), soil depletion and degradation through erosion is less advanced than on parcels that are owner-operated. More distant parcels are often located at the base of the hillside and in the valleys where the degenerative effects of soil erosion are less severe, and where lands have been brought into production more recently.

In the Anloga region of Ghana farmers are more apt to invest labor and capital in fields that are closer to the household residence, which is ordinarily built up on sand bars (Migot-Adholla, Hazell, and Place 1990). Because of the particular location of these fields vis-à-vis sand bars, they are more prone to damage from heavy rains and therefore require heavier preventative and reparative investment. Susceptibility to rain damage may be one important factor in the farmer’s decision to invest in nearby fields. This pattern of investment, however, may also be a reflection of the “tyranny of space,” or the additional costs incurred (time spent en route, energy required to haul materials, etc.) in improving less proximate parcels.

Despite potential advantages of greater agro-environmental diversity (Bently 1990), there may be good reason to believe that farm fragmentation inhibits farmers from enhancing

productivity. The greater level of investment required and the relative risk of investing in distant parcels may diminish the incentives for certain types of conservation investments. Farm fragmentation, as a demographically induced change in the structure of landholding, is integral to our understanding of how population pressure can lead to land degradation.

2.4. Cultivation of Marginal (Fragile) Lands

Increasing cultivation of marginal lands and their subsequent degradation is a phenomenon common to densely populated countries around the globe (Gregersen, Oram, and Spears 1992). In many arid and semi-arid areas, and in most forest ecosystems in the tropics and semi-tropics, the problem is acute (Getahun 1991). Because off-farm opportunities are lacking, rural populations look to the process of ecological expansion—the exploitation of resources formerly outside of their immediate environments (Hawley 1950). Migration onto marginal lands, seen here as a significant change in the structure of landholding, is well recognized for its impact on the environment (Hecht 1985; Millikan 1992). The particular form of environmental degradation that results from movements onto marginal lands is quite context-specific. In Guatemala, for example, it is deforestation and watershed destruction; in Sudan, decertification and rangeland stress have followed changes in the management of fragile lands (Bilsborrow and DeLargy 1990). Whatever the case, as farmers/herders attempt to increase production in fragile areas, the dynamics of human-environment relationships in those areas change dramatically. How this shift onto fragile lands affects farmer investments and land use strategies in Rwanda, and how resulting problems of land degradation have emerged, are fundamental questions addressed in this study.

In situations where population growth and land scarcity have pushed farmers to occupy mid and upper slopes, erosion problems are particularly common. The characteristic lightness and thinness of these soils make them especially prone to erosion; these characteristics also keep yields low and diminish returns to investments in soil conservation. Thus a downward spiral of low production and low investment is easily set into motion (Pingali and Binswanger, 1984) as these marginal lands are taken out of their traditional uses (forest, long fallow, rangeland, etc.) and put under more intensive cultivation. Expansion of cultivation onto marginal lands has resulted in degradation largely because the traditional uses of these lands, notably rangeland, long fallow, and forest are less disruptive of the soil and its natural processes than are seasonal or annual cropping. Clearing these fragile areas of trees and vegetation for purposes of cultivation leaves the bare soils most vulnerable to accelerated erosion from both wind and water. Indeed, the maintenance of vegetative cover is one of the more effective means of controlling erosion in many environments.

The degree to which crops and other types of vegetative cover protect the soil in which they are grown from the effects of erosion varies greatly. Similarly, crops differ in the types and

levels of inputs they require. As farmers' holdings decline in size, options for cropping become more limited, and when forced onto marginal lands, their choices become more limited still. Specific slope and soil characteristics of plots not only constrain the choices available to farmers, but also condition the effect of cropping patterns on land degradation. Land use and crop selection is a dynamic process affected by external structures and local conditions. Market and policy constraints affect farmers' decisions to grow crops or employ practices that may be ill-suited for environments that are new to them. As technologies change, or degradation occurs, farmers adapt by adopting practices suitable to new conditions or by moving into environments that may be even more fragile.

The confrontation between human subsistence needs and environmental conservation has become intense and pervasive in Rwanda. Deforestation and protection of the mountain gorilla population are issues that have recently received extraordinary international recognition. And these environmental concerns have grown in recent years because of ongoing political and economic instability. But for the average farm household, changes of more immediate and profound consequence include the cultivation of fragile lands once reserved for pasture and woodlot. Historically, Rwandan farmers settled along the upper ridges of their hillsides where soils were more fertile and cultivation was a simpler task than it was farther down on the steeper slopes and in the marshy valleys. Immediately surrounding the household compound, they planted groves of bananas and other essential crops. Bananas have special significance in Rwandan culture because they are used for making a unique home-brewed beer which is served at virtually all formal and informal social gatherings, and is a principal source of income for a majority of farm households. Beyond the inner ring of bananas, a series of outer rings was customarily used to meet other nutritional needs of their households (Nwafor 1979, p. 59). The first such ring was farmed intensively with annual crops for both home consumption and sale. A bit farther down the hillside they grow coffee. Coffee is the country's principal export crop and as such is vigorously promoted by the government of Rwanda.

Beyond the coffee plots, the slope of the hillside was often at its steepest. Consequently, farmers traditionally reserve these areas for pasture and woodlots as well as for many of the less important crops (for which frequent fallow periods are commonly required). At the very outer rings, toward the base of the slope and in the swampy valleys—along ridges that are built up to facilitate water drainage, where farmers raise sweet potatoes and other vegetables to ensure a continuous food supply between harvest seasons.

Because of increasing land scarcity due to population growth, in recent decades many farmers have been obliged to depart from this traditional system. As the preferred lands along the upper slopes become occupied, more young farmers are facing the decision either to cultivate smaller and less fertile plots farther down the hillside or to migrate elsewhere in search of sufficient land resources. Similarly, land in fallow and in pasture have been declining because

of the need to increase food production (Clay and Lewis 1990). Only woodlots seem not to have suffered over the past few years, thanks to a strong government campaign aimed at replanting and maintaining them at both the household and communal levels.

Though some of the lost fallow and pasture may be land that is converted into woodlot, it appears that households with insufficient land holdings are being forced to plant ever-increasing proportions of their holdings with sweet potatoes and other tubers (Clay and Magnani 1987; Loveridge, Rwamasirabo, and Weber 1988). These tubers have a higher caloric value than do other crops, and tend to grow relatively well in poorer soils (Gleave and White 1969), such as those commonly found on steeper slopes. But as annual crops they do not compare with the traditional uses of these slopes (i.e., woodlot and pasture) in their ability to control soil erosion. In fact, elsewhere in Africa (Lewis 1985) and in Latin America (Ashby 1985) annual crops are associated with accelerated soil loss.

2.5. Years of Operation

In the past, Rwandan farmers have been able to relocate to other areas of the country in response to growing demographic pressure. In particular, they moved to the country's drier, eastern provinces which were previously the exclusive domain of the country's pastoralist population. This movement was largely spontaneous, though it was also supported by the government through the organization of large settlement schemes called *paysannats*. In total, about 80,000 families were settled in *paysannats* during the 1960s and 1970s (Olson, Clay, and Kayitsinga 1989). Today, however, in the absence of unoccupied lands, farmers continue to cultivate the same holdings year after year and in increasingly intensive fashion. It may be reasonable to hypothesize that long-term cultivation will increase the likelihood of investment in a given parcel. However, all else equal, it will be a sign of soil fatigue.

Thus, though farm size, dispersion, slope location, years of cultivation, and tenure represent five different dimensions of the overall structure of landholding in Rwanda, they are indirectly associated with one another through their concomitant variation with changes in demographic pressure. Population growth in recent decades has meant greater land scarcity. In turn, farmers must now feed their families from smaller holdings than operated by their parents, must cultivate slopes once thought to be too steep and fragile to farm, and must supplement their meager holdings by renting small and distant parcels from others—presumably from those whose resource endowment exceeds the supply of family labor.

The analyses presented in the following section address two interrelated questions, which together comprise the locus of this research: How do these demographically induced changes in the structure of landholding affect farmers' land-use strategies and their investments in soil

conservation and fertility? And how do these intervening land management variables in turn affect land productivity?

3. RWANDA CASE STUDY

3.1. Data and Research Procedures

The data analyzed in this paper derive from a nationwide stratified random sample of 1,240 farm households, undertaken as part of the 1991 Survey of Agroforestry in Rwanda.⁴ Direct interviews with heads of households and/or their spouses, taking about one and a half hours, were conducted over a six-week period beginning in June, 1991. Interviewers collected information on a variety of topics. At the household level, interviewers asked questions about the use, marketing and problems associated with fuel-wood and other types wood products. For each parcel of land operated by the sampled households, they asked questions or took measurements relative to: land tenure, steepness of slope, location of the field on the slope, soil conservation methods used, the use of fertilizer and other inputs, number and species of trees planted, distance from the household residence, and crops grown.⁵

Changes in Productivity. Interviewers asked farmers series of questions about the changes they observed in the productivity of each parcel of land. Was soil productivity improving or declining? Were these slight, moderate, or large changes in productivity? Parcels were ranked along a seven-point scale of productivity change ranging from “large decline” to “large improvement.” Table 1 shows, according to surveyed farmers, that the productivity of 48.7 percent of all cultivated farmland in Rwanda is declining, 37.5 percent has not changed, and only 13.8 percent has increased in productivity over time.⁶ For purposes of the present research on change in productivity, the analyses presented in the following section focus only on parcels that have been reported to be either increasing or decreasing in productivity.

Land Use. Erosivity of land use is measured using C-values. The C-value index, a well-known measure that reflects the overall protective quality of crops, is defined as, “the ratio of soil loss from an area with a specific cover and tillage practice to that from an identical area in tilled continuous fallow” (Wischmeier and Smith 1978). For any given field, the crop cover,

⁴ The complete sample frame includes a total of 1,248 households. However, due to military/political tensions in the prefecture of Byumba, along the Uganda border, interviewers were unable to conduct fieldwork in the region, and eight (0.6%) of the 1,248 sampled households had to be omitted from this study. Sampling weights have been adjusted accordingly.

⁵ Data on crops grown in each parcel were obtained several months earlier as part of DSA’s seasonal area and production survey. Because of a small amount of farm household turnover, and changes in land holdings between the two periods of data collection, the number of parcels on which complete data are available is reduced from 6,464 to 5,798. A comparison of fields dropped from the sample with those retained shows no significant bias on the principal landholding characteristics examined in this study.

⁶ Because these figures, and others presented in this analysis are based on data collected at the parcel level, they have been proportionally weighted according to parcel size as well as for the household’s probability of selection), thus eliminating any over-representation of smaller parcels and under-representation of larger parcels.

canopy, and tillage practices can vary throughout the year. C-values represent the average soil loss ratio resulting from these factors over the growing season. They must be obtained empirically, as planting and tillage strategies clearly vary from farming system to farming system for specific crops. For this reason, the use of the standard published C-values, based largely on farming practices in the United States, should not be used in Third World countries without first being evaluated. In the present study, the C-values used were based on field work undertaken in the Kiambu and Murang'a districts of the Kenya highland (Lewis, 1985) and a pilot study of soil loss in Rwanda (Lewis, 1988).⁷ Among crops commonly grown in Rwanda, C-values vary from .02 and .04 for coffee and bananas, to .35 and .40 for maize and sorghum. In general, perennial crops, pasture, fallow and woodlot all have low (less erosive) C-values. Annual crops, particularly grains, have high (more erosive) C-values. Tubers and leguminous crops tend to have values in the middle range. The average C-value for cultivated holdings in Rwanda is .14, a composite of many forms of land use and crop mix.

Table 1. Farm Holdings Classified by Level of Reported Change in Productivity Reported by Farm Operators

| Reported Level of Change in Soil Productivity | Percent of Land Area | Number of Parcels |
|--|-----------------------------|--------------------------|
| Large Decline | 21.5 | 1203 |
| Moderate Decline | 13.3 | 745 |
| Slight Decline | 13.9 | 777 |
| No Change | 37.5 | 2101 |
| Slight Improvement | 4.5 | 253 |
| Moderate Improvement | 5.8 | 322 |
| Large Improvement | 3.5 | 194 |
| Total | 100.0 | 5699 |

⁷ Some of these values differ greatly from those published in the United States. For example, the C-value of .45 found for tobacco in Rwanda is significantly larger than it is in the United States. This is the result of the differences in agricultural practices between the heavily subsidized commercial tobacco production in the United States, and small farmer production for home consumption and local sale in Rwanda.

Conservation Investments. Conservation investments were measured in meters and recorded separately for each parcel of land operated by sampled households. Rwandan farm households vary greatly in the degree to which they invest in soil conservation. Although hedgerows are planted and maintained in only 22.6 percent of holdings, anti-erosion ditches are installed in 47.8 percent, and grass strips are found in 60.3 percent of holdings. The mean lengths of such investments over all households are 56, 161, and 205 meters per hectare, respectively. Radical terraces can also be found in Rwanda, but these are relatively rare; only 1.4 percent of all farm households have invested in terrace construction. No data are available by which to compare the relative effectiveness of the four types of investment. Radical terraces, similar to those found in parts of Asia, are thought by some to be superior to the other forms of investment. However, given the lack of data and the rarity of radical terraces, no one type of investment is given greater weight than the others. For present purposes the four types of conservation investments are summed into a single, aggregate measure. Over three quarters of cultivated farm holdings in Rwanda receive some form of conservation investment. Among those that do, we find that investments average 555 m/ha.

Use of Farm Inputs. Because of hypothesized differences in the determinants of organic and purchased inputs, the two are treated separately in this analysis. Organic inputs consist of compost, manure, mulch, and green manure and are applied to 69.5 percent of cultivated holdings. Purchased inputs include chemical fertilizer and lime, and are applied by just 7.4 percent of households to an even smaller proportion (4.9 percent) of cultivated holdings. Difficulties inherent in obtaining precise quantities of inputs applied at the parcel level has limited information on input use to a dichotomous, yes-no response for each parcel operated by the household.

3.2. Findings and Discussion

Steady growth of the land rental market in Rwanda, resulting from increasing demographic pressure, has raised concerns about potential land degradation. Conventional wisdom and overwhelming empirical evidence, some of which has been reviewed above, tell us that farmers generally invest more in fields they own than in fields they rent from others. Data presented here also support this assertion; Table 2 confirms that owner-operated parcels in Rwanda are much more likely to have received organic fertility-enhancing inputs, such as manure or compost, and to have been improved through the adoption of anti-erosion technologies, such as terraces and grass strips. The use of purchased inputs, too, is higher on owned land, but the difference is not statistically significant. Land use practices also favor owner-operated parcels as they tend to be under vegetative cover with relatively low (less erosive) C-values.

Paradoxically, despite heavier investments, Rwandan farmers do not report a significantly greater improvement in productivity on parcels they own than on parcels they operate as tenants. This may be due to the fact that owner-operated parcels have been cultivated over a longer period (23.2 years on average), compared to only 10.7 years for holdings operated under lease agreements. The implication here is that the level of investment farmers are currently making in their own is necessary to compensate for the number of years of intensive cultivation and the loss of nutrients associated with this “mining of the soil,” a problem identified as one of the major barriers to agricultural growth and sustain ability across the entire highland region of East Africa (Getahun, 1991). This may also help us understand why Blarel (1989) found higher yields on parcels operated under short-term use rights than under ownership rights.

As population grows and farms become smaller, what happens to soil productivity? Table 2 suggests that declining productivity is more of a problem for small and mid-sized farms than for those in the largest quartile. Large holders are more likely than small holders to invest in fertilizers and other inputs, yet they are less likely to take soil conservation measures such as constructing terraces and hedgerows. This may reflect the large holder’s greater liquidity (needed particularly for purchased inputs) and ownership of livestock (to supply manure). Conversely, the small holder has a relative abundance of labor (needed for field improvements).

Land use practices, too, are associated with farm size. Small farms tend to have higher C-values since they place a much greater share of their holdings in annual crops. By contrast, large holders plant a greater proportion of their cultivated land in perennial crops such as bananas and coffee, which tend to be less erosive forms of land use. Large holders have greater flexibility in land use practices than do small holders, for whom the immediate demands of daily subsistence necessitate that nearly all holdings be intensively farmed rather than held in pasture, woodlot, fallow or other environmentally beneficial uses. Those with small operational holdings are able to compensate for less desirable land-use practices by focusing available family labor and scarce inputs on the production and conservation of a reduced number of fields.

The geographic dispersion of land parcels, another dimension of the structure of landholding, is here operationalized as the “distance” (in minutes, on foot) between parcels and the household residence. Competition for scarce land resources does not (yet) appear to be forcing Rwanda’s smallest holders to travel to increasingly distant locations in search of land to supplement the family holdings. Since 1983, the average amount of time required to walk from home to field has remained steady at approximately 7.5 minutes.

Though apparently not affected by demographic change in Rwanda, the dispersion of holdings does influence farmer investments in soil fertility (Table 2). This finding is fully consistent

with established theory and observation reported elsewhere. Farmers in Rwanda invest relatively little in holdings located more than a few minutes' walk from the household residence. This may be conditioned by the fact that distant fields are more likely to be operated under short-term use rights, but reflects the relatively high cost of transporting inputs and materials needed for soil conservation, as well as farmers' beliefs that their holdings in more distant locations have not yet reached the same degree of exhaustion as those in closer proximity.

Table 2. Conservation Investments, Land Use, and Reported Change in Soil Productivity by Structure of Landholding

| Structure of Landholding | Organic Inputs Used % of holdings | Purchased Inputs Used % of holdings | Anti-erosion Improvements (meters/ha) | Land Use (mean C-value) | Change in Productivity of Soil (mean score) | Number of Parcels |
|---|--|--|--|------------------------------------|--|--------------------------|
| Land Tenure | | | | | | |
| Operated by Owner | 73.2 | 5.0 | 429 | .16 | -1.26 | 5147 |
| Operated by Tenant | 26.8 | 3.7 | 366 | .21 | -1.20 | 448 |
| Total | 69.5 | 4.9 | 424 | .16 | -1.26 | 5596 |
| <i>Eta</i> | .27 | .02 | .03 | .20 | .01 | |
| <i>Significance</i> | ≤.001 | .20 | .01 | ≤.001 | .65 | |
| Size of Farm | | | | | | |
| Low quartile | 68.1 | 2.8 | 528 | .18 | -1.46 | 1413 |
| 2nd quartile | 66.2 | 2.7 | 456 | .17 | -1.29 | 1414 |
| 3rd quartile | 73.7 | 5.1 | 409 | .16 | -1.37 | 1393 |
| High quartile | 69.8 | 9.2 | 298 | .14 | -.91 | 1376 |
| Total | 69.5 | 4.9 | 424 | .16 | -1.26 | 5596 |
| <i>Eta</i> | .06 | .12 | .17 | .21 | .11 | |
| <i>Significance</i> | ≤.001 | ≤.001 | ≤.001 | ≤.001 | ≤.001 | |
| Distance from Residence (dispersion) | | | | | | |
| 0 min. | 93.0 | 7.4 | 474 | .16 | -1.37 | 2683 |
| 1-4 min. | 67.7 | 3.4 | 433 | .17 | -1.10 | 970 |
| 5-12 min. | 49.6 | 1.0 | 410 | .17 | -1.19 | 929 |
| 13+ min. | 26.5 | 3.5 | 302 | .17 | -1.03 | 978 |
| Total | 69.6 | 5.0 | 426 | .16 | -1.25 | 5560 |
| <i>Eta</i> | .56 | .11 | .12 | .12 | .07 | |
| <i>Significance</i> | ≤.001 | ≤.001 | ≤.001 | ≤.001 | ≤.001 | |
| Steepness of Slope | | | | | | |
| 0-8 Degrees | 68.2 | 3.8 | 390 | .18 | -.83 | 1584 |
| 9-15 Degrees | 71.7 | 5.5 | 497 | .18 | -1.19 | 1387 |
| 16-25 Degrees | 69.4 | 4.3 | 439 | .16 | -1.40 | 1457 |
| 26+ Degrees | 69.1 | 6.6 | 363 | .14 | -1.60 | 1166 |
| Total | 69.4 | 4.9 | 424 | .16 | -1.26 | 5594 |
| <i>Eta</i> | .02 | .05 | .10 | .21 | .15 | |
| <i>Significance</i> | .36 | ≤.01 | ≤.001 | ≤.001 | ≤.001 | |
| Years of Operation | | | | | | |

| | | | | | | |
|-------------|------|-----|-----|-----|-------|------|
| 0-10 years | 50.7 | 2.7 | 391 | .17 | -.84 | 1488 |
| 11-20 years | 73.1 | 5.9 | 440 | .16 | -1.23 | 1450 |
| 21-30 years | 81.9 | 7.3 | 438 | .17 | -1.13 | 1075 |
| 31-40 years | 79.1 | 5.0 | 437 | .15 | -1.53 | 1554 |
| 41+years | 68.8 | 1.8 | 423 | .15 | -1.87 | |
| Total | 69.3 | 4.7 | 424 | .16 | -1.26 | 5566 |

| | | | | | |
|---------------------|-------|-------|-----|-------|-------|
| <i>Eta</i> | .26 | .09 | .04 | .11 | .17 |
| <i>Significance</i> | ≤.001 | ≤.001 | .05 | ≤.001 | ≤.001 |

Farmers in Rwanda now occupy fragile lands once thought to be too steep and unproductive for cultivation. Formerly, farmers often held these slopes in pasture, but the demand for food from a rapidly growing rural population has caused many households to abandon livestock production in favor of crop production. In just 5 years, from 1984 to 1989, land held in pasture has declined from 10% to 4% of total operational holdings in Rwanda (DSA 1991). Although these steep slopes still have lower C-values than holdings on more level slopes, their degradation is reported to be the most severe of all. Farmers tend to apply more purchased inputs as slope increases, but not more organic inputs. Farmers are less likely to make field improvements on the very steepest slopes where relatively poor soils inhibit costly investment, and on gentler slopes, where the risk of soil loss is lower. Farmers tend to concentrate field improvements on slopes of medium steepness, where their cost effectiveness is the highest.

One of the most powerful determinants of fertility decline in Rwanda is the length of time the land has been cultivated. Table 2 shows that the most serious decline has occurred on holdings that have been cultivated for more than 30 years, and that fewer years of cultivation mean less decline. It is no surprise, then, that older fields tend to receive more organic and purchased inputs, as well as more conservation investments.

In viewing these patterns of investment more closely, however, the evidence suggests that farmers may be abandoning their oldest, most run-down fields. These fields may be past “the point of no return,” i.e., a threshold beyond which the marginal return on investments in conservation and fertility diminishes, and thus discourages investment. What leads to this conclusion is that all three types of investment grow with years of cultivation through 30 years, but then decline for parcels cultivated for 31 or more years—parcels reported to have declined in productivity far more than those in any of the younger groups.

How does the structure of landholding influence degradation once the intervening effects of farmer investments and land use patterns have been controlled? And, alternatively, to what degree do such management decisions provide the intermediate mechanism through which the structure of landholding affects the degradation of holdings in this context of intense demographic pressure? The stepwise OLS regression model in Table 3 helps us respond to these important questions. The first step introduces, ownership rights, farm size, fragility and other key structure of landholding variables. The second step introduces measures of land

management, such as conservation investments and use of inputs, in order to assess their impact independent of the structure of landholding.

Overall, the structure of landholding emerges as an important set of determinants of productivity change in Rwanda. As expected, fields located on steep slopes, those that have been operated for many years, as well as those on smaller farms, are more likely to be declining in productivity. Distance from the household residence is also an important factor; those in more proximate locations tend to be declining in productivity, probably because they are cultivated more intensively. Though land tenure is important at step 1, its impact disappears at step 2, once the land management variables are brought into the equation. Thus, the importance of land ownership is entirely accounted for by its effect on land management. Farmers invest in the land they own, which in turn improves productivity.

Findings reported in Table 3 also demonstrate that the application of organic inputs such as mulch and manure is the one management practice that exerts a positive and significant effect on long-term change in soil productivity. The use of purchased inputs shows a significant negative correlation with productivity change. This finding reflects the short-lived impact of purchased inputs and the fact that Rwandan farmers tend to apply these inputs, possibly as a last resort, to fields that have declined in productivity despite conservation investments and the use of organic inputs.

Table 3. OLS Stepwise Regressions: Structure of Landholding, Land Management, and Reported Change in Land Productivity

| Independent Variables | Reported Change in Land Productivity | |
|-----------------------|--------------------------------------|--------|
| | Step 1 | Step 2 |
| | | |

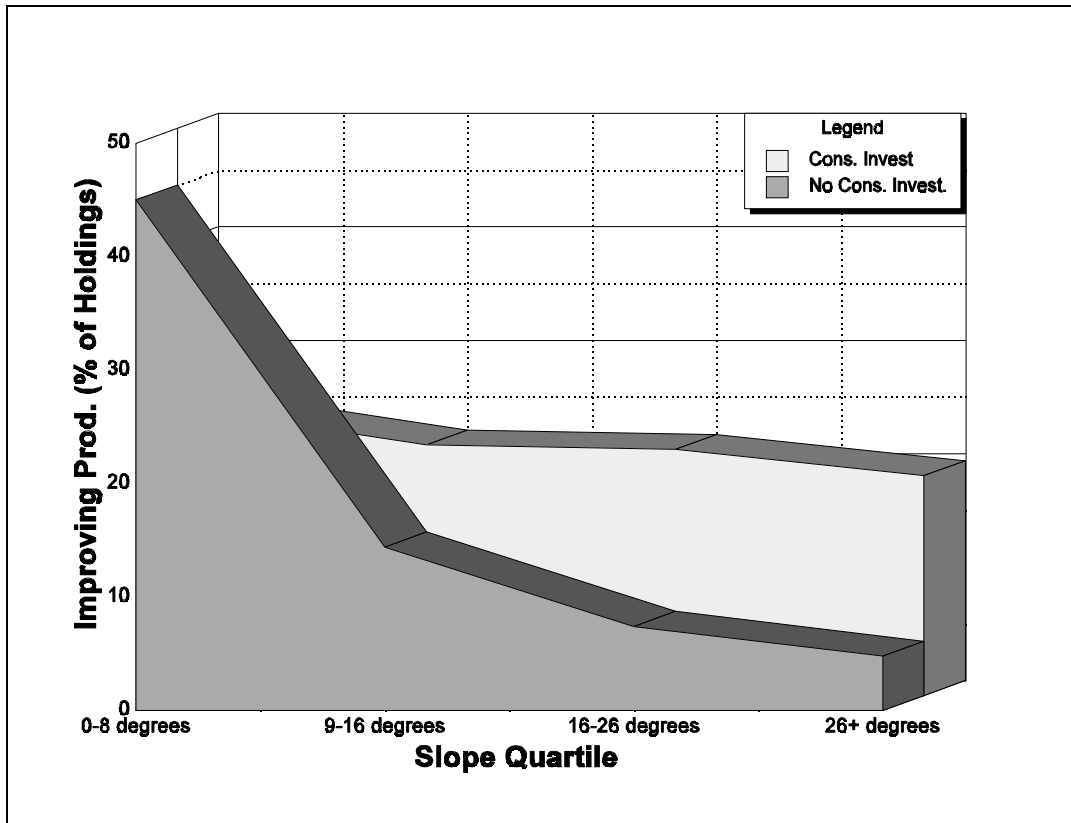
| | | |
|--|--------|--------|
| A. Structure of Landholding | | |
| Ownership rights (1 = own, 2 = lease) | -.06** | -.02 |
| Size of Land holdings | .15** | .15** |
| Distance from residence | .05** | .11** |
| Slope (degrees) | -.15** | -.15** |
| Years operated | -.19** | -.20** |
| B. Land Management | | |
| Organic inputs | | .16** |
| Purchased inputs | | -.07** |
| Conservation investments | | .01 |
| Land use (C-value index) | | -.02 |

*Sig T \leq .05 **Sig T \leq .01

Conservation investments and land use practices do not show a significant influence on change in productivity in this OLS regression. However, a subsequent analysis of variance shows that the interaction effects of conservation investments and slope exert a strong effect on productivity change. In other words, the effect of conservation investments emerges only in the combination with steepness of slope. As Figure 2 demonstrates, conservation investments have a negative association on gentle slopes, but become increasingly important to productivity change as slope increases. Among fields in the steepest slope quartile, productivity is far more likely to be increasing when conservation investments are present than when they are not.

In summary, the long-term sustainability of Rwandan agriculture will be challenged by continued population growth and resource scarcity. Analyses presented in this section confirm that demographically induced changes in the structure of landholding exert an appreciable impact on reported changes in soil productivity. To the extent that population pressure has resulted in less stable land use rights (i.e., land rental rather than ownership), expanded use of more distant and fragile lands on steep slopes, and longer periods of use, it has been detrimental to agricultural productivity in Rwanda.

Figure 2. Improvement in Productivity by Slope and Conservation Investments



3.3. Con

clusions and Study Implications

Population pressure has long been cited as one of the leading causes of environmental degradation in the Third World, but rarely does our understanding of the complex relationship between population and the environment extend beyond the most rudimentary level of generalization. We speak of how growing populations eventually exceed environmental “carrying capacities,” often without giving even cursory recognition to the socioeconomic and physical mechanisms through which land scarcity translates into land abuse. But gradually, we are coming to realize that demographically induced problems of resource scarcity can not be solved simply by slowing population growth or by increasing available resources (Simmons 1988:152). While independent research efforts on both sides of the equation are vital, and are highlighted by numerous context-specific successes and failures, the particular *mechanisms* through which mounting demographic pressure affects land degradation must be spelled out with greater conceptual clarity and empirical detail. Understanding these intermediate linkages will vastly broaden our spheres of policy action in the struggle to conserve precious land resources in those areas of Africa, Asia and Latin America where rising population densities are threatening long-term environmental sustain ability.

The research reported here has endeavored to identify and explore a small set of these mechanisms, specifically those involving demographically induced changes in the structure of landholding—the particular pattern of social and spatial relationships observed between farmers and their land. Emphasis has been placed on five important landholding variables of profound importance to farmers in Rwanda: tenure arrangements (ownership versus use rights), size of holdings, geographical dispersion of holdings, fragility (steepness of slope), and years of cultivation. Previous studies and current findings reveal that population pressure in Rwanda has been accompanied by dramatic changes along several of these dimensions of landholding. More than ever before, farmers must rent the land they operate, family land holdings have radically diminished in size, and they see little alternative to farming the steep and fragile slopes that once were held almost exclusively in pasture, woodlot and fallow.

How have these changes affected the long-term sustainability of farming in Rwanda? Traditional inputs such as compost, manure, and mulch, invariably go on fields owned by the farmers and especially on those located nearer to the family compound. The same principle holds for field improvements such as the installation of terraces, hedgerows, grass strips, and drainage ditches—rented fields and distant fields are largely ignored.

On owner-operated parcels, greater investment in conservation and fertility is seen by farmers as necessary to compensate for the detrimental effects of many more years of cultivation. Without these investments, owner-operated holdings would likely be far more degraded still. In general, the longer a field has been cultivated, the more conservation and fertility investments it will receive. Sure to raise concerns, however, is evidence that after 30 years or so, the level of investment by farmers levels off and begins to decline. Have these fields crossed a threshold in which declining returns to investments become a disincentive to further investment? Do limited resources eventually cause farmers to abandon completely these older holdings? What this means is that farmers are losing a difficult and deeply significant struggle; it means that their prize holdings, those they will pass on to their children, have been worked to the point where, under current circumstances, more investment makes little sense.

Providing incentives for farmers to plan for the long term is no easy matter. Innovative programs are needed. There must be incentive schemes, locally sponsored, that simultaneously extend viable technologies to farmers and encourage them to adopt those best suited to their own particular needs. The integration of trees into cropping systems, for example, has not yet been well extended in Rwanda, despite the reported successes of on-station research trials (Yamoah, Grosz, and Nizeyimana 1987). Green manure is applied to less than two percent of farm holdings, and hedgerows are grown on just 22.7 percent of holdings. Soil conservation in Rwanda is still a long way from what has been achieved in Nepal, Peru, the Mandara Mountains of Cameroon and in other regions where mountain agriculture prevails. Unfortunately, lessons to be learned from Rwanda's neighboring states are few. In Zaire, Uganda and Tanzania, problems of land scarcity have been far less intense

and more localized than in Rwanda; all are relatively land-rich and less mountainous. Burundi, on the other hand, has much in common with Rwanda, but policy makers there, too, are still searching for answers. Yet recent reports from the Machakos district of Kenya offer a sign of encouragement that the downward spiral can be reversed (Tiffen, Mortimore, and Gichuki 1994).

Rwanda may also have its “success stories.” A shortcoming of the present study is that by focusing on changes in productivity across all parcels, most of which have either declined or remained the same, we have said comparatively little about those holdings which appear to have improved in soil productivity. Though relatively small in total area (13.8 percent of all holdings), a focused study of this segment of successful fields may offer some insight into the conditions and investments that will be required of Rwandan farmers over the long haul.

Further, we must caution that the present study has not addressed the “off-farm” issue of deforestation, which is closely tied to “on-farm” changes and is an equally menacing problem in Rwanda today. Indeed, a recent IFPRI publication, *Priorities for Forestry and Agroforestry Policy Research* (Gregersen, Oram, and Spears 1992), underscores the need to develop optimal land-use strategies for small-scale cultivators in wet tropical forest zones, and to address issues of population growth and distribution, shortened fallow periods, and opportunities for incorporating trees and other perennial crops into established farming systems.

Though we can learn much from the kinds of nationwide survey data examined here, our understanding of the constraints farmers face in the application of specific conservation technologies, and of indigenous knowledge and practices already in use, is rather limited. We have a fundamental need for supplementary information of a more qualitative nature on these important questions. Until more is known about how farmers in Third-World, agrarian contexts perceive the notion of resource conservation, and until incentives can be developed to encourage farmers to embark on longer-term strategies that meet their needs, from both environmental and family planning perspectives, the cycle of resource degradation and poverty will most assuredly intensify. Poorly equipped and faced with the daunting charge of producing more food from smaller and depleted holdings, and now scarred by the atrocities of civil war, one must conclude that Rwandan farmers today are not well placed to engage in long-range strategic planning for the environment. They are, indeed, fighting an uphill battle.

REFERENCES

- Alcorn, Janis B. 1989. Process as Resource: The Traditional Agricultural Ideology of Bora and Huastec Resource Management and its Implications for Research. *Advances in Economic Botany*. 7:63-77.
- Ashby, Jacqueline A. 1985. The Social Ecology of Soil Erosion in a Colombian Farming System. *Rural Sociology*. 50 (3):337-396.
- Bently, Jeffry W. 1990. Wouldn't You Like to have All of Your Land in One Place? Land Fragmentation in Northwest Portugal. *Human Ecology*, 18(1):51-79.
- Bilsborrow, Richard E. and Pamela F. DeLargy. 1990. Land Use, Migration, and Natural Resource Deterioration: The Experience of Guatemala and the Sudan. In *Resources, Environment and Population: Present Knowledge and Future Options*, ed. Kingsley Davis and Mikhail S. Bernstam A supplement to *Population and Development Review*. 16:125-147.
- Blarel, Benoit. 1989. Régime Foncier et Production Agricole dans un Contexte de Forte Pression Démographique. Washington, D.C.: World Bank, Agricultural Policy Division, Department of Rural Economy (AGRAP).
- Boserup, Esther. 1965. *The Conditions of Agricultural Growth: The Economics of Agrarian Change Under Population Pressure*. Chicago: Aldine.
- Boserup, Esther. 1981. *Population and Technological Change*. Oxford: Blackwell.
- Boserup, Esther. 1985. The Impact of Scarcity and Plenty on Development. In *Hunger and History*, ed. R. I. Rotberg and T. K. Rabb. Cambridge: Cambridge University Press. pp. 185-209.
- Boserup, Esther. 1987. *Description Sommaire des Principales Caractéristiques de l'Agriculture au Rwanda*. Kigali: Ministère de l'Agriculture, de l'Élevage et des Forêts.
- Clay, Daniel C. and R. J. Magnani. 1987. The Human Ecology of Farming Systems: Toward Understanding Agricultural Development in Rwanda. In *Research in Rural Sociology and Development*, ed. H.K. Schwarzweller. 3:141-167
- Clay, Daniel C. and L. A. Lewis. 1990. Land Use, Soil Loss and Sustainable Agriculture in Rwanda. *Human Ecology*, 18 (2):147-161.

- Clay, Daniel C., Mark Guizlo, and Sally Wallace. 1994. Population and Land Degradation. EPAT Research Reports Series. Forthcoming.
- Cook, Cynthia C. and Mikael Grut. 1989. Agroforestry in Sub-Saharan Africa: A Farmer's Perspective. Washington, D.C.: World Bank Technical Paper Number 112.
- Division des Statistiques Agricoles (DSA). 1991. Enquête Nationale Agricole 1989: Production, Superficie, Rendement, Elevage et Leur Evolution 1984-1989. Rwanda: Ministère de l'Agriculture, de l'Elevage et des Forêts. DSA Publication No. 22.
- Dupaquier, J. ed. 1983. *Malthus Past and Present*. London: Academic Press.
- Getahun, Amare. 1991. Agricultural Growth and Sustainability: Conditions for Their Compatibility in the Tropical East Africa Highlands. In *Agricultural Sustainability, Growth, and Poverty Alleviation: Issues and Policies*, ed. S.A. Vosti, T. Reardon and W. von Urff. Published jointly by the International Food Policy Research Institute (IFPRI) and the German Foundation for International Development (DSE). pp. 451-468
- Gleave, M. B. and H. P. White. 1969. Population Density and Agricultural Systems in West Africa. In *Environment and Land Use in Africa*, ed. M.F. Thomas and G.W. Whittington London: Methuen. pp. 273-300
- Grabowski, Richard. 1990. Agriculture, Mechanisation, and Land Tenure. *Journal of Development Studies*. 27(1):43-55.
- Gregersen, Hans, Peter Oram, and John Spears. 1992. Priorities for Forestry and Agroforestry Policy Research. Report of an International Workshop. Washington, D.C.: International Food Policy Research Institute.
- Hawley, Amos. 1950. Human Ecology: *A Theory of Community Structure*. New York: Ronald Press.
- Hecht, Susanna B. 1985. Environment, Development and Politics: Capital Accumulation and the Livestock Sector in Eastern Amazonia. *World Development*. 13(6):663-684.
- Lewis, Lawrence A. 1985. Assessing Soil Loss in Kiambu and Nurang'a Districts, Kenya, *Geografiska Annaler*. 67 (A):273-84.
- Lewis, Lawrence A. 1988. Measurement and Assessment of Soil Loss in Rwanda, *Catena Supplement*. 12:151-65.

- Loveridge, Scott, S. Rwamasirabo, and M. T. Weber. 1988. Selected Research Findings from Rwanda that Inform Food Security Policy Themes in Southern Africa. Paper presented at the Food Security in Southern Africa Fourth Annual University of Zimbabwe/Michigan State University Conference. Harare.
- Maro, Paul S. 1988. Agricultural Land Management under Population Pressure: *The Kilimanjaro Experience, Tanzania*. Mountain Research and Development. 8(4):273-282.
- Mathieu, C. 1987. Contraintes techniques et sociales en conservation du sol et des eaux en zone à très forte densité de population: *l'Exemple des montagnes du Mumirwa au Burundi*. Tropicultura. 5 (3):137-146.
- Migot-Adholla, S. E., Peter B. Hazell, and Frank Place. 1990. Land Rights and Agricultural Productivity in Ghana, Kenya and Rwanda: A Synthesis of Findings. Washington, D.C.: World Bank, Agriculture and Rural Development Department.
- Millikan, Brent H. 1992. Tropical Deforestation, Land Degradation, and Society: *Lessons from Rondônia, Brazil*. Latin American Perspectives. 19(1):45-72.
- Nwafor, J. C. 1979. Agricultural Land Use and Associated Problems in Rwanda. *Journal of Tropical Geography*. 58:58-65.
- Nyamulinda, V. 1988. Contribution a l'Etude de l'Erosion par Mouvement de Masse dans les Milieux Aménagés du Rwanda. *Bulletin Agricole Rwanda*. 76-87.
- Office National de la Population, République Rwandaise (ONAPO). 1994. Enquête Démographique et de Santé Rwanda (1992). Columbia, Maryland: DHS/Macro International Inc.
- Olson, Jennifer, D. Clay, and J. Kayitsinga. 1989. Migration Permanente de la Population Agricole au Rwanda. Document de Travail. Rwanda: Division des Statistiques Agricoles (DSA), MINAGRI.
- Pingali, Prabhul and Hans P. Binswanger. 1984. Population Density and Farming Systems: *The Changing Locus of Innovations and Technical Change*. Discussion Paper No. ARU 24. Washington D.C.: World Bank.
- Reardon, Thomas and N. Islam. 1989. Issues of Sustain ability in Agricultural Research in Africa. Proceedings of The Symposium on the Sustain ability of Agricultural Production

Systems in Sub-Saharan Africa, Norwegian Center for International Agricultural Development. Occasional Paper Series C.

Riddell, James C. and David J. Campbell . 1986. Agricultural Intensification and Rural Development: *The Mandara Mountains of North Cameroon*. *African Studies Review* 29(3):86-106.

Rwamasirabo, Serge, Daniel C. Clay, and Michael T. Weber. 1991. Production Caprine au Rwanda 1953-1984: *Détermination de Potentiel pour un Développement Future*. DSA Publication No. 23. Rwanda: Ministère de l'Agriculture, de l'Élevage et des Forêts.

Rwanda (Bureau National de Recensement). 1982. *Recensement Général de la Population et de l'Habitat: Synthèse des Principaux Résultats*. Kigali: Imprimerie Scolaire.

Schmink, M., and C. Wood. 1987. The 'Political Ecology' of Amazonia. In *Lands at Risk in the Third World: Local Level Perspectives*, ed. P. Little and M. Horowitz. Colorado: Westview Press. 38-57

Simmons, Ozzie G. 1988. *Perspectives on Development and Population Growth in the Third World*. New York: Plenum Press.

Tiffen, Mary, M. Mortimore, and F. Gichuki. 1994. *More People, Less Erosion: Environmental Recovery in Kenya*. Chichester: Wiley.

Wischmeier, W. H. and D. D. Smith. 1978. Predicting Rainfall Erosion Losses, A Guide to Conservation Planning, *Agricultural Handbook No.537*. Washington, D.C.: United States Department of Agriculture. 1-58.

Yamoah, C. F., R. K. Grosz, and E. Nizeyimana. 1987. Field Studies on Growth Performance of Alley Shrubs in the Highlands Regions of Rwanda. Proceedings, FSR Symposium, Kansas State University. FSR Paper Series. 15:59-76.

MSU International Development Papers

How to order from the MSU Bulletin Office:

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

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

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

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

Fill out and send the order form provided to:

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

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

Available from the MSU Bulletin Office

MSU INTERNATIONAL DEVELOPMENT PAPERS

- IDP 13 *Sources and Effects of Instability in the World Rice Market* by T. S. Jayne. 1993. 104 pp. \$11.00 **(CDIE reference pending)**
- IDP 14 *The Impact of Agricultural Technology in Sub-Saharan Africa: A Synthesis of Symposium Findings* by James F. Oehmke and Eric C. Crawford. 1993. 33 pp. \$7.00 **(CDIE reference PN-ABP-321)**
- IDP 14F *L'Impact de la technologie agricole en Afrique subsaharienne: Synthese des conclusions du colloque* par James F. Oehmke and Eric W. Crawford. 1993. 34 pp. \$7.00 **(CDIE reference PN-ABQ-056)**
- IDP 15 *Market-Oriented Strategies to Improve Household Access to Food: Experience from Sub-Saharan Africa* by T.S. Jayne, D.L. Tschirley, John M. Staatz, James D. Shaffer, Michael T. Weber, Munhamo Chisvo, and Mulinge Mukumbu.* 1994. 61 pp. \$9.00 **(CDIE reference PN-ABS-755)**
- IDP 16 *Improving the Measurement and Analysis of African Agricultural Productivity: Promoting Complementarities between Micro and Macro Data* by Valerie Kelly, Jane Hopkins, Thomas Reardon, and Eric Crawford. 1995. 44 pp. \$7.00 **(CDIE reference pending)**
- IDP 17 *Promoting Food Security in Rwanda Through Sustainable Agricultural Productivity: Meeting the Challenges of Population Pressure, Land Degradation, and Poverty* by Daniel C. Clay, Fidele Byiringiro, Jaakko Kangasniemi, Thomas Reardon, Bosco Sibomana, Laurence Uwamariya, and David Tardif-Douglin. 1995. 115 pp. \$11.00 **(CDIE reference pending)**
- IDP 18 *Promoting Farm Investment for Sustainable Intensification of African Agriculture* by Thomas Reardon, Eric Crawford, and Valerie Kelly. 1995. 37 pp. \$7.00 **(CDIE reference pending)**.

- IDP 19 *Effects of Market Reform on Access to Food by Low-Income Households: Evidence from Four Countries in Eastern and Southern Africa* by T.S. Jayne, L. Rubey, D. Tschirley, M. Mukumbu, M. Chisvo, A. Santos, M. Weber, and P. Diskin. 1995. 83 pp. \$9.00. **(CDIE reference pending)**
- IDP 20 *Cash Crop and Foodgrain Productivity in Senegal: Historical View, New Survey Evidence, and Policy Implications* by Valerie Kelly, Bocar Diagana, Thomas Reardon, Matar Gaye, and Eric Crawford. 1996. 140 pp. \$13.00 **(CDIE reference pending)**

WORKING PAPERS

- IDWP 39/1 *The Impact of Investments in Maize Research and Dissemination in Zambia. Part I: Main Report.* Julie Howard with George Chitalu and Sylvester Kalonge. 1993. 112 pp. \$11.00 **(CDIE reference PN-ABS-724)**
- IDWP 39/2 *The Impact of Investments in maize Research and Dissemination in Zambia. Part II: Annexes.* Julie Howard with George Chitalu and Sylvester Kalonge. 1993. 81 pp. \$9.00 **(CDIE reference PN-ABS-727)**
- IDWP 40 *An Economic Analysis of Research and Technology Transfer of Millet, Sorghum, and Cowpeas in Niger* by Valentina Mazzucato and Samba Ly. 1994. 104 pp. \$11.00. **(CDIE reference PN-ABT-283 or PN-ABS-728)**
- IDWP 41 *Agricultural Research Impact Assessment: The Case of Maize Technology Adoption in Southern Mali* by Duncan Boughton and Bruno Henry de Frahan. 1994. 95 pp. \$11.00 **(CDIE reference PN-ABS-729)**
- IDWP 42 *The Rate of Return to Agricultural Research in Uganda: The Case of Oilseeds and Maize* by Rita Laker-Ojok. 1994. 56 pp. \$7.00 **(CDIE reference PN-ABS-730)**
- IDWP 43 *Assessing the Impact of Cowpea and Sorghum Research and Extension in Northern Cameroon* by James A. Sterns and Richard H. Bernsten. 1994. 48 pp. \$7.00 **(CDIE reference PN-ABS-731)**

- IDWP 44 *Food Security II Cooperative Agreement: Project Fact Sheets (1994 Version)* by MSU Food Security II Research Team. 1994. 104 pp. \$11.00 **(CDIE reference pending)**
- IDWP 45 *The Potential Returns to Oilseeds Research in Uganda: The Case of Groundnuts and Sesame* by Rita Laker-Ojok. 1994. 50 pp. \$7.00 **(CDIE reference pending)**
- IDWP 46 *Understanding Linkages among Food Availability, Access, Consumption, and Nutrition in Africa: Empirical Findings and Issues from the Literature* by Patrick Diskin.* 1994. 47 pp. \$7.00 **(CDIE reference PN-ABS-732)**
- IDWP 47 *Targeting Assistance to the Poor and Food Insecure: A Review of the Literature* by Mattias Lundberg and Patrick Diskin.* 1994. 56 pp. \$7.00 **(CDIE reference PN-ABS-733)**
- IDWP 48 *Interactions Between Food Market Reform and Regional Trade in Zimbabwe and South Africa: Implications for Food Security* by T.S. Jayne, T. Takavarasha, and Johan van Zyl. 1994. 39 pp. \$7.00 **(CDIE reference pending)**
- IDWP 49 *A Strategic Approach to Agricultural Research Program Planning in Sub-Saharan Africa*, by Duncan Boughton, Eric Crawford, Julie Howard, James Oehmke, James Shaffer, and John Staatz. 1995. 59 pp. \$9.00 **(CDIE reference pending)**
- IDWP 50 *An Analysis of Alternative Maize Marketing Policies in South Africa*, by T.S. Jayne, Milan Hajek and Johan van Zyl. 1995. 51 pp. \$7.00 **(CDIE reference pending)**
- IDWP 51 *Confronting the Silent Challenge of Hunger: A Conference Synthesis*, by T.S. Jayne, David Tschirley, Lawrence Rubey, Thomas Reardon, John M. Staatz, and Michael Weber. 1995. 37 pp. \$7.00 **(CDIE reference pending)**
- IDWP 52 *An Ex-Ante Evaluation of Farming Systems Research in Northeastern Mali: Implications for Research and Extension Policy*, by Bruno Henry de Frahan. 1995. 82 pp. \$9.00 **(CDIE reference pending)**
- IDWP 53 *Who Eats Yellow Maize? Preliminary Results of a Survey of Consumer Maize Preferences in Maputo, Mozambique*, by David L. Tschirley and Ana Paula Santos. 1995. 16 pp. \$7.00 **(CDIE reference pending)**
- IDWP 54 *Food Security II Cooperative Agreement: Project Fact Sheets (1995/96 Version)*, compiled by MSU Food Security II Research Team. 1996. 151 pp. \$13.00. **(CDIE reference pending)**
- IDWP 55 *Trends in Real Food Prices in Six Sub-Saharan African Countries*, by T.S. Jayne, et al. 1996. 70 pp. \$9.00 **(CDIE reference pending)**
- IDWP 56 *Food Marketing and Pricing Policy in Eastern and Southern Africa: Lessons for Increasing Agricultural Productivity and Access to Food*, by T.S. Jayne and Stephen Jones. 1996. 40 pp. \$7.00 **(CDIE reference pending)**
- IDWP 57 *An Economic and Institutional Analysis of Maize Research in Kenya*, by Daniel David Karanja. 1996. 24 pp. \$7.00 **(CDIE reference pending)**
- IDWP 58 *Fighting an Uphill Battle: Population Pressure and Declining Land Productivity in Rwanda* by Daniel C. Clay. 1996. 28 pp. \$7.00 **(CDIE reference pending)**

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

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

MSU Bulletin Office

10-B Agriculture Hall

Michigan State University

East Lansing, MI 48824-1039

Fax: (517) 353-7168

Phone: (517) 355-0240

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

ORDER FORM for Papers Available from MSU

Required with all charge card orders:

Check one: _____ VISA _____ MasterCard

Card number: _____

Signature: _____

Expiration Date: _____ Daytime Phone Number: () _____

SHIP TO:

Name: _____

Address: _____

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

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

| | | |
|--------------------|-----------------------|---------------------|
| ___ IDP 13 \$11.00 | ___ IDWP 39/1 \$11.00 | ___ IDWP 47 \$7.00 |
| ___ IDP 14 \$7.00 | ___ IDWP 39/2 \$9.00 | ___ IDWP 48 \$7.00 |
| ___ IDP 14F \$7.00 | ___ IDWP 40 \$11.00 | ___ IDWP 49 \$9.00 |
| ___ IDP 15 \$9.00 | ___ IDWP 41 \$11.00 | ___ IDWP 50 \$7.00 |
| ___ IDP 16 \$7.00 | ___ IDWP 42 \$7.00 | ___ IDWP 51 \$7.00 |
| ___ IDP 17 \$11.00 | ___ IDWP 43 \$7.00 | ___ IDWP 52 \$9.00 |
| ___ IDP 18 \$7.00 | ___ IDWP 44 \$11.00 | ___ IDWP 53 \$13.00 |
| ___ IDP 19 \$9.00 | ___ IDWP 45 \$7.00 | ___ IDWP 54 \$13.00 |
| ___ IDP 20 \$13.00 | ___ IDWP 46 \$7.00 | ___ IDWP 55 \$9.00 |
| | | ___ IDWP 56 \$7.00 |
| | | ___ IDWP 57 \$7.00 |
| | | ___ IDWP 58 \$7.00 |

Sub-Total \$ _____
15% (foreign orders, surface mail) \$ _____

International Airmail postage \$ _____
(call or e-mail for rates)
Total Amount \$ _____

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



How to Order MSU International Development Papers from USAID:

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

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

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

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

Mail: Development Information Services Clearinghouse
1500 Wilson Blvd., Suite 1010
Arlington, VA 22209-2404

Telephone: 703-351-4006

Fax: 703-351-4039

Telex: 703-351-4038

Internet e-mail address: AIDDISC@CAPCON.NET

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

Telephone: 703-875-4818

Fax: 703-875-5269

Prices

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

Exchange programs

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

Deposit accounts

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

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

MSU INTERNATIONAL DEVELOPMENT PAPERS

- IDWP 4 *Sub-Contracting in Rural Areas of Thailand* by Donald C. Mead. 1982. 53 pp. **(CDIE reference PN-AAN-192)**
- IDWP 5 *Microcomputers and Programmable Calculators for Agricultural Research in Developing Countries* by Michael T. Weber, James Pease, Warren Vincent, Eric W. Crawford, and Thomas Stilwell. 1983. 113 pp. **(CDIE reference PN-AAN-441)**
- IDP 1 *Research on Agricultural Development in Sub-Saharan Africa: A Critical Survey* by Carl K. Eicher and Doyle C. Baker. 1982. 346 pp. **(CDIE reference PN-AAL-692)**
- IDP 1F *Etude Critique de la Recherche sur la Developpement Agricole en Afrique Subsaharienne* par Carl K. Eicher et Doyle C. Baker. 1982. 345 pp. **(CDIE reference PN-ABA-840)**
- IDWP 6 *Periodicals for Microcomputers: An Annotated Bibliography* by Thomas Stilwell. 1983. 70 pp. **(CDIE reference PN-AAN-443)**
- IDP 2 *A Simulation Study of Constraints on Traditional Farming Systems in Northern Nigeria* by Eric W. Crawford. 1982. 136 pp. **(CDIE reference PN-AAP-677)**
- IDWP 7 *Employment and Housing in Lima, Peru* by Paul Strassmann. 1983. 96 pp. **(CDIE reference PN-AAN-396)**
- IDP 3 *Farming Systems Research in Eastern Africa: The Experience of CIMMYT and Some National Agricultural Research Services, 1976-81* by M.P. Collinson. 1982. 67 pp. **(CDIE reference PN-AAM-826)**
- IDWP 8 *Faire Face a la Crise Alimentaire de l'Afrique* by Carl K. Eicher. 1983. 29 pp. **(CDIE reference PN-AAN-444)**
- IDP 4 *Animal Traction in Eastern Upper Volta: A Technical, Economic and Institutional Analysis* by Vincent Barrett, Gregory Lassiter, David Wilcock, Doyle Baker, and Eric Crawford. 1982. 132 pp. **(CDIE reference PN-AAM-262)**
- IDWP 9 *Software Directories for Microcomputers: An Annotated Bibliography* by Thomas C. Stilwell. 1983. 14 pp. **(CDIE reference PN-AAN-442)**
- IDP 5 *Socio-Economic Determinants of Food Consumption and Production in Rural Sierra Leone: Application of an Agricultural Household Model with Several Commodities* by John Strauss. 1983. 91 pp. **(CDIE reference PN-AAM-031)**
- IDWP 10 *Instructional Aids for Teaching How to Use the TI-59 Programmable Calculator* by Ralph E. Hepp. 1983. 133 pp. **(CDIE reference PN-AAP-133)**
- IDP 6 *Applications of Decision Theory and the Measurement of Attitudes Towards Risk in Farm Management Research in Industrialized and Third World Settings* by Beverly Fleisher and Lindon J. Robison. 1985. 105 pp. **(CDIE reference PN-AAU-740)**
- IDWP 11 *Programmable Calculator (TI-59) Programs for Marketing and Price Analysis in Third World Countries* by Michael L. Morris and Michael T. Weber. 1983. 105 pp. **(CDIE reference PN-AAP-134)**
- IDP 7 *Private Decisions and Public Policy: The Price Dilemma in Food Systems in Developing Countries* by Peter Timmer. 1986. 58 pp. **(CDIE reference PN-AAZ-091)**
- IDWP 12 *An Annotated Directory of Statistical and Related Microcomputer Software for Socioeconomic Data Analysis* by Valerie Kelly, Robert D. Stevens, Thomas Stilwell and Michael T. Weber. 1983. 165 pp. **(CDIE reference PN-AAP-135)**
- IDP 8 *Rice Marketing in Senegal River Valley: Research Findings and Policy Reform Options* by Michael L. Morris. 1987. 89 pp. **(CDIE reference PN-AAZ-092)**
- IDWP 13 *Guidelines for Selection of Microcomputer Hardware* by Chris Wolf. 1983. 90 pp. **(CDIE reference PN-AAR-106)**
- IDP 9 *Small Scale Industries in Developing Countries: Empirical Evidence and Policy Implications* by Carl Liedholm and Donald Mead. 1987. 141 pp. **(CDIE reference PN-AAX-734)**
- IDWP 14 *User's Guide to BENCOS A SuperCalc Template for Benefit-Cost Analysis* by Eric W. Crawford, Ting-Ing Ho and A. Allan Schmid. 1984. 35 pp. **(CDIE reference PN-AAQ-682)**
- IDP 10 *Maintaining the Momentum in Post-Green Revolution Agriculture: A Micro-Level Perspective from Asia* by Derek Byerlee. 1987. 57 pp. **(CDIE reference PN-AAZ-093)**
- IDWP 15 *An Evaluation of Selected Microcomputer Statistical Programs* by James W. Pease and Raoul Lepage with Valerie Kelly, Rita Laker-Ojok, Brian Thelen, and Paul Wolberg. 1984. 187 pp. **(CDIE reference PN-AAQ-683)**
- IDP 11 *The Economics of Smallholder Maize Production in Zimbabwe: Implications for Food Security* by David D. Rohrbach. 1989. 100 pp. **(CDIE reference PN-ABD-549)**
- IDWP 16 *Small Enterprises in Egypt: A study of Two Governorates* by Stephen Davies, James Seale, Donald C. Mead, Mahmoud Badr, Nadia El Sheikh and Abdel Rahman Saidi. 1984. 187 pp. **(CDIE reference PN-AAU-610)**
- IDWP 17 *Microcomputer Statistical Packages for Agricultural Research* by Thomas C. Stilwell. 1984. 23 pp. **(CDIE reference PN-AAZ-516)**
- IDWP 18 *An Annotated Directory of Citation Database, Educational, System Diagnostics and Other Miscellaneous Microcomputer Software of Potential Use to Agricultural Scientists in Developing Countries* by Thomas C. Stilwell and P. Jordan Smith. 1984. 34 pp. **(CDIE reference PN-AAZ-523)**

WORKING PAPERS

- IDWP 19 *Irrigation in Southern Africa: An Annotated Bibliography* by Amalia Rinaldi. 1985. 60 pp. **(CDIE reference PN-AAZ-524)**
- IDWP 20 *A Microcomputer Based Planning and Budgeting System for Agricultural Research Programs* by Daniel C. Goodman, Jr., Thomas C. Stilwell and P. Jordan Smith. 1985. 75 pp. **(CDIE reference PN-AAZ-525)**
- IDWP 21 *Periodicals for Microcomputers: An Annotated Bibliography, Second Edition* by Thomas C. Stilwell. 1985. 89 pp. **(CDIE reference PN-AAZ-526)**
- IDWP 22 *Software Directories for Microcomputers: An Annotated Bibliography, Second Edition* by Thomas C. Stilwell. 1985. 21 pp. **(CDIE reference PN-AAZ-528)**
- IDWP 1 *Farming Systems Research (FSR) in Honduras, 1977-81: A Case Study* by Daniel Galt, Alvaro Diaz, Mario Contreras, Frank Peairs, Joshua Posner, and Franklin Rosales. 1982. 48 pp. **(CDIE reference PN-AAM-827)**
- IDWP 2 *Credit Agricole et Credit Informal dans la Region Orientale de Haute-Volta: Analyse Economique, Performance Institutionnelle et Implications en Matiere de Politique de Developpement Agricole* by Edouard K. Tapsoba. 1982. 125 pp. **(CDIE reference PN-AAZ-527)**
- IDWP 3 *Employment and Construction: Multicountry Estimates of Costs and Substitutions Elasticities for Small Dwellings* by W.P. Strassmann. 1982. 42 pp. **(CDIE reference PN-AAM-455)**

| | | | |
|-----------------------|---|--------|--|
| IDWP 23 | <i>A diagnostic Perspective Assessment of the Production and Marketing System for Mangoes in the Eastern Caribbean</i> by Alan Hrapsky with Michael Weber and Harold Riley. 1985. 106 pp. (CDIE reference PN-AAZ-529) | RP 2 | <i>Influencing the Design of Marketing Systems to Promote Development in Third World Countries</i> by James D. Shaffer with Michael Weber, Harold Riley and John Staatz. 1987. 21 pp. (CDIE reference PN-AAV-230) |
| IDWP 24 | <i>Subcontracting Systems and Assistance Programs: Opportunities for Intervention</i> by Donald C. Mead. 1985. 32 pp. (CDIE reference PN-AAZ-943) | RP 3 | <i>Famine Prevention in Africa: The Long View</i> by Carl K. Eicher. 1987. 18 pp. (CDIE reference PN-AAZ-119) |
| IDWP 25 | <i>Small Scale Enterprise Credit Schemes: Administrative Costs and the Role of Inventory Norms</i> by Carl Liedholm. 1985. 23 pp. (CDIE reference PN-AAU-615) | RP 4 | <i>Cereals Marketing in the Senegal River Valley</i> by Michael L. Morris. 1987. 126 pp. (CDIE reference PN-AAZ-120) |
| IDWP 26 | <i>Subsector Analysis: Its Nature, Conduct and Potential Contribution to Small Enterprise Development</i> by James J. Boomgard, Stephen P. Davies, Steve Haggblade and Donald Mead. 1986. 57 pp. (CDIE reference PN-AAZ-101) | RP 5 | <i>The Food Security Equation in Southern Africa</i> by Mandivamba Rukuni and Carl K. Eicher. 1987. 32 pp. (CDIE reference PN-AAZ-121) |
| IDWP 27 | <i>The Effect of Policy and Policy Reforms on Non-Agricultural Enterprises and Employment in Developing Countries: A Review of Past Experiences</i> by Steve Haggblade, Carl Liedholm, and Donald C. Mead. 1986. 133 pp. (CDIE reference PN-AAV-001) | RP 6 | <i>Economic Analysis of Agronomic Trials for the Formulation of Farmer Recommendations</i> by Eric Crawford and Mulumba Kamuanga. 1988. 41 pp. (CDIE reference PN-AAZ-370) |
| IDWP 28 | <i>Rural Small Scale Enterprises in Zambia: Results of a 1985 Country-Wide Survey</i> by John T. Milimo and Yacob Fisseha. 1986. 76 pp. (CDIE reference PN-AAZ-102) | RP 6F | <i>L'Analyse Economiques des Essais Agronomiques pour la Formulation des Recommendations aux Paysans</i> par Eric Crawford et Mulumba Kamuanga. 1987. 33 pp. (CDIE reference PN-AAZ-122) |
| IDWP 29 | <i>Fundamentals of Price Analysis in Developing Countries' Food Systems: A Training Manual to Accompany the Microcomputer Software Program 'MSTAT'</i> by Stephen Goetz and Michael T. Weber. 1986. 148 pp. (CDIE reference PN-AAZ-103) | RP 7 | <i>Economic Analysis of Livestock Trials</i> by Eric Crawford. 1987. 36 pp. (CDIE reference PN-AAZ-371) |
| IDWP 30 | <i>Rapid Reconnaissance Guidelines for Agricultural Marketing and Food System Research in Developing Countries</i> by John S. Holtzman. 1986. 75 pp. (CDIE reference PN-AAZ-104) | RP 7F | <i>L'Analyse Economique des Essais Zootechniques</i> par Eric Crawford. 1987. 36 pp. (CDIE reference PN-AAZ-123) |
| IDWP 31 | <i>Contract Farming and Its Effect on Small Farmers in Less Developed Countries</i> by Nicholas William Minot. 1986. 86 pp. (CDIE reference PN-AAZ-105) | RP 8 | <i>A Field Study of Fertilizer Distribution and Use in Senegal, 1984: Summary Report</i> by Eric Crawford and Valerie Kelly. 1987. 32 pp. (CDIE reference PN-AAZ-124) |
| IDWP 32 | <i>Food Security Policy and the Competitiveness of Agriculture in the Sahel: A Summary of the "Beyond Mindelo" Seminar</i> by Thomas S. Jayne and Nicholas Minot. 1989. 27 pp. (CDIE reference PN-ABF-570) | RP 8F | <i>Enquete sur la Distribution et l'Utilisation de l'Engrais au Sénégal, 1984: Résumé Analytique</i> par Eric Crawford et Valerie Kelly. 1988. 43 pp. (CDIE reference PN-ABC-173) |
| IDWP 33 | <i>Small Scale Manufacturing Growth in Africa: Initial Evidence</i> by Carl Liedholm and Joan Parket. 1989. 18 pp. (CDIE reference PN-ABB-945) | RP 9 | <i>Improving Food Marketing Systems in Developing Countries: Experiences from Latin America</i> by Kelly Harrison, Donald Henley, Harold Riley and James Shaffer. 1987. 135 pp. (CDIE reference PN-AAZ-125) |
| IDWP 34 | <i>Food Security and Economic Growth in the Sahel: A Summary of the September 1989 Cereals Workshop</i> by Victoire C. D'Agostino and John M. Staatz. 1989. 44 pp. (CDIE reference PN-ABD-956) | RP 10 | <i>Policy Relevant Research on the Food and Agricultural System in Senegal</i> by Mark Newman, Eric Crawford and Jacques Faye. 1987. 30 pp. (CDIE reference PN-AAZ-126) |
| IDWP 35 | <i>User's Manual for the SADCC Cereals Trade Database Compiled by the University of Zimbabwe and Michigan State University</i> by David Kingsbury. 1989. 44 pp. (CDIE reference PN-ABF-378) | RP 10F | <i>Orientations et Programmes de Recherche Macro-Economiques sur le Systeme Agro-Alimentaire Sénégalais</i> par Mark Newman, Eric Crawford et Jacques Faye. 1987. 37 pp. (CDIE reference PN-AAZ-127) |
| IDWP 36 | <i>Managing Food Security Action Programs in Botswana</i> by Sisay Asefa. 1989. 36 pp. (CDIE reference PN-ABF-377) | RP 11 | <i>A Field Study of Fertilizer Distribution and Use in Senegal, 1984: Final Report</i> by Eric Crawford, Curtis Jolly, Valerie Kelly, Philippe Lambrecht, Makhona Mbaye, and Matar Gaye. 1987. 106 pp. (CDIE reference PN-AAZ-128) |
| IDWP 37 | <i>User's Guide to BENCOS Lotus 1-2-3 Templates for Benefit-Cost Analysis</i> by Eric Crawford and A. Allan Schmid. 1990. 23 pp. (CDIE reference PN-ABF-530) | RP 11F | <i>Enquête sur la Distribution et l'Utilisation de l'Engrais au Sénégal, 1984: Rapport Final</i> par Eric Crawford, Curtis Jolly, Valerie Kelly, Philippe Lambrecht, Makhona Mbaye, et Matar Gaye. 1987. 106 pp. (CDIE reference pending) |
| IDWP 38 | <i>Research Methods in the MSU Food Security in Africa Project: Conceptualizing and Implementing Policy Relevant Studies</i> by James F. Tefft with Michael T. Weber and John M. Staatz. 1990. 128 pp. (CDIE reference pending) | RP 12 | <i>Private and Public Sectors in Developing Country Grain Markets: Organization Issues and Options in Senegal</i> by Mark D. Newman, P. Alassane Sow, and Ousseynou NDoye. 1987. 14 pp. (CDIE reference PN-AAZ-129) |
| | | RP 13 | <i>Agricultural Research and Extension in Francophone West Africa: The Senegal Experience</i> by R. James Bingen and Jacques Faye. 1987. 23 pp. (CDIE reference PN-AAV-929) |
| | | RP 13F | <i>La Liaison Recherche-Developpement en Afrique de l'Ouest Francophone: L'Experience du Sénégal</i> par James Bingen et Jacques Faye. 1987. 32 pp. (CDIE reference PN-AAZ-130) |
| | | RP 14 | <i>Grain Marketing in Senegal's Peanut Basin: 1984/85 Situation and Issues</i> by Mark D. Newman. 1987. 16 pp. (CDIE reference PN-AAZ-131) |
| REPRINT PAPERS | | | |
| RP 1 | <i>The Private Sector Connection to Development</i> by Carl Liedholm. 1986. 19 pp. (CDIE reference PN-AAW-353) | | |

- RP 15 *Tradeoffs between Domestic and Imported Cereals in Senegal: A Marketing Systems Perspective* by Mark D. Newman, Ousseynou NDoye, and P. Alassane Sow. 1987. 41 pp. **(CDIE reference PN-AAZ-372)**
- RP 15F *Céréales Locales et Céréales Importées au Sénégal: La Politique Alimentaire a Partier Systemes de Commercialisation* par Mark D. Newman, Ousseynou NDoye, et P. Alassane Sow. 1987. 48 pp. **(CDIE reference PN-ABC-326)**
- RP 16 *An Orientation to Production Systems Research in Senegal* by R. James Bingen. 1987. 88 pp. **(CDIE reference PN-AAZ-373)**
- RP 16F *Orientation de la Recherche sur les Systemes de Productions au Sénégal* par R. James Bingen. 1987. 94 pp. **(CDIE reference PN-AAZ-374)**
- RP 17 *A Contribution to Agronomic Knowledge of the Lower Casamance (Bibliographical Synthesis)* by J.L. Posner. 1988. 47 pp. **(CDIE reference PN-AAZ-375)**
- RP 17F *Contribution a la Connaissance Agronomique de la Basse Casamance (Synthese Bibliographique)* par J.L. Posner. 1988. 47 pp. **(CDIE reference PN-ABC-167)**
- RP 18 *Acquisition and Use of Agricultural Inputs in the Context of Senegal's New Agricultural Policy: The Implications of Farmers' Attitudes and Input Purchasing Behavior for the Design of Agricultural Policy and Research Programs* by Valerie Auserehl Kelly. 1988. 30 pp. **(CDIE reference PN-AAZ-376)**
- RP 18F *Acquisition et Utilisation d'Intrants Agricoles dans le Contexte de la Nouvelle Politique Agricole du Sénégal: Implications des Attitudes et du Comportement d'Achat d'Intrants des Exploitants pour l'Elaboration d'une Politique Agricole et de Programmes de Recherches* par Valerie Auserehl Kelly. 1988. 35 pp. **(CDIE reference PN-AAZ-377)**
- RP 19 *Farmers' Demand for Fertilizer in the Context of Senegal's New Agricultural Policy: A Study of Factors Influencing Farmers' Fertilizer Purchasing Decisions* by Valerie Auserehl Kelly. 1988. 47 pp. **(CDIE reference PN-AAZ-378)**
- RP 19F *Demande d'Engrais de la Part des Exploitants dans le Contexte de la Nouvelle Politique Agricole au Sénégal: Une Etude des Facteurs Influcant les Decisions d'Achat d'Engrais Prises par les Exploitants* par Valerie Auserehl Kelly. 1988. 58 pp. **(CDIE reference PN-AAZ-379)**
- RP 20 *Production Systems in the Lower Casamance and Farmer Strategies in Response to Rainfall Deficits* by J.L. Posner, M. Kamuanga, and S. Sall. 1988. 33 pp. **(CDIE reference PN-ABC-162)**
- RP 20F *Les Systemes de Production en Basse Casamance et les Stratégies Paysannes Face du Deficit Pluviométrique* par J.L. Posner, M. Kamuanga, et S. Sall. 1988. 33 pp. **(CDIE reference PN-ABC-163)**
- RP 21 *Informing Food Security Decisions in Africa: Empirical Analysis and Policy Dialogue* by Michael T. Weber, John M. Staatz, John S. Holtzman, Eric W. Crawford, and Richard H. Bernsten. 1989. 11 pp. **(CDIE reference PN-ABE-627)**
- RP 21F *Comment Informer les Decisions Traitant de la Sécurité Alimentaire en Afrique: Analyses Empiriques et Dialogue Politique* par Michael T. Weber, John M. Staatz, John S. Holtzman, Eric W. Crawford, et Richard H. Bernsten. 1989. 13 pp. **(CDIE reference PN-ABD-104)**
- RP 22 *The Creation and Establishment of Production Systems Research in a National Agricultural Research Institute: The Senegal Experience* by Jacques Faye, James Bingen, and Etienne Landais. 1988. 25 pp. **(CDIE reference PN-ABC-161)**
- RP 23 *Foreign Trade of Agricultural Products and Inputs in Senegal from 1975 to 1984* by Frederic Martin and Alioune Dieng. 1988. 45 pp. **(CDIE reference PN-ABC-164)**
- RP 23F *Le Commerce Exterieur de Produits et d'Intrants Agricoles du Sénégal de 1975 a 1984* par Frederic Martin et Alioune Dieng. 1990. 45 pp. **(CDIE reference PN-ABF-529)**
- RP 24 *Regulatory Uncertainty and Government Objectives for the Organization and Performance of Cereal Markets: The Case of Senegal* by Mark D. Newman, P. Alassane Sow, and Ousseynou NDoye. 1988. 24 pp. **(CDIE reference PN-ABC-159)**
- RP 24F *Incertitude Réglementaire, Objectifs Gouvernementaux, Organisation et Performances des Marchés Céréaliers: Le Cas du Sénégal* par Mark D. Newman, P. Alassane Sow, and Ousseynou NDoye. 1988. 24 pp. **(CDIE reference PN-ABC-160)**
- RP 25F *Etude sur la Commercialisation des Céréales dans la Région du Fleuve Sénégal: Méthodologie* par Michael Morris. 1988. 48 pp. **(CDIE reference PN-ABC-172)**
- RP 26 *The Regulation and Organization of Cereal Markets in Senegal: Report on the Marketing Campaigns of 1983/84 and 1984/85* by P. Alassane Sow and Mark D. Newman. 1988. 29 pp. **(CDIE reference PN-ABC-165)**
- RP 26F *La Réglementation et l'Organisation des Marchés Céréaliers au Sénégal: Situation des Campagnes des Commercialisation 1983/84 et 1984/85* par P. Alassane Sow et Mark D. Newman. 1988. 35 pp. **(CDIE reference PN-ABC-166)**
- RP 27 *Farm Level Cereal Situation in Lower Casamance: Results of a Field Study* by C.M. Jolly, M. Kamuanga, S. Sall, and J.L. Posner. 1988. 35 pp. **(CDIE reference PN-ABC-157)**
- RP 27F *Situation Céréaliere en Milieu Paysan en Basse Casamance: Résultats d'une Enquête de Terrain* par C.M. Jolly, M. Kamuanga, S. Sall, et J.L. Posner. 1988. 41 pp. **(CDIE reference PN-ABC-158)**
- RP 19F *Annexe 1 Budgets de Culture et Analyse des Marges dans le Bassin Arachidier.* 1988. 134 pp. **(CDIE reference PN-ABC-169)**
- RP 19F *Annexe 2 Budgets de Culture et Analyse des Marges au Sénégal Oriental et en Casamance.* 1988. 204 pp. **(CDIE reference PN-ABC-170)**
- RP 19F *Annexe 3 Budgets de Culture et Analyse des Marges dans la Vallée du Fleuve Sénégal.* 1988. 214 pp. **(CDIE reference PN-ABC-171)**
- RP 29 *Agricultural Development and Policy in Senegal: Annotated Bibliography of Recent Studies, 1983-89* by Eric Crawford, R. James Bingen, and Malcolm Versel. 1990. 254 pp. **(CDIE reference PN-ABE-271)**
- RP 30 *Lowland Cropping Systems in the Lower Casamance of Senegal: Results of Four Years of Agronomic Research (1982-1985)* by Joshua Posner, Mulumba Kamuanga, and Mamadou Lo. 1990. 130 pp. **(CDIE reference pending)**
- RP 31 *Farming Systems Research in Southern Senegal: The Djibelor Experience (1982-1986)* by Mulumba Kamuanga and Joshua L. Posner. 1992. 57 pp. **(CDIE reference pending)**