Population, Environment, and Development in Africa

Dynamic Linkages and their Implications for Future Research and Development Programming

Daniel C. Clay
Institute of International Agriculture
Michigan State University

Thomas Reardon
Department of Agricultural Economics
Michigan State University

Asif Shaikh
International Resources Group

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EXECUTIVE SUMMARY

Population, Environment, and Development in Africa:

Dynamic Linkages and their Implications for Future Research and Development Programming

Background and Problem

Turning the tide on rapid population growth, declining agricultural productivity, and natural resource degradation are three portentous and immediate challenges facing Africa's development community.

These challenges are not isolated from one another; they are intimately related. What happens to agriculture affects the environment on and off the farm. What happens to forests affects the food security strategies of farmers and biodiversity of the ecosystem. What happens in the off-farm rural economy affects the options farmers have to farming, as well as their capacity to sustainably intensify farming. And what happens to rural households' food security and incomes affects their health and childbearing decisions.

Strategic planning and development programming, however, tend to focus on individual sectors such as the environment, agriculture, and population; they do not explicitly take into account the compatibilities and inconsistencies among them. Sectoral solutions of the past are no longer adequate. The downward spiral of population pressure, poverty, and degradation have created new complexities and we must be prepared to adjust our approach in ways that will capture and respond to this complexity.

Approach

African farm households and their livelihood strategies are at the core of the intersectoral linkages approach advocated in this monograph. The approach focuses on the behavioral alternatives to demographic pressure, resource degradation, and poverty. The alternative paths, and the dynamic linkages among them, are far and away the farm household's most worrisome concern. Farmers must weigh the differences between, and synergies among, alternative "sectoral" paths such as intensifying farm production, seeking off-farm employment, and limiting or spacing births.

In parallel fashion, government officials and development programmers must seek effective synergies and balance among "sectoral" program goals such as agricultural intensification, income diversification (through the promotion of off-farm businesses), and family planning. In short, government and donor strategic and program planning needs to address the very same set of sectoral interactions confronted daily by poor rural households. Understanding how these paths are linked is imperative for household decision-making as well as for development policy and program action.

This monograph addresses the need for an intersectoral approach to development policy and programming in two distinct but integrated ways. First, we target key gaps in the population-environment-development research debate, and draw on findings from three African case studies to begin to bridge these gaps. Second, we use the case studies to demonstrate the usefulness of the intersectoral approach for drawing new insights and examining their strategic implications.

Each of the three country case studies presented in this document is uniquely different from the others in terms of specific research focus, but all three hold several things in common: 1) they represent one or another geographical or climatic region of sub-Saharan Africa, 2) they represent countries experiencing population growth, increased poverty, and environmental decline, and 3) they adopt an intersectoral population-environment-development framework. Rwanda, Niger, and Madagascar are the three case study countries presented.

Knowledge Gaps in the Population-Environment-Development Debate

Classical and NRM models of population-development-environment interactions have focused on the alternative macro-level strategies that populations adopt in response to increasing population pressure and re-

source scarcity. Malthus, Boserup, and others define the classical demographic and economic positions in the debate. Others have since refined the debate by focusing on the alternative agricultural intensification paths. Addressed in this monograph are three important knowledge gaps:

1. Household strategies as the behavioral basis of population-environment-development links

   In general, conceptual and empirical work in the tropics has focused on how broad groups of farmers, in particular agroclimatic zones and policy contexts, face incentives (such as relative prices) and conditions (such as access to markets or new technologies) for following one or the other intensification path.

   Missing from the mainstream of research is an understanding of the behavioral and structural basis for intersectoral linkages, i.e., how households integrate demographic, income, and resource use strategies, and how they relate actions and opportunities in one sector relative to those in another. Understanding the subtle interactions between households' employment off-farm, for example, and their incentive and capacity to invest in sustainable intensification, food purchases, education of their children, and so on, is instrumental to strategic thinking and the way we approach development programming.

2. Conditioning factors

   The classical model of the context and characteristics of intensification is conditioned by three factors that subsequent macro-level analysis and debate have not taken into account. They are as follows:

   First, the model is limited to traditional rural, farm economies, and focuses on technological change to the exclusion of employment/income diversification.

   Second, the classical model of agricultural intensification presupposes a traditional peasant context where farmers buy and sell little in the food and fiber markets. But the modern African peasant's world is much more commercial and monetized; they are regular participants in food and fiber markets. These factors must be incorporated into our research and strategic thinking.

Third, previous research fails to recognize that peasant strategies that promote intensification (or cope with unsuccessful intensification) may require labor, thereby increasing the incentive for childbearing.

3. Using the research findings

The need to understand what the population-environment-development debate means for practical concerns like strategic thinking and development programming is long overdue. The absence of a more practical focus stems from the fact that so much of the research has been based on historical analyses of broad societal trends, and that development practioners have not tended to drive the debate. The study of the interactions and synergies that make household strategies successful must be clearly articulated and extended to the program level.

Informing the Debate: Key Study Findings

1. *Efforts to save the forests and bio-diversity cannot succeed without first meeting the income needs of rural households and promoting "sustainable intensification" on the lands they are already farming.*

Sustainably intensifying production on current holdings will reduce the pressure on poor farmers to push onto fragile margins and to rely on labor-intensive gathering strategies off-farm in the biodiversity-rich commons. Cropping intensification need not be the enemy of the environment. It can be accomplished in a way that meets food and fiber supply goals and helps the environment on- and off-farm.

2. *Protecting the environment is crucial to economic growth.*

Soil conservation measures have a large positive effect on farm productivity. Hence, soil degradation hurts the food security of households and regions by undermining farm productivity and food and fiber output growth.

3. Nonfarm employment, small enterprise promotion, and cash crop promotion, can be important to the environment through their positive impact on sustainable agricultural intensification.

In the current farm economy of Africa, having one's own sources of cash income is crucial to being able to buy farm inputs. The key sources of this cash are nonfarm jobs (locally or in migration) and cash crops. And where there is "surplus population" in the rural areas that cannot be employed productively on the farm, nonfarm jobs allow an "escape valve" to lessen pressure on the land. Moreover, diversified incomes (both on farm, and off-farm) help poor farmers deal with risk, reducing their need to use the fragile commons as a "buffer" to deal with risk, and helping them buy food.

4. *Government and donor attempts to slow population growth (via family planning) are not necessarily seen by households as complementary to their income strategies.*

Particularly among farm households, having *more* children often increases family "success" and continuity through greater household wealth, security, and social standing. Thus, farm households see children as an asset, while public policy and program action see more children as a growing liability. These incongruous views and behaviors create a "demographic tragedy of the commons."

5. *Population changes are not independent of, or exogenous to, changes in household strategies, environmental degradation, and income growth.*

Conventional NRM and economic development frameworks and literature have tended to reinforce sectoral thinking and sectoral boundaries by characterizing population variables (fertility, mortality, and migration) as "unmanageable." Demographic patterns do influence income strategies and the ways in which households manage land and other resources, but these population variables are in turn in affected by household income and resource management (i.e., reverse effects).

6. *Land markets and land tenure are critical policy issues mediating how population increase translates into problems for agriculture and the environment.*

The *structure of landholding* (including land tenure and bio-physical characteristics) is found to be central to on-farm population-environment

interactions. Farmers need confidence in the longer term through secure land tenure. This means reducing the risk of appropriation and the right to transact land. Enhancing farmer access to the land markets will require reform of existing and antiquated land laws prevalent throughout sub-Saharan Africa.

Program Implications

In general, government officials and development programmers must seek effective synergies and balance among "sectoral" program goals such as agricultural intensification, income diversification through small business promotion, and family planning. Government and donor strategic and program planning needs to mirror the same set of interactions made by poor rural households. Understanding how rural households behave, how they plan, how their strategies are formed and linked, is critical to understanding how programs and policies can best increase their welfare and reduce conflicts among goals.

1. Farmers constitute the great majority of the population of Africa, and hence will be the main actors affecting the achievement of the three goals of protecting the environment, slowing population growth, and promoting broad-based development. Understanding their logic and strategies and their needs will be crucial to addressing these three goals.

2. Rural households' strategies are centered on the need to sustain food security through a mix of income-earning activities, and typically has a short-term planning horizon. Where there is an imbalance in government or donor programs that puts undue emphasis on rapid change in a single "sector" such as the environment, without addressing the immediate survival needs of rural households, there will be an unavoidable undermining of the program. The rural household's overall goal should inform the "results" objective of the sum of government and donor programs.

3. If the government or the donors want rural households to discontinue one of their strategies, such as cutting down the forest, it is important to have alternatives in place that replace the foregone income. While changes in policies and regulations and even in governance will help create these alternatives, they are necessary but not sufficient—there will usually be a need for investment in the public goods such as in roads or dams that will

make the alternatives possible. Fiscal and foreign assistance resources are scarce, and so these investments have to be chosen carefully to remove crucial bottlenecks.

4. It also takes time—years—to change the underlying economic behavior and strategies of rural households. It is naive to expect rapid changes in "indicators" without putting in place a new economic context that allows the basic strategies to change without disrupting household income and food security.

5. Quick action can be called for to keep households' compelling urge to survive from turning into long-lasting damage to the environment. An example is where emergency relief can reduce the immediate reliance of refugees on the surroundings.

6. The success of a given program can hang on the success of other programs in other sectors. Farm sector programs, for example, can be crucial to the success of forest and wetland protection programs.

PART I

OVERVIEW

Daniel C. Clay
Thomas Reardon
Asif Shaikh

1. INTRODUCTION

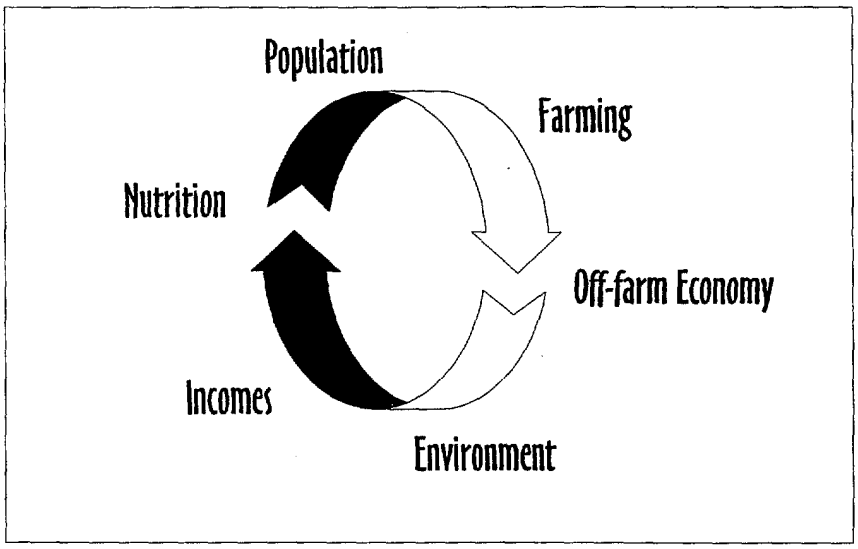
Sub-Saharan Africa is facing challenges as formidable today as they ever have been in the fifty years since the end of the colonial era. The collective voice of Africa's development community asks how can we slow the most explosive population growth the world has ever known, while absorbing its flow into the city or generating new productive employment in the countryside? How can we turn the tide on declining agricultural productivity and growing poverty, a pervasive trend observed across the subcontinent? How can we achieve environmental sustainability in the face of continuing degradation of scarce land, forest, and water resources? And finally, how can these challenges be met in an environment that has become increasingly unstable due to political and ethnic conflict?

Trends and Links

These portentous trends and challenges are not isolated from one another; they are intimately related. Population growth is putting more pressure on farmland. Farmers with access to affordable inputs and in areas where agriculture is profitable are intensifying sustainably. That is, they are farming more on the same land but making appropriate land improvements and using inputs to maintain or enhance soil fertility. But far more common are the farmers who push their land to the limit without using enough fertilizer, manure and compost, or without protecting the land with terraces and bunds, or those who push their farming out into the commons to sur-

vive.[1] If they can foot the migration costs, they move to the cities and to the mines and plantations for work. In turn, the degradation is reducing land productivity and increasing food insecurity. This growing poverty then results in higher birth rates, and the cycle is perpetuated. The policy and economic context has in some cases exacerbated this vicious circle by undermining the public agricultural support system. That system, in past decades (although in a costly and fiscally unsustainable way) helped make farm inputs affordable. Moreover, the reigning instability of prices and climate makes farming risky, which reduces the incentive to make the kinds of investments that would reduce the environment-agricultural tradeoff.

Figure 1. Dynamic Links



In short, the links in this system form a cycle. Figure 1 shows that population growth affects how farming is practiced. In turn, the links are strong between the farm, the environment, and the rest of the economy, and these economic and physical outcomes in turn affect population growth. What happens to agriculture affects the farm environment, as well as the environment off farm in forests, hillsides and wetlands. And what happens

[1]The "commons" here refers to land under collective stewardship. It includes unexploited, virgin territories as well as heavily used farm and range lands.

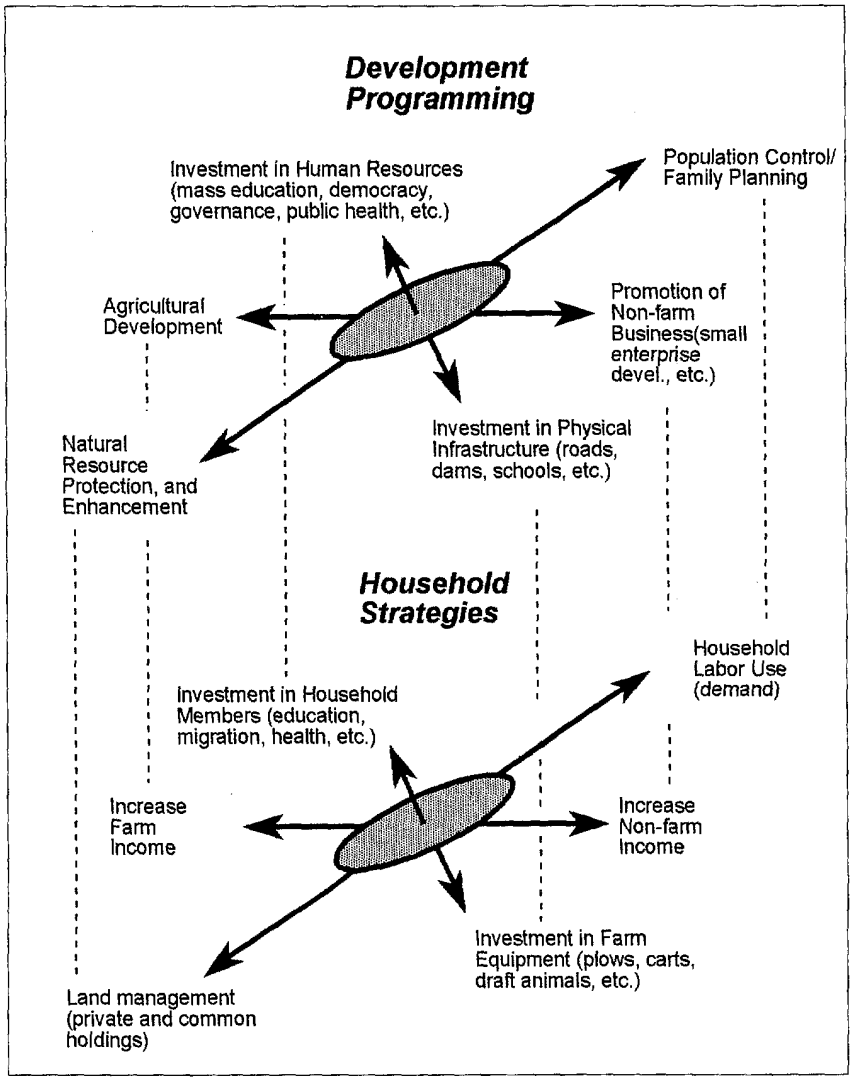
to forests then affects food security strategies (wood and wild flora/fauna gathering and use of commons resources as inputs into service and small-scale manufacturing activities of rural families). It also affects the bio-diversity of the ecosystem which is important to farming through species provision, and is often important culturally and socially, etc. What happens in the cities and the off-farm rural economy affects the alternatives farmers have to farming, as well as the means they can employ to buy inputs and hire labor to sustainably intensify farming. And what happens to rural households' food security and incomes influences their demographic fertility choices and their health, which in turn affect land resources.

African farm households and their livelihood strategies are at the core of the intersectoral linkages described above and depicted in Figure 1.[2] We take as our starting point the farm household surrounded by the conditions described above, and now pervasive in sub-Saharan Africa: growing population pressure, declining agricultural productivity, and growing poverty. The approach focuses on the behavioral alternatives to demographic pressure, resource degradation, and poverty. The alternative paths, and the dynamic linkages among them, are far and away the farm household's most worrisome concern. As such, they must also constitute the top priority of the development planner, and figure prominently in major program decisions.

The above constellation of household-level paths and alternatives is depicted in the lower half of Figure 2. Farm/rural households can adopt a mix of activities in the farm and nonfarm sectors. To undertake these activities, they use family and/or hired labor, land they own or rent, and capital equipment and other inputs. Based on their "means of production" (family size and wealth in terms of land, money, and equipment), their short term problem is to pursue activities that meet the income and food needs of the household. These choices, both in the short and the longer term, affect their health and nutrition, they affect the quality of their land, and they affect the forests, wetlands, and hillsides around them. In the longer run, choosing to invest in the "means of production" will affect household welfare. How many children they have, health care and education they invest in, and their migration patterns will affect labor availability for farm and nonfarm activities. Investment in farm capital or purchase of fertilizer

[2]Support for the household strategies approach is gleaned from the recent conclusion by Falcon (1996) that the reformulation of the household as an economic entity is one of the most important research breakthroughs of the past decade, and that additional research on households and how they work is one of the most interesting analytical issues for the future.

Figure 2. Linking natural resources, human resources and farm/non-farm activities is as important for development programmers as for farm households. Investments in human and physical capital cross-cut these linkages at both levels.



and animals will affect their ability to intensify production sustainably on the land they have. Their capacity to make investments will be conditioned

by credit markets, but also by the wealth available from livestock husbandry, cash cropping, and nonfarm activity. The latter is often of special importance both as a source of cash to make farm investments, or, alternatively, as an "escape valve" to relieve growing pressure on that land.

Hence, the farm household sees that what it does in the nonfarm sector affects what it can do in the farm sector, what education investments it can make, and how reliant it is on the land. It also sees that its childbearing and education decisions affect what chances it has to work off-farm (and at what wage), and how much family labor it will have to meet farming and land improvement needs. In short, the household must engage in cross-sectoral strategic planning to meet its needs. It can combine complementary sectoral choices, or choose between alternative paths.

We argue here that governments and donor missions face very similar sets of choices and opportunities, but at an aggregate level. We posit further that these actors, unlike households, are less likely to recognize the links among these choices and take them into account in their strategic planning, and this to their detriment.[3] The top half of Figure 2 shows the interrelated challenges to development programming, and one can see that they parallel those faced by rural households. Where the household weighs investments in human capital (in education, in health, in numbers) and in "social capital" (in connections to local governments, in social status, in links to other households), governments and donors weigh investments in education, public health, democracy and governance structures, and so on. Where households make decisions about household members and labor (childbearing, training, time allocation, etc.), governments and donors weigh the relative merit of family planning programs, worker training, extension service funding, and so on. Where households make choices about farm and off-farm capital investments, governments and donors weigh the hard and soft infrastructure alternatives such as roads, dams, dikes, irrigation systems, agricultural research institutions, communications, and so on. Where households strike a balance between farm and off-farm income generation, governments and donors strike a similar balance in their support for agricul-

[3]While we underscore household and national-level choices and behaviors here, it is clear that intermediate aggregations such as regions, watersheds, and communities are also important. Our attention to national-level decision-making stems from the fact that economic, agricultural, and population policy is almost always formulated at that level and because government and donor development program goals are typically cast in national terms. We recognize, however, that communities and other "grass roots" aggregations can be closer to households in their stated needs and actions than to their national governments.

tural development and nonfarm small business promotion. Finally, where households struggle with erosion and degradation of their farm lands, as more and more time is spent searching for grazing land or fuelwood or clean water, governments and donors struggle with the aggregate consequences of peasant survival strategies, of logging, mining, and plantation land-use, and of profit-making strategies on the land and its water and biodiversity resources, both on-farm and in the commons.

Hence, the parallels are striking between what the household must decide in a "multisectoral world," and what the government and donor face. But where the household sees naturally the links because it must (for instance, it knows it must start an off-farm business to generate the cash to buy a plow), very different thinking and strategizing prevails in many governments and donor missions. For instance, rarely does a ministry of agriculture meet with a ministry of industry to confer on complementary strategies for rural development to make the links and create "virtuous spirals" of growth in the two sectors. Rarely would a small business promotion unit in a donor mission mesh its strategy with that of the agricultural development office; rarely would the population unit take into close account the rural household's economic survival strategies on and off the farm, and how these relate to their fertility, migration, health care, and education decisions.

This lack of strategic linkage can be dangerous, not only because it means stopping short of finding the best possible complementary solutions, but because a seemingly well-conceived "sectoral" strategy can be easily undermined by factors developing outside that sector, factors that need to be spotted and dealt with as part of the larger program strategy. For example, a program designed to protect a biodiversity-rich forest in Madagascar cannot neglect imposing problems in the farm sector. To survive, farmers will relentlessly push farming up the hillsides and into the forest. If fertilizer becomes too expensive, or roads too poor, or farmland too degraded, farming is undermined and desperate extensification ensues. A good farm strategy can thus be at least as important as a good forest strategy in saving those forests.

Not too late, we think, there are moves afoot to start making these strategic links, in a practical way, in governments and donor missions. AID's reengineering has that idea at its base, as did the Rio conference, the

GREAN initiative,[4] and others. This monograph provides grist and support for making these links—deeper and faster in donor mission and government strategizing and programs—and provides examples of where links are important and action is called for. We do so in two distinct but integrated ways. First, we target key gaps in the population-environment-development research debate, and draw on findings from three African case studies to begin to bridge these gaps. Second, we use the case studies to demonstrate the usefulness of the intersectoral approach for drawing new insights and examining their strategic implications. The second is clearly dependent on the first, since coherent and effective strategic planning requires a firm grasp of how the problems of population growth, poverty, and resource degradation are linked.

Each of the three country case studies presented in this document is uniquely different from the others in terms of specific research focus, but all three hold several things in common: 1) they represent one or another geographical or climatic region of sub-Saharan Africa, 2) they represent countries experiencing population growth, increased poverty, and environmental decline, and 3) they adopt an intersectoral population-environment-development framework. Rwanda, Niger, and Madagascar are the three case study countries presented. The case studies have been written as stand-alone chapters for this monograph, but with the exception of the Madagascar study, they are based on research funded primarily by sources other than EPAT. They are briefly described below:

1. In the Rwanda case study, Clay and Reardon examine the impact of population pressure and resource scarcity among Rwandan farm households, and on the survival strategies they adopt in response. The study also seeks to learn more about how strategies such as agricultural intensification, off-farm employment, and fertility reduction are linked (e.g., conflicting or mutually reinforcing) in this East African highland context.

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[4]GREAN (Global Research on the Environmental and Agricultural Nexus for the 21st Century) is a strategy designed to promote and fund collaboration between U.S. scientific institutions, centers in the Consultative Group for International Agricultural Research (CGIAR), and the National Agricultural Research Systems (NARS). The goal of this three-way collaboration is to address simultaneously the triple global challenge of environmental degradation, population increase in the worlds poorest nations, and declining agricultural productivity (GREAN 1995).

2. The third case study looks at how demographic pressure has altered the economic rationale of land use and production systems in rural Niger, in the semi-arid tropics of West Africa. In this study, Shaikh and McGahuey focus on how the need to restore the nutrient balance in agriculture interacts with the growth of urban and export markets, the growth of the cash economy, and with household strategies for risk management through diversification of both income and production. The analysis pays particular attention to differentiating between trends which lie within and outside the influence of public policy, and to the optimal role of government and donors in the on-going structural transformation of Niger's economy.

3. The Madagascar case study by Shaikh, Reardon, Clay, and DeCosse is perhaps better described as a "case application." It differs from the first three case studies in that its sole purpose is to apply some of the insights gained from research in the other sites to help understand population-environment-development linkages in the highland areas of Madagascar. In turn, it provides a set of talking points and guidelines for intersectoral development programming.

The remainder of this overview proceeds as follows. Section 2 briefly reviews the literature and identifies knowledge gaps emerging from the population-environment-development debate. Section 3 summarizes what we have learned that will help inform the debate and lessons learned for development programming. Key conclusions of the study are presented then backed up by specific empirical research findings from the case studies. Section 4 discusses implications of these findings and provides recommendations for practical ways to organize thinking and develop government and donor intersectoral program strategies.

2. KNOWLEDGE GAPS IN THE POPULATION-ENVIRONMENT-DEVELOPMENT DEBATE

The population-environment-development debate is important to us because it provides a framework for understanding intersectoral linkages, and because it helps us define the context and very nature of the individual linkages. In turn, policy and development programming can be improved by taking into account what we know about the compatibilities and inconsis-

tencies among strategic objectives in key sectors. This section provides an overview of the ongoing debate, identifies shortcomings in previous research and associated gaps in the literature, and presents findings from our case studies and related research that helps to fill in where other work has left off. We begin with a short review of the defining parameters of the debate.

Ecological theory tells us that, over the long term, there are two interrelated sets of responses that populations will muster in adapting to greater population pressure and resource scarcity (Gibbs and Martin 1959, Bilsborrow 1987). They are systemic adaptations that occur gradually, usually over periods of one or more decades, that can profoundly change the structure of rural life. The first response is to change the population's size through lower fertility, higher mortality, and/or emigration. The second is to change the productive economy of the population toward more diversified and specialized use of labor, and using more productive technologies (Cohen 1968). We note that the economic response often entails a demographic change when household members are obliged to migrate to cities and mines and other places where more diversified and specialized jobs can be found.

These two adaptive responses, one largely demographic and the other economic, have received considerable research attention over the years, and their relative importance to understanding present day development issues has been hotly debated. Our objective in this section is not to review the many twists and turns in this great volume of literature.[5] Rather, we briefly discuss some of the cornerstone positions and research directions that define the debate.

2.1 Cornerstones of the Population-Environment-Development Debate

The demographic response has been a focal point the debate since the time of Malthus, whose writings depicted the dangers of population growth— notably higher mortality through disease, war, famine, and other "positive checks" that populations endure as they readjust to the carrying capacity of their resource base (Malthus 1798). To Malthus, and to his latter-day disciples (e.g., Meadows et al. 1972, Demeny 1981, Ehrlich and

[5]See Weeks (1989) for a detailed review of the population-development debate.

Ehrlich 1991), demographic change is necessary to avert continued resource degradation and a declining standard of living.

Yet a main, perhaps the main, place where environment, population, and development interact is *on* the farm itself, and this is important because the vast majority of Africans are farmers (there are very few landless unlike in Asia, and there are few hunter/gatherers who live directly from the commons). What happens on the farm affects whether and how much farmers need to rely on the commons for new farm land to extensify, or for alternative income through selling wood or herding. Hence, whether farmers can derive greater output from their landholdings—through intensification—is a crucial issue.

Boserup (1965, 1981), Ruthenburg (1980) and others have focused the debate on the economic (income generating) response (intensification) with the hypothesis that demographic pressure causes populations to intensify their systems of agricultural production with more labor, improved inputs, etc. Boserup (1965) outlines a number of technology and investment paths to agricultural intensification that farmers follow in the wake of increased land constraints—conditions that result from population growth, increased demand for agricultural products, or reduced transportation costs (Boserup 1965, Pingali et al. 1987). To set the stage for our subsequent discussion, we distill and stylize from her work two broad paths.

The first we refer to as *capital-led* intensification, which entails, in addition to the use of farm labor and land, the use of "capital," the latter broadly defined to include nonlabor variable inputs that enhance soil fertility (such as fertilizer) and quasi-fixed capital that protects the land. The second path makes little or no use of "capital" (as defined above), so we refer to it as *labor-led* or *labor-only* intensification. Farmers merely add (unaugmented) labor to the production process on a given unit of land, allowing them to crop more densely, weed and harvest more assiduously, and so on.

Empirical research on intensification in Africa has illustrated the two intensification paths initially described by Boserup, and here labeled the capital-led and labor-led paths. Several studies have categorized the agricultural systems in certain regions of Africa where demographic pressure has pushed farmers to intensify along these paths. Matlon and Spencer (1984) note that the capital-led path is more sustainable and productive in fragile, resource-poor areas. Lele and Stone (1989) categorize a variety of agroclimatic and policy settings in terms of these two paths, focusing especially on the need for the capital-led path (which they term "policy-led"). They

maintain that the labor-led path (the "autonomous model" in their words) has not led to land productivity growth in sub-Saharan Africa, and that policy-led intensification is needed so that land quality and productivity will be maintained and even enhanced as cropping is intensified.

In much of the African tropics, the labor-led path to intensification is unsustainable, and leads to land degradation and stagnation of land productivity (Matlon and Spencer 1984). This danger is at its maximum in the East African highland tropics and other highland areas such as central Madagascar, which are characterized by heavy rainfall and steep slopes. In the latter setting, the capital-led path of intensification that incorporates land conservation investments with the use of organic matter and fertilizer is much more sustainable. By contrast, areas that follow only the labor-led path in that setting are on course for long-run ecological degradation and poverty.

Hence, the question of what determines the particular technology and investment paths that households follow is of critical importance in the current debate on sustainable development. The three research gaps described below are areas we believe to be germane to advancing the population-environment-development debate in general and to understanding household livelihood strategies in particular.

2.2 Knowledge Gap #1: Household Strategies as the Behavioral Basis of Population-Environment-Development Links

Conceptual and empirical work in the tropics has contributed to the above debate by focusing on how broad groups of farmers, in particular agroclimatic zones and policy contexts, face incentives (such as relative prices) and conditions (such as access to markets or new technologies) for following one or the other intensification path. For example, Pingali, et al. (1987), examine how costs and returns to intensification through the use of animal traction can be categorized according to the economic and physical characteristics of agroclimatic zones. Smith, et al. (1994), and Freeman (1994) examine the nature of intensification in maize production over locations with differential access to infrastructure, technology, and prices.

Yet much less empirical research, especially in Africa, has addressed the issue of specifically what determines the path taken by particular groups of farm households. Unanswered are the questions of whether and why particular types of households, situated in given demographic, agroclimatic, and policy contexts, and facing similar incentives to intensify, take the labor-led or capital-led intensification path. Specifically, there have been

relatively few studies that analyze the determinants of smallholder investments in land conservation capital, and use of nonlabor variable inputs such as organic matter and chemical fertilizers, in settings of rapid population growth and degradation. Recent exceptions are Place and Hazell (1993), who focus on the effects of land tenure on land improvements in Rwanda, and Lopez-Pereira, et al.(1994), on the hillsides of Honduras.

One reason for the paucity of household-level work is that the data requirements for this kind of analysis can be forbidding. The fieldwork can be costly and highly complex. Thus, such studies are rare and are almost always compromised in terms of geographical coverage and substantive focus. Aggregated data and historical accounts are more readily available and thus tend to serve as the empirical basis for much of the linkages work.

Tiffen's et al. (1994) compelling historical analyses of population-environment-development linkages in Kenya's Machakos District is a rather striking example of this. They conclude that higher incomes and sustainable agricultural practices in Machakos grew "spontaneously" from increasing population pressure, and were reinforced by a number of enabling conditions such as a nearby urban market for horticultural products, roads and other infrastructure, and an improved extension program. Though carefully conducted, their analysis is based largely on a comparison of parallel historical trends observed in the study area: growing population density, higher incomes, and more sustainable land use practices.

What's missing from the Machakos study, indeed, from the mainstream of research on intersectoral linkages, is an understanding of the behavioral and structural basis for these kinds of macro associations. As stated in our introduction, we need to know how households integrate demographic, income, and resource use strategies, and how opportunities in one sector reinforce those in another. Understanding the interactions between households' employment off-farm, for example, and their incentive and capacity to invest in sustainable intensification, food purchases, education of their children, and so on, is instrumental to strategic thinking and the way we approach development programming. The same is true for household decisions about childbearing, decisions that are intimately linked to both income and sustainable land management strategies.

2.3 Knowledge Gap #2: Conditioning Factors

Though sustainable agricultural intensification has become necessary and common in densely populated regions across Africa, the "classical

model" (Boserup 1965) of the context and characteristics of intensification is conditioned by three factors that subsequent macro-level analysis and debate have not taken into account.[6] The household strategies approach adopted here draws the three factors into clear view and provides a framework for examining alternative intensification paths.

First, the model is limited to traditional rural, farm economies, and focuses on technological change to the exclusion of employment/income diversification. But the modern African peasant's world is much broader and, consistent with ecological theory, their household economies have diversified into the non-farm sector, both through migration and local off-farm employment.

Income diversification matters because it is at the same time an inducement not to intensify and not to reduce population size,[7] and an enabling condition for intensification in that nonfarm jobs (diversification) provide a crucial source of cash to hire workers and buy improved inputs and materials—a source that has taken on more importance as diversification has increased and as rural public credit institutions have been dismantled under structural adjustment programs started in the 1980's (Reardon et al. 1994).

Second, the classical model of intensification presupposes a traditional peasant context where farmers are generally autarchic, buying and selling little food and fiber in the market. But the modern African peasant's world is much more commercial and monetized; they are regular participants in the food and fiber markets—and often pay for purchases with nonfarm and cash crop income. Market participation through cash crop sales, like income diversification, affects farmers' incentives and capacity to intensify. On the one hand, farmers are often drawn to the market because cash cropping is usually more profitable than subsistence food cropping. On the other hand,

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[6]These three factors were first described by Clay and Reardon (1996) in their discussion of population-environment-development linkages in Rwanda.

[7]By reduction in population size we mean natural decline, especially through lower fertility—not through outmigration. In the present context it is more appropriate to consider migration out of the rural sector to be a form of "spatially removed" income diversification, thus as an organizational response to demographic pressure, not as a demographic response. This is because migration generally occurs as a more distant search for off-farm employment, and because migrants generally continue to support the household of origin (through remittances) in much the same way as do those employed off-farm locally (Clay and Vander Harr 1993).

as a source of cash and by increasing access to improved inputs, cash cropping can enhance farmers' capacity to intensify. Moreover, the market offers those farmers with cash from off-farm activities and cash crop sales the opportunity to purchase food, relieving them of the need to produce it themselves for home consumption.

Third, the classical model of intensification does not properly allow for the possibility that peasant strategies that promote intensification and cope with unsuccessful intensification (strategies such as cash cropping and nonfarm activity) may require labor. This requirement works as an incentive for higher childbearing, which in turn increases the need for intensification, diversification and cash cropping.

2.4 Knowledge Gap #3: Using the Research Findings

Though research on the population-environment-development debate has been a subject of increasing interest in the larger development community,[8] the need to understand what it all means for practical concerns like strategic thinking and development programming is long overdue. As suggested by the preceding discussion, the debate has, to date, been confined to relatively abstract generalities.

The absence of a more practical focus is a serious shortcoming of existing intersectoral linkages work, one that this monograph looks to address. It stems in part from the fact that so much of the research has been based on historical analyses of broad societal trends, and that development programmers have not tended to drive the debate. As a result, findings have been largely disconnected from the policy realm.

Our use of multisectoral data at the household level enables us to explore the behavioral (influenceable) aspects of population-environment-development links, and what they mean for development policy and programming. Indeed, by focusing on household strategies, we are forced to think in terms of linkages and their practical implications. Does off-farm income lead to greater on-farm intensification? Does intensification reduce environmental degradation? Does lower household fertility improve the household's ability to generate off-farm income and adopt more sustainable farm practices?

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[8]See Cleaver and Schreiber (1994), for example.

These questions illustrate the kinds of connections that households, as well as government and donor program specialists, must factor into their strategic planning and decision-making. The study of the interactions and synergies that make household strategies successful must be clearly articulated and extended to the program level. By first drawing the key household-level findings, and then working through their implications for development programming, the following two sections of this overview are specifically intended to accomplish this task.

3. INFORMING THE DEBATE: KEY STUDY FINDINGS

3.1 *Efforts to save the forests and bio-diversity cannot succeed without first meeting the income needs of rural households and promoting "sustainable intensification" on the lands they are already farming.*

Except in situations where large-scale logging is an important determinant of deforestation and wetland destruction, the main determinants of the latter are: (1) farmers clearing and cultivating forests and wetlands and pushing onto hillsides; (2) rural households and townsfolk cutting down trees and bushes for fuelwood, and forage for animals.

Farmers move onto these fragile margins, this virgin land, either because (1) they do not perceive virgin land to be scarce, or (2) they perceive its scarcity, but they have no option as they are not able to grow more on the land they already have under cultivation. This lack of options relates to the point in the introduction that inputs might be too expensive to increase the capital intensity of farming, or knowledge to do so might be lacking. Our Rwanda case study illustrates that situation.

In various places (such as Madagascar and Rwanda) it is common to find government and donor programs to limit access to forests and wetlands, perhaps with a fence, or patrols, or signs; fines or imprisonment are the punishments for violation. In some cases, "alternative income source projects" (ecotourism, honey production) are put in place to provide income in place of revenues lost when forest access is curtailed. We found in our review of evidence in Madagascar that the alternative income sources yielded well below the lost income.

There are three problems we have found with such limitation of access: (1) it does not solve the "farm problem" that drives the farmers to seek new land in the forest; (2) it does not solve the problem of demographic pressure;

(3) often (as in the Madagascar case) the alternative income projects only replace a (small) portion of the income lost.

Faced with these problems, we have observed that farmers violate the forest protection to survive, even if punished. Hence, though we agree that limited-access regulation is necessary, it is far from a sufficient condition to protect forests and other wild lands. Protection of forests that are crucial to watershed management and the survival of endangered species will never be fully successful in the long run if rural households cannot reduce their numbers, cannot farm adequately on land outside the forest and other virgin land, and/or cannot find alternative means for securing their livelihoods.

"Integrated conservation development programs" have been useful, for example in Madagascar, in that they address the "buffer zones" next to protected areas, but they do not go far enough because they do not bring agricultural lands squarely into the center of the environmental debate.

The upshot of this observation is that increased farm productivity and agricultural growth, with concomitant increases in food availability, help the environment now and in the long run.[9] Sustainably intensifying production (where the resource base permits more intensified use) on land currently cultivated will pressure poor farmers to push onto fragile margins and to rely on labor-intensive gathering strategies off-farm in the biodiversity-rich commons. For example, Tribe (1992) surmises that had there been no Green Revolution in India (in which production was greatly intensified), 44 million hectares of land now under forest would now be plowed and farmed!

The land-use intensification practiced in Africa is, however, often of an unsustainable type. Many poor farmers in land-limited areas of Africa turn to "labor-led intensification," that is, farming more on the same land by reducing fallow periods, planting seeds more densely, pushing the land harder, etc. But few can afford to offset this mining of the soil by applying fertilizer and manure to restore soil fertility and prevent soil erosion. Extracting more without giving more back is one of the most important environmental issues in Africa—and at the heart of the agricultural crisis. International Resources Group analyses in the Sahel found that current production is being maintained by progressively depleting soil nutrients. Michigan State University research in Senegal shows that increasing peanut seeding density without applying manure and fertilizer is rapidly leading to soil exhaustion (Kelly et al. 1996).

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[9] This section draws on Reardon and Shaikh (1995).

In Africa, agricultural pollution is not at all the problem that it is in areas of Asia where Green Revolutions have occurred (Pingali and Rosegrant 1993) or in North America or Europe. Fertilizer, pesticide, and even manure use is extremely low in Africa. Even a 10-fold increase in use would not create serious chemical-runoff problems. On the contrary, the real problem is using too little fertilizer and manure, which undermines sustainable intensification and forces farmers to seek new lands to clear. For this reason, *not* intensifying agriculture will undermine farmlands and the commons in the medium to long run, and will mean that food needs go unmet. Low-input agriculture, which typically allows growth of 1 percent a year (Ruttan forthcoming), cannot meet demand growing at 3 to 4 percent a year. The land frontier is closing, making intensification a critical agricultural *and* environmental goal.

Cropping intensification need not be the enemy of the environment, however. Intensification can be accomplished in a way that meets food and fiber supply goals and helps the environment on- and off-farm. In "capital-led intensification," farmers crop more intensively but offset harmful effects on soil fertility by enhancing the soil with fertilizer, manure, or compost and protecting it with bunds, terraces and windbreaks. This approach checks degradation and can enhance the on-farm environment.

3.2 *Protecting the environment is crucial to economic growth.*

Most of the African rural population depend on the land, water, and forests for a living, and much of the urban population is indirectly dependent on it. Degradation of farmlands and forests undermines the national economies in every agroclimatic region while desertification undermines the fragile soils of the semi-arid regions. Protecting farmland is crucial to farm productivity, and protecting the commons is crucial to maintaining biodiversity and to the survival of poor households.

Soil conservation measures have a large positive effect on farm productivity. Hence, soil degradation undermines the food security of households and regions by undermining farm productivity and food and fiber output growth. In areas with fragile environments, this holds for the short as well as for the long run. Byiringiro (1995) shows that in Rwanda, degraded farms obtain yields 30 to 40 percent lower than those in non-degraded areas, controlling for other factors. By contrast, yields are raised 25-30 percent when soil conservation investments are undertaken. These are large changes for families near the brink of absolute poverty.

Biodiversity in the commons serves as a species pool for improving cropping and animal husbandry; using land races often is an important stabilizer for yields (Bellon and Taylor 1993). The degradation of the commons can undercut biodiversity and thus affect agriculture. Deforested areas near the village mean that women spend more time searching for fuelwood and less time on farming and household activities (Kumar and Hotchkiss 1988).

But degradation of the commons can also affect off-farm income strategies that rely on gathering wood and other wild plant products, fishing, hunting. Often, the poorest households depend most on the commons since the economic activities undertaken there have low "entry barriers" (more on this below) and can be started with modest means. Improved pastures are needed for animals that area a critical insurance mechanism and source of cash income and manure for poor farm households.

3.3 *Nonfarm employment, small enterprise promotion, and cash crop promotion can be important to the environment through their positive impact on sustainable agricultural intensification.*

Structural adjustment programs have often cut public credit institutions in rural areas. Moreover, in many areas, informal credit markets were already severely underdeveloped and constrained. That means that in the current farm economy of Africa, having one's own sources of cash income is crucial to being able to buy farm inputs. The key sources of this cash are nonfarm jobs (locally or in migration) and cash crops. Often the former are most important numerically. The Rwanda case illustrates both of the above; the Burkina case (Reardon et al. 1992) also supports this point.

Nonfarm employment for farm families has other benefits in terms of helping the environment, promoting farm investment, and reducing population growth locally. Where there is "surplus population" in the rural areas that cannot be employed productively on the farm, nonfarm jobs allow an "escape valve" to lessen pressure on the land. Moreover, diversified incomes (both on farm, and off-farm) help poor farmers deal with risk, reducing their need to use the fragile commons as a "buffer" to deal with uncertainty, and helping them buy food. Finally, nonfarm services such as input provision and crop processing and distribution raise the profitability of agriculture and reduce price instability, thus promoting farm investment, including in soil conservation investment.

Hence, rural business promotion and agriculture, environment, and population programs have consonant goals and can be mutually reinforcing.

There are two worries, however. First, studies in the Sahel conducted by Michigan State University and the International Food Policy Research Institute (IFPRI) have shown that most rural nonfarm employment is "production-linked" upstream or downstream to the farm sector, so it will be hard to spur this employment without "getting agriculture moving" (Reardon et al. 1994). The farm sector also determines food prices, which influence real incomes and thus poverty of rural people; the latter affects the environment and determines whether farm families can make requisite investments in land improvements (Reardon and Vosti 1987).

Second, we find that many poor farmers cannot overcome "entry barriers" to start nonfarm businesses and grow cash crops. We found (in Rwanda and in outside Sahel studies) that the inter-household distribution of off-farm income, and the inter-zone distribution of off-farm income and cash cropping, is quite skewed. Poor households and zones unfavored with infrastructure have the greatest obstacles. The credit market does not help because it requires collateral the poor don't have. Other important barriers include lack of cash, lack of knowledge, and immediate risk aversion. Making the nonfarm business and cash crop programs more accessible to the poor will then actually have an environmental benefits in addition to the traditionally expected effect on poverty.

3.4 *Government and donor attempts to slow population growth (via family planning) are not always seen by households as complementary to their income strategies.*

All of the countries examined in this monograph, Rwanda, Niger, and Madagascar are under considerable ecological stress due in large measure to decades of unprecedented demographic growth. The governments in all four of these countries are committed to relieving the pressure of population growth through lower birth rates.

While policy-makers and public opinion in these countries recognize the importance of slowing high birth rates, fertility behavior at the household level often runs counter to this antinatalist position. Particularly among farm households, having *more* children increases family "success" and continuity through greater household wealth, security, and social standing. More hands mean more land is farmed and more food is grown; a larger family helps diversify income sources and manage risk; some land improve-

ment and intensification practices are labor intensive and require a larger pool of household and/or hired labor; a large family is a sign of household standing in the community, and can help ensure that parents are cared for in their old age. Our Rwanda study illustrates the importance of increased fertility to household success. Evidence from Niger, Madagascar, and many other parts of sub-Saharan Africa shows a similar pattern.

Thus, we conclude that at the household level, the level at which fertility and family planning decisions are made, the classic demographic response discussed earlier is flawed. Reducing fertility, for households in sub-Saharan Africa facing land constraints, is *not* perceived to be an alternative to other strategies such as income diversification, cash cropping, and intensification. Indeed, to make these income strategies work, households often see the need for even greater household labor through higher birth rates.

What factors account for these incongruous views? We believe, but do not test, that the contradiction between public (national and community) and private (households) fertility goals is tied to the notion of intergenerational wealth flows. In rural Africa, the net flow of wealth moves from the younger generation to the older generation—from children to parents.[10] Despite the initial costs of raising and feeding children (among the Z-good costs), their labor, beginning as early as six years of age and continuing through the parents' lifetime, will far surpass these initial outlays to raise them. Labor provided by the younger generation can take a number of forms, from herding cattle, gathering wood, and looking after younger siblings as children, to adult tasks such as tilling the fields and caring for parents in their old age. On balance, parents see children as a net asset to the household economy, not as a liability (Caldwell 1976, p. 343). Thus, more children are better than fewer, and this is true even for poor households whose access to land and other opportunities are limited.

Yet, the entry barriers to eventually finding employment off-farm are high and often insurmountable, especially for children of landless (few in Africa) and near-landless households. These include school fees and related costs, the expense of sending migrant adolescent children to the city and maintaining them during their search for work, and the on-farm opportunity costs of their schooling and/or migration. Thus, when asked about what

[10]See Clay and Vander Harr (1993) for a review of intergenerational support and childbearing in the Third World.

children will need to do to survive in the absence of sufficient land, we found that the Rwandan parents in our case study sample responded overwhelmingly that their children will just have to "make do on their own."[11]

This response reflects the peasant farmer's preoccupation with the survival of the household and extended family group, even if it means that some of its members may be marginalized and left to their own devices. Focusing on what's best for the household is what has ensured household success in the past.[12] High fertility and a large pool of household labor is what's best for households in which wealth flows upward.

As a result, many of these children fall short of parental aspirations. More often than not, the social costs associated with their failure to find productive employment falls on the shoulders of the larger population, and not on those of the parental household. But therein lies the dilemma—it is a veritable "demographic tragedy of the commons" (Clay and Reardon 1996). While households maximize their fertility to enhance their own station in life, those landless and unskilled children who are unable to find ways to contribute to the household economy are left to fend for themselves. Often they make their way to the city or to labor-deficit rural areas (Clay and Ngenzi 1990). The fortunate ones find employment as occasional wage laborers, but many others do not. Their costs in terms of schooling, housing, medical care, crime prevention, criminal justice, and social instability are borne by the larger community.

Indeed, we contend that the perception of "population pressure" is unknown to households where wealth flows from the younger to the older generation. The smallholder does not "feel" demographic pressure any more than the largeholder does. The two face the very same challenge: to keep the *household* out of poverty—which can be hard work and fraught with uncertainty even for those with resources. To be sure, those with little access to land are closer to the margin and more uncertain since their strategies for employing household labor are not as simple as for those with plenty of land to till. But in either case, a larger family is more likely to secure the future of the household than is a smaller family, since only those children who

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[11]Source: unpublished tables from the 1988 Rwanda Non-farm Strategies Survey conducted by the Rwanda Ministry of Agriculture.

[12]Indeed, elevating the household/family group above individual needs is a cultural imperative, a universal cultural adaptation that has helped ensure the continuation of human populations through the course of time.

manage to contribute to the household economy count toward household success. Those who do not or cannot contribute are not viewed as a sign of failure where wealth flows from children to parents.

Thus, from the household's point of view, the challenge is one of working out a livelihood strategy that maximizes the use of household labor vis-a-vis available land and capital. Our study shows that the challenge is greater and the linkages among strategies are stronger among households with the least land. The pressure is to find employment, either on the farm or off, for all able household members. All else equal, prosperity accrues to households who are large in number and who manage their numbers effectively. Failure to do so is a missed opportunity for the household; it is a tragedy for the child who faces a potential lifetime of poverty, and for the community that shares this cost.

Even though fertility rates in Rwanda, Niger, and Madagascar have begun to decline in recent years, resistance to fertility control measures will remain strong in these countries because of the importance of household labor to the success of intensification and income diversification strategies, as observed in this study. Until the intergenerational flow of wealth reverses direction, as it has already throughout the West and other parts of the developed world, the tragedy will play on. Other research has shown that reversing the direction of wealth flows is closely linked to investments in human capital, notably the education and autonomy of women (Caldwell 1980, 1982).

3.5 *Population changes are not independent of changes in household strategies, environmental degradation, and income growth.*

The separation of strategic planning in the population domain from that in the environment, agriculture, and enterprise development domains is unfortunate for the reasons described above. Conventional NRM and economic development frameworks and literature have tended to reinforce sectoral thinking and sectoral boundaries by characterizing population variables (fertility, mortality, and migration) as "unmanageable," i.e., as an immutable force that lies outside of the "influenceable" realm. The treatment of population in the AID's NRM framework is illustrative of this limitation. It groups population with agro-ecological conditions (such as rainfall and soil type) and other non-behavioral, exogenous variables.

One factor that has contributed to the practice of treating the demographic side of the population-environment-development nexus as exoge-

nous to the others is the notion of "population momentum," i.e., that even if children alive today reduced their own childbearing to replacement-fertility levels, because of their sheer numbers, it would take 30 years or more for the population to actually stop growing. While this is fundamentally true, we must note that the adverse impact of population growth would decline steadily to zero during these 30 years.

Not often recognized is the fact that environmental changes and improvements in household incomes can be equally slow in coming, and generally require far greater human and physical capital investment by households, governments, and donors. For example, land lost to poor land management practices (e.g., lack of conservation investments in Rwanda, hillside and forest slash-and-burn (*tavy)* production in Madagascar, bush-cover removal and desertification in Niger) will take decades to turn around and make productive again. And changes that have led to a decline in livestock inventories, pasture, and knowledge of animal husbandry practices in Rwanda and Madagascar, coupled with low income levels, mean that development of more intensive livestock systems in these countries will now be doubly difficult to regenerate. There is an entire generation of young farmers in these countries who hold little or no experience in how to integrate livestock and cropping systems and it will take decades to rebuild this lost momentum.

Treating population as an exogenous variable is especially problematic in that it obscures the fact that population-environment-development links are highly interactive. Fertility, mortality, and migration patterns can all influence income strategies and the ways in which households manage land and other resources, but these population variables are in turn affected by household income and resource management (i.e., reverse effects). As one can glean from the three case studies, incomes and access to resources can be important determinants of household migration. Likewise fertility and mortality rates are known to vary with income levels and landholding. In Rwanda, for example, we show that access to land, resulting higher incomes and better nutrition, has increased household labor through lower mortality.

Labor availability and use is never taken for granted by households in their efforts to generate income and keep a step ahead of poverty. Governments and donor organizations can learn from this insight, and not treat population variable as "given" in their approach to development programming.

3.6 *Land markets and land tenure are critical policy issues mediating how population increase translates into problems for agriculture and the environment.*

The link between population pressure and land degradation is indirect. To address this link in terms of policy or program action we must focus on the intermediate mechanisms that connect the household's labor supply to its land management strategy (land use and investments in land conservation and fertility). Findings presented in this monograph draw particular attention to the *structure of landholding* as central to on-farm population-environment interactions. The structure of landholding is that set of bio-physical characteristics (size of holdings, fragmentation and dispersion, fragility, and years of cultivation, etc.) and economic/social characteristics (land tenure and profitability of land use) that define the farmer's incentive to invest in the long-term sustainability of his/her land.

Increasing population pressure and the ensuing competition for scarce land resources precipitates a restructuring of these physical and social attributes of landholding. Observations from our case studies reveal some of these changes. More than ever before, farmers must rent the land they operate (shorter term use rights), family landholdings have radically diminished in size, and in highland areas farmers 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 and Madagascar, for example, we found that 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, distant fields, and the steep, fragile fields are largely ignored. Unless farmers can anticipate an economic return commensurate with their level of investment there will be little incentive for them to adopt such practices. As fields become 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.

Thus, apart from the obvious need for political stability in countries like Rwanda and Madagascar, our focus on population-environment-development linkages shows that farmers need confidence in the longer term

through secure land tenure. This means reducing the risk of appropriation and the right to transact land. Enhancing farmer access to the land market will require reform of existing and antiquated land laws prevalent throughout sub-Saharan Africa.

4. STRATEGIC AND PROGRAM IMPLICATIONS

Government officials and development programmers must seek effective synergies and balance among "sectoral" program goals such as agricultural intensification, income diversification, and family planning. Government and donor strategic and program planning needs to mirror the same set of interactions made by poor rural households. Understanding how rural households behave, how they plan, how their strategies are formed and linked, is critical to understanding how programs and policies can best increase their welfare and reduce conflicts among goals.

4.1 The Context for Strategic Thinking

The window of opportunity is closing. African economies are in transition. The options available today—for individuals and for public policy—are different from those which will be available at later stages in the transition. For example, if the emerging battles over resource access, rights, and tenure give way to a formalization of a "land grab" by narrow elites, a major opportunity for economic dynamism will have been lost for generations. In Botswana, once animal numbers have dwindled and migration routes are intersected with livestock fences, eco-tourism may no longer remain an economic option. Once farmers have moved up the hillsides in Madagascar, the prospects for protecting biodiversity are severely constrained. When rural producers in the Sahel become the urban poor in West Africa's cities, the social, economic and political dynamic of positive change will be fundamentally altered. Throughout Africa, the opportunity to capitalize on the positive momentum of change is at, or near, its peak. Change itself will continue to occur for reasons beyond public sector strategies, but the opportunities for positively influencing change will diminish over the next two decades.

Social and political stability hang in the balance. The countries which have not begun to change, such as Zaire, Kenya and Nigeria, face a transition of unknown intensity and duration. The fledgling democracies, such

Mali, Benin, South Africa, Madagascar and Malawi, have unleashed competing dreams and unmet expectations which, increasingly, are difficult to control. The tragedies in Liberia, Somalia and Sudan are testimony to the costs of eliminating the bad with nothing but anger to replace it. The Gambia and Niger are among the set of cases perhaps the most representative of the coming wave of change: a step backwards—sharply divergent futures still hanging in the balance—on a rocky path to democracy. The structural transformation underway can be positive. If it is not, there is a substantial risk of widespread unrest and human suffering.

International resources for African development are shrinking. Foreign aid budgets are shrinking because all of the traditional donors face domestic budgetary constraints. In addition, with the Cold War over, Africa has been judged to be of little geopolitical significance. There is limited and uneven interest in aiding African development for commercial reasons. There are positive aspects to the lowered international profile: inefficient and unresponsive governments can no longer get "easy money" and political support by playing the geopolitical card; hundreds of thousands of lives are no longer being lost through civil wars fueled by arms and money from competing global powers. At the same time, countries which have taken up the mantle of reform (free elections, economic liberalization, etc.) are finding themselves on a political limb without the anticipated financial support from the donor community. The absence of superpower rivalry heightens the potential for unchecked civil conflicts such as in Liberia and Somalia, where the world powers lack the interest or financial commitment to help any of the combatants to prevail.

International donors no longer accept primary responsibility for broad-based development in Africa. As their resources dwindle, donors are under increasing pressure to focus on a limited number of sectors which reflect their assistance priorities. The pressure is made more acute by the fact that domestic political support for foreign aid comes increasingly from those who have very specific goals which they seek to promote through such aid. There is a growing schism between the traditional economic community which emphasizes macroeconomic growth and structural reform, and the new development lobbies which focus on sectoral agenda, from environment to maternal and child nutrition to empowerment of local communities. This divergence in emphasis coexisted more easily when there was enough money to fund both communities. Today, the issue boils down to one of how scarce donor resources should be allocated.

Donor choices continue to have a major impact on Africa's development options. A twin dependency influences Africa's options. First, private choices are disproportionately dependent on government policy and on the allocation of public investment because (a) poverty and underdevelopment still create constraints on private initiative and (b) public policies are still in transition from "centrist" to more "enabling" systems. Second, government policies and investments are disproportionately dependent on donor decisions because most African governments have limited financial, human, and institutional resources with which to define and implement their own agendas. Often, the majority of government operating budgets and over 90% of investment budgets are financed by the international community. Therefore, if donor programs are not based on a strategic vision, African governments cannot allocate resources strategically. To take but one example, Madagascar, is awash in environmental money, but is a pauper in funding for basic education, health care and agricultural infrastructure.

4.2 Five Strategic Questions for Donor Assistance in Africa

1. What are the desired results of development assistance?

Results-oriented assistance implies three fundamental shifts in development practice. First, to achieve results, we cannot ignore the related outcomes (linkages) on which those results depend. Second, it is no longer sufficient to fund activities in the target sector if they do not alter the dynamic which leads to those results. Third, and most important, the very complexity of attaining any result forces the setting of priorities.

2. What can we do to make the results "self-sustaining?"

Underlying the focus on results is the need to revisit the definition of "development" as it is being applied in assistance programs in Africa. The sum of donor projects do not equal development, and this fact is now widely recognized. Positive exceptions in the face of a generally negative dynamic are not "development" either, as the increasing emphasis on governance in Africa acknowledges. Finally, it is now widely accepted that true development assistance is transitional, and must promote recurrent, internally-generated outcomes which achieve the desired results. That is, true development must be self-sustaining.

3. What human activities influence the desired results?

Except where the goal is to provide relief or infrastructure, virtually all of the desired results of development assistance are influenced by human activity. Indeed the difference between "developed" and "developing" economies does not lie in the existence of negative outcomes. Rather, it lies in the economies' internal capacity to alter or remedy such outcomes. It is of key strategic importance to focus on what people do, who does it, why they do it and how it influences the development dynamic.

4. What choices do people have?

Too often in development programs, the question of what people should do precedes the more important question of what choices they have. People do what they do for a reason, and their choices typically are rational, given the context. The context may be complex, including culture, knowledge, technology, belief and opportunity. However, those who are close to the margins of survival do not voluntarily make choices which they perceive as financially irrational. Unless real economic choices change, the results they influence are unlikely to change.

5. What is the right balance in allocating scarce assistance resources?

To achieve results, root causes must change. To sustain results, recurrent choices must change. No amount of development aid can, for example, succeed in protecting Africa's natural resources base if rational economic survival strategies require the majority of people to degrade it. Yet, widespread change in the economic dynamic which causes resource destruction takes time. Irreplaceable resources, such as Madagascar's biodiversity or Southern Africa's wildlife herds, may not survive the wait, even if it ultimately leads to success. The balance to be struck is therefore between direct sectoral intervention (in environment, in health care delivery, in food security, etc.) and broader development intervention which alters macro trends.

4.3 Strategic and Program Implications of the Dynamic Linkages Analysis

1. Throughout Africa, ninety percent of the people whose activities determine the fate of the rural environment are farmers and herders. The majority of environmental degradation results from economic choices they make for survival. Changes in rural production systems are a necessary precondition for sustainable environmental management.

2. Rural production systems do not operate in isolation, however, and they are already changing rapidly. Under demographic stress, and with new market opportunities through urbanization, trade and exposure to new technologies, the forces driving rural change are beyond the control of public policy or donor programs. However, their impact can be influenced in ways that are more, or less, positive, and donor programs have their greatest leverage through influencing the impact of trends which are internal to the economic and social system.

3. Land (for cultivation, settlement and grazing), wood and forage account for the vast majority of resource depletion throughout the continent. There are only three generic choices which rural producers can make while meeting their economic needs: (a) to mine resources and accelerate degradation as population grows; (b) to use resources more efficiently (through improved natural resources management techniques, conservation and management of common property, intensification of production); (c) to change their economic activities (urbanization, commerce, eco-tourism, etc.). It is unrealistic for development programs to expect broad or sustainable behavior change which is not driven by one of these options.

4. Widespread improvements in the efficiency of agricultural and livestock production will have greater positive impact on environmental conservation than the sum of all donor-funded environmental programs. Because they alter the economic choices available to rural producers, they can have a more lasting impact as well. At present, three million hectares per year are cleared for agricultural production alone in sub-Saharan Africa.

5. The governance and economic policy context in much of rural Africa directly undercuts environmental sustainability. Central versus local resource management authority, coupled with the inability of central authority to exercise effective control, promotes the "tragedy of the commons." Insecure tenure discourages production and resource management investments. Economic and trade barriers undercut incentives to greater efficiency. Improved governance and economic frameworks are a necessary—though not sufficient—condition for environmental conservation.

6. Within the context of improved governance and an enabling economic framework, the principal lever available to the public sector is to make environmentally-friendly choices more attractive to rural producers. This can be accomplished through policy, infrastructure (both financial and physical), transparency, property rights and similar measures to change the real economic options available to resource users.

7. Promotion of markets and the strengthening of civil society imply that decision-making authority (power exercised within a set of transparent rules) must devolve from the center to localities, households and production units. Simple participation in projects which flow from external decisions does little to foster sustainable resource management. At the same time, devolution of authority without policy and related changes which influence recurrent choices poses the substantial risk that, within existing options, people will not freely choose to conserve the environment.

8. None of the major desired results can be sustained if Africa does not eventually make the transition from aid to trade. The core of this transition has two elements: a stable, open society, widespread opportunities for income growth through productivity increases and the internally-generated capacity to choose sustainability and to enforce those choices. Sectoral programs, such as in environment, health care and fertility reduction, can make a vital contribution to economic growth. However, they do not sum to a growth strategy, and are not a substitute for it. Poverty generates recurrent options which can readily swamp the progress achieved under sectoral programs, and is also the enemy of political stability and good governance. Without the right balance

between broad-based economic growth and direct programmatic interventions, development programs amount to little more than straws in the wind.

4.4 Programmatic Implications and Questions for Donor Missions

1. Donor Missions should undertake, in collaboration with the host government and other major donors, a Results Framework whose primary objective is broad-based and self-sustaining economic growth. Missions' strategic objectives should be assessed for their contribution to and consistency with this "national" Results Framework.

2. On-going and planned re-engineering efforts should focus on linkages between Strategic Objectives and government and other donor programs. Particular attention should be given to the links between environment & natural resources, and the productive capacity of the rural economy.

3. Donor missions in Africa should devote resources and attention to population-environment-development linkages, and to testing the feasibility of environmental programs in light of demographic and economic trends.

4. Population programs tend to stress family planning, while population-environment-development links are much broader than family planning alone. Expanding the scope of population programming to include household labor demand, old-age security, labor migration, intergenerational wealth flows, and other population issues will enhance intersectoral programming opportunities.

5. All environment & natural resources programs, and rural productivity strategies, should be subject to a minimum 20-year trends analysis to assure compatibility with on-going demographic and resource-use changes. In particular, financial and economic feasibility studies should include sensitivity analyses which take into account changing relative scarcities of labor and resources.

6. In much of sub-Saharan Africa, urban markets can spur changes in rural commodity prices, technologies and efficiency over the next

twenty years. Donor missions should, as part of the re-engineering process, develop economic profiles and scenarios for urban demand, with focus on the possible implications for the transformation of the rural sector.

7. Market infrastructure—transport infrastructure, transport networks, availability of commercial inputs, distribution and retailing systems for products—can have an enormous impact on rural productivity, and hence on environmental sustainability. The Results Frameworks developed in the re-engineering effort should specifically address the adequacy of such infrastructure to facilitate increases in rural output.

8. Donor missions should place greater emphasis on changes in the policy environment, in order to create conditions favorable to agricultural intensification and to sustainable management of the commons. Priority policy issues include community management rights over village common property, tenure rights on production lands, fertilizer pricing policies, and local governance.

References

Bellon, M.R. and J.E. Taylor. 1993. "'Folk' Soil Taxonomy and the Partial Adoption of New Seed Varieties." *Economic Development and Cultural Change*, 41(4):763-786.

Boserup, E. 1965. *The Conditions of Agricultural Growth: The Economics of Agrarian Change Under Population Pressure*. Chicago: Aldine.

_____. 1981. *Population and Technological Change*. Oxford: Blackwell.

Bilsborrow, Richard E. 1987. "Population Pressures and Agricultural Development in Developing Countries: A Conceptual Framework and Recent Evidence." *World Development*, 15:2, pp. 138-203.

Byiringiro, F.U. 1995. *Determinants of farm productivity and the size-productivity relationship under land constraints: The case of Rwanda*, M.S. thesis, Dept. of Agricultural Economics, Michigan State University.

Caldwell, John C. 1976. "Toward a Restatement of Demographic Transition Theory." *Population and Development Review*, 2:321-366.

_____. 1980. Mass Education as a Determinant of the Timing of Fertility Decline." *Population and Development Review*. Vol. 6,2: 225-255.

_____. 1982. *Theory of Fertility Decline*. London: Academic Press.

Clay, Daniel C. 1995. "Fighting an Uphill Battle: Population Pressure and Declining Land Productivity in Rwanda." In H.K. Schwarzweller and T.A. Lyson (eds.) *Research in Rural Sociology and Development*, Vol. 6. Greenwich, Connecticut: JAI Press, Inc.

_____ and Innocent Ngenzi. 1990. "Migration Temporaire dans les Ménages Agricoles au Rwanda." *Documents de Travail,* Division des Statistiques Agricoles, Ministère de l'Agriculture, de l'Elevage et des Forêts, Rwanda.

_____ and Thomas Reardon. 1996. "Linking Population, Development, and the Environment: How Households Confront Poverty and Demographic Pressure in Rwanda." Michigan State University Population Research Group. Research Paper Series. Paper 96-04.

_____ and Jane Vander Haar. 1993. "Patterns of Intergenerational Support and Childbearing in the Third World." *Population Studies*, 47.

Cleaver, K.M. and G.A. Schreiber. 1994. Reversing the Spiral: The Population, Agriculture, and Environment Nexus in Sub-Saharan Africa. The World Bank, Washington, D.C.

Cohen., Y.A. 1968. *Man in Adaptation: The Cultural Present*. Chicago: Aldine Publishing Company.

Demeny, P. 1981. "The North-South Income Gap: A Demographic Perspective." *Population and Development Review*. 7(2):297-310.

Ehrlich, P.R. and A.H. Ehrlich. 1991. *The Population Explosion*. Simmons an Schuster Inc. New York.

Falcon, W. P. 1996. "Commentary: Food Policy Really Matters." *IFPRI Report*, Volume 18:1, International Food Policy Research Institute, Washington, D.C.

Freeman, Ade H. 1994. "Population Pressure, Land Use, and the Productivity of Agricultural Systems in the West African Savanna." Pp. 103-114 in S.A. Breth (ed.), *Issues in African Rural Development 2*. Winrock International. Arlington, Virginia.

Gibbs, Jack P. and W.T. Martin. 1959. "Toward a Theoretical System of Human Ecology." *Pacific Sociological Review*, 2:1.

Kelly, V., B. Diagana, T. Reardon, M. Gaye, and E. Crawford. 1996. "Cash Crop and Food grain Productivity in Senegal: Historical View, New Survey Evidence, and Policy Implications." Michigan State University, Department of Agricultural Economics, International Development Paper no. 20.

Kumar, S.K. and D. Hotchkiss. 1988. Consequences of Deforestation for Women's Time Allocation, Agricultural Production, and Nutrition in Hill Areas of Nepal. International Food Policy Research Institute (IFPRI). Washington, D.C.

Lele, U and S.W. Stone. 1989. *Population Pressure, the Environment and Agricultural Intensification: Variations on the Boserup Hypothesis.* MADIA Discussion Paper 4. The World Bank. Washington, D.C.

Lopez-Pereira, M.A., J.H. Sanders, T.G. Baker, and P.V. Preckel. 1994. "Economics of Erosion-Control and Seed-Fertilizer Technologies for Hillside Farming in Honduras." *Agricultural Economics*, 11, pp. 271-288.

Malthus, T.R. 1798. *An Essay on the Principle of Population.* New York: August Kelley, Bookseller: reprinted in 1965.

Matlon, P. and D.S.C. Spencer. 1984. "Increasing Food Production in Sub-Saharan Africa: Environmental Problems and Inadequate Technological Solutions." *American Journal of Agricultural Economics*, 64 (Dec).

Meadows, D.H., D.L. Meadows, J. Randers, and W.W. Behrens III. 1972. The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind. London. Earth Island.

Pingali, P., Y. Bigot, and H.P. Binswanger. 1987. *Agricultural Mechanization and the Evolution of Farming Systems in Sub-Saharan Africa.* Johns Hopkins University Press, Baltimore.

_____ and M. Rosegrant. 1993. "Confronting the Environmental Consequences of the Green Revolution in Asia." Paper presented at the 1993 AAEA International Preconference on *Post-Green Revolution Agricultural Development Strategies in the Third World: What Next?* August, 1993, mimeo.

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

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

_____ and A. Shaikh. 1995. "Links Between Environment and Agriculture in Africa: Implications for Economic Growth and Policy." Policy

Brief no. 2. Natural Resources Policy Consultative Group for Africa. World Resources Institute, Washington, D.C.

_____ and S. Vosti. 1987. "Issues in the Analysis of the Effects of Policy on Conservation and Productivity at the Household Level in Developing Countries." *Quarterly Journal of International Agriculture*, (October) pp. 380-396.

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

Ruthenberg, H. 1980. *Farming Systems in the Tropics*. Third edition. Oxford: Clarendon Press

Ruttan, V.W. Forthcoming. "Sustainable Growth in Agricultural Production: Poetry, Policy, and Science," in Vosti and Reardon (eds.) *Agricultural Sustainability, Growth, and Poverty Alleviation: Agroecological and Policy Perspectives*. Johns Hopkins University Press.

Smith, J., A.D. Barau, A. Goldman, and J.H. Mareck. 1994. "The Role of Technology in Agricultural Intensification: The Evolution of Maize Production in the Northern Guinea Savannah of Nigeria." *Economic Development and Cultural Change*, 42, 3, pp. 537-554.

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

Tribe, D.E. 1994. "Feeding and Greening the World: The Role of International Agricultural Research. CAB International (in association with the Crawford Fund for International Agricultural Research.

Weeks, John. 1989. *Population: An Introduction to Concepts and Issues.* Fourth Edition. Belmont California: Wadsworth Publishing Company.

Part II

CASE STUDIES

RWANDA CASE STUDY

Dynamic Linkages Among Population, Environment, and Agriculture in the Highlands of East Africa

Daniel C. Clay
Thomas Reardon

Introduction

The horror of genocide and civil war have recently turned the world's attention to Rwanda. But before that conflict and since, smallholder agriculture in this highland African nation has been defined by severe land scarcity and degradation, declining land productivity, poverty, and hunger. This case study focuses on how smallholders are trying to meet this challenge of agricultural decline, and what determines their investments in sustainable intensification of farming.

Specifically, we examine the livelihood strategies of Rwandan farm families under conditions of growing population pressure. We focus on the alternatives to poverty and the declining economic circumstances brought on by demographic pressure and natural resource degradation. These alternative paths, and the dynamic linkages among them, are important both to farmers and to development planners. While the farm household must weigh the relative advantages of intensifying farm production, seeking off-farm employment, and limiting or spacing births, so, too, national and donor development officials must seek an effective balance among agricultural intensification, income diversification, and family planning as program goals.

Thus, understanding how these paths are linked is imperative for household decision-making as well as for policy and program action. We conclude that most farm households have a firm intuitive grasp of their alternatives and how they fit together; their survival depends on it. But for the development community, including their associated research institutions, understanding population-environment-development linkages remains a formidable challenge.

This challenge motivates us to take a close look at sustainable intensification, off-farm employment, cash cropping, household demography, and other alternative levers used by African farm households to improve their lives, or, for many, simply to stem the tide of poverty. Intense demographic pressure, declining agricultural productivity, and natural resource degradation draw our attention to Rwanda, a bellwether for poor, ecologically stressed areas throughout the highlands of East Africa.

We present this case study in two sequential sections: the first focuses on the interrelationships among household survival strategies in the context of intense demographic pressure, poverty, and resource degradation. The second section examines household-level determinants of sustainable intensification with particular reference to non-farm linkages in enhancing the capacity of Rwandan farm households to follow the "capital-led" path. The study concludes with a review of major findings from both parts and a discussion of research and policy implications.

1. SECTION ONE

Understanding Population-Environment-Development Linkages in Rwanda Through Household Strategies Research

1.1 Goal and Orientation

Part One of this case study is an empirical analysis of Rwandan farm households and their strategies for survival, strategies that have emerged in response to the highest rural population pressure on the African continent. We know that some Rwandan farms have followed the traditional "labor-led intensification path", while others have taken the "capital-led" path (Clay et al. 1995a). And for some, off-farm activities and cash cropping have been the key to success, either as a complement to intensification, or as a substitute. Our goal in this case study is to provide insight into how these strategies are linked to one another and how they are affected by growing population pressure.

Our analysis of household strategies derives from a uniquely rich data set that combines observations on Rwandan farm and non-farm activities and characteristics, as well as crop yields and net food purchases outcomes. We compare the strategies and outcomes of small farms, those for whom demographic pressure is most severe, to those of (relatively) large farms;

within each of these groups, we compare farmers who achieve especially high crop yields with lower-yield farmers to identify the elements of success.

In the remainder of Section One we describe the data and research setting, then present findings from our analyses (ANOVA and regressions).

1.2 Data

One reason for the dearth of empirical research on intensification and other household strategies in Africa is the difficult data requirements. On one hand, such research requires data on the extent of farmers' intensification practices such as conservation investments, implying either the physical measurement of terraces, for example, or on cash and labor time required to build them, or both. On the other hand, a broader set of data is needed to understand the farm management and household strategy context of these investments. Household farm and nonfarm income, assets, demographic characteristics, and the ecological properties of farm holdings, are examples of the kinds of information required. Such multi-level data are rare.

The data examined here, however, meet these varied requirements. They derive principally from a nationwide stratified-random sample of 1,240 farm households (operating 6,464 parcels) interviewed in 1991 by the Agricultural Statistics Division (DSA) of Rwanda's Ministry of Agriculture. Interviews with heads of households and/or their spouses were conducted over a six-week period beginning in June 1991. The survey instrument treated both household-level variables (such as nonfarm income) and parcel-level variables (such soil conservation investments, land tenure, and land use).

1.3 Data Patterns and Context

Ninety-three percent of Rwanda's population lives in rural areas and nearly all rural households farm. The main food staples include beans, sorghum, sweet potatoes and cassava, while coffee, bananas, and white potatoes are important cash crops. Farming is labor intensive—hoes and machetes are the basic farm implements, and animal traction is nonexistent. Livestock husbandry is integral to the farming system, but the progressive conversion of pasture into cropland has caused a reduction in livestock production in recent decades, and a parallel decline in the amount of

manure available for improving soil fertility. Rwanda's average population density is among the highest in Africa. Virtually all arable land is now used for agriculture; marginal lands once set aside for pasture or left in long-fallow are now coming under more intensive cultivation. Rural informal and formal credit markets are severely underdeveloped.

Key variables examined in this study are grouped and listed in Table 1.1. It is important to note that for purposes of the present analysis, many of the summary statistics in this table are reported at the household level, while others are reported below that level (at the parcel level) and above that level (at the secteur and prefectural levels), as indicated. Also, because of our use of conservation investments and farm inputs as indicators of agricultural intensification, parcels in pasture and woodlot (13.4 percent of all parcels), which do not receive such investments, have been excluded from this analysis.

Table 1.1 Descriptive Statistics for Study Variables and Exogenous Control Variables

Variables	Overall Mean or Percent	Coeff. of Variation	Level of Observation *Parcel = 5,596 HH = 1,240 Secteur = 78 Pref = 10*
Study Variables			
1. Farm size (ha/ae)	.20	.98	Household
2. Avg value product of land	45,855	1.01	Household
3. Off-farm income	16,366	2.52	Household
4. Net food sales/purchases	5,821	1.30	Household
5. Cash crop sales	11,460	1.46	Household
6. Agricultural Intensification			
A. HH intensification index	14.91	1.12	Household
B. All conserv. invest. (m/ha)	459	1.05	Parcel
Grass strips (m/ha)	224	1.12	Parcel
Anti-eros. ditches (m/ha)	162	1.49	Parcel
Hedgerows (m/ha)	72	2.86	Parcel
Radical terraces (m/ha)	1	10.00	Parcel

Variables	Overall Mean or Percent	Coeff. of Variation	Level of Observation *Parcel = 5,596 HH = 1,240 Secteur = 78 Pref = 10*
C. Organic inputs (% of parcels)	69%	--	Parcel
D. Chem. inputs (% of parcels)	5%	--	Parcel
7. Percent livestock in perm. stables	.27	1.59	Household
8. Percent land under cash crops	.26	.65	Household
9. Percent land under fallow	.13	1.23	Household
10. Farm fragmentation (Simpson)	.51	.52	Household
11. HH labor/fertility (ages 15-65)	2.64	.53	Household
12. Pct of land declining productivity	49%	--	Parcel
Control Variables			
13. Agro-ecological Characteristics			
A. Rainfall	1,218	.14	Secteur
B. Soil type	2.77	.29	Secteur
C. Crop index (C-values)	.13	.23	Secteur
D. Dist. from paved road	21.9	1.11	Secteur
14. Prices and Profitability of Agric.			
A. Price variation for major crops	.20	.25	Prefecture
B. Ag. profit. index (AVP labor)	101	.39	Secteur
15. Head of Household			
A. Age of household head	45.8	.33	Household
B. Education of household head	1.64	.54	Household
C. Percent male heads of household	79%	--	Household

Table 1.1 shows that the average cultivated landholdings per adult equivalent in Rwanda is only .20 hectare—well below the land area of most farms in Africa. On average, our sampled households cultivate about .91 hectares of land, and the distribution of landholdings is inequitable by the standards of African smallholder agriculture (with a seven-fold difference in land per person between highest and lowest landholder quartiles). In our presentation of findings we refer to "small farms" and "large farms;" it is

evident that we mean this in relative terms in the Rwandan context, as both groups are small compared to the African average.

Almost all land in rotation is cropped; little is kept under fallow. Farms are highly fragmented, fields tend to be located on slopes, and annual rainfall is high. These factors provide strong incentive for farmers to take appropriate measures aimed at controlling soil loss. The vast majority of landholdings are owner-operated; only 7.1 percent, on average, are rented.

The average yield (in value terms) is about 330 dollars US per hectare;[1] hence the average farm produces approximately 230 dollars US of output—about 70 percent of the average yearly income of rural Rwandans. Value of farm yields (from both food crops and cash crops) is used here as an indicator of on-farm livelihood strategy success. The other 30 percent comes from off-farm activities (local businesses farm and nonfarm wage employment, migration remittances, etc.). Note that there is extreme variation over households in levels of off-farm income. Two-thirds of households earn some share of their income from off-farm sources.

The average farm household sells cash crops (coffee, bananas, white potatoes) valued at 82 dollars US, or about 35 percent of the total value of farm output. Note that there is also large variation over households in cash crop sales. Coffee and bananas serve both as the main source of cash from agriculture, and, because they are perennial crops, as an important form of protection against soil erosion. Despite these advantages, only 26 percent of farmland is kept under cash crops, though because they are higher in value per unit produced than other crops, their share in the value of farm output is a disproportionately high.

Most Rwandan households both buy and sell food throughout the course of the year, but on average they buy more food than they sell—approximately 42 dollars more—with variation over households being less than for either cash crop sales or off-farm income. The phenomenon of selling food and then buying it back throughout the year is common to African smallholders (Sahn and Delgado 1989). This pattern also concords with studies by Loveridge et al. (1988) and Ngirumwami (1992) showing that Rwandan rural households import a substantial amount of food from neighboring countries, in particular Zaire and Uganda. The average household can pay for net food purchases using only a portion of off-farm income and cash crop sales.

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[1]Converting the table's values to dollars at 140 RWF/dollar.

The agricultural intensification index reported in Table 1.1 is a composite scale reflecting household soil conservation investments, organic inputs use, and purchased inputs use (notably chemical fertilizer and lime).[2] The average index value is 15, with broad variation across households. Summary statistics for each of the major types of farm household conservation investments and inputs used are presented in items 6B-D of Table 1.1. There is significant variation in the degree to which households invest in soil conservation measures: grass strips are most common, followed by anti-erosion ditches, then hedgerows; radical terraces are rare in Rwanda. An average of only 4.8 percent of cultivated holdings receive fertilizer/lime, but the average percentage of farm holdings treated with organic matter (mulch, manure, etc.) is much higher at 67.2 percent. The average application per hectare of chemical fertilizer is extremely low. Despite their efforts to combat soil loss and fertility decline, 49 percent of cultivated farm holdings are reported by farmers to be declining in fertility over time.

Most households own a few small ruminants; less than a quarter own cattle. Farmers who stable their animals are in the minority—only a quarter use this husbandry intensification technique, despite the rapid disappearance of grazing lands.

Household labor (fertility) is measured as the number of persons in their economically active years (15-65) living in the household. The average among our sampled households is 2.64 persons, with a moderate degree of variation around this average. We also use this measure of household labor as a proxy for household fertility since our more direct measures of fertility (children ever born and surviving children) are available only on a 49.5 percent subsample of farms, and this subsample is biased toward younger families.[3] Despite these problems we found that

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[2]Our intensification index is calculated as: (A) conservation investments * (B) organic matter use * (C) purchased inputs use. Where conservation investments = the sum of the proportions of cultivated holdings with each of the four major conservation investments (grass strips, hedgerows, anti-erosion ditches, radical terraces) + 1; where organic matter use is the sum of the proportions of cultivated holdings using each of the six major organic inputs used (mulch, manure, etc.) + 1; and where purchased inputs use is the sum of the proportions of cultivated holdings using fertilizer and lime + 1.

[3]Fertility data were collected on the 49.5% subsample as part of a study of child and maternal nutrition. Since the subsample was selected as households with children under the age of 5 years, it is biased toward younger households and thus less suitable for current purposes.

household labor is highly correlated with the number of surviving children (r=.47), and in parallel analyses found that the two variable produced virtually identical results.

1.4 Results and Discussion

1.4.1 A Comparison of Farm Strata

Table 1.2 shows a nested comparison of farm household means (using analysis of variance): (1) between categories of farm size per adult equivalent (smaller third versus larger two-thirds), and then for each farm size stratum, (2) between the decile of farms with the highest yields (aggregate value of output per hectare) and the rest (called "lower productivity farms"). The smaller farm tercile represents those farms for which demographic pressure is exceptionally high. We are particularly interested in their case because it is illustrative of the interaction between population growth and agricultural intensification. By isolating farms with exceptionally high yields, we are able to gain an understanding of what is required for successful intensification by those farms under acute demographic pressure.

The cross-strata comparisons shown in Table 1.2 control for major agroecological, infrastructural, demographic, and economic differences. The control variables include: rainfall, soil type, distance to paved road, price variation for major crops, agricultural profitability, secteur-level crop index, and the age, education and sex of the household head. Key results emerging from these comparisons are as follows.

Off-farm income, cash cropping, and food purchases. Off-farm income is relatively high among all groups with the exception of the higher-yield/large-farmers; among the latter it is negative, meaning that they hire (farm) laborers but earn little in off-farm employment. Although this exception is not statistically significant, we believe it to be valid based on the overall pattern of findings—the higher-yield/large-farm group also buys much less food than all other groups, and because they are both relatively productive and land rich, their cash needs can be met through their exceptionally high cash crop sales (Figure 1.1). On the other hand, lower-yield farms finance food purchases from a combination of off-farm income and cash crop sales.

Smaller farmers are also net buyers of food. It is unexpected and interesting, however, that the opposite relationship holds in the small-farm

Table 1.2 Comparison of Household Means (ANOVA) Across Key Indicators by Farm Size (ha/ae) and Land Productivity (AVP of Land), Controlling for Agroecological Differences and other Covariates*

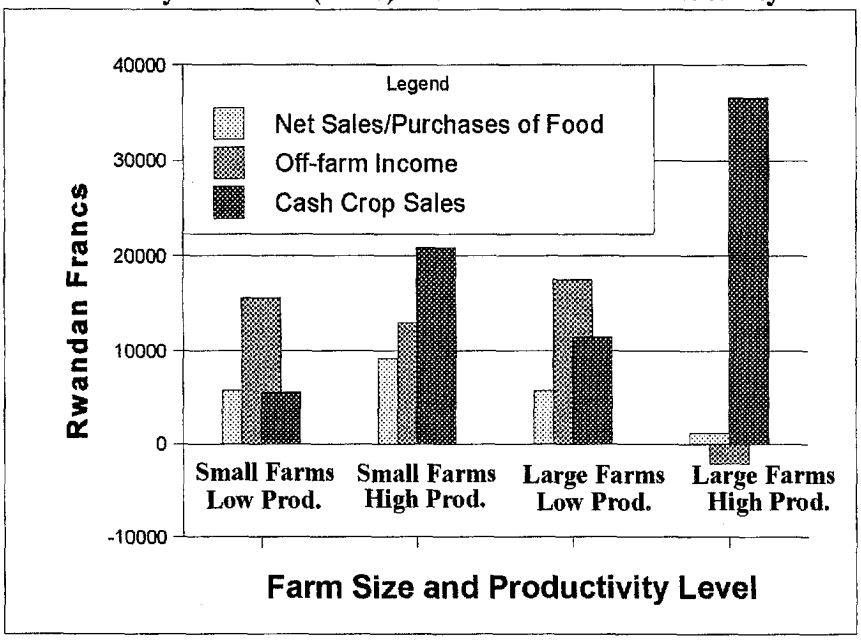
	Small Farms (ha/ae)		Large Farms (ha/ae)			
	Lower Productivity	High 10% Productivity	Lower Productivity	High 10% Productivity	Total	Signif (F)
Off-farm income	15,605	13,020	17,504	(2,114)	16,175	0
Net food purchases (FRW)	5,725	9,153	5,683	1,115	5,831	≤.001
Cash crop sales (FRW)	5,529	20,823	11,524	36,625	11,274	≤.001
Intensification index	16.0	32.3	14.2	13.2	15.8	≤.001
Conservation invest. (m/ha)	5.55	10.14	4.23	4.38	4.93	≤.001
Use of organic inputs	1.26	1.57	1.40	1.40	1.38	0.02
Use of purchased inputs	0.01	0.06	0.06	0.02	0.05	0.07
Perm. stabling of livestock (%)	0.30	0.33	0.25	0.33	0.27	≤.01
Area under cash crops	0.26	0.40	0.24	0.35	0.26	≤.001
Area under fallow	0.09	0.04	0.16	0.10	0.13	≤.001
Farm fragmentation	0.51	0.44	0.53	0.52	0.52	≤.048
Household labor/fertility	2.70	2.63	2.72	2.41	2.70	0.322
Change in land productivity	-20.4	-23.4	-47.9	-26.6	-38.3	≤.001

*Covariates controlled in ANOVA include: rainfall, soil type, distance to paved road, price variation for major crops, agricultural profitability, secteur-level crop index, and the age, education and sex of the household head.

group: the higher-yield farms in that group are twice as great net buyers of food. As the higher-yield/small-farmers have about the same off-farm income as the lower-yield/small-farmers, the explanation of their much greater purchases of food is that the higher-yield/small-farms have substituted toward cash crops; they sell four times more cash crops than their lower-productivity counterparts.

The above results point to the importance of the relationships among net sales of food, off-farm income, and cash crop sales. Exploring these links further, we find that among smaller farms, increased cash crop sales are paralleled by a rapid increase in net food purchases from 4,533 to 11,432; in per adult equivalent terms this represents a doubling, from 1,083 (net food purchases) to 1,835 RWF per adult equivalent.

Figure 1.1 Off-farm Income, Cash Crop Sales and Net Food Purchases by Farm Size (ha/ae) and Level of Land Productivity



This pattern is further reinforced by the comparison of cultivated area under cash crops—as low as 25 percent for the lower-yield farms in both farm size categories, and as high as 40 percent for the higher-yield/small-farms and 35 percent for the higher-yield/large-farms. Hence, there is a

strong "substitution path" between food cropping and cash cropping among small farmers. For larger farmers, the relationship is weaker; comparing the lowest category of cash crop sales to the highest, net food purchases increase from 3,632 to 5,793, or in adult equivalent terms, from 1,089 to 1,361. Households with much larger farms are less compelled to choose between food and cash cropping, as they can comfortably accommodate both on their large holdings.

Agricultural intensification. Higher-yield/small-farms are twice as intensified as lower-yield/small farms, but the degree of intensification does not differ between the high and low yield groups of large farmers. Moreover, higher-yield/small-farms are twice as intensified as all other groups.

Closer examination shows that there are also differences across strata in the components of intensification—conservation investments, organic matter use, and chemical fertilizer use. Interestingly, the higher-yield/small-farmers have double the conservation investments of each of the other strata. In part, this explains their high yields—Clay et al. (1995b) found that soil conservation investments by Rwandan farmers make for a 25-30 percent yield gain, controlling for other factors. Higher-yield/small-farmers appear to be under greater pressure to intensify (and especially to protect their holdings with soil conservation investments) because they have a lower share of land in fallow than do other farms (only a third of the average over all groups). Moreover, large farms have about twice as much of their land in fallow as do small farms. This is important, as fallow is an alternative means to conservation investments and organic matter use for maintaining soil fertility and integrity.

But higher-yield/small-farm use of organic matter is only about 25 percent above that of the other strata. Moreover, whereas proportionately the higher-yield/small-farms use much more chemical fertilizer than do the lower-yield/small-farms, the absolute level of use is extremely low (by African standards, which are in turn very low by overall developing country standards).[4]

Livestock intensification. Differences in livestock husbandry intensification, as proxied by the use of permanent stables, are small but significant. High-productivity farms, both large and small, keep a larger share of their

[4] The average fertilizer use in Africa in 1988 was 8 kg/ha, versus about 56 kg/ha in the developing world overall (Bumb, 1988).

animals in permanent stables than do the less productive farms. Use of permanent stables is both a land use decision and a land improvement decision, since it allows farmers to convert pasture to cropland and to make optimal use of animal manure collected from the stables. The result is higher farm yields.

Farm fragmentation. Higher-yield/small-farms tend to be slightly less fragmented than other farms. This is an unexpected finding since fragmentation is often a sign of the intense demographic pressure faced by farmers in this group. But fragmentation is also part of the traditional labor-led strategy in which farmers exploit a diversity of micro-climates on hillsides and in the more distant valleys to ensure food security throughout the year. This group of highly productive small farmers has abandoned the traditional strategy of maximum agroecological diversity in favor of maximum income diversification. Other strata of households do not appear to have made this important substitution, either because they (as large farms) lack the incentive, or (as lower-yield/small farms) lack the capacity.

Household labor/fertility. There are no significant differences in household labor availability (fertility behavior) across strata. This finding suggests that farm labor, as a reflection of household fertility patterns is equally important as a production factor for large and small farms and for high and low productivity farms. We must also note that the absence of variation in household size across strata is due in part to the fact that the strata are determined on the basis of farm size per *adult equivalent*, thereby nullifying the strong differences that exist in labor/fertility when compared across farm size categories not adjusted for household adult equivalents (Clay and Johnson 1991). What's more, even though on-farm labor does not vary across farm size/productivity strata, this does not mean that it is unimportant as a factor in the livelihood strategies of Rwandan farm households. Its connections to other household strategies such as off-farm employment and intensification are reviewed in the following section.

Declining productivity. Though households in all strata report that the productivity of their land has declined over time, the data show that the larger farmers have experienced the most dramatic decline of all. We interpret this to mean that demographic pressure has obliged the small farms to invest in their land to stem the tide of degradation, as reflected in

their higher degree of intensification.[5] By contrast, the larger farms, particularly those with lower yields, invest the least in protecting their land. Living farther from the margin, these farms are less concerned about "husbanding" their land and consequently observe the most rapid decline.

Thus, for this select group of smallholders (the higher-yield/small-farms), food security is achieved through the use of cash crop and off-farm earnings to buy food, and through greater intensification on the small and relatively concentrated holdings they operate. This intensification is based to a large degree on costly soil conservation investments. Larger and less productive farms tend to adhere to the traditional practices of extensification. The extent to which these and other alternative paths reinforce one another, or act as substitutes, is further explored below.

1.4.2 Alternative Paths

Table 1.3 reports, separately for small farms and large farms, intercorrelation matrices of our main study variables (intensification, off-farm income, net food purchases, cash crop sales, share of land in fallow, farm fragmentation, and household labor). The coefficients reported are partial correlations derived from multivariate regressions that control for the other study variables in the matrix as well as the same set of conditioning variables (agroecological, infrastructural, demographic, and economic) held constant in the analysis of variance presented above. Several results are significant.

Agricultural intensification. Among the small farms in our sample, agricultural intensification is positively associated with off-farm income and cash crop sales. The cash from these two sources can be used to hire labor, and to buy improved inputs and materials. Own sources of liquidity are particularly important for farm capital investments where rural credit markets are underdeveloped (Reardon et al. 1995), which is the case in Rwanda. And cash crops have much higher yields in value terms than do subsistence crops, creating an inducement for farm investment in intensification (land conservation and improved input use). Moreover, cash crop schemes, in particular for coffee and white potato, have input distribution systems and extension programs that facilitate intensification and improved

[5]See Clay (1995c) for a detailed discussion of the impact of population pressure on land degradation in Rwanda.

Table 1.3 Regression Coefficients Among Study Variables (Intensification, Off-farm Income, etc.). Coefficients Control for all Study Variables in Matrix and other Conditioning Variables[a]

	Intensification	Off-farm Income	Net Food Purchases	Cash Crop Sales	% Land in Fallow	Fragment-ationion
Small Farms (ha/ae)						
Intensification	1.00					
Off-farm Income	.09*	1.00				
Net Food Purchases	.01	.33**	1.00			
Cash crop Sales	.13**	-.08**	.35**	1.00		
Prop. Land in Fallow	-.04	-.03	.07*	-.11**	1.00	
Farm Fragmentation	-.34**	.00	.02	.11**	.07	1.00
Household Labor/Fertility	.03	.08**	.11**	.12**	.02	.04
Large Farms (ha/ae)						
Intensification	1.00					
Off-farm Income	-.04	1.00				
Net Food Purchases	.05	.06	1.00			
Cash Crop Sales	-.01	.01	.14**	1.00		
Prop. Land in Fallow	-.09**	-.03	.03	-.04	1.00	
Farm Fragmentation	-.27**	.06	.14**	.00	-.02	1.00
Household Labor/Fertility	.14**	.14**	.11*	.18**	.03	-.03

[a]Control variables used in regressions: intensification,off-farm income,net food purchases/sales,cash crop sales, proportion of holdings in fallow, farm fragmentation,household labor, rainfall, soil type, distance to paved road, price variation for major crops, agricultural profitability, secteur-level crop index, and the age, education and sex of the household head.

* Significant at ≤.10 ** Significant at ≤.05

farm management. Note, too, that more fragmented farms intensify less—fragmentation increases the transaction costs of making farm investments, and intensification partially off-sets the need for the agro-ecological diversity that comes with greater fragmentation. Finally, in the absence of a correlation between intensification and net food sales and purchases we surmise that Rwandan farmers intensify only as much as is necessary to meet their subsistence needs, and not to generate a food surplus for the market. If intensification were seen as a means to generate a food surplus, we might expect there to be a positive association between intensification and food sales.

By contrast, intensification among large farms is not significantly associated with either cash cropping or off-farm activity. This is consistent with the finding that cash crops are grown using less intensive technology on larger farms, as reflected in their lower land productivity (Byiringiro 1995). Moreover, the need to intensify diminishes as the share of land in fallow increases. Finally, large farms differ from small farms in that their intensification is associated with more labor. This may be a reflection of the larger farm's ability to absorb and fully employ household labor for intensification. Alternatively the use of more labor on smaller farms often results in underemployment, as exhibited in their lower rates of labor productivity (Byiringiro 1995).

Income diversification. Among small farms, off-farm income is positively associated with net food purchases, as it is a major source of cash to buy food. At the same time, off-farm income and cash crop sales are inversely related. This suggests that income diversification and cash cropping represent *alternative* paths for small farmers to generate cash for food purchases.

Moreover, larger households generate higher off-farm earnings, as more hands permit a greater division of labor within the household—a portion of the family can stay at home to work on farm and household tasks while others work off-farm. A similar relationship between income diversification and household size has been observed in the West African context (Reardon et al. 1992). Higher fertility can mean greater wealth among parental households in Rwanda, but only to the extent that family members can be employed either on or off the farm. Similarly, demographic research in Rwanda has shown that there is a reverse, positive effect of greater wealth on child survival and household size (Clay and Johnson 1992). This important bi-directional association underscores the importance of intergenerational wealth flows (mainly from children to

parents) as a determinant of fertility rates in Rwanda. From a broader perspective, given the importance of off-farm income for food purchases, this could be an inducement to larger families in the long run.

By contrast, the off-farm earnings of large farms are not an important determinant of food purchases. This is partly because households with large farms buy less food (they can produce enough to meet their needs), and partly because they have high cash crop earnings. Here again, households with more family labor can earn more off-farm income.

Cash cropping. Among small farms, cash crop sales are positively associated with net food purchases. Alternatively, although it is rare for small farmers to be net sellers of food, one could say that food and cash crop sales are substitute means to earn cash. Moreover, households with more family labor buy more food.

Higher cash crop sales mean more net food purchases for large farms too. But in contrast to small farmers, cash crop and food crop sales may be substitute sources of cash. Though on average both large and small farmers are net food buyers, many of the large farmers (15 percent), are net food sellers. For these larger farmers, food sales and cash crop sales appear to be substitute paths for generating needed cash. However, as suggested above, off-farm income and cash crop sales are not substitute paths for the larger farmers. Until demographic forces are brought to bear, these large holders will have more options and fewer constraints than small holders in the strategies they choose to follow.

Among small farms, more cash crop sales are associated with a lower share of land in fallow. Perhaps this is because small farmers must push their farms harder to make room for cash crops, or simply because they have proportionally more cultivable land on their farms and are careful to make the most of it. This means keeping it under cultivation and, as shown earlier in Table 1.2, investing in soil conservation and improved inputs.

Alternatively, cash crop sales among larger households appear to be more a function of the household labor supply—a key factor given the labor-intensive techniques associated with maintenance of coffee and banana plantations. Indeed, cash crop sales are much higher in households with more labor. Byiringiro (1995) shows that labor productivity in Rwanda is higher among large farms, hence their additional labor should have a strong positive effect on crop output.

Farm fragmentation. The strong negative association between intensification and farm fragmentation confirms the incompatibility of soil conservation and fertility investments with the strategy of agroecological

diversification. Moreover, previous research has shown that Rwandan farmers rarely invest in more distant fields, a corollary of farm fragmentation (Clay and Reardon 1994).

Household labor/fertility. Much has already been said above about the connections between household labor/fertility decisions and household livelihood strategies. In short, larger families show a positive association with virtually all of the strategies pursued by the households in our sample. Larger families generate more off-farm and cash crop income, they have higher food purchases, and are more likely to intensify.

These findings might lead us to the conclusion that lower fertility is not an alternative to livelihood strategies, as ecological theory hypothesizes it is. Rather, it seems to be an inimitable ingredient to their success. And traditionally this has been true, particularly where land was seen as an unlimited resource—large households were successful households. In Rwanda's farm sector, children are still seen as an asset to the household economy because of the labor they provide. Thus, the intergenerational flow of wealth in rural Rwanda still moves from children to parents. To be sure, Rwandan parents are concerned about the welfare of their children. But when asked about what children will need to do to survive in the absence of sufficient land resources, the overwhelming response from parents is that children will just have to "make do on their own."[6]

Parental responsibility is focused first on the survival of the family/household unit, and only second on what will become of children who can no longer contribute to the household economy. A shift in orientation to where parents put their children's futures ahead of the immediate gain of the household has occurred in many parts of the developing world, especially in Asia, Latin America and in many urban African settings. But in rural Rwanda, this transformation is just beginning. Perhaps this is why we find that the importance of labor/fertility to intensification, off-farm employment and other key dimensions of farm livelihood strategies is considerably lower among small farms than among large farms in our sample. In time, perhaps, the association will diminish further, or even reverse itself, as the long-term costs of raising children in Rwanda meet or exceed their short-term economic benefits for land-poor households.

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[6]Source: unpublished tables from the 1988 Rwanda Non-farm Strategies Survey conducted by the Rwanda Ministry of Agriculture.

In summary, the findings presented in this section reflect differences in demographic pressure faced by small and large farmers. Because smaller farms are under intense resource constraints, their options are limited. Thus there are strong correlations among the paths available to them—for example, between intensification and off-farm activities or cash cropping. One must substitute for the other, or one must reinforce the other. They must make the most of what they have, and it must be strategic. By contrast, large farmers have room to maneuver. More abundant resources permit them to pull more levers and explore more options, or, for some, to simply continue along the traditional labor-intensive, low investment path. Consequently, with the exception of the labor/fertility path, for reasons described above, linkages among the paths are relatively weak among the large farm group.

2. SECTION TWO

Population-Environment-Development Linkages and Sustainable Intensification in Rwanda

2.1 Introduction

Historically, Rwandan farmers settled along the upper ridges of 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 (Nwafor 1979). But rapid population growth has in recent decades brought several changes in the traditional agricultural system: (1) farm holdings have become smaller due to constraints on land availability; (2) holdings are more fragmented; (3) cultivation has pushed onto bottom lands and fragile margins on steep slopes previously held in pasture and woodlot; (4) many households now rent land, particularly those owning little land or with large families; (5) fallow periods have become shorter, and cultivation periods have grown longer (Clay 1995).

A consequence of farming more intensively and farming on steep slopes is the high incidence of soil loss due to erosion, and along with it, declining soil fertility. Rwanda's National Agricultural Commission estimates that half the country's farmland suffers from moderate to severe erosion (CNA 1992). Clay (1995) reports that farmers observe a decline in the productivity of nearly half their holdings due to land degradation.

Byiringiro and Reardon (1995) show that erosion severely reduces farm yields in Rwanda.

Land use pressure and concomitant declining productivity have led farmers to intensify agricultural production along several paths (Boserup 1965). These are paths that, according to Boserup, emerge spontaneously from the context of increased land constraint—conditions that result from population growth, increased demand for agricultural products, or reduced transportation costs.[7]

Boserup's work identifies two broad paths which we condense and describe briefly as follows. The first we call "capital-led" intensification, which, in addition to the use of farm labor and land, implies the use of "capital." We broadly defined capital to include nonlabor variable inputs that enhance soil fertility (e.g., fertilizer) and quasi-fixed capital that is used to maintain soil fertility. In Rwanda, the predominant capital inputs include:

- land conservation infrastructure (grass strips, hedgerows, anti-erosion ditches, and radical terraces),
- organic matter such as mulch, compost, manure, and green manure,
- chemical inputs such as fertilizer, pesticide, and lime.

We also classify the planting and maintaining of cash perennials such as coffee and bananas as long-term capital, and thus characteristic of the capital-led path. These capital inputs are acquired in one of two ways: they are *purchased* (fertilizer, for example) or they are *produced* (e.g., manure is collected and anti-erosion ditches are dug using farm labor and other farm capital such as shovels and carts) (Clay et al. 1995b).

The second path distilled from Boserup's work we refer to it as *labor-led* or *labor-only* intensification because it makes little or no use of "capital" (as defined above). Farmers on this path merely add to the production process on a given unit of land by increasing amounts of (unaugmented) labor. Typically this labor is used to crop more densely, weed and harvest more assiduously, etc.

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[7]Also see Pingali et al. (1987).

These two intensification paths initially described by Boserup and here labeled the capital-led and labor-led paths have been the subject of considerable empirical research in Africa. There are studies that have categorized the agricultural systems in particular *regions* of Africa where demographic pressure has pushed farmers to intensify along these paths. A main conclusion from this work has been that the capital-led path is more sustainable and productive in fragile, resource-poor areas (Matlon and Spencer (1984). Other studies have categorized a variety of *agroclimatic and policy settings* in terms of these two paths (Lele and Stone 1989).

Matlon and Spencer (1984) conclude that in much of the African tropics, the labor-led path to intensification is unsustainable, and leads to land degradation and stagnation of land productivity. The East African highland tropics, characterized by heavy rainfall and steep slopes, are an extreme example of this danger. Far more sustainable in such areas is the capital-led path of intensification that incorporates land conservation investments with the use of organic matter and fertilizer. Farm households that follow only the labor-led path in highland African settings such as Rwanda, Kenya, and Ethiopia, have set a course for long-run ecological degradation and poverty. Hence, critical to the debate on sustainable development is the question of what determines the particular technologies and investments—intensification paths—followed by households in these fragile areas.

Our review of the research literature in this area shows that, in general, conceptual and empirical work in the tropics has addressed the question in terms of broad groups of farmers. For example, how do farmers in particular agroclimatic zones and/or policy contexts, face incentives and conditions for following one or the other intensification path. Pingali, et al. (1987), examine how costs and returns to intensification by use of animal traction can be categorized according to the economic and physical characteristics of agroclimatic zones. Other researchers have examined the nature of intensification in maize production over locations with differential access to infrastructure, technology, and prices (Smith, et al. 1994, Freeman 1994).

Nearly absent in the empirical research literature, particularly in the African context, are studies addressing the specific determinants of the intensification paths taken by farm households. There is a need to understand *why* households situated in given agroclimatic and/or policy context and facing similar incentives to intensify, take the labor-led or capital-led intensification path. More specifically, in settings of rapid

population growth and degradation, relatively few studies have analyzed the determinants of smallholder investments in land conservation capital, and use of nonlabor variable inputs such as organic matter and chemical fertilizers. One recent exception is Place and Hazell (1993), who focus on the effects of land tenure on land improvements in Rwanda; another is the work of Lopez-Pereira, et al. (1994), on the hillsides of Honduras.

Part Two of this case study addresses this gap in research in two ways. First, we provide an empirical analysis of the capital-led path of intensification, focusing on household-level differences in the determinants of intensification within a given agroclimatic zone (the East African highland tropics) and policy context (Rwanda). Second, we highlight household-level determinants of "sustainable intensification" that have not commonly been treated in the literature on intensification. More specifically: (a) We show the importance of household-level intersectoral links—specifically, "reverse linkages," where nonfarm income affects farm investment—to enhancing the capacity of households to follow the capital-led path. (b) We address the subject of landholding structure that recent literature has brought to center stage (Clay 1995, Place and Hazell 1993). Here we examine the links between demographic pressure, changes in the structure of landholding, and, in turn, the technology paths taken by farmers.

We proceed as follows: Section 2.2 discusses our general model. Section 2.3 discusses the specific variables, regression specification, and working hypotheses. Section 2.4 describes general patterns in the model variables. Section 2.5 presents and discusses regression results.

2.2 General Model

We set out a general model for farm investments, which is then broken out in the following section into four regression equations for the land and input use and land conservation investments under study.

We follow the literature on firm and farm-level investment theory (Christensen 1989, Feder et al. 1985, 1992), and model farm-level investments as a function of four sets of variables:

$$\text{Investment} = f(1.\ \text{financial returns}, 2.\ \text{physical returns}, 3.\ \text{riskiness, and } 4.\ \text{wealth and cash sources}) \quad (1)$$

In general, a higher return on investment will stimulate a higher rate of investment. Conversely, greater risk leads to lower investment for risk-

averse farmers. In the present context, we focus on risk from price and rainfall instability, which Feder, et al. (1985) term "confidence in short term," and from insecurity of land tenure, hence risk of appropriation of capital, which they label "confidence in the long term."[8]

While the incentive to invest can be great, capacity to invest may be low. Thus income and wealth (in terms of human capital and cash and labor sources) are important general determinants of such investments. In theory, household liquidity is important to include in contexts where the credit market is underdeveloped or absent. This is generally the case in the tropical highlands of East Africa for these sorts of investments.

2.3 Regression Specification and Hypotheses

The general model described above explains investment in terms of the incentives and disincentives facing farm households and the capacity of households to undertake investments.

Table 2.1 shows the regression specification, reproduced as follows:

Land conservation investments (m/ha) = f (variable categories 1,2,3,4)	(2)
Use of organic inputs = f (1,2,3,4)	(3)
Use of chemical inputs = f (1,2,3,4)	(4)
Land use erosivity (C-value) = f (1,2,3,4)	(5)

The dependent variables are land conservation investments and nonlabor variable input use (organic matter and chemical inputs), and land use erosivity.

The first three reflect what can be termed "capital investments"—such as ditches, manure, and chemical fertilizer—that protect the land and enhance the soil. Land conservation investments are the combined investments (measured in meters per hectare) of on-farm infrastructure (grass strips, ditches, windbreaks, and radical terraces). Organic matter use (composting, manure, green manure, mulch) and chemical input use (chemical fertilizer, pesticides, and lime) are each measured as binary variables (used or not used on the plot), as we do not have data on quantities used.

[8]Also see Newbery and Stiglitz (1981).

The fourth dependent variable is the "C-value"—an indicator of the erosivity of land use.[9] As its value goes down, so does the erosivity of land use. Controlling for production techniques, the C-value essentially reflects crop mix—land use is less erosive with more perennials (coffee, bananas), and more erosive with more annuals (tubers, pulses, grains). The land use (erosivity) equation requires further explanation, as it is a land use decision that explicitly reflects choice of an outcome (erosivity), but is a decision that in practice reflects a crop choice (cash perennials versus cash and subsistence annual crops). The choice between these two sets of crops can, however, be based on two sets of incentives (controlling for physical, cultural, and economic constraints): (1) to reduce erosion, which is a long-term objective that requires short-term (crop) choices; (2) to maximize returns to land and labor, which is a short-term objective that requires a short-term choice of crops with high returns. We have thus modeled this "dual variable" as a function of variables that reflect incentives related to the long-term objective (e.g., steeper slopes of fields should spur investment in perennials to control runoff), and of variables that reflect short-term profitability considerations (e.g., the price of bananas relative to sweet potatoes).

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[9]Erosivity of land use is measured using C-values. The C-value index is a well-known measure that reflects the overall protective quality of crops. It 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, 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 of specific crops vary over farming systems. 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.

This was done in our case: The C-values we use are 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). 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 .16, a composite of many forms of land use and crop mix.

Given the calibrated C-value estimates from these studies in the region, one only has to know the crops planted on the plot to know the C-value of that plot. Hence, we used our data on crop and cropped area per plot to calculate C-values.

Regressors are listed in Table 2.1 in the four following categories: (1) monetary incentives to invest; (2) physical incentives to invest: (3) risk of investment; (4) cash sources, physical wealth, and human capital. Note that some variables are classed for simplicity as either incentive or capacity variables, but actually are both (an example is farm size). The variables in each of the four categories are discussed individually below, along with our hypotheses concerning their effects on the dependent variables.

2.3.1 Monetary Incentives to Invest

Returns to agricultural and nonagricultural activities. We expect better returns to agriculture to lead to more land conservation and soil fertility investments. Relative returns to agriculture are measured here as the average value product of labor per prefecture, calculated using aggregated household data. By contrast, we have ambiguous expectations for the effect of the return to nonagricultural activities (measured here by the off-farm wage). On one hand, better returns off-farm mean competition with on-farm investment. On the other hand, greater off-farm income means more cash available to the household to invest on-farm. But labor and cash diverted to off-farm uses might also reduce the pressure on the land; it would provide cash to buy food, and might encourage the household to use land in less labor-demanding ways, such as perennial crops, fallow, and pasture—ways that are also less erosive and degrading of soil fertility.

Crop prices and transaction costs: We include prices in the model, as explained above, to reflect short-term profitability considerations related to crop choice. We expect better prices for perennial crops to induce land use patterns with lower C-values. We represent perennial crops with the banana price, as the coffee price is set administratively and does not vary over prefectures. We represent annual crop prices with the price of sweet potatoes; ideally we would have included a vector of annual prices, but they are highly correlated, as one would expect.

Market prices do not fully reflect the actual prices received by farmers. To control for this, we introduced two variables, distance of the household to the nearest main market and the distance to a paved road (reflecting transaction costs). We expect both to be inversely related to investments in agriculture.

2.3.2 Physical Incentives to Invest

Share of farm under fallow, woodlot, and pasture. We expect that farmers with more land in non-cropping uses will be less likely to invest in capital to intensify the use of their cultivated land, as they rely less on presently-cultivated land. As with slope steepness, decline in fallow has attained more importance as an issue as population density has increased. Fallow and pasture have been declining in recent years because of the need to increase food production (Clay and Lewis 1990). Only woodlots seem not to have suffered, thanks to a strong government campaign aimed at replanting and woodlot maintenance at both household and communal levels.

Declining fallow appears to be linked to changes in land use. Though some of the lost fallow and pasture may be land that has been converted into woodlot, other findings suggest that households with insufficient landholdings are being forced to plant more land in sweet potatoes and other tubers (Clay and Magnani 1987, Loveridge et al. 1988). Tubers have a higher caloric value than other crops, and tend to grow relatively well in poorer soils (Gleave and White 1969) such as those commonly found on steeper slopes. But in terms of soil erosion, tubers are worse than the traditional uses of these slopes (woodlot and pasture). Elsewhere in Africa (Lewis 1985) and in Latin America (Ashby 1985), tubers have been associated with accelerated soil loss.

Plot slope and location on the hillside. Steeper slope (particularly where rainfall is high) increases the incentive to invest in land protection and to adopt less erosive forms of land use. Steeper plots are more susceptible to erosion. But we expect that steepness will discourage the use of chemical fertilizer and organic matter because of runoff.

The issue of field slope has become more important with increased population density. In Rwanda, the steepest areas have traditionally been reserved for pasture, woodlot, and minor crops, and frequent fallow periods were commonly required. At the very outer rings of cultivation, toward the base of the slope and in the swampy valleys, crops are grown along ridges that are built up for purposes of water drainage. Increasing land scarcity has obliged many farmers in recent decades to depart from this traditional system. As the preferred lands along the upper slopes became occupied, young farmers were faced with the decision to either cultivate smaller and less fertile plots farther down the hillside or to migrate elsewhere in search

of sufficient land. Thus, our interest is both in steepness of slope, and in hillside location (i.e., upper, mid or lower, with the value of the regression variable increasing as one descends the slope), the two of which are closely associated, with the steepest holdings being located on the mid-slope areas.

Farm fragmentation, plot size, and plot distance from residence. Fragmentation entails the geographic dispersion of plots (measured by the Simpson index). We expect that as fragmentation increases, and plots are more dispersed, farmers will have less incentive to make land improvements because of higher travel and transaction costs. The same "transaction cost" reasoning can be applied to plot size and distance from residence. Moreover, smaller and more distant parcels are often at the base of the hillside and in valleys where the degenerative effects of soil erosion are less severe, and where lands have been brought into production more recently.

Plot age. We measure this as years since operation began by the current operator or a member of his family. We estimate that for the vast majority of fields (over 85 percent), age of plot reflects the number of years since clearing and first cultivation. In the past, Rwandan farmers could migrate in response to growing demographic pressure; they tended to move to the drier, eastern provinces, once the exclusive domain of the pastoralists. Today, however, in the absence of unoccupied lands, farmers cultivate the same holdings year after year, and in increasingly intensive ways. 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, and perhaps a disincentive to invest.

Annual rainfall. Greater rainfall is expected to lead to less erosive land use practices and more land conservation investments. This was discussed above in the section concerning plot slope.

2.3.3 Risk of Investment

Land tenure/Plot use rights. We measure this as a binary variable, 1= own plot, 2= rent plot. This variable reflects what Feder et al. (1985) term degree of "confidence in the long term." We expect farmers to make fewer longer-term land improvements such as bunds and terraces on holdings that are rented-in. These holdings have short-term use rights, and as such make long-term investments risky. But empirical evidence for similar contexts is mixed. For a smaller sample in Rwanda (in three prefectures: Butare, Gitarama and Ruhengeri), Place and Hazell (1993) found farmers tended

to invest less in rented land. And Migot-Adholla, et al. (1990), show for Ghana that plots owned or under long-term use rights are more likely to be improved (fertilized, mulched, irrigated, or have trees planted on them) than those under short-term use rights such as rental. But for Kenya they found the relationship between tenure and land improvements to be weak—because farmers feel secure in their ability to cultivate rented plots continuously.

Moreover, we expect, as do Cook and Grut (1989), that rented holdings will tend to be used for annual crop production, rather than for more protective perennial crops and woodlot whose value is returned over a longer time period.

Price risk. We measure this as a prefecture-level coefficient of annual price variation over 1986-1992. This variable is classified by Feder et al. (1985) as a variable affecting "confidence in the short term." In Rwanda price variability is tied to rainfall variability, and we expect it to be a disincentive to investment.

2.3.4 Wealth and Liquidity Sources

Cash income. We represent this with two variables: (1) noncropping income, which we measure as the sum of off-farm labor sales plus receipts from non-cropping business (including such things as brewing banana wine, construction, and so on), and (2) cash crop income (sales of bananas, coffee, and white potatoes).

With perfectly functioning credit markets and perfect information, household wealth and cash sources should not affect investment. But where there are imperfections in the credit market, as is probably the case in rural Rwanda, theory suggests that own liquidity sources (such as off-farm income and crop sales) will be critical to on-farm investments where there is failure of, or constraints in, the credit market (Reardon et al. 1992). Moreover, even where the credit market is functioning but underdeveloped, Reardon and Vosti (1987) contend that the least likely investments to receive credit are conservation measures.

Thus we posit no clear hypothesis about the effect of noncropping income on investment. It is conceptually a "two-edged sword," providing liquidity for on-farm investments but also potentially competing (as a destination for such income) with these investments.

Ideally we would also have a variable reflecting access to credit, but do not have observations on this. One can think of the variable "distance to road" as a rough proxy of such access (at least to formal credit).

Livestock holdings. As these are a major source of wealth, and of manure, one would expect these to spur investments.

Land holdings. Our hypothesis concerning farm size is ambiguous, as its effects are complex and inconsistent. On the one hand, larger farmers are better able to spare land to set aside for anti-erosion measures and for fallow and pasture or woodlot. Larger farmers also tend to be wealthier, so have more cash to hire labor and buy inputs for land improvements (Grabowski 1990).

On the other hand, smaller farmers tend to have more household labor available per hectare, which can be used to build and maintain land conservation infrastructure that require a substantial and continuous supply of labor.

Farmers with smaller landholdings also have greater incentive to improve their land as they are dependent (*ceteris paribus*) on less land than larger farmers (Boserup 1981, Ehui et al. 1992). Boserup also maintains that as population density increases and land becomes scarce (farms grow smaller), fallow periods must be shortened, and technologies that are intensive in factors that substitute for land must be adopted. Maro (1988) shows that increased population density in highland Tanzania has led to agricultural intensification using irrigation in one area, and terracing of steep slopes in another. In the highland tropics, use of fertility-enhancing inputs and land conservation capital can increase the intensity of production and sustain its use, thus substituting for long fallows. Alternatively, more intensive use of family labor has facilitated the construction of terraces, living fences, mulching and other land conservation technologies (Cook and Grut 1989). Yet applying more labor to a given unit of land, and planting more densely, are practices that seem unlikely to improve soil fertility in the longer run. On the contrary, without additional inputs or fallowing, we expect that the labor-led path to intensification would deplete the soil further.

However, the "ceteris paribus" assumption described above allowed us to ignore for a moment what we must now recognize—that small farmers are driven to diversify incomes off-farm to manage risk in fragile resource settings—risk that provides an incentive to diversify their asset portfolios and incomes to deal with an uncertain environment (Binswanger 1986, Robison and Barry 1987).

In sum, smaller farmers are compelled on the one hand to make these investments because they depend more on their small holdings, they must seek ways to intensify as a substitute for fallow, and they have more labor per hectare to use for land improvements. On the other hand, the very smallness of their farms and the riskiness of their environments mean that the desire to divert resources to diversifying their incomes is stronger. Yet the cash from these off-farm activities can help them make improvements, a subject treated below.

Own-labor holdings. This is measured as the number of adults in the household. Own labor is expected to be a crucial determinant of investments that require a significant labor counterpart (such as collecting manure, and digging anti-erosion ditches). The construction and maintenance of land conservation infrastructure can be very labor-intensive. We thus expect that larger households, *ceteris paribus,* will be more able to undertake them. *Dependency ratio* is the share of children in total size of family. This is expected to affect negatively investments, as it children are an alternative destination for time and money.

Human Capital. This is proxied by variables reflecting *literacy, age, and knowledge of conservation practices, each pertaining to the household head.* The more literate, experienced, and knowledgeable in conservation practices are household heads, the more we expect them to make investments and manage resources carefully. Gender of household head *(1 for man, 2 for woman)* is included to reflect access to resources.

2.3.5 Sector-Level Variables

Our nation-wide sample of 1200 households can be broken into 78 "sectors" (about 20 households each). We aggregated household observations for each of the four dependent variables across the households in a secteur to create secteur-level variables. They represent social and administrative conditions in the immediate area, and are expected to have a positive influence (especially in the case of the same type of investment). We also confirmed that the sectoral variables are not correlated with the (more aggregate) prefecture-level variables.

Table 2.1 Land Use/Conservation Investments/Inputs Model Variables*

Model Variables	Overall Mean or Percent	Coeff. of Variation	Level of Observation *Parcel= 5,596 HH = 1,240 Sector = 78 Pref. = 10*
1. *Land Use/Conservation Investments/Inputs*			
Land Use (C-value)	.16	0.43	Parcel
All Conserv. Invest. (m/ha)	424	1.18	Parcel
Grass Strips (m/ha)	205	1.34	Parcel
Anti-eros. Ditches (m/ha)	161	1.68	Parcel
Hedgerows (m/ha)	56	2.86	Parcel
Radical Terraces (m/ha)	1.17	25.20	Parcel
Organic Inputs (% using)	69.5%	--	Parcel
Purchased inputs (% using)	4.9%	--	Parcel
2. *Independent Variables*			
A. Monetary Incentive to Invest			
Ag. profitability index	105.9	.41	Prefecture
Non-ag wage in pref.	216	.39	Prefecture
Price of banana (FRW)	23.9	.14	Prefecture
Price of sweet potato (FRW)	14.6	.22	Prefecture
Dist. to nearest market (min.)	4.6	.33	Sector
Dist. to paved road (min.)	24.5	1.10	Sector
B. Physical Incentive to Invest			
Share of land in fallow	.16	1.06	Household
Share of land in woodlot	.09	1.56	Household
Share of land in pasture	.04	2.50	Household
Slope (degrees)	16.7	.65	Parcel
Location on slope	.52	.33	Parcel
Farm frag. (Simpson)	1,214	.52	Household
Size of Parcel (ha)	.80	1.02	Parcel
Dist. from residence (min.)	7.4	2.13	Parcel
Years operated	22.2	.66	Parcel
Annual rainfall (mm)	1095	.34	Sector
C. Risk of Investment			
Land use rights	1.08	.25	Parcel
Price variation (1986-92)	.20	.25	Prefecture
D. Wealth and Liquidity Sources			

Model Variables	Overall Mean or Percent	Coeff. of Variation	Level of Observation *Parcel= 5,596 HH = 1,240 Sector = 78 Pref. = 10*
Non-cropping inc. (FRW)	26,489	.00	Household
Cash crop income (FRW)	15,428	.00	Household
Value of livestock (FRW)	20,494	.00	Household
Landholdings owned	153	.83	Household
Human Capital :			
Nmbr of adults (15-65)	3.16	.51	Household
Dependency ratio	115	.78	Household
Literacy (% of Heads)	50.3%	--	Household
Knows of conserv.	2.37	1.01	Household
Age of head (years)	47.96	.30	Household
Sex of head (% male)	79.2	--	Household
E. Sector-level Variables			
Sector land use (C-value)	.13	.15	Sector
Sector conserv. invest. (m/ha)	411	.53	Sector
Sector org. inputs (% area)	.67	.22	Sector
Sector chem. inputs (% area)	.05	1.60	Sector

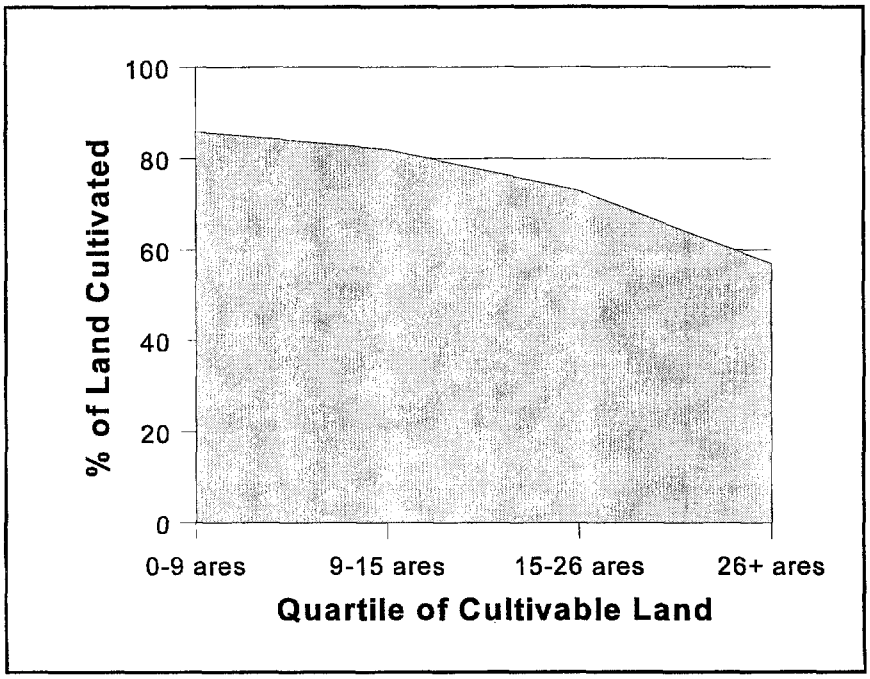
*Summary statistics reported at the parcel level are for all holdings under cultivation or fallow (thus excluding pasture and woodlot). Parcel-level summary statistics may differ slightly from those aggregated and reported in other chapters at the household level.

2.4 Data Patterns and Context

The model variables are grouped and listed here (Table 2.1) according to the model specified above. It is important to note that for purposes of the present analysis, many of the summary statistics in this table are reported at the plot level, while others are reported at the household or prefectural levels (as indicated). Also, because of our current focus on conservation investments and inputs use, parcels in pasture and woodlot (13.4 percent of all parcels) have been excluded from this analysis.

Land use is on average fairly non-erosive (with a C-value of .16) though variation across parcels is high (with a coefficient of variation of .43). There is also great variation over farm households in the degree to which they invest in land conservation measures: grass strips are most common, followed by anti-erosion ditches, then hedgerows. Only 4.9

Figure 2.1 Proportion of Land Under Cultivation by Farm Size



percent of parcels receive fertilizer/lime, but most (69.5 percent) receive organic matter (mulch, manure, etc.).

Almost all land in rotation is cropped; little is kept under fallow. Larger landholders hold a greater share of land in fallow than do smaller farmers. Figure 2.1 shows that the quartile of households with least cultivable land per adult equivalent cultivates 86 percent of this area, whereas for the least land-scarce quartile the figure stands at only 57 percent. Fields tend to be on slopes, and annual rainfall is high. These factors provide strong incentive for farmers to take appropriate measures aimed at controlling soil loss.

Nonfarm income (wages from hired agricultural and non-agricultural work plus own-business income) constitutes about one third of total income, and about two-thirds of households earn some nonfarm income. Operational holdings are very small, and are fragmented into many smaller plots. The vast majority of landholdings are owner-operated; only 8 percent are rented. Most households own a few small ruminants; less than a quarter own cattle. There is strong variation over households in their (self-reported) degree of knowledge of various land conservation and productivity-

enhancing practices. Agricultural profitability, as well as price variability, show considerable variation across prefectures.

2.5 Regression Results and Discussion

This section examines the determinants of land management strategies in Rwanda. Ordinary Least Squares (OLS) and logistic regressions on land conservation investments, fertility-enhancing input use, and land use (C-values) are estimated using the variables described above. The regressions explaining C-values and conservation investments are run using OLS.[10] Organic inputs and chemical fertilizer use are estimated using logistic regression, as the regressands are dichotomous due to data limitations. The results for conservation investments and input use are discussed first, followed by those for the land use erosivity regression. Regression results are reported in Table 2.2.

2.5.1 Correlations among Regressands

There is a moderately strong negative association between use of organic inputs and erosivity of land use (Table 2.2), as one would expect: where cropping patterns are less erosive, there is less loss due to runoff and thus more effective use of inputs.

There are significant correlations between land conservation investments on the one hand, and use of organic and chemical inputs on the other. Again, the former guards against runoff, thereby enhancing the effectiveness of the latter. Finally, there is a small but significant relationship between organic input use and chemical input use: if it had been negative, that would have implied that farmers treat them as substitutes. But agronomic recommendations are for the two to be used together, and their positive correlation implies that, by and large, farmer behavior is consistent with these recommendations.

[10]Because the OLS regressions are estimated using plot-level observations, estimates are weighted according to parcel size, as well as for the household's probability of selection.

Table 2.2 OLS and Logistic Regressions: Investments, Inputs, Land Use Model

Independent Variables	Investments/Inputs/Land Use: Cons. Invest. (m/ha) (OLS)	Organic Inputs (Logistic)	Purchased Inputs (Logistic)	Land Use (C-value) (OLS)
Correlation Matrix: Land Use, Investments and Inputs				
Conservation investments	1.00	–	–	–
Organic inputs	.21**	1.00	–	–
Purchased inputs	.06**	.11**	1.00	–
Land use (C-value index)	.05**	-.18**	-.02	1.00
OLS and Logistic Regressions				
A. Monetary Incentive to Invest				
Ag. profitability index	.00	.00	.04**	-.05*
Non-ag. wage in pref.	-.01	-.02**	-.05**	.00
Price of banana	.01	.00	.00	.02
Price of sweet potato	-.00	.00	.07**	-.05**
Dist. to nearest market	.01	.00	.02*	.01
Dist. to paved road	.01	.00	-.09**	.02
B. Physical Incentive to Invest				
Share of land in fallow	-.00	-.03**	-.02*	-.09**
Share of land in woodlot	-.05**	.00	-.03**	-.14**
Share of land in pasture	-.06**	-.12**	-.11**	-.07**
Slope (degrees)	-.02	-.05**	-.09**	-.02
Location on slope	-.14**	-.11**	-.03**	.05**
Farm frag. (Simpson)	-.00	.00	.00	-.07**
Size of Parcel	-.01	.18**	.14**	-.15**
Dist. from residence	-.05**	-.21**	.04**	.08**
Years operated	.00	.02**	.00	-.00
Annual rainfall	.03	.00	.05**	.03
C. Risk of Investment				
Land use rights	-.04**	-.17**	.00	.23**
Price variation	.00	-.01**	-.03**	.03
D. Wealth/Liquidity Sources and Human Capital				
Non-cropping inc.	.05**	.04**	.01	.00
Cash crop income	-.01	.00	.00	-.04**
Value of livestock	.04**	.08**	.05**	.03*
Landholdings owned	-.11**	-.10**	.00	.12**
Human Capital :				
Number of adults	.04**	.04**	-.02**	.04**
Dependency ratio	.00	.00	-.06**	.02*

Independent Variables	Cons. Invest. (m/ha) (OLS)	Organic Inputs (Logistic)	Purchased Inputs (Logistic)	Land Use (C-value) (OLS)
Literacy of Head	-.00	.00	-.06**	.00
Knows of conserv.	.01	.00	-.03**	-.03**
Age of head	-.01	-.04**	-.05**	.01
Sex of head	.00	.02**	-.07**	-.00
E. Sector-level Variables				
Sector land use	-.01	.00	.03**	.39**
Sector conserv. invest.	.41**	.00	-.04**	-.02
Sector use of org. inputs	-.01	.13**	-.01	.00
Sector use of chem. inputs	.02**	.00	.28	.06**
Adj R^2 or % Correct prediction	.24	81.9%	96.3%	.25

*Sig T ≤.10 **Sig T ≤.05

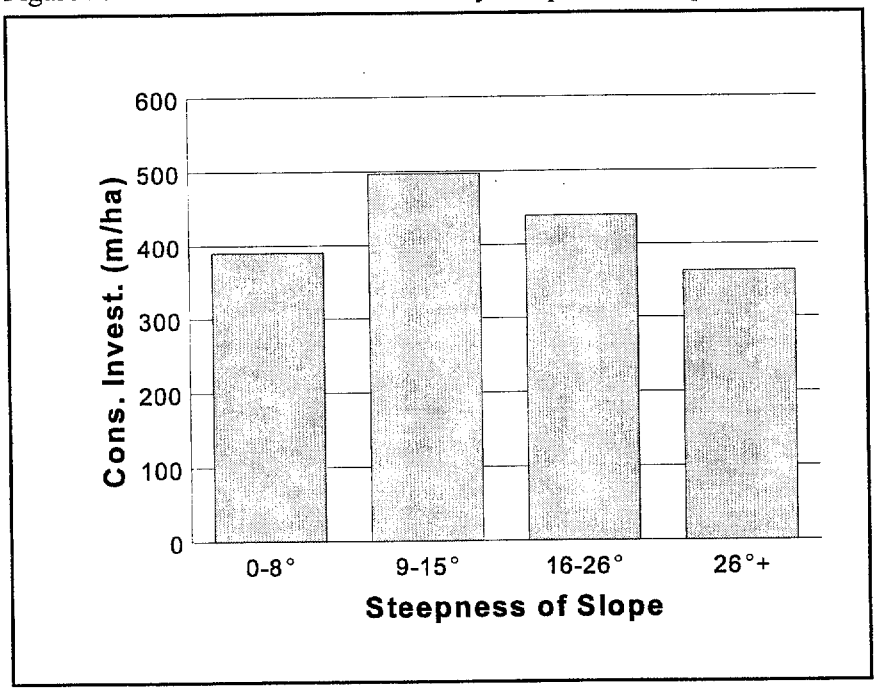
2.5.2 Land Conservation Investments: OLS Results

Monetary Incentives. Higher relative returns to agriculture do not significantly affect land conservation investments. Crop prices also do not affect these investments. Thus, contrary to expectations, it appears that short-term economic incentives play less of a role than do some of the non-price, "structural" conditions discussed below. This may be because most crops are not commercialized.

Physical Incentives. Four results are significant. First, farmers are more likely to make investments in land conservation if their holdings are located higher on the slope. Historically, erosion has been the most severe on these upper slopes, where farmers tend to grow beans and other important annual crops. The relationship between conservation investments and field slope is complex. Though the linear OLS regressions in Table 2.2 show no significant association, closer examination of the relationship between slope and conservation investments (see Figure 2.2) shows that farmers invest most heavily in slopes of *medium* steepness—those steep enough to need conservation investments, but not so steep as to discourage investment for the following reasons: (a) Traditionally, farmers placed their steepest slopes under pasture, woodlot, and perennial crops because of their high susceptibility to erosion. (b) It is very costly to maintain investments on these slopes. (c) The lightness and thinness of these soils make them especially prone to erosion. These characteristics also keep yields low and

diminish returns to investments in land conservation. Thus a downward spiral of low production and low investment is easily set into motion as these marginal lands are taken out of their traditional uses (forest, long fallow, rangeland, etc.) and put under more intensive cultivation.

Figure 2.2 Conservation Investments by Steepness of Slope



Second, more distant fields receive fewer investments.

Third, contrary to expectations, more rainfall does not lead to more investment in erosion control.

Fourth, consistent with the capital-led intensification path discussed above, conservation investments substitute for woodlot, and pasture (but not fallow). Farms with little land in woodlot and pasture are more likely than others to intensify by adopting land conservation measures.

Risk. As anticipated, lands that are rented-in (a riskier context for investment) provide farmers with less incentive to invest in land conservation.

Wealth. Six results are significant. First, noncropping income as a liquidity source for investments (hiring labor, buying materials) exerts a positive effect on conservation investments.

Second, livestock holdings have a significant effect on conservation investments. More livestock are also linked to greater use of organic inputs and higher C-value crops. It is likely that these associations are mutually reinforcing, and that wealth is not the only relevant factor to consider. Farms with livestock, for example, will use more organic inputs not simply because they are wealthier, but because they have a steady supply of manure.

Third, larger farms tend to make fewer conservation investments than do smaller farms. This may confirm that credit (with land as collateral) is not important to these investments. Large holders also have more land under fallow and thus may feel less pressured to protect the soils of their operational holdings. It may also be that larger holders are not compelled to take conservation measures to meet daily food and cash needs. Many small holders, on the other hand, appear to recognize that such investments are vital to their livelihoods, even in the short run. Thus, pressure to intensify farming practices is lower for larger holders than for small holders.

Fourth, more on-farm labor (larger families) spurs land conservation investments, which are often very labor-intensive to build and maintain. Moreover, with more persons per hectare, the need is perhaps more acutely felt to conserve the land.

Fifth, the knowledge variable appears to have little effect on conservation investments when measured as an aggregate of all four types of investment, as we do here. However, Clay and Reardon (1994), using the same data but disaggregating types of land conservation practices, show that some conservation practices are positively affected by this knowledge, while others are not. In particular, farmers who have had greater exposure to conservation and fertility-enhancing technologies are more apt to plant hedgerows than are other farmers. However, this is not true for other investments. The difference may emerge because, unlike grass strips and ditches, the use of hedgerows to control soil loss is a relatively new technology for Rwandan farmers, and its application is less widespread. As the extension service is an important vehicle for dissemination of this technology, it is perhaps for this reason that the positive effects of farmer knowledge are greater for hedgerows than for other, more traditional conservation investments.

Sixth, the sector-level variables reflecting local-area prevalence of land conservation investment (perhaps due to promotion by local authorities) and chemical input use encourage farm-level investment. The latter could be because of the interest in controlling runoff which washes away fertilizer.

2.5.3 Use of Organic Inputs and Chemical Inputs: Logistic Regression Results

We estimated two separate regressions for organic inputs and chemical inputs because of their different agronomic effects, labor requirements (organic inputs require collection and distribution), and cash requirements (chemical inputs are purchased). But for comparison we discuss the two sets of results side-by-side.

Monetary Incentives. Three results are significant. First, better returns to agriculture do not significantly affect use of organic matter but do promote chemical input use. This confirms our qualitative impression from fieldwork and Rwandan collaborator statements that while most farmers used organic matter to enhance soil fertility even in subsistence cropping, it is usually only in the more profitable, commercial situations where farmers use chemical inputs—where cash outlay must be recompensed with cash return. That greater distance to a paved road leads to lower use of chemical inputs reinforces this interpretation.

Second, as expected, non-agricultural wage rates exert a negative effect on use of both kinds of inputs, perhaps because of competing nonfarm opportunities.

Third, while crop prices do not affect use of organic inputs, better sweet potato prices are correlated with more chemical fertilizer use. This, we surmise is because sweet potato and white potato prices are highly correlated, and white potatoes, a cash crop in Rwanda, receive relatively high applications of chemical inputs.

Physical Incentives. Five results are significant. First, fields higher on the slope are more likely to receive both organic and chemical inputs. Second, also as expected, steeper slopes are less likely to receive either organic matter or chemical inputs, because of runoff. Third, older plots receive more organic matter, presumably to restore soil fertility. Fourth, plots further from the residence receive fewer organic inputs, a reflection of higher transaction costs and farmer preference for cultivating high value and other important crops (on which inputs are used) close to the residence.

Fifth, farms with more land under fallow, woodlot, and pasture, use less of both classes of inputs. This makes particular sense in the case of organic inputs which are agronomic substitutes for the effects of fallow.

Risk. Two results are significant. First, as anticipated, for the use of organic inputs, lands that are rented-in provide farmers with less incentive to invest, as the risk of appropriation is greater. However, the use of chemical inputs is not affected by ownership rights. Since the effects of fertilizer, lime, and pesticides tend to be more immediate, typically lasting for only one growing season at a time, renters are as likely as owners to make this form of investment. Second, price variation (short term risk) discourages the use of both organic, and, especially, chemical inputs. That commercial disincentives especially affect the inputs put mainly on commercialized crops makes sense.

Wealth. Five results are significant. First, as expected, farmers with more nonfarm income—having controlled for the opportunity cost effect via the nonfarm wage—are more likely to use inputs, particularly organic matter. Despite low overall use rates for chemical fertilizer, lime, and pesticides, Figure 2.3 shows that farms in the higher non-farm income categories are about twice a likely as the lower nonfarm income groups to use these inputs.

Second, farms with more livestock are more likely to use organic inputs (they have more manure).

Third, larger farmers are less likely to use organic inputs than are smaller farmers (as they are a means of intensification). Again, larger farmers also have more fallow which substitutes for the application of organic matter.

Fourth, larger families use more organic matter. This finding makes sense as manure and other forms of organic matter are labor-intensive to collect and apply.

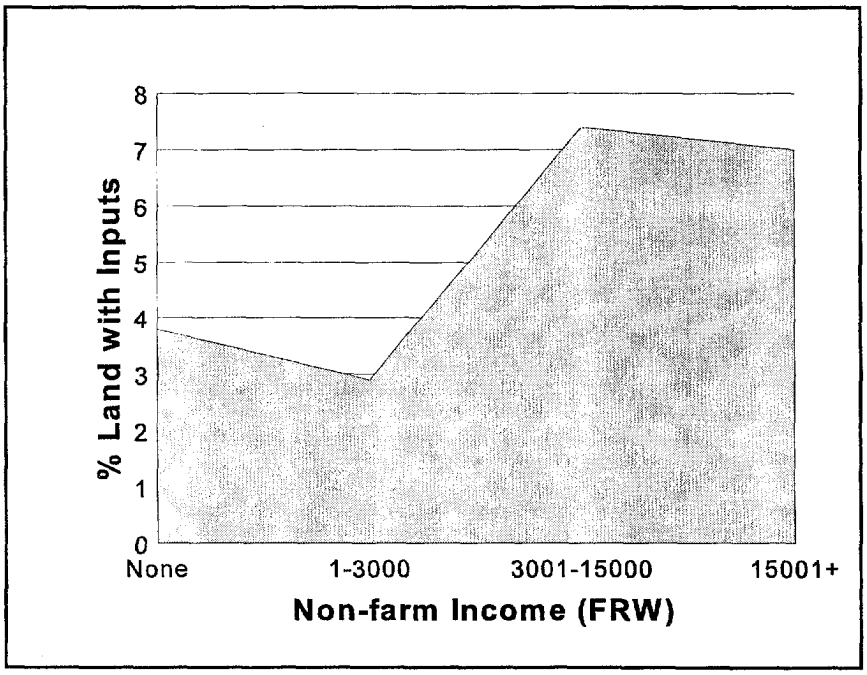
Fifth, female-headed households are more likely to use organic matter, and less likely to use chemical (purchased) inputs, as expected.

2.5.4 Land Use Determinants: OLS Results

Monetary incentives. Two results are significant. First, as expected, OLS results show that where agriculture is more profitable, C-values are lower, indicating protective land uses. Crops that provide the best vegetative cover against soil erosion are perennials, mostly bananas and coffee, which generally provide relatively high returns to labor. Second, we

observe that as the price of sweet potatoes rises, less erosive crop mixes are employed. This implies a reverse effect (with a maintained hypothesis that producer responses to price are not perverse), where a relative abundance of perennials reflects a dearth of annuals and their associated higher price.

Figure 2.3 Use of Purchased Inputs by Level of Off-farm Income



Physical incentives. Three results are significant. First, farmers are choosing more protective land uses on the hillsides rather than in the valleys, and on steeper slopes (although this latter is not significant). In particular, woodlots, pastures, and fallow are more often located on the slopes. Moreover, more land is allocated to bananas on the hillsides than in the valleys, in part because households prefer to locate bananas close to their home compounds, which for historical and cultural reasons are more often located on the moderately steep hilltops than in the valleys. The relationship between C-value and slope would probably be even stronger except that, as Clay and Lewis (1990) argue, farmers have not grown their more protective crops (bananas and coffee) on the very steepest slopes.

This may also help explain why fields at greater distance from the domicile have more erosive land uses.

Second, more of the farm's land under fallow, pasture, and woodlot reduces the C-value on a given cultivated plot. The relation is not direct, but could be that, having controlled for landholding size, farms that are under less pressure to crop their land—reflected in their using more land for noncropping purposes—are under less pressure to crop erosive annuals for immediate food needs.

Third, the more fragmented a farm is, the less erosive is a given plot's cropping pattern, which implies that fragmentation allows better matching of crops to microclimates.

Risk. Consistent with Cook and Grut's observation discussed earlier, land use rights also affect the use of trees and shrubs. Rwandan households are far less likely to grow low C-value crops (bananas, coffee, and other perennials) in land they rent than in land they own. This may be because they feel more confident that they and their families will reap the benefits of the investments they make in perennial crops, or simply because they have had more time to make such investments.

Wealth. Five results are significant. First, having cash crop (banana, coffee, white potato) income reduces the C-value, as expected because the cash crops are mainly perennials and thus less erosive.

Second, more livestock translates into more erosive land uses, but the reason is not clear.

Third, greater landholdings, having controlled for family size and share of land in non-cropping uses, increases the erosivity of land use. This suggests that larger farmers are under less pressure to husband the land they have, as they are further from the margin of survival.

Fourth, however, greater family size, having controlled for land-holdings— hence greater population pressure on the land—translates into more erosive land uses. Presumably larger families are using the land to grow annual food crops.

The results above concerning land use erosivity, labor, and land paint an ambiguous picture. To shed light on these perplexing relationships, Kangasniemi and Reardon (forthcoming) explored in more detail the issue of the difference in C-values of smaller and larger farmers in Rwanda. They take into account (by adjusting the C-values accordingly) that small farmers: (1) crop more densely (mixed and inter-cropping), such as densely planted banana groves, and (2) grow more trees per hectare. They show that land use practices among the most land-scarce quartile of households do

not appear to be any more erosive than those among higher quartiles. In other words, although the current patterns of land use threaten the long-term sustainability of Rwandan agriculture, small farmer strategies in the short to medium run have, overall, offset the inevitable impacts of population growth on the land.

However, Kangasniemi and Reardon also find that above 2,000 meters altitude, which covers one-fourth of Rwanda's agricultural area, land use practices are highly erosive and are becoming more so with population growth. The explanation lies in that few bananas are grown in these cooler areas, where banana yields are poor and their sugar content is low. Thus, while growing more bananas has been one of the main responses of rural households to increasing land scarcity in most parts of Rwanda, this option is not attractive to land-scarce farmers in the high-altitude areas. Farmers in these areas are more inclined to grow tubers, which have much higher yields (in that area) than do bananas, whether measured in terms of calories or market value, but are less effective than bananas at controlling soil loss.

Also, coffee, the second most important perennial, is rare at very high altitudes. DSA data from 1984 and 1990 also show a major expansion in the allocation of land to protective perennials. Land planted in bananas and coffee has expanded by one-fourth. Land in tubers that provide modest protection against erosion has also increased, largely at the expense of maize and sorghum, which provide only minimal protection against erosion.

Overall, both the cross-sectional view and comparisons over time suggest that the erosive trend toward more cultivation is accompanied by a strong trend toward crops that cover the soil relatively well against erosion. However, land use practices are only one front in a larger war against erosion. How crops are managed is equally important. For instance, the effectiveness of coffee depends in large measure on mulching, and our observations in the field show that many coffee fields were without mulch in the early 1990s, in contrast to the nearly universal mulching before. Some observers of Rwandan agriculture predicted over a decade ago that as the availability of organic matter from previously uncultivated valley bottoms and other areas declines, mulching will decrease (Jones and Egli 1984). On the other hand, mulching of coffee is mandatory and was rigorously enforced until the early 1990s. The decline in mulching in recent years may have more to do with the low coffee prices which resulted in farmers neglecting their coffee trees, and the reduced government control

that allowed them to do so, than with any decline in the availability of mulch.

In the case of bananas, the outlook is better, since in contrast to coffee, bananas produce their own mulch. Thus, unless fuelwood shortage forces rural households to dry and burn their banana leaves and trunks, bananas will continue to protect land well against erosion. Of the ongoing land use changes, the rapid expansion of banana groves is particularly important for soil fertility. While bananas do not fix nitrogen, they do produce much organic matter and are not dependent on fallow periods for their long-term productivity.

Fifth, farmers' knowledge of conservation techniques is significantly associated with less erosive forms of land use (lower C-values).

Sector-level variables, specifically land use erosivity and chemical input use, were significant, with the former reducing plot erosivity, and the latter increasing it (as chemical fertilizer tends to be applied to annual crops).

3. CONCLUSIONS AND IMPLICATIONS

Section One of this case study contributes to the population-environment-development debate in two ways. First we have examined the impact of population pressure and resource scarcity on Rwandan farm households, and on the survival strategies these households adopt in response. Second, we have sought to learn more about how these strategies are linked. Whether they conflict or mutually reinforce one another can dramatically affect farm productivity, food security, and other measures of household well-being.

Section Two contributes to the general debate concerning what are referred to here as the labor-led and capital-led paths to sustainable agricultural intensification. We address the questions of whether and why particular types of farm households situated in a given agroclimatic and policy context, and facing similar incentives to intensify, take the capital-led intensification path. Specifically, we focus on the determinants of smallholder investments in land conservation capital and the use of improved inputs such as fertilizer and organic matter in Rwanda—a setting in the East African highland tropics characterized by rapid population growth and land degradation.

For more than two decades, population density in rural Rwanda has exceeded that of all other African nations, and the pressure continues to mount. To secure their livelihoods, farmers can no longer push onto virgin land in previously unsettled areas of the country, or onto the badly stressed marginal lands of their steeper slopes. Their options are few: 1) reduce population growth rates—the demographic response—and/or 2) change what they do to make a living (diversification), or how they do it (the tools and inputs used to intensify), i.e., the organizational response. We examined a cross-sectional sample of 1,240 Rwandan farm households to learn to what extent farmers are pursuing these demographic and organizational strategies, how successful they are in terms of yield outcomes, and what tradeoffs or complementarities there are between them.

Beginning with the organizational option, our analysis in Part One of this study has underscored the importance of sustainable agricultural intensification and its linkages to both the nonfarm sector and cash crop sales. We have found that the average household for the whole sample earns one-third of its income off-farm, and two-thirds in farming. Of the farming income, one-third is from cash crops (coffee, bananas, and white potatoes). One-seventh of household income is spent on net purchases of food. Agricultural intensification consists of conservation investments, and use of organic matter and chemical inputs. Household labor averages 2.6 adults.

Among the larger farms in our sample, those with higher yields tend to pursue the following strategies compared to low-yield farms: 1) they earn less off-farm income and buy less food; 2) they grow far more cash crops (but this does not compete with food crops for subsistence); 3) they are not more intensified (in use of non-labor inputs per hectare), nor do they need to be; they keep a relatively high share of their land in fallow (relative to small farms) to maintain soil fertility; 4) the intensification they do practice is not associated with more cash-cropping or off-farm activity; 5) but they have more household labor available, which enables them to cash crop more; those with more labor are also able to intensify more; 6) the advantages of labor are an inducement to childbearing; and 7) they feel their land is degrading over time, but not as quickly as the lower-yield farms do.

By contrast, small farms with high yields have the following strategies compared to lower-yield farms; 1) they buy far more food (and the small farmers buy more food than do the large farmers); 2) they produce nearly four times the amount of cash crops; 3) they earn about the same from off-

farm activities; 4) they farm twice as intensively (with non-labor inputs, especially greater use of soil conservation investments and organic matter), and fallow less, i.e., they "push" their farms harder; 5) they face increasing land degradation, but are doing more about it than lower-yield farms (see 4 above); and 6) for both subgroups, bigger families earn more off-farm—another inducement to higher fertility.

Hence, reduction of fallow, farm size, and soil fertility has been met by small farmers through a strategy of buying more food. The high-yield path is a combination of emphasis on cash cropping for high yields in value terms, off-farm earnings, and heavy investments in intensification. Small farms keenly perceive the competition between this commercialization strategy and traditional food cropping, but a group of them find the risk acceptably low and food markets (for purchase) sufficiently reliable to allow it.

Moreover, cash earnings obtained from off-farm activity and cash cropping appear to be a critical component for large farms to hire labor, and for small farms to buy inputs for intensification and food to relieve the food production constraint. In addition, both large and small farms benefit in this cash-earning strategy by having larger families—which in turn induces still greater demographic pressure.

Viewing these findings collectively, it is clear that the associations among the various paths, both positive and negative, are significantly stronger among small farms than among the large farms in our sample. This we attribute to differences in demographic pressure faced by the two groups. Small farms are under greater pressure; they have fewer options to choose from and fewer resources to work with. They live closer to the margin, and as such are forced to make the hard decisions. Do they seek work off the farm, or do they find ways to produce more food? If they choose to increase production, do they rely on the traditional method of increasing the pool of household labor by bearing more children, or do they intensify using cash earned off the farm? Sometimes the linkages are mutually reinforcing; other times they are diametrically opposed. In either case, they are strong.

Alternatively, the pattern of association found among the larger farmers suggests that many of these hard decisions have not yet been made. For example, greater off-farm employment for these households does not come at the expense of food production, and it is less likely to affect their decisions about capital-led intensification. These decisions are made independently, since the resources for one path are not necessarily required

for another. The linkages are weaker. They have more degrees of freedom, and it seems likely that they will continue along the traditional extensive path until the intersection of demographic growth and declining productivity bears down and threatens their own welfare.

Our focus in Part Two on the determinants of sustainable intensification in Rwanda provides empirical confirmation of two sets of conclusions, both of which have clear implications for external donor programming, and for the broader "relief to development" trajectory that the international donor community envisions for post-crisis Rwanda.

First, the structure of landholding is an important conditioning link between population pressure and the intensification paths taken by farmers. Land tenure, slope, fragmentation, years of cultivation, share of holdings under fallow, woodlot, and pasture, and size of holdings are important determinants of farmer investment strategies. In general, investments in land conservation and fertility are greater on land owned (not rented) by farmers, where slopes are of medium steepness, where land is less fragmented and younger, and among smaller farmers and those with little land in fallow, woodlot, and pasture. Thus, apart from the obvious need for political stability in this war-torn country, our work shows that farmers need confidence in the longer term through secure land tenure. This means reducing the risk of appropriation—which in the past several years has been extremely high—and the right to transact land. Enhancing farmer access to the land market will require reform of existing and antiquated land laws.

Second, household-level intersectoral links—specifically, "reverse linkages," where nonfarm income affects farm investment—enhance the capacity of households to follow the capital-led intensification path. Nonfarm income as an important source of own liquidity, in this setting of underdeveloped credit markets, is important for households to by materials, to buy animals, and to by labor, all of which are needed for sustainable intensification. It can also provide a "buffer" by allowing farmers breathing space to make long-term investments in higher-yielding and cash-earning perennials. Nonfarm activities also increase the demand for crops through downstream production linkages. And as an alternative source of income it can reduce pressure on the land, enabling households to meet food needs through market access rather than subsistence.

Livestock husbandry is very important for organic matter use, and it is important to enhance livestock holdings via intensification of husbandry.

Third, short-term economic profitability of cropping, commercialization, lower price risk, and more accessible infrastructure helps chemical fertilizer use, which is important to enhancing soil fertility.

Fourth, extension is important to the production of cash perennials (coffee, banana) which reduce the erosivity of land use. Extension is also potentially important for certain land conservation techniques.

This case study has drawn special attention to the demographic side of the population-environment-development equation, both as a cause and as a consequence of changes in sustainable intensification. We conclude that even though marital fertility in Rwanda has begun to decline (the demographic option) in recent years,[11] because of the importance of household labor to the success of intensification and income diversification strategies, as observed in this study, resistance to fertility control measures will remain strong. In Rwanda, at the household level, children are still seen as a net asset to the household economy—and they often are, their productive value is high when paired with adequate resources (land), training and opportunities. But these imperatives are not available to all, and those young people without resources or the wherewithal to make their livelihoods in the non-farm sector will be un- or under-employed. They will be, and are, victims of poverty; their numbers are growing. Thus, despite the perceived advantages of a large labor pool at the household level, from the broader societal perspective, rapid population growth places a heavy burden on Rwanda's resource-poor economy—it is a demographic tragedy of the commons.

So long as the wealth continues to flow from child to parent, and children are seen as a potential asset, as a source of short-term gain for the larger family, households will continue to bear more children. Not until they are seen as a net economic liability (the longer-term view), will parents begin to change their fertility behavior (Caldwell 1980, 1982). This will require a fundamental shift in the values and attitudes of the rural population. Educational curricula, mass media, religious institutions, and family planning programs can all play a part in bringing about this change.

But in the medium long run, large farms will continue to subdivide into small farms to a point where only the successful "capital-led" farms will remain—primarily those who manage to diversify their sources of income

[11]The National Office of Population (ONAPO) estimates that total fertility rates dropped from 8.6 in 1987 to 6.2 in 1992 (May 1995, ONAPO 1994).

through non-farm activities and cash crop sales. Landlessness will become a more serious problem, and will carry the potential for significant class differentiation (Clay and McAllister 1991), or as Bardhan (1988) has observed in India, demographically-induced agricultural prolitarianization. These households, which, underemployed on their own farms, must rely on the meager wages they earn as day laborers, will provide a growing supply of labor to the non-farm sector. Creating a policy environment that encourages the growth of this sector and that carefully targets direct assistance programs designed to improve the access of small holders to information, to inputs, and to management and technical skills (Mead and Liedholm, 1989), will undoubtedly soften the hardship of poverty for many.

References

Ashby, J.A. 1985. "The Social Ecology of Soil Erosion in a Colombian Farming System." *Rural Sociology*, 50(3), pp. 337-396.

Bardhan, P.K. 1988. "Demographic Effects on Agricultural Proletarianization: The Evidence from India." In R.E. Lee, et al. (eds.), *Population, Food, and Rural Development*. Oxford: Clarendon Press.

Bilsborrow, Richard E. 1987. "Population Pressures and Agricultural Development in Developing Countries: A Conceptual Framework and Recent Evidence." *World Development*, 15:2, pp. 138-203.

Binswanger, H.P. 1986. "Risk Aversion, Collateral Requirements, and the Markets for Credit and Insurance in Rural Areas," in P. Hazell, Pomareda, and Valdes (eds.), *Crop Insurance for Agricultural Development*, Johns Hopkins University Press.

Boserup, E., 1981. *Population and Technological Change*. Oxford: Blackwell.

_____. 1965. *The Conditions of Agricultural Growth: The Economics of Agrarian Change Under Population Pressure*. Chicago: Aldine.

Bumb, B.L. 1988 "Fertilizer Supply in Sub-Saharan Africa—An Analysis." In T.B. Tshibaka and C.A. Baanante (eds.), Workshop Proceedings, Fertilizer Policy in Tropical Africa, Lome, Togo. IFDC and IFPRI.

Byiringiro, F.U. 1995. Determinants of farm productivity and the size-productivity relationship under land constraints: the case of Rwanda, M.S. thesis, Dept. of Agricultural Economics, Michigan State University.

_____ and T. Reardon. 1995. "Farm Productivity in Rwanda: Effects of Farm Size, Erosion, and Soil Conservation Investments." Michigan State University Staff Paper no 94-10. East Lansing, Michigan.

Caldwell, John C. 1982. *Theory of Fertility Decline*. London: Academic Press.

_____. 1980. Mass Education as a Determinant of the Timing of Fertility Decline." *Population and Development Review*. Vol. 6,2: 225-255.

Christensen, G. 1989. *Determinants of Private Investment in Rural Burkina Faso*, Ph.D. Dissertation, Cornell University.

Clay, Daniel C. 1995. "Fighting an Uphill Battle: Population Pressure and Declining Land Productivity in Rwanda." In H.K. Schwarzweller and T.A. Lyson (eds.) *Research in Rural Sociology and Development*, Vol. 6. Greenwich, Connecticut: JAI Press, Inc.

_____, F. Byiringiro, J. Kangasniemi, T. Reardon, B. Sibomana, and L. Uwamariya. 1995. *Promoting Food Security in Rwanda Through Sustainable Agricultural Productivity: Meeting the Challenges of Population Pressure, Land Degradation, and Poverty*. International Development Papers. Department of Agricultural Economics, Michigan State University. East Lansing, Michigan.

_____ and Nan Johnson. 1992. "Size of Farm or Size of Family: Which Comes First?" *Population Studies*, 46:491-505.

_____ and L.A. Lewis. 1990. "Land Use, Soil Loss and Sustainable Agriculture in Rwanda." *Human Ecology*, 18(2), pp. 147-161.

_____ and R.J. Magnani. 1987. "The Human Ecology of Farming Systems: Toward Understanding Agricultural Development in Rwanda." Pp. 141-167 in H.K. Schwarzweller (ed.) *Research in Rural Sociology and Development*, Vol. 3.

_____ and J. McAllister. 1991. "Family Development Cycle, Social Class and Inequality in Rwanda." *Rural Sociology*, 56 (1), pp. 22-40.

_____ and T. Reardon. 1994. "Determinants of Farm-Level Conservation Investments in Rwanda." IAAE Occasional Paper no. 7. *IAAE Conference Proceedings*, 22nd Congress of the International Association of Agricultural Economists, August 1994. Harare, Zimbabwe.

_____, Thomas Reardon, and J. Kangasniemi. 1995a. "Sustainable Intensification in the Highland Tropics: Rwandan Farmers' Investments in Soil Conservation and Fertility." Michigan State University , Department of Agricultural Economics Staff Paper No. 95-21. East Lansing, Michigan.

_____ and Jane Vander Haar. 1993. "Patterns of Intergenerational Support and Childbearing in the Third World." *Population Studies*, 47.

Cohen., Y.A. 1968. *Man in Adaptation: The Cultural Present*. Chicago: Aldine Publishing Company.

Commission Nationale d'Agriculture (CNA). 1992. "Rapport de Synthèse: Rapport Préliminaire," Government of Rwanda.

Cook, C. and M. Grut. 1989. *Agroforestry in Sub-Saharan Africa: A Farmer's Perspective*. World Bank Technical Paper Number 112. Washington, D.C.

Demeny, P. 1981. "The North-South Income Gap: A Demographic Perspective." *Population and Development Review*. 7(2):297-310.

Ehrlich, P.R. and A.H. Ehrlich. 1991. *The Population Explosion*. Simmons an Schuster Inc. New York.

Ehui, S.K., B.T. Kang, and D.S.C. Spencer. 1992. "Economic Analysis of Soil Erosion Effects in Alley-Cropping, No-Till, and Bush Fallow Systems in Southwestern Nigeria," in Moock and Rhoades (eds.), *Diversity, Farmer Knowledge, and Sustainability*, Cornell University Press.

Feder, G., L.J. Lau, J.Y. Lin, and X. Luo. 1992. "The Determinants of Farm Investment and Residential Construction in Post-Reform China." *Economic Development and Cultural Change*, vol. 41(1), pp. 1-26

_____, R.E. Just, and D. Zilberman. 1985. "Adoption of Agricultural Innovations in Developing Countries: A Survey." *Economic Development and Cultural Change* 33 (2), pp. 255-298.

Freeman, Ade H. 1994. "Population Pressure, Land Use, and the Productivity of Agricultural Systems in the West African Savanna." Pp. 103-114 in S.A. Breth (ed.), *Issues in African Rural Development 2*. Winrock International. Arlington, Virginia.

Gibbs, Jack P. and W.T. Martin. 1959. "Toward a Theoretical System of Human Ecology." *Pacific Sociological Review*, 2:1.

Gleave, M.B. and H.P. White. 1969. "Population Density and Agricultural Systems in West Africa." Pp. 273-300 in M.F. Thomas and G.W. Whittington (eds.), *Environment and Land Use in Africa*. London: Methuen.

Grabowski, R. 1990. "Agriculture, Mechanisation, and Land Tenure.," *Journal of Development Studies*, 27(1), pp. 43-55.

Jones, W.I. and R. Egli. 1984. *Farming Systems in Africa: The Great Lakes Highlands of Zaire, Rwanda, and Burundi*. World Bank Technical Paper Number 27, The World Bank, Washington, D.C.

Kangasniemi, J. and T. Reardon. Forthcoming. "Demographic Pressure and the Sustainability of Land Use in Rwanda." IAAE Occasional Paper no. 7. *IAAE Conference Proceedings*, 22nd Congress of the International Association of Agricultural Economists, August 1994. Harare, Zimbabwe.

Lele, U. and S.W. Stone. 1989. *Population Pressure, the Environment and Agricultural Intensification: Variations on the Boserup Hypothesis.* MADIA Discussion Paper 4. The World Bank. Washington, D.C.

Lewis, L.A. 1985. "Assessing Soil Loss in Kiambu and Nurang'a Districts, Kenya," *Geografiska Annaler*, 67 (A), pp. 273-84.

Lewis, L.A. 1988. "Measurement and Assessment of Soil Loss in Rwanda," *Catena Supplement*, 12, pp. 151-65.

Lopez-Pereira, M.A., J.H. Sanders, T.G. Baker, and P.V. Preckel. 1994. "Economics of Erosion-Control and Seed-Fertilizer Technologies for Hillside Farming in Honduras." *Agricultural Economics*, 11, pp. 271-288.

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, 1988.

Malthus, T.R. 1798. *An Essay on the Principle of Population.* New York: August Kelley, Bookseller: reprinted in 1965.

Maro, P.S. 1988. "Agricultural Land Management under Population Pressure: The Kilamanjaro Experience, Tanzania." *Mountain Research and Development*, 8(4), pp. 273-282.

Matlon, P. and D.S.C. Spencer. 1984. "Increasing Food Production in Sub-Saharan Africa: Environmental Problems and Inadequate Technological Solutions." *American Journal of Agricultural Economics*, 64 (Dec).

May, John F. 1995. Policies on Population, Land Use, and Environment in Rwanda." *Population and Environment: A Journal of Interdisciplinary Studies*, 16(4):321-334.

Mead, Donald C. and Carl Liedholm. 1989. "Policies to Promote Industrialization, and the Role of SMEs: The Case of Low income African Nations." Draft chapter of monograph, *Employment and Enterprise Policy in Economic Development.*

Migot-Adholla, S.E., P.B. Hazell and F. Place. 1990. *Land Rights and Agricultural Productivity in Ghana, Kenya and Rwanda: A Synthesis*

of Findings. The World Bank, Agriculture and Rural Development Department. Washington, D.C.

Newbery, D.M.G., and Stiglitz, J.E. 1981. *The Theory of Commodity Price Stabilization: A Study in the Economics of Risk*. Oxford: Clarendon Press.

Ngirumwami, J.L. 1992. Analysis of Food Crop Production and Marketing Trends in Rwanda with Emphasis on Dry Beans. Plan B Paper, Department of Agricultural Economics, Michigan State University.

Nwafor, J.C. 1979. "Agricultural Land Use and Associated Problems in Rwanda." *Journal of Tropical Geography*, 58:58-65.

ONAPO (Office Nationale de la Population, République Rwandaise). 1994. Enquête Démographique et de Santé Rwanda 1992. DHS/Macro International Inc., Columbia, MD.

Pingali, P., Y. Bigot, and H.P. Binswanger. 1987. *Agricultural Mechanization and the Evolution of Farming Systems in Sub-Saharan Africa*. Johns Hopkins University Press, Baltimore.

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

Reardon, T., E. Crawford, V. Kelly, and Bocar Diagana. 1995. "Promoting Farm Investment for Sustainable Intensification of African Agriculture. MSU International Development Paper No 18. Department of Agricultural Economics, Michigan State University, East Lansing, Michigan.

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

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

_____ and S. Vosti. 1987. "Issues in the Analysis of the Effects of Policy on Conservation and Productivity at the Household Level in Developing Countries." *Quarterly Journal of International Agriculture*, (October) pp. 380-396.

Robison, L.J. and P.J. Barry. 1987. *The Competitive Firm's Response to Risk*. New York: Macmillan Publishing Co.

Ruthenberg, H. 1980. *Farming Systems in the Tropics*. Third edition. Oxford: Clarendon Press

Sahn, D.E. and C. Delgado. 1989. "The nature and implications for market interventions of seasonal food price variability" in D.E. Sahn (ed.) *Seasonal Variability in Third World Agriculture: The Consequences for Food Security*, Johns Hopkins University Press, pp. 179-195

Smith, J., A.D. Barau, A. Goldman, and J.H. Mareck. 1994. "The Role of Technology in Agricultural Intensification: The Evolution of Maize Production in the Northern Guinea Savannah of Nigeria." *Economic Development and Cultural Change*, 42, 3, pp. 537-554.

Weeks, John. 1989. *Population: An Introduction to Concepts and Issues.* Fourth Edition. Belmont California: Wadsworth Publishing Company.

Wischmeier, W.H. and D.D. Smith. 1978. "Predicting Rainfall Erosion Losses, A Guide to Conservation Planning." *Agricultural Handbook No.537*. USDA, Washington, D.C., pp. 1-58.

NIGER CASE STUDY

Capitalizing on Change[1]

Asif M. Shaikh
Michael McGahuey

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1. NIGER IN 1994

1.1 Changes in the Status Quo

In March, 1993, Niger moved from 33 years of authoritarian and single-party rule to its first democratically-elected government. In January, 1994, the overvalued CFA franc, long cited as an insurmountable obstacle to economic development, was devalued by 50 percent.[2]

The Rural Code process to clarify and formalize resource tenure has moved into full swing since 1990-91. It has changed the stakes for rural resource access, and is altering the economic options for resource management.

For the first time, Niger has a free and flourishing press. Energized by the collapse of authoritarianism, new parties and new interest groups have joined the political fray. Political awareness and participation are both higher than they have ever been.

Under conditionality agreements with USAID and other donors, Niger has committed itself to major structural reforms in agricultural marketing, natural resources, health delivery systems, enterprise development and other areas.

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[2]The change was from 50 CFA to 100 CFA per French franc.

We do not know if things will get better, get worse, or continue on the same path. But whatever the outcome, the structure and dynamic of Nigérien society is fundamentally different than it was 24 months ago. It calls for a fresh start in donor strategies. Without bloodshed, Niger has taken bold steps to put its house in order. It is a fragile time, during which, as yet, more pain than benefit has come from the reforms. Arguably, Niger has earned the support of the international community for its development strategy.[3]

1.2 The Backdrop for Change

Fiscal Crisis

Since 1991, the country has sunk into the worst fiscal crisis in its history, more the result of past rather than current management failures. The disintegration of the Ali Seibou régime accelerated capital flight, both out of the country and from the formal to the informal (non-taxed) sector. Declining uranium prices have made the situation worse. The government is unable to pay its bills, and barely able to pay salaries. A demoralized civil service has faced several months at a time without a paycheck. Workers and students are increasingly vocal political players as their resources shrink. Devaluation has sharply reduced urban purchasing power, further irritating already raw urban nerves.

Potential Impacts of Devaluation

Three potential impacts of devaluation are important to its success:

- The shift in urban demand away from imports and toward domestic goods, which are, in principle, now twice as competitive as before;

[3]Since this study was conducted, Niger's brief attempt at democracy was extinguished by a military coup on January 27, 1996. In light of the coup, the analysis in this section no longer addresses an opportunity to preserve and strengthen democracy. It stands, instead, as a statement of an opportunity foregone. Given the coup, the authors would change the last sentence of this paragraph to read: "Arguably, the democratic Government of Niger had earned the support of the international community for its development strategy, but such support did not come in time."

- A steady growth in exports, particularly to Nigeria and coastal countries, which currently import large volumes of meat and food from Europe and South America;

- A viable supply response in both rural and, eventually, urban production. Neither import substitution nor export needs can long be satisfied without (a) increased efficiency in production, commercialization and marketing, and (b) diversification of production to meet a broader range of demand, particularly urban demand. Devaluation has established an important precondition for diversified domestic production, but other hurdles must now be overcome, including access to scarce foreign exchange for essential inputs to agricultural intensification.

The power of devaluation is evidenced by the surge in sales of cattle on-the-hoof to Nigeria. It is not yet known how much of this surge is a one-time drawdown of large CFA surpluses which had built up in Nigeria and how much is a more permanent increase in exports as a result of increased competitiveness of Nigérien products. But there is already indication elsewhere in the Sahel of an uptick in agricultural investment to exploit opportunities created by the devaluation.

1.3 Strategic Framework for Assistance

Priorities for 1995-2020

1. Reductions in long-term population growth trends through immediate and on-going efforts to reduce fertility, improve maternal and child health and increase access to the means of controlling births as a function of desired family size.

2. Conservation of the natural environment and the productive resource base through improved natural resources management by households and communities, better defined local resource management rights and responsibilities and adoption of key national and local policy reforms to enhance incentives for sustainable resource stewardship.

3. Macro-economic growth.

Jointly, these objectives seek to (a) stabilize the rural production system (b) reduce the imbalance between resource potential and demographic pressure (c) increase the prospects for new forms of productive economic activity by reducing the ratio of dependent to working populations, with particular emphasis on reducing the social and economic burdens on women in the coming transition.

The On-Going Need for Disaster Mitigation

Even if this strategy is successful over time, we recognize that the economy remains susceptible to severe fluctuations in production and welfare in the short to medium term. For this reason, disaster mitigation and relief remains a necessary part of Niger's strategy, at least in the near term. An important outcome of success over the next decade would be the stabilization of rural production so as to:

- reduce the likelihood of periodic food crises and the severe human suffering and development costs that they entail;
- increase the percentage of outside assistance that can be devoted to development rather than relief;
- provide the breathing room—through reduced fluctuations and slowing population pressure—for positive economic change to take hold.

Cross-Cutting Themes of the Strategy.

The process of focusing resources on strategic priorities is a positive outcome of resource scarcity. Neither the Government of Niger nor the donors has the luxury of pursuing all goals with equal emphasis. Yet the need for a strategic framework also underscores the interrelationships between sectors and objectives. Within this strategy, there are important cross-cutting themes which shape the agenda. Three warrant special mention:

- *Democracy, governance, and decentralization.* Both as a basic human right and as an efficient form of social organization, continued democratization is the cornerstone of future development in

Niger. The process has begun at the national level, but important changes in "governance," including in decentralization, devolution of authority, public finance and the principles of "civil society" remain to be undertaken. These changes are a key component of improved natural resources management and of the individual and family choices underlying the population equation.

- *Economic liberalization.* Devaluation, structural adjustment, reduction in the size of the civil service, and transfer of greater economic and resource authority to local communities and households are all part of the Government's recognition that a command-and-control economy is not workable. The very premise of the NRM sub-strategy is that local initiatives driven by economic choices will determine the fate of the environment and of economic development. All aspects of the development strategy should seek to strengthen the emerging market economy.

- *Human resources development.* For those who periodically become discouraged about the development prospects in the Sahel, it is worth noting that in 1972, there was a *cumulative* total of 48 college graduates in Niger. Since then, thousands of Nigériens have received university and higher degrees abroad, most through donor support. A new generation of political actors, policy-makers, technical staffs and potential economic leaders is taking over. In general, their base of training and experience is profoundly different from that of the last generation. This progress must be viewed as a major success of development assistance. On-going investment in human resources development is a necessary part of Niger's long-term strategy.

Monitoring Progress.

The strategic underpinnings of the program are future-oriented, recognizing that development assistance can influence some trends in the next five years, and others only over ten, fifteen and twenty years. Yet the basic terms of success and the main lines of the path to getting there are definable. Hence the *indicators of success* over the intervening years are also definable. This is not to say that we yet have a defined set of indicators that we

know to be correlated with the changes we want to track. What we do have, at this stage, is:

- A reasonable sense of what underlying changes we want indicators of.

- A coherent, and, we believe, sound hypothesis on why the changes we seek to promote and monitor will directly contribute to Niger's sustainable development. The policy community, both national and international, has also sharpened its understanding of how the strategic pieces fit together over the coming decades. Given the fresh start in Niger's economic and political direction, it is particularly appropriate to think in terms of the future, and to better understand what we can influence today versus what we can influence over time.

The Importance of Human Resources Development.

Analysis of Niger's development challenges suggests that the next thirty years will be dominated by rapid, deep-seated social and economic change. Many of the main trends driving that change are known, but the specific outcomes depend on Nigérien society's capacity to capitalize on the new opportunities that are created. The strategic emphasis on conserving the productive resource base and reducing the rate of demographic growth will, it is hoped, buy time in the near term, reduce pressure in the long run, and allow positive economic changes to take root. But the likelihood that more successful strategies will eventually emerge will heavily depend on underlying changes which take place between now and then. Little, if anything, can equal the potential impact of the new ideas, initiative, confidence and skills that democracy, participation, an open economy and a deepening human resources base can bring.

2. DEMOGRAPHIC AND ECOLOGICAL TRENDS

2.1 Population as a Driving Force

The 1988 census found Niger's population to be just under 8 million. With a 3.2 percent growth rate, and allowing for variations in migration, the 1994 population is estimated to be approximately 9.5 million.

Niger's population growth rate is among the highest in the world. Total population is expected to double within 25 years. Economic and political conditions in Nigeria, Côte d'Ivoire, Bénin and Togo have reduced the role of outmigration as an economic and demographic safety valve.

In 1950, Niger's population was about 2.5 million. Niamey, Zinder and Maradi were little more than provincial towns, with barely 100,000 people in total among them. The ratio of population to natural resources and land area allowed long fallow cycles, during which natural renovation restored the fertility of soils held out of production. As the nutrient balance on cultivated lands decreased, production shifted to land which nature and time had restored.

What changed forty years ago, in a structural sense, was the first beneficial effect of contact with modern technologies: mortality rates, including infant mortality, began their long decline. The widening gap between births and deaths yielded unprecedented levels of population increase.

After forty years of rapid growth, future growth is built in to the population age structure. Forty eight percent of Niger's female population today is under 15. There are nearly 50 percent more girls between 0 and 15 than women between 15 and 35. There are 83 percent more girls in the bottom three age quintiles (0 to 15) than in the next three age quintiles (15-30). Population growth rates will remain high for decades as these girls reach maturity and have children of their own.

The key variables which drive population growth are the *number of women of child-bearing age* and the *number of children per woman* of child-bearing age. The age pyramid assures that the number of women of child-bearing age will continue to grow. Whether each of these women has as many children, on average, as in the past depends on the fertility rate.

Fertility rates in Niger are very high. To date, there has been little progress in bringing them down. For reasons of culture, politics, the perceived needs of the rural economy and women's low social and economic power, fertility control has been slow to take root. But the situation is beginning to change. In all areas of rural development, efforts are being

made to enhance the empowerment of women. This is perhaps most pronounced in natural resources management efforts, and is driven both by conviction and by the basic fact that women play a key role in the implementation and success of resource management initiatives. The huge increase in seasonal outmigration (*l'exode rural*) in recent decades has made women single heads of household for nine months of the year.

At the same time, the evidence is now clear that people see and feel the impact of population pressure. It is impossible to go into a village in most zones without finding a village elder who talks about the way things used to be when trees, water and wild game were abundant. The absence of fallow is on many minds, including those of men who will be fathers. None of this has yet translated into anything like a conscious desire to control fertility. But the economic calculus that has caused farm families to prefer large families to help with the fields has changed, even if tradition and social expectations haven't yet.

The evidence from Niger is not yet clear, but throughout the world, urbanization (especially when coupled with income growth, which is not yet happening) has been a powerful force to drive fertility reduction. Urbanization is an inescapable part of Niger's future. Total urban population is in the order of 1 million. It is growing at over twice the overall growth rate, and nearly four times the rate of rural population growth.

Under an optimistic family planning scenario, falling fertility rates will bring about gradual reductions in the rate of population growth over the next twenty years. But even this optimistic scenario will not result in an appreciable difference, by 2025, between high and low growth scenarios. *Niger's total population level thirty years from now is likely to reach at least 17 million no matter how successful fertility reduction efforts prove to be.* This fact is self-evident to the population community, but has important and less obvious implications for the links between population, environment and development. These implications are discussed in the next section of this report.

The target impacts of the fertility reduction effort will be different in the short, medium and long term. In the short to medium term, we expect to see increased contraceptive availability, awareness and use, leading to gradual decreases in the fertility rate. While the quantitative impact on total population levels in thirty years will be small, major impacts will be felt in the thirty to fifty year time frame. *Unless fertility reduction efforts are accelerated now, even a successful economic and environmental transition*

over the next thirty years will be crushed under the weight of a further doubling of population in the next generation.

Even in thirty years, however, there can be important changes in the age structure of Nigérien population: a lower ratio of dependent to working age populations, with major social benefits, particularly for women in an increasingly urbanized economy.

2.2 Shifts in the Urban-Rural Balance

Rapid urbanization is as important a demographic trend as is total population growth. Burgeoning cities and towns[4] have absorbed some pressure on agriculture and livestock production, but also create demand and opportunities for unsustainable exploitation of rural resources, such as fuelwood. Very weak employment generation in urban areas stands as a major challenge to macroeconomic sustainability. Our analysis suggests that a faltering urban economy also inhibits long-term strategies to conserve the environment and enhance the natural resources base, as discussed below. Conversely, a healthy urban economy can play a very positive role in the agricultural and ecological transformation of Niger.

Urban population in Niger is growing at an annual rate of 7 percent—a doubling time of ten years. If this rate continues, urban population will reach 8 million, or nearly half of total population, by 2025. Projections of urban population over the next thirty years are necessarily speculative. There are several major unknowns which will affect the final outcome: the future ability of coastal economies to absorb potential urban migrants; the prospects that deteriorating urban conditions will make staying in the countryside a *relatively* more attractive prospect for both economic and "social" migrants; the possibility of improving rural conditions reducing the potential outflow. A particularly important unknown is the potential role of communications and telecommunications technologies in reducing the sense of social isolation which is now a dominant factor in many villages. Whatever the final impact of these concurrent changes, all of the major projections suggest that even a slowing rate of urbanization will result in *at least a five-fold increase in urban population by the year 2025 (see Table 1).* It is the "order of magnitude" of the urbanization trend, and not a specific projection, on which our analysis is based.

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[4]Demographically, if not economically

Table 1. Urban Population of Niger

Year	Low Estimate	High Estimate
1995	1 million	1 million
2005	1.7 million	2 million
2015	3 million	4million
2025	5 million	8 million

Throughout Africa, efforts to reduce the rate of urbanization have failed. There is a clear link between rural outmigration and economic hardship in the agriculture and livestock sectors. The population of Niamey went from 60,000 in the early 1970s to over 200,000 at the end of the 1972-74 drought. Each drought cycle, whether nation-wide or localized, has created an additional burst of permanent migrants to the city. Economic hardship in the countryside is, of course, not limited to drought years. Declining yields, disappearing fallow and uncertain income have caused many families to diversify income through seasonal or permanent migration of some family members. In each of the dozens of Nigérien villages visited by the Opportunities team,[5] and by the staff and consultants of USAID since 1988, more than half of working age males are reported to be absent from the village during the dry season. Even if the rural production system is stabilized over the coming decades, the number of economic migrants will continue to grow. This has important implications for urban growth, as well as for changing economic roles in the countryside. In particular, women in rural Niger are, increasingly, becoming single heads of household, with vastly increased production, work and family burdens.

Economics is not the only factor driving urbanization. Quite possibly, it is not even the most important one. Consumption and social aspirations in villages have been transformed by contact with the outside world, especially among the young. In many villages, virtually all able-bodied males practice *l'exode rural* during nine months of the year. It has, in the words

[5]Shaikh, A., Arnould, E., Christophersen, K., Hagen, R., Tabor, J. and Warshall, P., Opportunities for Sustained Development: Successful Natural Resources Management in the Sahel, IRG-E/DI, 1988.

of the extension agent in Samdi Seydou, "become a way of life." For each group that leaves during part of the year, some percentage does not return. Large numbers of young people are going to the cities by choice and for social freedom. Throughout the world, the "city lights" continue to attract the young, and there is little reason to believe Niger will break this trend.

There were 2.5 million Nigériens in 1950, with only three substantial provincial towns. There was forest, rangeland, fallow, wild game and "space." Within the span of one lifetime (by 2025), there are likely to be between 6 and 8 million urbanites, many second and third generation city dwellers. In addition to traffic, crime, sewage and television, two contrasts stand out: an entirely new socio-economic framework, and the need to *purchase* in order to live. The difference between 1950 and 2025 is therefore not mainly a difference of numbers, but of structure. There is a parallel between falling mortality rates and growing urbanization. In both cases, the triggering mechanisms have been *external* to social and technological development. Nigérien society neither created them nor has it mastered them. As with an explosion which takes place without warning, many pockets of society have not yet fully realized what happened and what it implies for their future.

There are major opportunities present in urbanization. Urbanites must eat, and their food, mostly grains, meat, and vegetables, will originate from outside the cities. The devaluation of the CFA suggests that less of it will be imported. There are, however, several unanswered questions, most of which revolve around the classic issues that have plagued development planners: the need to stimulate domestic production, both urban and rural, and the need to define comparative advantages for exports while gradually reducing dependence on imported food and consumer goods.

It is premature at this point to fine-tune speculations of how these questions will play out. The growing potential for urban-rural economic linkages is worth noting, however.

Urban demand for food and other rural products will continue to grow, and will provide increasing opportunities for commercial production in the agriculture and livestock sectors. The percentage of rural production which is monetized is likely to grow sharply. In revenue terms, the primary sector of Niger is likely to undergo the same transformation as have most previously agrarian societies, with a much higher proportion of revenue coming from marketed goods than from subsistence production. Much of this change has already occurred near urban centers. The devaluation of the CFA has also made Nigérien primary exports, including of livestock and onions,

more competitive in Nigeria and coastal markets, further strengthening this trend.

Potential Influence of West African Regional Trends

A key question will be whether the agricultural and livestock sectors are capable of providing the supply response needed to meet urban and export demand at competitive prices. *The following section of this study establishes that this response, if successful, also holds the key to stabilizing the rural production system through improved natural resources management.*

As we consider the demographic, biophysical and trade options in Niger, it is impossible to separate what will happen inside Niger in the next thirty years from what is happening in the larger West Africa economic region. It is, for example, useful to compare the demographic projections for the region with those of Niger. Land scarcity, urbanization, greater economic specialization and increased opportunities for trade will grow *throughout the region.* As has been noted for the potential impact of South Africa in Southern and Eastern Africa, the fate of Nigeria (and, to a lesser extent, Ghana and Côte d'Ivoire) will have as much, and possibly more, impact on Niger's prospects as will purely domestic concerns.

Regional trends are likely to reinforce the underlying forces discussed in this report: opportunities for a successful agricultural transformation, coupled with heightened dangers of political, social or economic disruption. However, we emphasize that there is increasing attention to analyzing regional trends—at the OECD, the World Bank, the European Community, CILSS, ECOWAS, the African Development Bank and AID. Donor strategies should formalize links to those engaged in regional studies, and should regularly update *national* strategic priorities in light of regional feedback and changes.

2.3 Natural Resources and Rural Productive Capacity

Maintaining the Nutrient Balance

The organizing principle of traditional agriculture was the effort to maintain the nutrient balance of land under cultivation. With an abundance of land relative to population, long fallow periods allowed *natural renovation* to make the principle contribution to restoring soil fertility. The other

key contribution was made by the *organic matter* from livestock during the transhumance. The interaction between herding and agriculture represents one of the most complex pieces of the whole, biophysically and socially (the interdependence of "specialized" ethnic groups). This interaction is often poorly understood by outside analysts and planners. Finally, *vegetation* served as the custodian of ecological equilibrium, providing forage for the animals, supplying forest products and fallback foods for communities, cycling nutrients and protecting the soil from the impact of wind and water erosion. Therefore, despite the absence of external inputs and modern technologies (or perhaps to compensate), traditional land use patterns in Niger were relatively complex.

Ecological Disequilibrium

Under the pressure of rapid population growth, traditional equilibrating mechanisms no longer work.

In the first instance, it has been possible to temporarily extract more nutrients from the soil than are put back in. This practice, known as *soil mining*, has been documented in several scientific studies throughout the Sahel, including in recent studies by the Royal Tropical Institute (KIT) and by the Centre for Agrobiological Research (CABO), both in Holland.[6] Over the last generation, shortening fallow periods have contributed to a decline in agricultural productivity through widespread mining of the soil. The strategy has been successful for a number of years in obtaining higher than sustainable yields. However, the long term cost is an accelerating loss of resiliency in the ecological system. Demographic pressure, which has forced resource mining in the first place, is now causing the "other shoe" to drop: throughout the country, fallow is rapidly disappearing as a farming systems option. As a result, the present situation is more acute. *Jachère contrainte* ("forced fallow") involves simply abandoning land which will no longer produce, but does not necessarily assure access to land which is more productive. Often the *glacis* (crusted over soils denuded of vegetation) offer the best available option for restoration and intensified management.

Farmer-herder relationships are under stress, but have by no means broken down. Both sides need each other. The mutually beneficial relation-

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[6]See, for example, Floris van der Pol, *et. al.*, *Soil Mining: an Unseen Contributor to Farm Income in Southern Mali*, Royal Tropical Institute, 1994. The study assesses nutrient balances for cotton and millet production in the CMDT zone in Mali.

ship is under stress because both sides are, to an increasing extent, now competing for *primary access* to the same resources: agriculture is moving into herding zones, vegetation for forage and for fuelwood is scarce, and the transhumant corridors are closing as agricultural settlement becomes more dense. Nevertheless, there are also farmers who are willing to *pay* herders to graze animals on their land in order to help restore the nutrient balance.

Vegetative cover has been in a long, slow decline for decades. The recurrent demand for fuelwood, construction materials and forage have all kept pace with the tripling of rural population since 1950. Each new rural inhabitant also requires approximately one half hectare of agricultural land.[7] Since 1950, at least 4 million hectares of vegetated land has been converted to agriculture. *Sustainable yields* from the forest are well below what is being consumed in all parts of Niger, both as a result of increasing demand and a shrinking number of vegetated hectares. The gap is being filled by *resource mining*—eating into the resource stock and further aggravating future imbalances between sustainable yields and consumption.

Fuelwood supplies over 80 percent of household energy needs in Niger, including about 70 percent of domestic energy demand in urban areas. Urban energy demand has been particularly destructive to the environment because urban energy is purchased, not self-collected. Consequently, urban demand creates powerful cash incentives for the use of modern technologies and transport systems in uncontrolled forest exploitation.

Whether the process which is taking place is called "ecological disequilibrium," "natural resources degradation," "desertification" or whatever else comes into fashion, its implications remain clear: *traditional rural production systems require environmental balance in order to function; given population pressure and even the current level of resource depletion, the key to the restoration of both rural income and the environment is a new set of equilibrating mechanisms which go beyond what traditional systems can provide.*

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[7]This number has been *growing* as demographic pressure has increased, although intuition leads us to expect shrinking average land holdings with increased population density. The reason is the expansion of agriculture northward into marginal zones, requiring more hectarage for a given level of output. As these zones have also become fully occupied, we are beginning to see more downward pressure on average landholding.

The Capacity to Respond: Biophysical Potential

The inevitable question for policy-makers is whether Niger has the biophysical capacity to restore equilibrium and to sustainably support a growing population. The question is frequently asked within the donor community, and it is important for it to be addressed as clearly as possible. By way of summary, the question does not lend itself to a simple "yes" or "no" answer. The answer is "yes, if..." —if certain conditions are met.

Table 2. Soil Nutrient Depletion Rates

	Nitrogen	Phosphorous	Potassium
Exports			
	Uptake by Crops (54%)	Uptake by Crops (74%)	Uptake by Crops (64%)
	Leaching (6.6%)	Leaching (0.8%)	Leaching (7.9%)
	Erosion (17%)	Erosion (25%)	Erosion (28%)
	Volatilization (22%)		
Imports			
	Residues (11%)	Residues (26%)	Residues (33%)
	N Fixation (5.2%)	Deposition (17%)	Deposition (5.3%)
	Deposition (18%)	Weathering (13%)	Weathering (7.3%)
	Manure (5.2%)	Manure (8.3%)	Manure (6.9%)
	Fertilizer (13%)	Fertilizer (32%)	Fertilizer (4.3%)
	Deficit (47%)	**Deficit (3.2%)**	**Deficit (43%)**

Source: van der Pol, Floris, *Soil Mining: An Unseen Contributor to Farm Income in Southern Mali*, Royal Tropical Institute, the Netherlands, 1994.

Given current population and traditional land-use practices, biophysical capacity is not only insufficient to *increase* production, it is also insufficient to maintain current production. The KIT (van der Pol) studies from Mali, under similar ecological and land-use conditions, estimate that 47 percent of the nitrogen, 3 percent of the phosphorous and 43 percent of the potassium used up in crop production comes from depleting the soil of these nutrients (Table 2). In Niger, the situation is the most severe in areas where the ratio of population to fertile land is highest. This includes the arid (350 mm rainfall) upper reaches" of the agricultural production zone, and the relatively fertile but more densely populated areas between Niamey and Gaya. Land availability varies more widely in the "prime" agricultural belt from Niamey to Zinder, but all available evidence suggests that, even in this

zone, natural renovation is no longer able to restore soil fertility from one production cycle to the next, primarily because fallow periods are getting shorter as population increases. *Even if a given area is not now in deficit, it will be within the next decade or so.*

Improved natural resources management can allow increased production for a number of years. That is, it "buys time." Referring again to the van der Pol study of the Southern Zone in Mali, significant percentages of the nutrients used in production are *lost* through erosion and leaching, both of which can be controlled. On the input side, manure, residues, nitrogen fixation and water retention can all be significantly improved through better management of *existing resources*. How much time can be "bought?" The answer depends on the rate of depletion and on how much has already been taken from the soil in the past. And the answer will obviously vary from one region of the country to the next. However, as an overall estimate, we believe that improved "NRM" can buy between 20 and 30 years during which production can be maintained at acceptable levels. Depending on the rate and efficiency of adoption, probably 10 to 15 years of *yield and production increases* are reasonable. If nothing else happened but the widespread adoption of improved land-use management based on natural resources alone, a generation of population increase would eventually bring things back to where they are today.

A combination of improved NRM, small-scale infrastructure and the use of external inputs—including chemical fertilizers—can extend the horizon of stable or growing per capita production another 20 to 40 years. Once again, the van der Pol and CABO studies suggest that the longer-term scenario, to be sustainable, will require external inputs.

We return to the central question of this section, and to strategic concern of policy-makers: "Does Niger have the biophysical capacity to restore equilibrium and to sustainably support a growing population?" We find that the answer has two parts:

- Biophysical capacity will support *real per capita growth in agricultural output of 2-4 percent per year for the next generation*, if there is widespread adoption of improved land-use management practices, and if this eventually gives rise to the use of external inputs as well.

- This success *is biophysically feasible, but cannot be separated from changes in the incentives system, from the cost-benefit of specific*

land-use and investment choices, from the growth of markets, and from trade and commercial production. The devaluation of the CFA, the growth of urban markets, and regional economic and trade impacts, particularly vis-à-vis Nigeria, are likely to have a dominant impact on the transition.

3. CHANGES IN THE RURAL ECONOMY

If democracy, devaluation, structural adjustment, policy reforms, and urbanization dominate the "macro" scene, they are matched at the "micro" level by changes that are at least as far-reaching.

3.1 The Base of Field Observations

The authors of this study have been directly involved over the last decade in monitoring smallholder initiatives for improved natural resources management. AID, CILSS, the Club du Sahel, the World Bank, other donors and host governments have also sponsored several dozen field observation and monitoring efforts throughout the Sahel, since 1987, to build an understanding of what land-use management choices rural populations are making and why. The authors have had the opportunity to participate in or lead the majority of these studies, and to interact closely with the colleagues who have conducted the remainder. The base of evidence from which we can draw, therefore, now consists of several hundred field observations, primarily in five countries: Niger, Mali, Senegal, Burkina Faso and The Gambia.

Finally, the authors of this study have also had the benefit of being directly involved in efforts for environmental and production system stabilization in Niger in the 1960s and 1970s, and to therefore draw lessons from recent studies with a longer-term perspective as well.

The following section attempts to bring the main lessons from this growing body of field evidence to bear on issues of development strategy.

3.2 The Approach to Field Observations and Monitoring

The approach to field observations and monitoring of impacts used in Niger and in other Sahel programs builds on the AID/Africa Bureau "NRM Analytical Framework" and on the understanding of (a) what factors influence household land-use management decisions and (b) how those decisions

affect production, natural resources and sustainable income. A simplified form of the analytical framework is shown below:

Within this framework, the field observation approach has been to:

- Identify successful or promising initiatives
- Understand the contributors to success
- Feed lessons into development programs
- Calibrate development programs based on this feedback in order to broaden their impact

The approach is an *on-going* process, in which initial lessons are refined during program implementation based on what is working at the field level.

3.3 What Are People Doing?

Investing in grain production

Seven years ago, when the *Opportunities for Sustained Development* review was begun, there was clear evidence of farmers investing labor and, where available, cash, for production of commercial outputs such as wood for fuel and construction materials, fodder, and marketable agricultural crops. Field surveys in Niger since 1990 have reinforced this evidence. The 1994 field tour shows, for the first time, evidence of cash investments for grain production. Traditionally, scarce cash resources were devoted either to consumption needs or to investments which would increase cash income. Field interviews suggest that in the two areas (six villages) visited, the practice is spreading.

In the *glacis* farmers seem to be investing primarily to harvest water and to concentrate manure. In deeps sands (farther south) the focus was on nutrient cycling and concentrating manure:

- In the village of Antaraimey (and in several other villages near Badiguicheri), farmers were paying local labor between 25 and 50 CFA francs per *demi lune* (semi-circular shallow pits of about 1.5 meters across). On the hard surfaces of the *glacis*, crops are planted within the *demi-lune*, which captures and concentrates water runoff

and topsoil. Depending on the size of each *demi-lune*, there may be as many as several hundred per hectare. The investment per hectare therefore is of several thousand francs. The practice has been promoted by the IFAD-sponsored project in Badiguicheri and appears to have caught on. The principal incentive is the potential for substantial increases in millet production. Project studies indicate yield increases of up to 100 percent in normal years. In addition, they also show lower variability of production during dry years. Hence, yield increases (versus control plots) are highest when rainfall is below normal.

- In the Dallol Bosso, the team saw several examples of cash investment in millet production. To cite one example, in the village of Samdi Seydou, a farmer obtained a loan of 130,000 CFA francs to construct a well. The loan, available through a small credit program, will be paid back over ten years. The well is not being used for drinking water or for irrigation. Instead, it serves to provide water for the cattle of a local Peulh herder. The farmer and herder have entered into a "contractual relationship" in which the farmer bears the cost of the well, in return for which the herd is kept on the farmland during the dry season to assure the concentration of manure on millet fields. Other farmers in the area have undertaken similar "contracts," paid either in cash or in sacks of millet.

The team interviewed farmers and local extension and project personnel to learn more about why farmers felt these investments to be a good use of cash. In both zones, the main reason cited was that the shortage of fallow land was forcing them to maintain production on the land they had. The team also inquired into the cash inputs and outputs which make these investments possible. When cash is spent either for a one-time investment or for commercial production which yields future cash income, the overall "cash balance" is positive or neutral. In these investments, on the other hand, the cash balance may be negative unless a reasonable portion of the millet crop is marketed. The answers varied, but several factors were cited: The *exode rural* is providing recurrent cash income for many villagers; the relative importance of agricultural investments versus consumption purchases is higher, given land scarcity; near urban areas, there is more diversification and marketed production. We believe it important to monitor this aspect of cash transactions and income closely over the coming years.

Finally, the team noted a progression in the strategies of households who were making cash investments in grain production. The initial investments (such as for *demi-lunes*) increase the returns on further investments, because they establish the conditions for making more efficient use of all inputs. Just as important, farmers appear to perceive this as well. As a result, *demi-lunes* have been followed by concentration of manure. In some instances, because *demi-lunes* themselves reduce risk (by concentrating water and assuring minimum water levels during dry years), more farmers are also purchasing fertilizer. Here again, we believe it important to monitor these trends closely in years to come.

Diversifying

In the 1994 field tour, as well as in previous observation tours conducted in Niger since 1987, the evidence points towards sharp increases in diversification of rural production. The *Opportunities* Report and the ASDG II project paper annexes document this trend.

The combination of necessity and opportunity, in the form of increased population pressure, variable rainfall and access to new techniques is slowly transforming rural production, especially around cities and market routes. Throughout the corridor from Niamey to Zinder, there are examples of both spontaneous and project-sponsored adoption of improved resource management techniques. Several recent studies by IFPRI and other organizations have found significant diversification of household economic activity within 100 kilometers of the major cities. The income of a majority of households in these zones now comes from integrated crop and livestock management, and from a combination of subsistence and commercial production. Up until a year ago, when the economic situation entered its most recent downturn, 76 percent of the income in the Département de Zinder was estimated to be from non-agricultural sources. As the Zinder example shows, it has been two steps forward and one step back. Nevertheless, changes of this scale, if validated, are of macro-economic importance.

Diversification of Household Income

- Suchet production
- Trees as poles
- Fuelwood as a managed crop
- Animal production
- Off-farm income

The majority of rural households appear to face three basic choices: subsistence production of foodgrains, small-scale on-farm commercial production (often by women, and including non-agricultural activities such as forest products) and off-farm, non-agricultural income. Most important in the latter category is income from seasonal migration to urban areas—the rural exodus (*l'exode rural*). In areas with access to markets and transportation, *the majority of rural households is already practicing some mix of these three options*. The emphasis on cash income is growing for a number of reasons: increased market demand and opportunity; growing population and diminished rural income; most importantly, the recent need for cash for urgent small-scale investments (digging water catchments, constructing a well, etc.) to maintain agricultural production. Cash income continues, of course, to play its traditional role in meeting expenses for weddings and other social obligations, and in providing valued consumption goods, such as radios and bicycles.

Having broken through the "subsistence barrier," many families near urban areas have developed *recurrent sources of cash income*. This, in turn, is giving rise to *recurrent cash expenditures* for agricultural inputs, although this trend remains on a relatively small-scale.

Leaving the land

The "macro" trends towards urbanization and emigration are documented. At the field level, the majority of working age males was absent in every village the team visited. West Africa has always had high rates of migration. We do not have the statistical evidence to indicate whether seasonal outmigration is growing, but the *cumulative effects* which can be observed at the village and household level are noteworthy:

- *L'exode rural* is more than an economic activity. Young men, whatever the initial reasons that attracted or forced them into *l'exode,* now also have an urban lifestyle to which they are accustomed. Over a number of years of migration cycles, they are as much urban dwellers visiting the village as they are villagers seasonally migrating to the cities. The *exode rural* was repeatedly described as now being a "way of life" for young men who have nothing to keep them in the villages during the dry season.

- In the majority of villages visited, women have become single heads of household for nine months of each year. By itself, this fact is causing a dramatic increase in women's' work burdens, and in the range of household responsibilities they bear.

- At the same time, women are also bearing the burdens of a worsening agricultural picture, which requires more work for equal production.

- Finally, a substantial share of diversification activities—gardening, commercial agriculture on women's plots, micro-enterprises—are in fact being initiated by women.

In sum, "leaving the farm" is an important part of the rural household strategy. The positive consequences are increased (and sometimes recurrent) cash income. The negative consequences include a deep-rooted disruption of social and household structure, and extraordinary new burdens on women.

3.4 What Has Changed?

Perceived urgency of resource degradation

The most dramatic change observed at the field level over the last five years is the perceived urgency of the need to "do something" to compensate for degrading resources. In areas where the ratio of population to fertile land is high—from the rich and densely populated areas of the Dallol Bosso to the arid and sparsely settled zones around Badaguicheri—*there is little or no fallow left*. Thus, the passage from low-input rainfed production to more intensified management has become personal and immediate, often about this year's crops, only a few months from planting. The vision of what to do is still evolving, although some form of intensification appears to be the most common response.

As more farmers have intensified production to offset falling yields, the benefits of intensification are more visible. In each village visited, some farmers have visibly increased production and income, while stabilizing resources.

Income differentiation is growing

The flip side of the pockets of successful transition visible in the villages is the growing gap between those farmers who have pursued a successful strategy and those who have not. Subsistence production, where it still assures reasonable survival, also limits income growth and imposes an upper bound on income inequality. However, subsistence production in the villages we visited is less and less viable because of resource degradation and the long-term effects of resource mining. Those who still depend primarily on low-input subsistence production are facing worsening income and food security. Those farmers who have successfully broken through the subsistence barrier (primarily through intensification), showed increases in both income and capital accumulation.

It is important to note that what is driving this inequality is that some have succeeded despite the general downward trend. In this sense, it is not a negative development, particularly to the extent that a growing number of rural households can follow the successful examples which have been set. What is of concern, however, is the potential social and political impact of inequality, which only exacerbates an already difficult economic transition for the rural poor.

Enabling conditions affect NRM decisions

The effect of "enabling conditions"—the public policy framework, community resource management rights, local governance, participation, access to tenure, access to technology, to markets, and to technical assistance, etc.—on land-use management decisions has been extensively documented. A principle finding of the *Opportunities* study, of the Segou Roundtable and of the Africa Bureau's analytical framework is that the highest payoff role of the public sector is to help establish a set of enabling conditions which favor resource-sustaining land-use management decisions by households acting in their own self-interest. The study team's field visits strongly reinforced these findings. The comparison between the villages of Samdi Seydou and of Zindarou (both in the Dallol Bosso area) provide a dramatic case in point:

- Both villages share similar ecological, economic, population, market, and agricultural conditions.

- Both lie within the program area of a Canadian NGO-sponsored project.

- With extension and project support, both villages have formed village committees operating within the broad mandates of a *gestion de terroir villageois* approach.

- The village committee in Samdi Seydou has been based on broad community participation, has organized important subgroups within the village, including women, and has actively sought to resolve joint problems such as resource access and illegal wood cutting. It has also encouraged and supported individual initiatives and sought credit and other support for community members.

- The village committee in Zindarou has been locked in internal struggles over control, with dominant groups reluctant to involve or share power with other members of the community.

Project and extension personnel reviewed statistics on the two villages with the team. Production, income, investment, health and education indicators in Samdi Seydou have shown sharp improvements. The number and percentage of farmers who have adopted new techniques and successfully intensified production is also sharply higher. In Zindarou, the same set of indicators show little or no improvement. In addition, the mood and vibrancy of the two villages was palpably different.

Primary interest in income generation and stabilization

A common thread in the villages visited in each of the tours of Niger since 1987 has been the *primary interest by local populations in income generation and stabilization.* Successful programs to manage communal resources—such as the USAID-sponsored Guesselbodi natural forest management project— have capitalized on this interest by making cash income from sustainable harvesting and sale of forage and other forest products an organizing theme for the project. The most active and widespread participation by local populations—in the Badaguicheri area, in the Dallol Bosso, in the SIM project area near Maradi, in Keita, Ouri Hamija, under the Projet Gao, and elsewhere—has been for initiatives to protect or increase household income through improved natural resources manage-

ment. Therefore, the primary interest of rural households has been in initiatives that affect *farmlands* rather than in common property resources which do not generate income.

A greater sense of ownership over natural resources

This difference in incentives, which has been cited in a number of previous field studies, has been a continuing problem for efforts to stabilize the environment in Niger, as elsewhere in the Sahel. While this remains a difficult issue for policy-makers, the *gestion de terroir villageois (GTV)* approach shows some promise for addressing it. The underlying concept of GTV is to give the village community clear rights and responsibilities over a defined land area, including production land *and common property resources surrounding the village*. One immediate effect has been to narrow the definition of "common": the resources belong to the *village community*, and not to all who would choose to exploit them.[8]

The concept of *gestion de terroir villageois* can hardly be called a success as yet. However, what has sunk in is the idea that there is a resource worth protecting and that the community has a definable land area over which it has some management *rights*. In some instances, this has accentuated tensions between farmers and herders (each of whom may have different perceptions of who has what rights); in other instances, it has led to a more forward-looking accommodation between farmers and herders.[9] But the common element is that both sides are viewing God-given natural endowments as defined "resources" to which they want access and which they seek to protect, at least from others if not yet from themselves.

The idea of rights over resources, whether with conflict or accommodation, parallels the idea of democracy, and it is hard to separate the psycho-

[8]This discussion cannot easily be separated from changes which have taken place over the last half century. The initial expansion of the definition of "common property" was partially a result of official state ownership of all land. This removed traditional authority exercised by local communities and did not replace it with effective control by the state. The land and its resources tended to become "*terres vacantes et sans maître,*" subject to the classic tragedy of the commons: no one had the incentive to refrain from depleting resources which would otherwise be depleted by someone else.

[9]See the earlier case example of Samdi Seydou in the Dallol Bosso area.

logical influences of democracy and decentralization.[10] Some rural populations are already relating to public authority in a different way. For anyone who knows the recent history of the Sahel, it is dramatic to see a village committee imposing sanctions on unauthorized wood cutting, and *threatening to call in the forestry agent to impose a fine if the guilty party does not make amends*. The use of public authority (the forestry agent) as a *guarantor* of community rights not only represents an obvious change in the sense of local empowerment, it advances the perception of the *terroir villageois* as an economic resource.[11]

Financial incentives for "NRM+" are growing

Finally, a corollary of degrading yields and the perceived need for short-term action is that the financial incentives for improved natural resources management, plus, over time, the use of external inputs ("NRM +") are growing. The IFAD yield studies in Badaguicheri provide dramatic evidence of this. More broadly, the driving variable in benefit-cost analyses of such interventions as in-field tree planting, windbreaks, contour dikes, *demi-lunes*, concentration of manure, concentration of residues, and the application of fertilizer has been the difference in yield with and without the interventions. Population pressure has, to date, primarily had the effect of shortening the fallow cycle, resulting in long-term soil mining and declining yields. But land scarcity is now becoming acute, and even shortened fallow cycles are not always possible. The net result is that the potential yields from continuing to farm soils that have already been severely depleted are no longer viable. The difference in yields with and without interventions is therefore dramatically higher, as are the financial incentives to invest.[12]

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[10]Although it is generally conceded that, given fractional parties and economic stagnation, there is more enthusiasm at present for decentralization than for democracy.

[11]The downside of a greater sense of democratic "rights" is that majority power may be used to restrict others' rights. There is particularly strong potential for this with respect to farmer-herder relationships.

[12]For a detailed analysis of the returns to various NRM interventions, and the impact of declining yields on financial incentive, see Volume III of *Opportunities for Sustained Development.*

4. IMPLICATIONS FOR A DEVELOPMENT STRATEGY

4.1 A Working Definition of Sustainability

"Sustainable development" is clearly an important goal of donor assistance to Niger. It is also a term which is now so widely used that it appears in the title of virtually every book or report on natural resources and environment. As a result, it has come to mean different things to different people. Because its definition has important implications for donor assistance strategy, a brief summary of issues is in order.

- *Natural sustainability* refers to maintaining the balance between inputs and outputs through purely natural phenomena, such as natural renovation of the soil during the fallow cycle, the growth in vegetation, and so on. To a large extent, Niger's traditional, low-population systems of fifty to a hundred years ago approached natural sustainability.

- *Ecological sustainability* refers to maintaining the input-output balance of the ecosystem, whether through natural phenomena or *through the action of Man,* including infrastructure, resource management, and use of external inputs. As we have seen, Niger's biophysical endowment will permit maintenance of ecological sustainability even while increasing per capita production and supporting a growing population.

- *Economic sustainability* is a bit more nuanced. It requires, in addition to maintaining the input-output balance of the ecosystem, that the measures needed to maintain equilibrium also be financially and economically feasible. Specifically, soil restoration investments (of money, labor, resources) and the purchase and application of external inputs must pay off for farmers, or they will not happen—they will certainly not be sustainable. Given Niger's public budgetary constraints, recurrent subsidies through payments, food-for-work or "non-replicable" intensities of extension or project attention are also not economically sustainable.

A viable development strategy in Niger must seek to maintain ecological balance primarily[13] through initiatives which pay off for the hundreds of thousands of households which must undertake them. The only affordable—and hence the only strategic—use of public resources is to focus on (a) creating a favorable climate for private choices which enhance resources and (b) targeting limited public investment budgets on efforts that will spur private initiative (infrastructure, demonstration projects, etc.) and that will yield recurrent revenues at least equal to any recurrent costs.

Development realities in Niger imply that *economic sustainability* is essential to the prospects of achieving *ecological sustainability*. However, what is economically sustainable changes over time, as the economy's structure and built-in incentives change. Economic structure and incentives are very likely to undergo profound change in the next thirty years as a result of population growth, urbanization and regional trade. *The key question, therefore, is how ecological sustainability can best be achieved within the context of underlying economic change.*

4.2 Capitalizing on New Opportunities

In the simplest terms, the natural resources *and* the development strategy of Niger depend on the ability to capitalize on new opportunities. Population and past degradation alone *no longer permit a stable environment based on traditional subsistence production alone*, however desirable the goal of self-sufficient subsistence producers may be.

Environmental instability and economic flux are also powerful catalysts for change. At the macro level, the potential for positive change clearly exists, given the *converging dynamics* of demographic, biophysical and economic transformations:

- Farmers are increasingly aware of the need to invest in the land; increasingly, they have no immediate option.

- Over time, external inputs will be required to maintain ecological equilibrium.

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[13]There are, of course, exceptions. Certain priorities, such as for protected areas and to maintain biological diversity, may in fact require recurrent subsidy. Even in these areas, however, someone must be willing *and able* to pay for such subsidies.

- Recurrent use of external inputs will depend on recurrent cash income—from commercialized production and from non-agricultural sources.

- Urban cash demand for rural products is likely to grow eight-fold from urbanization trends alone. This impact may be even greater if devaluation stimulates demand for more domestic products versus demand for imports. Devaluation also creates the potential for increased exports—both within West Africa and outside the region.

5. INDICATORS OF PROGRESS

5.1 Background

There have been fifty years of intensive effort to develop indicators which meet a variety of information needs. Major, early indicator sets were developed in the post-War years to monitor, and eventually predict, key variables affecting the national economy. The "Leading Economic Indicators" are among the best known indicator sets. Demographic indicators—birth rates, mortality rates, fertility rates, etc.—are equally well-known and well-developed. In many respects, the use of demographic indicators pre-dates the development of macroeconomic indicators.

The development of environmental indicators is more recent. A substantial amount of methodological work was done in the 1960s, but the most intensive efforts began in the early 1970s. Initial efforts on environmental indicators focused on the "brown end": industrial pollution, air and water quality, waste management. Methodological attention to *natural resources* indicators is more recent still, and can be further subdivided into two distinct areas: global indicators to track the status of natural assets such as rainforests and biological diversity, and locally-based indicators of sustainable natural resources management.

Since 1970, however, there has been an enormous amount of formal, theoretical and applied analysis of environmental and natural resources (ENR) indicators. The rapidly growing volume of literature on the subject is itself an indicator of a key fact: it has, in general, proven to be more difficult to find a limited set of cost-effective, credible, reliable and accurate indicators in ENR than in macroeconomics or demography. One result has

been an *excess of indicators* coupled with a *shortage of consensus* on which ones are important or what they mean.

5.2 What Do We Want to Know About?

The difficulty in finding suitable natural resources indicators stems, to a large extent, from the fact that the definition of "successful" natural resources management necessarily involves a good deal of local variation. Yet the shortage of clear benchmarks of success has too often provided cover for use of indicators which themselves are ambiguous as to what is being tracked. Two areas of this ambiguity must be addressed as a prelude to developing useful indicators:

Indicators of What? The term indicator is used to mean a variety of different things, including "social indicator," "natural resources indicator," or "program indicator." For example, "program indicators" may provide evidence that a given program is achieving its stated objectives (policy reforms). But these program indicators would not necessarily tell us anything about the condition of the natural resources base. Indicators on the status of the natural resources base, on the other hand, could tell us that resources are getting better or worse, but may say nothing about whether development programs contributed to that success.

What is the Desired Outcome? For indicators to be useful, there must be a clear connection between the indicator and the larger *outcome* being tracked. Part of the ambiguity surrounding natural resources indicators has to do with the fact that the desired outcome of "natural resources management" means different things to different people. For some, improved NRM implies direct impact on preserving natural resources; for others, it implies the ability to derive sustained income from the resource base, even if that involves some reduction in natural capital. Depending on the underlying hypothesis of the analyst, there are clear differences in short, medium, and long-term program goals.

A key starting question, therefore, is "what do we want to know about?" To answer it, we must state what we want indicators of (i.e. of program success, of resource status, of risk factors, etc.) and we must clearly state what it is that constitutes success.

5.3 Approach and Criteria for Indicator Development

5.3.1 What Information Do We Need?

An indicator must be easy to observe and it must also be correlated with changes we want to know about, but which may be harder to observe directly.

"Indicators are telltales: they tell us something about underlying conditions or processes and about their changes. Indicators are things that are easy to observe and that are coupled or linked supposedly or in reality to the things that are harder to observe, but which we consider important."[14]

Typically, where complex processes are involved, it is impractical to directly observe desired changes. In some instances, even if cost, time and resources were not obstacles, there are no agreed-upon, direct *measures* of what we seek to know. One example is when we seek to know in advance about something that has not yet occurred. It cannot yet be measured, but there may be observable indicators, thought to be correlated with it, which tell us if it is more or less likely to occur. Hence the "leading economic indicators" provide an indication that the economy is moving in a given direction before that movement can be directly measured. As this example demonstrates, an indicator would be useless if there were no reason to believe it was correlated with what we want to know about. Yet because it is merely an indicator and not the actual phenomenon, that correlation can only be *hypothesized.* The hypothesis can be extremely informal ("a hunch"), or very formal (an econometric model). However elaborate or simple, *this "conceptual model" is the linchpin of indicator development.*

The practical relevance of the *conceptual model* cannot be underestimated. If the "model" is wrong (the correlation it hypothesizes does not in fact exist) then we do not really have indicators. Instead, we simply have a disjointed collection of easily observed statistics. This inseparability between conceptual rigor and the much muddier reality of field information creates a tension which all indicators development exercises must manage. The tension is best characterized by what may be called a "systems approach" versus a "policy approach." Basically, two questions drive the debate. The first is relatively straightforward: "how rigorous does the

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[14]Deutsch, Karl W. "On the Utility of Indicator Systems." In Charles Lewis Taylor, ed. *Indicator Systems for Political, Economic, and Social Analysis.* Cambridge, Massachusetts: Oelgeschlager, Gunn & Hain, Publishers, Inc. 1980.

conceptual model have to be?." The answer can reasonably depend on what information and resources (money, time, analytical capacity) can be devoted to the effort. The second question is more problematical: "even if the resources were available, might the increased rigor in fact misstate (over specify) what in reality is not a rigorous process?"

For purposes of this study, and practical need, we focus on establishing the case for the hypothesized correlation between proposed indicators and the outcomes the program wants to bring about. That is, we seek to create *a strong conceptual model,* but not to impose greater analytical rigor than the current analytical understanding of relationships supports. In this sense, the proposed indicators must evolve if they are to remain useful. They will do so for many reasons: the analytical understanding of relationships improve; natural resources priorities become clearer; program focus is refined; and, most importantly, field-testing provides feedback on which indicators appear to generate the most useful information.

5.3.2 Methodology: How Do We Develop the Information Needed?

Whatever the level of rigor that best serves practical needs, several methodological steps are necessary for indicator development. These steps, which are briefly outlined below, remain relevant even after an initial set of indicators has been developed, because they guide subsequent iterations of feedback and adjustment.

Clarification of objectives. If program objectives are unclear, inconsistent or poorly understood, indicators of program performance will reflect these weaknesses. The more important issue is that any real-world program will, to some extent, be unclear, inconsistent and incompletely understood, particularly in its initial phases. Such inconsistencies are not fatal to the indicator development process but they should be identified as they will affect the next step in the process: modeling. While clarification of objectives is a necessary first step, the feedback from applying indicators is equally important in subsequent iterations, both to further clarify objectives and to better understand priorities.

Developing the conceptual model. It is important to develop a conceptual model of the relationship between program objectives and all influences ("variables") that affect these objectives. The models may range between verbal expressions of relationships, the use of diagrams, or the development of mathematical equations with parameters estimated by sophisticated econometric techniques. The actual modeling technique will depend on such

factors as data availability, the need for accuracy and precision, and on whether mathematical statements are even possible or relevant. The key issue is that the hypothesized relationships should be articulated so that the relevant variables of interest are subject to some degree of measurement. The "model" should be as complete as possible, in that all variables of significant influence should be specified, including those that may not be under the direct influence of the policy maker.

Determining candidate indicators. Candidate indicators are those variables in the conceptual model that correlate with program objectives. For the kinds of programmatic objectives being considered here, the conceptual model itself is unlikely to yield a clear result as to whether a "statistical relationship" between the variables and the objectives are strongly correlated, weakly correlated, or simply non-existent. In these circumstances, candidate indicators must meet two less precise but important tests: 1) "Why do we think they qualify as candidate indicators, and why are they better than the alternatives?" 2) "Do they, after application, provide useful feedback?"

Preliminary evaluation of candidate indicators. All candidate indicators should be assessed preliminarily by the criteria listed above. Clearly, not all criteria are equally important. The importance of various criteria depend on the purposes to which the indicator will be put. However, in most cases, it will be necessary at a minimum to assess the *costs* of measuring the variable relative to the *benefits* of the information provided. The evaluation is preliminary since final assessment will depend on indicator performance. This final evaluation can only take place after the indicator is used for a period of time.

Selection and final evaluation of indicator(s). Based on the above evaluation, indicators should be selected for use (e.g., program evaluation, early warning, etc.). As noted, final evaluation will depend on how well the selected indicators perform over time.

5.3.3 Indicators and Criteria of Quality

Not all indicators are created equal; some closely represent the phenomenon being measured, while others are more cost-effective or have an ability to be comprehended by a majority of potential users. Each candidate indicator must be evaluated according to the type of information that the indicator can provide, the availability of data and the resources to collect and analyze the data, and on the needs of the indicator users. These criteria will deter-

mine the relative value of any one indicator over another. Criteria for selecting indicators include the following:

Accuracy. The degree to which the indicator conforms to the entity being indicated. Sometimes accuracy is distinguished from precision (below).

Precision. The degree to which repeated estimates of the indicator conform to each other. In statistical terms, accurate indicators lack bias while precise indicators lack variance.[15]

Consistency. The degree to which the indicator conforms to the entity over time or with repeated observations. Consistency, in a sense, is a compromise between the criteria of accuracy and precision.

Efficiency. The degree to which the indicator utilizes an optimal allocation of indicator-development resources. Efficient indicators are those that maximize the difference between the benefits provided by the indicator and the costs of attaining the information needed to generate that indicator.

Sufficiency. The degree to which an indicator economizes on the use of available information. Sufficient indicators utilize all pertinent information in their development and ignore information that is not pertinent. Thus, sufficient indicators are cost-effective indicators.

Redundancy. A redundant indicator describes the same entity as another indicator. While redundant indicators may be viewed as inherently inefficient, they may, nevertheless, be desirable if they help overcome uncertainty as to whether a particular indicator is accurately measuring some entity. Redundant indicators thus provide a margin of safety.

Comprehensibility. A comprehensible indicator is one whose connection to the entity being described is clear to some group in the population. Clearly, an indicator may appear comprehensible to one group but not to another.

The relative importance of these criteria depends on the uses to which indicators may be put. Thus, if the intended use of an indicator is for general

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[15]To understand the difference between accuracy and precision, consider the following. Suppose the true measure of an objective, *O*, has a numerical value of 50. Consider two indicators, *A* and *B*, where each indicator is used to provide six measurements of *O*. The measurements according to indicator *A* are: 45, 55, 40, 60, 30, and 70 while those according to indicator *B* are: 55, 53, 52, 56, 51, and 57. According to the above definitions of accuracy and precision, indicator A is more *accurate* than *B* since *on average A* approximates the true measure, 50. In contrast, on average *B* provides an (upwardly) biased estimate of the true value. However, *B* provides a more *precise* estimate since the individual measures by *B* cluster far closer together than do those by indicator *A*.

public education, a comprehensible indicator may be preferred to an accurate indicator. On the other hand, qualities of efficiency and sufficiency are generally desirable regardless of the intended use. Indicators that meet these two criteria make optimal use of the traditionally low budgets that are available for data and indicator development. Nevertheless, it is sometimes desirable to trade some efficiency for redundancy when the quality of the indicator is uncertain.

5.4 Program Objectives and the Intended Use of Indicators

5.4.1 Purposes for Which Indicators are Being Developed

It is impossible to determine the quality of an indicator without knowing its intended purpose. This is true even if the outcomes about which the indicator provides information are the same. For example, consider "nutritional status" as the outcome about which indicators are being developed.

- If the purpose is to report to Congress on the nutritional status of rural populations in Niger, it is reasonable to select indicators which provide the best correlation with nutritional status. By definition, since the collection of indicators is not without cost, it is also reasonable to reject indicators which provide imprecise and unreliable feedback on nutritional status.

- If the purpose of the indicators on nutritional status is early warning to prevent famine—as is the case for the Famine Early Warning (FEWS) program—candidate indicators may be quite different. In fact, FEWS typically retain imprecise and unreliable indicators which provide the earliest danger signal that closer monitoring may be warranted for a given area. At the same time, they reject indicators which, while easy to collect and closely correlated with nutritional status, occur too late to influence the outcome.

Frequently, indicators serve more than one purpose, or a hierarchy of purposes, one or more of which may be of relatively greater importance. However, once these purposes have been established, all other aspects of the indicator development process are influenced by them.

5.4.2 Implications for Development of Niger NRM Indicators

The nature of the outcomes being monitored, as well as the purposes, influence the *form* of candidate indicators. Many of the outcomes being tracked are non-quantifiable. Moreover, the relationships between indicators and outcomes are, necessarily, judgmental. They do not lend themselves to rigorous modeling or even to much conceptual precision. While this is both typical and perfectly acceptable for indicators of complex social science outcomes, it does create a potential danger which must be managed. Two points are at issue.

First, candidate program indicators will not relieve program managers of the need to understand program linkages and to continually reevaluate both the indicators and the program relationships as circumstances evolve. More rigorous scientific objectives (whether children are immunized against polio, for example) allow indicators that place much lower on-going analytical burdens on program managers.

The second point flows from the first. If indicators are simply based on "judgment" and are not quantified, then progress can only be measured ordinally (e.g. "more" or "less"). While such ordinal statements of progress are not without value, they can often be ascertained by project managers without the need for explicit indicators or an elaborate indicator framework. Hence the importance of defining indicators which (a) move in the same direction as the objective being monitored, (b) are quantifiable, wherever possible, in units of measure that are not simply arbitrary, and (c) are relatively independent and objective—that do not change arbitrarily as judgments or preferences change. If the candidate indicators entirely fail to meet these criteria, they add little to what can be known without them.

MADAGASCAR CASE APPLICATION

Dynamic Linkages Among Environment, Population, and Development in Madagascar[1]

Asif Shaikh
Thomas Reardon
Daniel C. Clay
Philip DeCosse

SUMMARY

This case application concerns the extent and nature of environment, population, and agriculture linkages in Madagascar. The work is based on field observations, interviews, and a review of the empirical literature by a team from International Resources Group, Ltd. (IRG) and Michigan State University (MSU). The elements of the argument are as follows:

- Madagascar's population will double in the next generation, no matter how successful fertility reduction programs are .

- To feed twice as many people, food availability must double in 25 years, or grow at 3 percent per year. Most of this will need to come from growth in crop output and yields rather than imports.

- Most farmers in Madagascar are poor smallholders, and most practice traditional land management. Little "intensification" of land use is as

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yet taking place, and most increases in output driven by the growing population's need for food security and survival take place through "extensification" of land use—pushing up fragile hillsides and out into biodiversity-rich forests. This means land degradation and shrinking commons—both of which spell even greater impoverishment of farmers and of the country as a whole.

- Breaking the vicious circle of extensification and degradation of the farmlands and commons cannot sustainably be accomplished by simply barring smallholders from forests or hills—their strategies are based on desperation and current lack of alternative strategies.

- Rather, the battle to protect Madagascar's biodiversity will be won or lost on agricultural land away from the forest, because the battle in which rural populations are engaged is about production, livelihoods, and land use, not about the environment. In this battle, environmental outcomes are the by-product of land management and production decisions. In the absence of a land management and agricultural production policy, there is no viable resource conservation policy, because how people manage land and production options determines what they do to the forest.

- In program terms, our findings underscore the need to strike the right balance in program resource allocation. Specifically, the environment strategy needs to be adjusted by substantially increasing the emphasis on rural development and smallholder land management on farmlands and open-access lands, especially in areas where population pressure is the greatest, which are often far from the protected forests and parks. This will require coming to grips with the links between sectoral programs.

  Environmental protection goals and programs are important, but their long-term success is contingent upon the success of the rural development and population programs.

- The rural development path suggested is: 1) to intensify production in the valley floors and lower hillsides, and 2) to protect the land through anti-erosion investments on hillsides and upper watersheds. Intensification will require much more fertilizer and manure use, and roads and

jobs to generate cash to help buy these imports and to sell the products. Land protection will require improved extension, cash income to hire labor, and greater valley yields to buy breathing room to make more investments.

- But poverty alleviation needs to be a key part of the strategy—rural poverty is the enemy of intensification and land protection, hence widespread rural poverty is directly and indirectly driving destruction of Madagascar's forests and hillsides. Poverty also exacerbates the dilemma by encouraging population growth. Poverty alleviation will enhance the effectiveness of family planning programs.

- There are critical time and scale elements in this strategy. It must respond quickly enough for poor peasants on the margin of survival. And it must make substantial numbers of smallholders better off, rather than just reaching the small communities of people in the buffer zones around forests. And even in these adjacent areas, compensation strategies have not been enough (Ferraro and Kramer 1995).

1. BACKGROUND

1.1 The Underlying Premise

The underlying premise of this "nexus" analysis (of links among population growth, environment, and agriculture) is the following: If we are serious about achieving sustainable results in any sector, we must address the root causes of the problems to be remedied. To address root causes, we must understand the ***causal relationships***. Causal thinking leads to the conclusion that complementary actions outside the target sector may be equally important to actions within the sector. Linear approaches that do not take account of causal linkages may be an inefficient use of scarce development resources. Ultimately, if they undercut success in meeting objectives, they may also be an indefensible use of resources.

1.2 Specific Relevance to the Madagascar Program

The Government of Madagascar and its donor partners have placed significant emphasis on conserving the island's forest resources, which

provide the habitat for its unique flora and fauna. Over the past six years, efforts under the National Environmental Action Plan (NEAP) have focused on sectoral projects in the environment and natural resources sector, and particularly on parks and protected areas. Yet there is a growing awareness that the strategy for the environment has not paid due attention to the underlying problems which cause environmental degradation (Larson, 1993).

Analysis of causal relationships in the land management decisions of rural populations strongly suggest that the battle to conserve dwindling forest resources *will be won or lost on agricultural land far from the forest.* Analysis of *dynamic linkages* over time suggests that the nexus of forces driving forest destruction will intensify without a structural transformation of the agricultural production system. The rural poor are clearing forests to expand agricultural production so that they can feed their families in response to increased demographic pressure. Neither Government nor donor projects can prevent forest clearing if local populations view it as a condition for their survival. Therefore, without significant alternative means of meeting local food and income needs, the huge investment in sectoral programs for environmental conservation will inevitably be undercut. In short, if we are serious about protecting the environment, we must be accountable for implementing a strategy that can succeed, not simply for the volume of resources expended in or around protected zones.

A successful agricultural transformation is an achievable target. There are important obstacles, which have deepened over two decades of socialist rule. However, the structure of smallholder production in rural Madagascar, with a strong base of monetized production and exchange, also creates significant opportunities for use of agricultural inputs and for market-driven increases in production through intensification.

2. DYNAMIC LINKAGES

2.1 Sectors Do Not Operate in Isolation

Three key trends bind together environmental sustainability, demographic pressure, and rural production systems. Together, they form the core of the "nexus" and will strongly influence the options for a sustainable environment over time:

- *Population will double in the next generation, no matter how successful fertility reduction efforts are.* Development and environment strategies must factor in the fact that, at the high annual growth rate of 3.3 percent, total population will grow—within 25 years—from its current level of 13 million to 33 million by 2020 (Sussman, Green, and Sussman 1994). Fertility reduction efforts are urgent precisely because the built-in "demographic momentum" means it will take 25-30 years for population to stabilize even if fertility rates start dropping soon.

- *To feed twice as many people, food availability must double in 25 years,* implying a compound annual growth rate in food production of over 3 percent for the entire period. In the absence of such growth, food imports or food insecurity will grow. Madagascar does not currently have the foreign exchange margins to vastly expand food imports. Rural populations do not have the subsistence margins to further reduce their income and caloric intake. Doubling food production will require that agricultural production be "jumpstarted." The urgency of the agricultural transformation is underscored by the World Bank Poverty Assessment Report (page 47): *"To feed a substantially larger population, even with drastic declines in the fertility rate will require a doubling of domestic food production over the next thirty years, unless the Government resorts to large increases in food imports."*

- *Without a structural transformation of current land use practices, the production system will continue to be extensive.* Rural smallholders will continue to clear the forests, cultivate the hillsides and degrade the watersheds in the effort to meet short-term survival needs. Primary forest has disappeared rapidly, and land constraints have begun to be felt in many parts of the highlands (Keck et al. 1994, Farraro and Rakotendra 1995; Teyssier 1990). Valley rice irrigation infrastructure has degraded with siltation and administrative collapse (Droy 1991), hillsides have eroded, and primary and secondary forests have disappeared under traditional slash and burn agriculture (Sussman, et al. 1994).

Why is this? Because traditional land management practices rely on extensive agriculture, which must continuously bring new land into production to feed a growing population. The virgin forests provide the best and most fertile land for agricultural expansion. Poor farm households do not

perceive that forest resources are limited. Their cultural experience over 1500 years has suggested otherwise. Indeed, there is a rural Malagasy saying that "*la foret est sans fin.*" Moreover, even if smallholders can be convinced that long-term sustainability is a real issue, they are forced by poverty to sacrifice the future in order to feed their families today and tomorrow.

If forests are being destroyed for short-term reasons of food and income, then sensitizing populations to the long-term benefits of conservation will not be sufficient to effect a change in their behavior. It will also be essential to fundamentally alter the agricultural production equation in favor of land management systems which can *produce more* on *less land*—intensified systems. As population doubles in a generation, unless this shift to more intensified production is widespread, remaining forest and biological resources cannot be protected. To be widely adopted, intensification must be sufficiently attractive in terms of income and security that the majority of rural households view it as being *in their own economic self-interest.*

Therefore, smallholder land management decisions are the point at which the main lines of the "nexus"—demographic pressure on resources, environmental conservation objectives, rural food security and the potential for income growth—intersect. It is also the key point of leverage for spurring longer-term macro-economic growth linkages which can carry the shift away from primary reliance on natural resources into the next generation.

2.2 Physical and Economic Productions Systems Are Linked

The Madagascar case application called for examination of key watersheds in the Fianarantsoa area in the center-south highlands and the Anjozorobe watersheds in the center-north highlands. Field observation in these areas focused on the local watershed primarily because the Malagasy land management system in the highlands is *physically* organized around areas of the *local watershed*: forest, upper and lower hillsides (*tanety*), and valley floors—each area is treated differently and each is used to produce different products essential to the rural economy. (1) Farmers grow irrigated rice and sometimes dry season vegetables in the valley floors of local watersheds. Communal canals are used but land is privately worked by households. (2) They grow rice/maize and cassava, and sometimes fruit trees, on the erodible hillsides. Burning the hillsides is often practiced to produce new grass growth for cattle (Jolly 1989), and to ease water runoff to valley floors to increase water availability to irrigated rice. (3) Slash and burn (*tavy*) is

practiced in privately held lands and open-access lands (often primary forests), mainly in the upper part of "greater watersheds".

Land management decisions in one area of the local watershed affect pressures on and conditions for use of other areas of the local watershed. For example, more intensive use of the valley floor relieves pressure on the hillsides; burning of hillsides can silt irrigation systems on valley floors (Rossi 1979). Moreover, land management choices in one local watershed, (e.g., a valley near Ranamofana) can affect land use conditions in other areas of the greater Fianarantsoa watershed (again in the Fianarantsoa greater watershed case, say road and production conditions in the upper coastal plains). We distinguish "local watershed" from "greater watershed," the latter generally containing a number of valley-floor-hill combinations, and generally extending from mountains down to coast.

Yet the dynamic linkages approach which underlies the nexus framework is not, by definition, limited to a physical zone such as a watershed. In the same way that macro-economic policy cannot be well-formulated without understanding production and behavioral relationships at the individual level, the relationship between environment and development options cannot be well-managed without understanding how the interactions between forest, hilltop, slope and valley floors drive land management and environmental decisions within the watershed. Watershed relationships are therefore the first stopping point in broadening the range of analysis from specific areas (such as buffer zones) to a unit (the watershed) which captures the full physical range of land management relationships. Ultimately, the analysis then proceeds to the linkages with broader macroeconomic policy, social, cultural, and demographic forces in the rural and the urban areas.

2.3 Remainder of this Study

Section 3 focuses on Madagascar's "demographic transition," focusing on the concept of rural population pressure, and relating it to land management practices, degradation, and land constraints. Section 4 adds the dimension of urban population growth and urban and export market growth as opportunities rather than threats to increasing the compatibility between agricultural growth, land management, and environmental enhancement. Section 5 focuses on the land management transition, specifically on current constraints to land use intensification and land protection, and policy and strategy options to relieve those constraints. Section 6 concludes with general strategic and program implications.

3. THE DEMOGRAPHIC TRANSITION IN MADAGASCAR

What are the impacts of rapid population growth on Madagascar's natural resource base and on economic growth, and how, in turn, do changes in natural resources and economic growth affect demographic trends?

3.1 Population Pressure and Natural Resource Degradation: Concepts and Perceptions

Is Madagascar's rapid population growth resulting in resource scarcity? Is population pressure eroding the resource base?

Population pressure (resource scarcity) is a relative term that must be defined in relation to what people *do* to sustain their own livelihoods—most notably the technologies and institutions developed by people to use natural resources. In general, where more intensive technologies are used (e.g., improved inputs), where land improvements are made (e.g., agroforestry) and where more specialized institutions are developed (e.g., bank credit), a larger population can be supported on a given resource base.

The slash and burn agriculture practiced in much of Madagascar is extensive (meaning farmers use more land to produce more output rather than increasing input use per unit of land to produce more output, the latter being an intensive system). This extensive system is not capable of sustaining high population densities (Oxby 1985). Population densities in Madagascar average 26 persons per square kilometer—much lower than many other African nations with comparable per capita income levels (e.g., Rwanda, Malawi). However, population densities vary from 8.8 persons per square kilometer in the province of Majunga to 26 in Fianarantsoa and 60 in the more urbanized Antananarivo province (RDM 1995).

The disappearance of park/forest land today is the consequence of the agricultural system begun more than a thousand years ago (Fukazwa 1989). Park/forest lands are areas where the traditional extensive system can still be practiced. Because the protected areas have been given special attention by the donor community, we have observed a common view that "demographic pressure" is synonymous with encroachment into park/forest areas.

It is a *misconception that where the edges of parks and natural forests are disappearing, population pressure is highest.* On the contrary, we found that population pressure is greater in areas where the natural forest cover has long since been cleared, where fallow periods have grown shorter after

each cutting and burning, and where farms have become smaller. It is in these areas that land management systems have begun to change, and that farm households have developed alternative strategies for meeting their basic needs. Intensification of resource use, e.g., intensified hill rice using tractors (Berg 1989), off-farm employment, migration, and fertility control are all elements of this transformation.

A second *misconception is that controlling population growth will stop natural resource degradation in Madagascar*. This notion appears to be based on the assumption that demographic pressure is the major driving force behind continued resource decline in Madagascar. It appears to be a common belief among the donor and larger development community that once family planning and other measures to reduce fertility rates finally take hold, Madagascar's environmental problems will subside.

On the contrary, *controlling population growth will not, on its own, stop natural resource degradation—but it will slow the pace of degradation.* More people mean faster erosion in the context of the traditional land management system in Madagascar. After several cycles of tavy (upland cutting and burning, crop production, and fallow) the soils pass the point at which their fertility can be regenerated naturally, through new forest growth, and they are abandoned (Oxby 1985, Keck et al. 1994). These are lands that are "lost forever," or until human interventions such as planting trees, applying organic matter, and building terraces (i.e., a fundamental change in land management) is brought to bear and their productive capacity is restored. Thus, even at very low rate of population growth, tavy will continue to degrade land and water, both on the hillsides and in the valleys. In the context of current land management techniques and institutions, high population growth simply adds fuel to that steadily burning fire.

Moreover, we hypothesize that population pressure also affects land management strategies by affecting land use rights, pushing farm fragmentation (Ferraro and Rakotondrajaona 1995) and spurring intensification of land use where opportunities for this exist (Berg 1989). In the highlands of Rwanda, for example, population pressure has lead to greater land rental (short-term use rights), and thus fewer long-term investments in erosion control and soil fertility (Clay 1995). Based on discussions with farmers and government officials in the Fianarantsoa area, it appears that population pressure (notably in the urban periphery) is raising the demand for land titles.

Much evidence from Africa indicates that by holding title to their land, farmers are more willing to make the kinds of long-term investments needed

to ensure improved and sustainable productivity (Migot-Adholla et al. 1990). We recognize, however, that this relationship cannot be naively assumed to apply to Madagascar. The important variable is security of tenure; the degree to which titles or any other institution leads to greater security depends on contextual factors. In Madagascar, land tenure is administrated at the *fokonolona* level where there is a wide variety of administrative styles and structures (Serre-Ratsimandisa 1978) and the relationship between titles and tenure security can be expected to vary. In some instances in Africa the process of creating individualized land titles has actually increased tenure insecurity (Critchley 1991). Findings from studies in some areas of Madagascar support the positive environmental effects of land titling (World Bank 1991), while results from other areas are inconclusive (Keck et al. 1994).

Not only does population growth affect land management, agricultural productivity, and economic growth, but it is in turn influenced by changes in these factors. The feedback loops can be both positive and negative. Poverty alleviation (higher incomes, more access to food) can reduce mortality rates in the short run, and in the longer run reduce fertility rates. The latter effect is crucial for slowing population growth and for enhancing the effectiveness of family planning programs. The inverse is that poverty spurs fertility and mortality rates. Economic growth is an ally of family planning; poverty is a foe.

Policy makers need to understand better the dynamic effects of growing population on land management and how in turn these affect rural development options.

3.2 Population and Migration

Labor migration and permanent out-migration are also central to the population component of the nexus approach. This is because migration, like fertility control, and like agricultural intensification, offers rural households an alternative to declining incomes associated with population pressure.

Permanent migration, either to urban areas or to other rural areas where land may be more abundant, is often *one of the first strategies employed by households squeezed between population growth and environmental decline.* In many areas, remittances sent by migrants back to the home community constitute a crucial source of cash for investment in more sustainable land use practices such as the use of improved inputs and the construction of

terraces. There is evidence of substantial flows of permanent migrants both between rural areas and between country and town in Madagascar. This marks a change from the previous trend in which most migrations from place of birth lasted less than 5 years, fewer than one third for a duration of more than 15 years (Battistini and Hoerner 1986). Ferraro and Rakotondrajoana (1995) note immigration into Ranomafana region as well as splinter groups, often young people, moving within the region to areas with available land. This observation has also been made adjacent to other protected areas where development activities associated with projects are presumed to attract newcomers.

Short-term seasonal migration is also common in Madagascar, and particularly from the high density areas such as those of Fianarantsoa. From demographers working in that area we learned that young men from poorer households in the region migrate to Majunga and other more productive areas to work as agricultural day-laborers on farms in these areas. We hypothesize that the poverty of these migrants is what causes them to sell their labor outside the region for a low but *immediate* wage, rather than to invest their labor in raising the productive capacity of their own farms, the payoff to which would be realized in the more distant future. Wide variation in environment and lifestyle among regions is frequently described (Battistini and Hoerner 1986, Ramanandraibe 1987), however Verin (1990) notes that migration has had a significant impact on regional lifestyles with some ethnic differences disappearing.

3.3 From "Population" to "People": Who Are the Land Managers that Drive the Dynamic and How Do *they* Perceive Population Pressure?

We begin with a review of some of the salient characteristics of Madagascar's land managers. It is worth noting that:

- They are *mainly poor farmers*. Half are small farmers (with less than 1.5 ha.); 80 percent of these are either extremely poor or poor. Half are medium-large farmers (with more than 1.5 hectares); 75 percent are extremely poor or poor (World Bank 1995). The great bulk of farmers live outside of the peripheral zones of primary forests, in highland watersheds or coastal plains.

- They use *small amounts of soil enhancing inputs*. On average Malagasy farmers use only about 2 kgs/ha. of fertilizer, only a third of the African

average, which in turn is only a seventh of the developing country average. Very little manure is used.

- Most *grow mainly food crops* (rice, cassava, maize, beans). and a few (about 5 percent) grow industrial/export crops (coffee, vanilla, cloves). Overall, *only a quarter own livestock.* This is not the case in northern and western regions of Madagascar where livestock is more prevalent (Dorosh et al. 1990). At one time, the population of livestock was estimated to exceed that of humans on the island (Rauh 1979). Recent research mentions an increase in cattle rustling and lack of cash for initial investment affecting pastoral systems (Ferraro and Rakotondrajoana 1995, Teyssier 1990).

- Malagasy farmers *do not fit the image of the "subsistence peasant,"* as most operate in the market economy—buying and/or selling food and labor. About 35 percent of small farmers' income is from sources outside of farming (salaried employment, non-farm self-employment, transfers, property income, and other); the figure is about 20 percent for medium-large farmers (World Bank 1995).

How does this group perceive population pressure? From our interviews, it appears that farmers in the highlands see valley floor land as already quite limited. Yet it is still not common that they "intensify" (farm more on given land) by growing off-season crops (such as vegetables), or by applying manure/fertilizer to raise yields in the valley bottoms. Intensification using improved inputs and canal improvements has mainly been tried in the plains irrigation schemes (e.g., Lac Alaotra and Marovoay), and not much in the highlands.

By contrast, farmers tend to view hillsides and forest land as *relatively abundant in the short term but limited in the medium-long term.* The actual constraint, and probably the farmer's view of it, differs greatly over local watersheds depending on how many times the tanety has been burned, whether there is access to forest, how constraining legal limits to forest use are actually perceived, and perhaps on how much livestock husbandry is practiced or itinerant groups come through the area and use the hillsides.

4. THE MARKET TRANSITION

The rural land managers described in the previous section receive market signals which shape their choices. Over time, as urban areas grow and the macroeconomic environment changes, the signals received by land managers change. This section adds the urban population and market growth dimension of the dynamic, both of which can create important opportunities for land management change and rural development.

4.1 Urban Demand

Madagascar's urban population growth is an important part of the dynamic which can create opportunities for intensification and resource conservation.

Urban market opportunities for rural producers will increase. This is because urban population is growing at over 5 percent a year while rural population is growing at less than 3 percent. Even if the per capita income of the populations of the cities and towns does not grow, the total urban demand for food will increase at least at the rate of urban population growth.

If, to take a more hopeful perspective, urban incomes rise even as urban population rises, then urban demand for food will increase even faster as the bulk of the urban poor focus the expenditure of new income on food and other basic necessities. To estimate the size of these demand impacts on the food production sector, one would need to know more about income elasticities of demand for different income groups. But one thing is clear, each rural producer will need to produce more output to satisfy the growing urban demand. In this sense, growing cities can serve as a leverage to agricultural growth and intensification in rural areas.

As incomes change, so do food preferences. Bennett's Law tells us that the proportion of income spent on "starchy staples" (grains, pulses, tubers) declines as household income increases. Proportionately, the demand for vitamins, sugars, fats, and animal proteins increases as incomes grow. What does this mean for Madagascar? It means that the demand for items like fruits, vegetables, meat, milk, and milk products will expand with a growing economy. Indeed, these goods can be expected to increase at a faster rate than income growth.

Many of these goods *provide the opportunity for, and are complementary to, agricultural intensification and resource conservation.* Increased consumption of these goods by urban areas can help in the following ways:

- Dairy and livestock production in peri-urban areas is typically accompanied by intensive feedlot operations and fodder market development, as we saw developing in peri-urban areas of Fianarantsoa. Livestock husbandry generates manure so desperately needed for cropping intensification. Stabling animals and feeding them fodder will also reduce grazing/burning pressure on fragile hillsides.

- Fruit trees, when planted on hillsides as we saw in Anjozorabe, retain fragile soils. They also increase farmers' cash incomes.

- Vegetables, as dry season crops planted in rice fields, allow intensification (through a second crop) of precious valley floors—reducing the pressure to use hillsides and forests.

With growth of the overall economy and of the urban economy, increased demand for forest products will create opportunities and risks. Pressure on high value forests, often the location of the richest variety of flora and fauna, will increase. To villagers who have lost land to parks, the opportunity costs of lost park lands will become greater. In general, conflicts over valuable forest land will become more severe. Issues of forest prices and access rules, similar to those USAID and the Government of Madagascar are currently examining, will be increasingly important.

To understand the dynamics of changing urban demand patterns on rural production options, policy-makers and researchers need to have a better understanding of income and substitution elasticities and a better understanding of the relative impacts of different crops on the quality of resources in areas where they are grown. But even in the absence of such information, experiences from elsewhere teach us that growth in incomes provides more diverse opportunities for rural production, and that many of the products demanded call for production which is both more intensive and less threatening to fragile resources. Madagascar, with its diversity of agroecological zones and micro-climates, is well suited to benefit from this dynamic.

4.2 Exports and Environmental Impact

While domestic demand is a leverage to short-term growth, exports are important to sustainable long-term growth. The Government of Madagascar, working with USAID and other donors, has made significant policy strides towards improving the climate for agricultural exports. What impact will

these changes have on the rural farm economy, and in turn on the environment?

The answer depends in great part on the crops that can be exported and the way those crops are produced. Some products can have a beneficial impact on the environment, while others may be detrimental. To illustrate the importance of product selection, and the impact it can have on smallholder production and the environment, we cite two examples. Stryker et al. (1993) note, in examining the export crop potential from Madagascar, that the north-east of the country, an area rich in biodiversity resources, has a comparative advantage in the export of robusta coffee. When planted on hillsides, coffee effectively limits soil erosion even while increasing the per hectare value of land. Cassava flour exports might, on the other hand, encourage more extensive and low input hillside cultivation, although agroforestry investments and terracing can greatly limit the damage from greater hillside use for cassava production.

Production of *export crops can create opportunities for intensification and soil conservation, but policy-makers must understand differential impacts* of export products. In determining the relative sizes of export taxes, policy-makers can provide incentives to those products which at the same time conserve the environment and increase export earnings.

4.3 Constraints to Taking Advantage of These Opportunities

Although the potential for meeting the growth and conservation objectives is real, serious constraints exist. Most importantly, essential soil-enhancing inputs are not readily available. Although farmers seem to understand the value of fertilizer and manure, they do not have access to them at reasonable prices. Fertilizer markets still suffer from the government's intervention of recent decades, while manure markets have not yet developed. The costs of transport in many regions, particularly those with lower labor to land ratios, constrains the dynamic from taking place (Keck et al. 1994). While farmers are well adapted to rice production, there is a constraint on the development and distribution of technologies for other production options. Research and extension directed toward technologies that encourage intensification, at least in regions where valuable flora and fauna resources are being threatened, could be effective tools for protecting those resources. The issues related to land use intensification and land protection are further explored in the next section.

5. THE LAND USE TRANSITION

5.1 The Near-term Need for Intensification and Land Protection

The market transition that will assist in propelling sustainable land management has not yet occurred. At present, land managers continue to extensify. Nevertheless, it appears that the "extensive margin" is rapidly disappearing. Within two decades it is probable that farmers in the majority of local watersheds in the highlands will perceive a land constraint in both the valleys and on the hillsides. In other words, they will have reached the end of the line and will need to turn increasingly to alternative paths to meet growing food and cash crop needs. As land becomes constrained, smallholders will need to:

- intensify the use of valley floors
- intensify use of lower hillsides and, to ensure sustainability
- vest in land protection (terraces, anti-erosion ditches, etc.)

At present it appears to be relatively rare that one finds farmers pursuing the above three measures. The next section presents hypotheses as to why this is so.

5.2 Current Constraints on Land Use Intensification and Protection

We have two sets of hypotheses based on our interviews and literature review. First, apparently many farmers still see extensification onto hillsides and into forests as a viable option—that is, they still feel they are well away from severe land constraints.

Second, most Malagasy farmers are so poor that they are limited in both ability and incentive to intensify land use and make adequate investments in soil and water conservation—to sustainably intensify.

Most Malagasy farmers are:

- poor in cash and credit, limiting their ability to buy fertilizer (which is generally perceived as too expensive) and animals (for meat, milk, and manure), and to hire labor for land improvements. For a discussion of credit availability and use see: Del Castillo (1993) on various systems and sources in the Ranomafana region, Keck et al. (1994) on access to formal credit by the poor; informal credit is most often used for imme-

diate needs such as school fees or ceremonies rather than agricultural investments.

- poor in "time margin," that is, they do not have sufficient savings or income beyond basic needs to pursue strategies that do not provide a quick return to time and investments.

- poor in infrastructure, in that most have to make do with poor roads or no roads, lack of culverts and dams and other public erosion and water control infrastructure, and few receive direct benefits from agricultural extension.

- poor in security, in that there are widespread fears that bandits will steal cattle and produce, that middlemen will wreck roads and/or pay them low prices for their produce, and that they will not have sure and long-term title to their land (Teyssier 1990). Also contributing to insecurity are recent political instability (e.g., roads are cut in protest), and the devaluation of local currency (FMG).

Below we present several strategic and policy measures that appear useful to encourage and enable farmers to adopt, in the next one-to-two decades, land management practices that lead to sustainable intensification of the valley floors and lower hillsides, and that protect the upper hillsides, and relieve pressure on the forests.

5.3 Policy and Strategic Measures to Promote Land Use Intensification and Protection

We start with three general strategic points.

- It is important to *tackle constraints to intensification now rather than waiting until land constraints are such that farmers will take less desirable paths*, including greater impoverishment, more aggressive encroachment into forests, or migration to cities and towns not yet able to offer them sufficient employment.

- It is important to help farmers *avoid pursuing agricultural intensification by merely adding more labor* per hectare of land once land constraints become pervasive a decade from now—this is just "labor-led

intensification" where farmers crop more frequently (with shorter fallow periods), and/or just plant more densely and weed more frequently. This can raise yields temporarily, but soon reaches a plateau and begins to exhaust the soil.

- Instead, it is important to help farmers *pursue a "capital-led intensification" path* to protect and enhance the fertility of the land. This requires: (1) using much more fertilizer and manure, and (2) protecting the land through canal rehabilitation and anti-erosion measures on the slopes. These investments require capacity (knowledge, cash, and labor) and incentives (profitability and security), which policy and development strategy can help promote. Though agricultural profitability can be an important overall incentive to capital-led intensification, we note that specific economic compensation programs designed to relieve pressure on specific protected areas have had mixed results (Ferraro and Kramer 1995).

Specifically, to encourage and enable Malagasy farmers to follow a double path of protecting the land and capital-led intensification of valley floors and lower hillsides, the following suggestions appeared most important to us during our mission.

Improved inputs: It is very important to use improved inputs in the watershed production system. Much more fertilizer and manure on the valley floors and lower hillsides are needed, and bush lines are called for on hillsides. These are "first-best solutions;" trying to promote rural development without putting the fertilizer subsector and livestock/manure development in priority position would be second best, and would not address a critical constraint. Our literature review and conversations with farmers and local institutions repeatedly emphasized the current exorbitant cost of fertilizer and problems of access to fertilizer and manure. It is crucial to tackle these access and cost issues.

Diversification: Crop diversification from both the local watershed and the greater watershed perspectives is important. Farming a second crop in valleys is one way to intensify. The resulting output can be marketed and generate cash income. A good example of this is the growing vegetable "contre saison" subsector in Fianarantsoa, which supply a growing urban and periurban demand (see section 4.1). Farming fruit trees on hillsides helps protect against erosion and is also a cash source, and again is linked to growing urban demand.

Cash Crops and Resource Protection: Farmers tend to produce crops that pay and have a sure market, and many of these crops tend to be products that can help in intensification and land protection (such as with fruit and vegetables, or livestock). Part of this is also that cash cropping also tends to be associated with the incentive and the means (cash income or credit) to use improved inputs, and to protect the land. This is at present just a hypothesis in the Madagascar case, but members of the team have found in case studies in West and East Africa that farmers invest in hillside anti-erosion measures and fertilizer primarily for use on cash crops such as a coffee and cotton, and not on subsistence crops whose returns are low and which not yield cash income (Reardon et al. 1994, 1995). Moreover, as markets for hillside crops grow, the incentive to protect hillsides will grow. We learned from the AID-funded CAP project in Fianarantsoa that this might be the case with cassava in that region; the market for cassava may soon grow due to processing investments.

Non-crop Investments: To relieve pressure on the land, to create markets for and inputs to agriculture, and to alleviate poverty and increase cash available to buy inputs, income diversification into noncrop activities is important—without neglecting agriculture as the base. Examples that appeared particularly promising in our field visits were: (1) livestock husbandry for cash, manure, and eventually export markets, in the Fianarantsoa area; (2) processing/service sector activities in small and medium enterprises, such as vegetable and fruit marketing and processing, cassava flour production, and perhaps canal maintenance; (3) Collecting forest products could be an alternative, but it is not clear to us how important an income generator this could become, at least in the short-medium term.

Infrastructure: Infrastructure is critical for both intensification and land protection, especially from the local and greater watersheds perspective, as well as linking watersheds to growing urban and export markets. Part of the infrastructure needed is community physical and social infrastructure (e.g., local participation in agroforestry projects, canal rehabilitation, marketing cooperatives). *However, community-level infrastructure is necessary but not sufficient.*

Complementary Investments: Complementary public investments are crucial, especially for their role in increasing the incentive and capacity of communities and farmers to make soil and water conservation investments, or to use improved inputs. They also set the economic and physical stage for sustainable intensification. Important examples are roads linking parts of greater watersheds and local watersheds and towns (a subject stressed

repeatedly in the literature and interviews), and water flow and erosion control structures: dams, culverts, forest projects at the tops of watersheds.

Land Security: Land use security needs to be improved. The issues are complex, however. On one hand, from our field visits we found that land security was most demanded where intensification and cash cropping were present. On the other hand, it appears that current titling options are cumbersome and in some cases make farmers feel that it increases their exposure to taxation and regulation. We believe that the importance of resolving this debate will grow rapidly over the next decade and will be crucial to immediate survival strategies and long-term poverty alleviation. The issue is what will work, not what we want people to do. For example, a recent study by Kramer et al. (1994) estimated that as a result of stopping agricultural expansion into a now protected area, adjacent rural populations suffered an *income loss* of approximately US $100 *per household.* This is a significant proportion of the average household's income—almost a 50 percent decline in income over the past two decades. Marginal income alternatives—from employment as park guides, from selling handicrafts (to the still awaited tourist influx), from receiving a percentage of park revenues, from donor projects whose presence local populations may view as ephemeral—may not be seen as sufficient compensation for a major loss of real income from the sources which have, for centuries, been at the center of production strategies and cultural systems.

- *Mental images of rural producers as impoverished subsistence households are misleading.* The majority of rural producers are poor. But it is also true that the vast majority of producers in the highlands are not *subsistence* farmers. Most sell at least a portion of their rice production, and many engage in commercial sale of a more diversified set of crops (including fruits and vegetables). The typical small farmer has had a more prosperous past than present, with sometimes significant past involvement in market transactions. Widespread cash sales create important opportunities for increasing the use of agricultural inputs, and for expanding downstream linkages with growing urban and export markets. In this sense, agribusiness strategies have a vital role to play in catalyzing small holder intensification, and in supporting more sustainable land use relationships within the watershed. Small holders are also commercial producers; thus the focus of agribusiness initiatives can be broadened to positively influence *small farmer* options.

6. PROGRAM IMPLICATIONS

Linkages: Restating the obvious? To some extent, the linkages we have traced may seem obvious to many. Yet, that planners have demonstrated difficulty in dealing with dynamic situations and change leads us to conclude that certain aspects must not be so obvious, at lest not to all key actors. The bulk of program energy is sectoral and it is difficult to design programs and projects which build on linkages. The majority of consultants are sectoral and partisan. Yet results-oriented initiatives (e.g., USAID's "reengineering") are asking for results, not projects.

Resource allocation: What is the right balance? The bottom line in program terms is achieving the right balance for program resource allocation—specifically, equilibrating the environment strategy by substantially increasing the emphasis on rural development and smallholder land management on privately held lands and open-access areas. From the Malagasy government, AID, World Bank, Swiss Cooperation, FAO, UNDP and FED, we found virtually unanimous opinions on this question. All agree that there needs to be a rethinking, as Madagascar enters the second phase of its national environmental action plan (EP2), that asks whether scarce resources are being allocated to the right things.

Program Needs. In Section 5 we discussed the most striking program and policy elements that are needed to emphasize the compatibility between necessary agricultural growth and required natural resource protection, all within the context of rapidly increasing population. We summarize the key needs here:

- Soil and water conservation in agricultural areas, including agroforestry, forage plants, fruit trees on hillsides, and canal rehabilitation on valley floors.

- Capital-led agricultural intensification on the valley floors and lower hillsides—through far greater use of fertilizer and manure and second season crops such as vegetables.

- Corollaries of the cropping intensification program direction are livestock husbandry and dairy programs. This would occur preferably with an emphasis on intensive operations where manure can be most efficiently built up and used and where the products can serve growing

secondary town and capital markets, not to mention eventual increase in exports.

- Complementary public investments—in roads, in dams, in culverts, in hilltop forest projects—to encourage and make affordable private investments by households and communities, and to decrease the cost of doing business.

- Program directions that help smallholders get more cash to use for intensification and conservation investments. These include (1) off-farm microenterprise activities, particularly those related to agriculture or forestry, (2) agribusiness activities in which poor smallholders can get a start, and (3) developing credit institutions and access for poor smallholders.

- "Getting beyond the second best" is crucial. We observed a tendency to accept critical constraints to more sustainable land management (crumbling infrastructure, expensive fertilizer, and so on) as "givens", and to seek second best solutions that do not directly tackle the constraints, such as attempts to bar the rural poor from using open access lands, or community participation and education programs where clear strong economic options are not apparent. It is not that the latter types of actions are not good or needed, but that without "first best" solutions first, that is, tackling the critical constraints, long-term success in the case of the second best solutions will be elusive.

Information and program tools needed for monitoring results in a Nexus framework: As government and donor officials rethink strategies for linking programs and building a greater compatibility among policies to pursue agricultural growth and natural resource protection goals in the context of growing demographic pressure, they will want to develop planning tools and information that reflect these dynamic linkages.

An illustration of such rethinking is USAID's "reinvention" to increase efficiency, coherence of linkage, and development impact of its programs. Such reinvention incorporates "re-engineering" undertaken in a "results framework" that emphasizes starting with target "results" based on one's development hypothesis, and continuing with implementation of "levers" such as programs and policy dialogue, then ending with "impact evaluation".

The paths leading to key results such as poverty alleviation, sustainable intensification of land use, and conservation of land, water, and biodiversity, have been discussed in the present case application. Suggestions have been made as to how to link sectoral programs (such as natural resource management, agribusiness, and marketing) to help poor smallholders move along paths of capital-led intensification and land protection, both for rural development and for conservation of valuable open access lands, which were shown to be mutually dependent goals.

To trace such paths and results we propose the development of a PERT chart that shows important decision and intervention points along the paths, and relates sets of program interventions (across program sectors) needed to influence the intervention points, and traces the expected outcomes of these programs. Such a dynamic, intersectoral perspective could be the basis for more detailed strategic planning matrices generated for successive stages of the long-term pursuit of the results. We perceive the need to fill a number of information gaps about specific programs and impacts and about what drives the behavior of rural households and communities. Addressing these information gaps will set the stage for a deeper analysis of intersectoral linkages and program options.

References

Battistini, Rene and Jean-Michel Hoerner. 1986. *Geographie de Madagascar.* Paris: EDICEF, SEDES.

Berg, E. 1989. "The Liberalization of Rice Marketing in Madagascar." World Development, 17(5).

Bernier, René and Paul A. Dorosh. 1993. *Constraints on Rice Production in Madagascar: The Farmer's Perspective.* Working Paper 34 of the Cornell Food and Nutrition Policy Program.

Clay, D.C. 1995. "Fighting an Uphill Battle: Population Pressure and Declining Land Productivity in Rwanda." In H.K. Schwarzweller and T.A. Lyson (eds.) *Research in Rural Sociology and Development,* Vol. 6. Greenwich, Connecticut: JAI Press, Inc.

Del Castillo, Dennis. 1993. *Final report for the agricultural development component of the Ranomafana National Park Project in Madagascar.* Soil Science Department, North Carolina State University.

Critchley, W. 1991. *Looking after Our Land: Soil and Water Conservation in Dryland Africa.* Oxfam (for the International Institute for Environ-

ment and Development and the Arid Lands Information Network). London.

Dorosh, Paul A., Rene E. Bernier, Alexander H. Sarris. 1990. *Macroeconomic adjustment and the poor: The case of Madagascar*. Cornell Food and Nutrition Policy Program.

Droy, I. 1991. "La rehabilitation des petis perimetres irrigues a Madagascar: une reponse aux importations de riz?" *Cahiers des Sciences Humaines* 27:117-127.

Ferraro, P. J. and Rakotondrajaona B. 1995. "Natural Resource Use in and around the Ranomafana National Park, Southeastern Madagascar." Unpublished working paper.

_____ and Randall A. Kramer. 1995. "Affecting Household-Level Behavior to Promote Rain Forest Conservation in Madagascar." Volumes I and II.

Fukazawa, H. 1989. "Land Use in the Dry Zone of Madagascar." *Southeast Asian Studies* 26(4).

Jolly, Alison. 1989 "The Madagascar Challenge: Human Needs and Fragile Ecosystems." In H. Jeffrey Leonard et al, *Environment and the Poor: Development Strategies for a Common Agenda.* New Brunswick: Transaction Books.

Keck, Andrew, Narendra Sharma and Gershon Feder. 1994. "Population Growth, Shifting Cultivation, and Unsustainable Agricultural Development: A Case Study in Madagascar." World Bank Discussion Paper 234. Washington, DC: The World Bank.

Kramer, Randall, Narendra Sharma, Priya Shyamsundar and Mohan Munasinghe. 1994. "Cost and Compensation Issues in Protecting Tropical Rainforests: Case Study of Madagascar." Environmental Working Paper No. 62.

Larson, Bruce A. 1993. "Changing the Economics of Environmental Degradation in Madagascar: Lessons from the National Environmental Action Plan Process." Unpublished paper written with the support of the EPAT Project.

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. The World Bank, Agriculture and Rural Development Department. Washington, D.C.

Oxby, Clare. 1985. Forest farmers: The transformation of land use and society in eastern Madagascar. *Unasylva* 37(2): 42-51.

Pryor, Frederic L. *The Political Economy of Poverty, Equity and Growth: Mali and Madagascar*. A World Bank Comparative Study. Oxford University Press, Oxford: 1990.

Rauh, Werner. 1979. "Problems of biological conservation in Madagascar." In *Plants and islands*, ed. D. Bramwell, 405-421. London: Academic Press.

Reardon, T., E. Crawford, and V. Kelly. 1995. "Promoting Investment in Sustainable Intensification of African Agriculture." Michigan State University, Department of Agricultural Economics, MSU Staff Paper no. 95-18.

_____, V. Kelly, E. Crawford, K. Savadogo, T. Jayne. 1994. "Raising Farm Productivity in Africa to Sustain Long-Term Food Security." Michigan State University, Department of Agricultural Economics, Staff Paper no. 94-77.

RDM (Republique Democratique Malgache), Ministère de l'Economie et du Plan, Direction Generale de l'Institut National de la Statistique. 1995. "Résultats Provisoires: Echantillon au 1/10è."

Rossi, G. 1979. "L'erosion a Madagascar: l'importance des facteurs humains." *Les Cahiers d'Outre-Mer* 128:355-370.

Stryker, J. Dirck, Jeffrey C. Metzel and Ashley S. Timmer. 1993. "Regional Specialization and Agricultural Led Growth in Madagascar." Volume 1: Final Report. Associates for International Resources and Development.

Sussman, R.W., G.M. Green, and L.K. Sussman. 1994. "Satellite Imagery, Human Ecology, Anthropology, and Deforestation in Madagascar." *Human Ecology* 22 (3) 333-354.

Teyssier, A. 1990. "Apports d'une demarche geographique dans une operation de gestion des espace ruraux." *Les Cahiers de la Recherche Developpement* 26:16-26

World Bank, The. 1995. "Madagascar: Poverty Assessment." Draft. The World Bank, Washington, D.C.