AGRICULTURAL EXTENSIFICATION IN THE WESTERN HIGHLANDS OF KENYA: IMPACTS ON MAIZE PRODUCTION AND ADOPTION OF SOIL FERTILITY ENHANCEMENT PRACTICES

By

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To Christy Gladwin

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LIST OF ABBREVIATIONS

ACT	African Conservation Tillage Network
AFC	Agricultural Finance Corporation
AIDS	acquired immune deficiency syndrome
CARLs	countries with abundant rural labor
DAP	diammonium phosphate, a fertilizer
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Statistical Database
FHH	female-headed household
H	hypothesis
Ha	hectare
HH	household
HIV	human immunodeficiency virus
ICRAF	International Centre for Research in Agroforestry
IEA	Institute of Economic Affairs
IIRR	International Institute of Rural Reconstruction
IMF	International Monetary Fund
KARI	Kenya Agricultural Research Institute
KFA	Kenya Farmers' Association
kg	kilogram
KIT	Royal Dutch Institute for Tropical Agriculture
KWFT	Kenya Women Finance Trust
MHH	male-headed household
MoARD	Ministry of Agriculture and Rural Development
NCPB	National Cereals and Produce Board

OFW	off-farm work
P	P-value
P2O5	phosphorous pentoxide, a fertilizer
PLAR	Participatory Learning and Action Research
Q	quantity
SAPs	structural adjustment programs
SID	Society for International Development
UNAIDS	The Joint United Nations Programme on HIV/AIDS
USAID	United States Agency for International Development
WHO	World Health Organization
X	independent variable
Y	dependent variable

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Soil fertility enhancement is a form of agricultural intensification. Without sufficient returns to agricultural investment, including labor, farmers will not bear its costs. If necessary, farmers will search for alternatives to agriculture. This study set out to identify factors affecting farmers' soil management practices in western Kenya and gauge trends in agricultural productivity. In doing so, the study addressed the following questions. Is agriculture in western Kenya intensifying or extensifying? Does off-farm work lead to an expansion or a contraction of on-farm investments? Does limited resource access lead to labor-intensive, "greener" farming practices? How does gender affect technological choice? Do agricultural extension efforts to disseminate soil fertility enhancing technologies have lasting effects on farming practices? How do factors originating outside the farm—at local and national levels—affect farming decisions?

In order to address these research questions, the study gathered both insiders' and outsiders' accounts of soil fertility management in rural western Kenya in its attempt to view agricultural decisions from the perspective of the farmer while locating those decisions within a broader context. Using ethnographic field methods and applying both

quantitative and qualitative analyses the study tested the interrelation of variables hypothesized to affect farmers' applications of fertilizer, "green manure," and improved fallows as well as farmers' maize production.

The study found that larger landholders in western Kenya, rather than increase the productivity of staple crops, substitute cash crop production for maize and bean production while land-poor farmers, rather than intensify food production, apply their labor towards agricultural wage work or nonfarm work. Thus larger landholders do not invest their wealth in inorganic soil fertility enhancements, such as mineral fertilizers, while smallholders do not invest their labor in organic soil fertility enhancements, such as green fertilizers or improved fallows. On average, farmers substitute land for fertilizer. Meanwhile, soil fertility enhancement and aggregate agricultural productivity remain low in this region, calling into question the efficacy of resource conservation and agricultural development efforts and pointing to a need for alternate food policies if economic structural transformation—the transformation of an agrarian economy to a diversified economy—is to take place in Kenya.

CHAPTER 1
INTRODUCTION: THE ROOTS OF EXTENSIVE AGRICULTURE

In 1985, Piers Blaikie wrote that soil erosion is not purely an environmental issue; it is also a political-economic issue. Individuals, not environmental forces, accelerate and intensify soil erosion through practices that are influenced by the local, national, and global structure of society. The deeper causes and wider consequences of soil erosion are located within a broad context. In turn, not only the environment, but human populations as well, are adversely affected by soil erosion. Blaikie and Brookfield (1987:1) suggested that land degradation, by definition, is a social problem insomuch as "'degradation' implies social criteria which relate land to its actual or possible uses." Thus, to understand the factors that affect soil degradation, one must inevitably examine the factors that impact human behavior. Often, this involves investigating the political ecology of farming decisions.

A political ecology perspective takes into account both political-economic and human-ecological analyses when addressing natural resource management (Stonich 1993). It examines the distribution and use of natural resources and "the interacting roles that social institutions (international, national, regional, and local) play in providing constraints and possibilities that affect human decisions that in turn affect those institutions as well as the natural environment" (Stonich 1993:25). Because soil degradation is often linked to agricultural practices, a political ecology approach to the study of soil management entails researching the opportunities and constraints faced by farmers. This requires looking at the social factors shaping farming decisions, as well as the economic and political policies at the local, national, and international levels that set the stage for these trends. Human resources and physical infrastructure also impinge upon farming decisions and indirectly affect soil management.

The importance of a political ecology approach is that location-specific solutions to soil degradation do not work if broader location-non-specific political and socioeconomic factors are not taken into consideration (Stonich 1993; Blaikie and Brookfield 1987; Blaikie 1985). For example, research indicates that even when agricultural development and extension programs widely disseminate soil conservation technologies to farmers, macroeconomic disincentives to agricultural intensification essentially nullify those efforts (Morera and Gladwin 2006; Morera 1999). Similarly, the present study will illustrate that extensive research, development, and dissemination of various soil fertility enhancement technologies in western Kenya have been a failure because soil infertility is not the sole factor limiting increased agricultural production. Many farmers cannot afford even the labor costs of ameliorating soil infertility through organic methods and low maize prices render unfeasible the rising costs of inorganic fertilizer. Without incentives for agricultural intensification, soil fertility enhancement technologies are for naught because farmers rather plant extensively with minimum application of inputs, including soil fertility enhancement practices.

Ironically, it has been suggested that soil fertility depletion is the chief cause of declining per capita food production in Africa (Sanchez et al. 1997). That is, even when other conditions such as seed production, research and extension services, and enabling government policies are remedied, agricultural productivity continues to decrease unless soil fertility depletion is addressed (Sanchez et al. 1997:3). However, the present study will indicate that soil fertility is just one of several causes of declining per capita food production in Kenya. Even when soil fertility is addressed, as it has been in areas where agricultural extension projects have temporarily achieved farmers' adoption of soil fertility enhancement practices, a disabling policy environment will effectively discourage ongoing increased agricultural production. Because soil fertility enhancement is a form of agricultural intensification, without sufficient returns to agricultural investment—including labor—farmers will not bear its costs. If necessary, farmers will search for alternatives to agriculture.

This study explores the context of soil management in Kenya. It addresses the reasons why farmers in Kenya have incentives to degrade their soils. Perhaps more importantly, the study also addresses the reasons why agricultural productivity in Kenya remains stagnant. Together, these issues contribute to the country's ongoing poverty.

The impetus for the study was ignited by a host of publications in which a strong case was made for the replenishment of soil nutrient deficiencies across Africa through the application of improved fallow and biomass transfer systems (Place et al. 2001; Franzel et al. 2000; Pisanelli et al. 2000; Sanchez 1999; Kwesiga et al. 1999; Swinkels et al. 1997; Buresh et al. 1997). Improved fallow systems were built on African farming techniques by improving traditional fallows with fast growing tree or shrub legume species, such as *Sesbania sesban, Crotalaria grahamiana,* and *Tephrosia vogelii*, which fix nitrogen from the air and return it to the soil. Biomass transfer systems were also built on African farming by utilizing hedges around homesteads and traditional live fences of common species such as *Tithonia diversifolia* and *Lantana camara*, for green manure. Together, these systems could provide smallholders with labor-intensive "green," organic soil fertility enhancing alternatives to cash-expensive industrial, inorganic fertilizers. The technologies were extensively researched and disseminated in western Kenya during the 1990s by the International Centre for Research in Agroforestry (ICRAF).

The results and publications of ICRAF'S work in western Kenya during the 1990s with improved fallow and biomass transfer systems were compelling. Nonetheless, my own work in Honduras in 1997 (Morera 1999) led me to conclude that economic constraints, particularly resulting from structural adjustment programs (SAPs), inhibit smallholders from investing in labor-intensive, fertility enhancing technologies—despite their proven capacity to ameliorate soil degradation and raise maize yields. Moreover, economic trends in Kenya indicated that the production growth of maize remained lower than population growth, rendering maize an importable commodity even after liberalization from 1992 onward (FAOSTAT 2004). With all of this in mind and amidst a growing concern surrounding Africa's relatively low consumption of inorganic fertilizer and correspondingly low agricultural productivity, I embarked on my own investigation of farming patterns among smallholders in western Kenya.

Thus the present study set out to identify factors affecting farmers' soil fertility management practices in western Kenya and to gauge trends in agricultural productivity. In doing so, the study addressed the following guiding questions: 1) Is agriculture in western Kenya intensifying or extensifying? 2) Does off-farm work lead to an expansion or a contraction of on-farm investments? 3) Does limited resource access, particularly to land and cash, lead to labor-intensive, "greener" farming practices? 4) How does gender affect technological choice? 5) Do research and development efforts to disseminate soil fertility enhancing technologies have lasting effects on farming practices? 6) How do factors originating outside the farm—at both the community and national levels—affect farming decisions?

In order to address these research questions, the study gathered both *emic* (insiders') and *etic* (outsiders') accounts of soil fertility management in rural western Kenya in its attempt to view agricultural decisions from the perspective of the farmer while locating those decisions within a general context. Using ethnographic field methods and applying both quantitative and qualitative analyses the study tested six hypotheses:

- **H1:** Farmers in western Kenya are intensifying agricultural production by increasing the availability of soil nutrients to their staple crops, thus increasing crop yields per area.
- **H2:** Nonfarm income generation leads to increased on-farm agricultural investments while agricultural off-farm income generation leads to decreased on-farm agricultural investments.
- **H3:** The wealthier a household, the more it invests in agricultural productivity.
- **H4:** There is no difference between male-headed and female-headed household investment in one or more of the following: kg/acre of green manure, square meters/acre of improved fallows, kg/acre of mineral fertilizer, days/acre of hired oxen, days/acre of hired labor, and/or kg/acre maize and bean seed.
- **H5:** There is no difference in soil fertility enhancement practices among farmers living in nearby villages where labor-intensive soil fertility enhancement technologies have been disseminated in some villages and not in others.
- **H6:** If the international price of oil rises and driving time between eastern and western Kenya increases, the price of imported inputs (i.e. fertilizer) will rise faster than the price of outputs (i.e. maize) and farmers will not invest in the intensification of their maize production through the application of fertilizer.

In the chapters ahead the results of the study will largely support all but the first hypothesis and indicate that in western Kenya, land-poor farmers, rather than intensify production, apply their labor towards agricultural wage work or nonfarm work while larger landholders, rather than increase agricultural productivity, substitute kale production for maize and bean production. Thus smallholders do not invest their labor in organic fertilizers or improved fallows while larger landholders do not invest their wealth in inorganic fertilizers. On average, farmers substitute land for fertilizer. Meanwhile, soil fertility enhancement as well as aggregate agricultural productivity remains low in this region of western Kenya, calling into question the efficacy of resource conservation and agricultural development efforts and pointing to a need for alternate food policies if economic structural transformation—the transformation of an agrarian economy into an industrial economy--is to take place in Kenya.

Chapter 2 sets the stage of the study by synthesizing and analyzing the literature on agricultural productivity and soil fertility management. The chapter illustrates that without incentives for agricultural intensification, soil fertility enhancement technologies are for naught because farmers rather plant extensively with minimum application of inputs, including soil fertility enhancement practices. It argues that if food prices fail to rise, marginal producers will not invest in the increased costs of intensification—which, essentially are the costs associated with fertility enhancement. Instead, they will cultivate until they degrade the land and must abandon the area or abandon agriculture.

Chapter 3 explores the region of western Kenya, noting the characteristics of the land, customs of its people, and nature of the various institutions and projects engaging it. By weaving primary data collected through participant-observation together with secondary data collected from published materials, the chapter presents a current, as well as historical, view of the ecological and socioeconomic features characterizing the study's research setting. In doing so, the chapter provides a context in which the theoretical framework, research methods, and empirical results of this study can be understood.

Chapter 4 discusses the motivations, assumptions, objectives, hypotheses, ethnographic techniques, and analytical tools involved in carrying out the empirical work of this study. Using ethnographic field methods and combining both quantitative and qualitative analyses, the study examines the nature of soil fertility management in western Kenya, investigating its role in agricultural productivity and exploring how it is affected by technological adoption, gender, off-farm work, and other off-farm factors. The study seeks to establish whether past institutional efforts to disseminate improved fallows and biomass transfer had lasting effects on the region's farming systems and whether off-farm work and gender affect soil fertility enhancement practices and, in turn, agricultural intensification.

Chapter 5 presents the results of quantitative and qualitative analyses of ethnographic data collected from 120 households located throughout the villages of *Mutsulio*, *Shikusi*, *Lugango*, and *Shinakotsi* in western Kenya. In doing so, the chapter addresses the six research questions and hypotheses raised at the launch of the study concerning agricultural productivity, soil fertility management, technological adoption, and the role of gender, off-farm work, and other off-farm factors on these. It provides the evidence that is used in Chapter 6 to reject the first hypothesis while supporting the rest.

Chapter 6 discusses the five major findings of the research study and examines their implications. Because results indicate that farmers in this part of western Kenya are producing maize and beans extensively through the application of inadequate amounts of soil fertility enhancement measures, the study concludes that farmers are degrading their lands and failing to increase the agricultural productivity of their staple crops. The study also concludes that no amount of agricultural extension can achieve long-term farmer adoption of soil fertility enhancement practices when macro policies provide disincentives to agricultural intensification. However, the consequence of staple crop extensification is low aggregate agricultural productivity and delayed economic development. Because raising aggregate agricultural productivity remains the most important development strategy for agrarian economies, increased efforts to intensify staple crop production will be necessary if structural transformation of Kenya’s economy is to be achieved.

CHAPTER 2
THEORETICAL FRAMEWORK: KENYAN SOIL FERTILITY MANAGEMENT IN CONTEXT

Introduction

This chapter explores the context of soil management in Kenya. Incorporating a political ecology analytical framework, it examines the interrelated processes at local, national, and international levels that contribute to soil fertility depletion, identifying the reasons why farmers in Kenya have incentives to degrade their soils. The chapter discusses the effects of soil degradation on agricultural productivity, explains the importance of agricultural productivity to economic development, and reviews key factors that affect agricultural land management and production. In addressing the obstacles to soil fertility replenishment and agricultural intensification in Kenya, the chapter also addresses the issues that contribute to the country's ongoing poverty.

Effects of Soil Degradation on Agricultural Productivity

Soil quality directly affects crop yields by limiting the amount of moisture and nutrients plants can derive from the soil. Soils are composed of inorganic particles, organic matter, air, and water. The inorganic particles comprise larger mineral fragments which are imbedded in finer colloidal materials (Brady 1974:40). The ratio between the larger and finer materials determines whether the soil is gravelly or sandy, or whether it is clayey (40). This relative proportion of particle sizes is known as soil texture and cannot be altered. "Thus, a sandy soil remains sandy and clay soil remains a clay" (40). On the other hand, soil structure refers to the arrangement of particles into aggregates and can be altered by farm practices such as tillage, cultivation, liming, and manuring (40). Organic matter—"the accumulation of partially decayed plant and animal residues"—also affects the structure of a soil and 'is a major source of phosphorous and sulfur and essentially the sole source of nitrogen" (14). Organic matter, soil structure, and soil texture all affect the pore space which is occupied by air and water.

Soils degrade in a variety of ways, either by soil particle movement or soil nutrient depletion (Eionet). Natural degradation results from wind, river, and sheet erosion as well as landslides and nutrient leaching (IIRR and ACT 2005). Human-induced degradation accelerates these natural processes through human activities. For example, tillage disturbs soil structure and increases the likelihood of nutrient leaching (IIRR and ACT 2005). Hillside farming increases the likelihood of landslides and runoff, speeding up erosion. Continuous cultivation depletes the soil of its nutrients.

In western Kenya, human-induced soil degradation usually results from continuous manual agricultural cultivation on small farms in two ways. First, whether land is tilled with a hoe by hand or with a plow by oxen, vegetation and crop residues are turned into the soil (or they are burned or used for fodder), accelerating the decomposition of organic matter. Because organic matter helps soils retain water, nutrients, and organisms, the elimination of organic matter hastens water evaporation, leaching, erosion, weed and pest infestation, and the destruction of soil structure (IIRR and ACT 2005). Moreover, hoeing and plowing both result in soil compaction and also destroy soil structure (IIRR and ACT 2005).

Second, continuous cultivation mines the soil of nutrients. While nutrient depletion is location-specific and depletion rates vary with soil properties (Sanchez et al. 1997), monocropping robs the soil of the same nutrients year after year, resulting in specific deficiencies. Throughout western Kenya, where the majority of smallholders mostly cultivate maize and beans, soils are particularly deficient in nitrogen, phosphorous, and potassium. According to Sanchez et al. (1997:27) "about 80% of farms in Vihiga, Siaya, Busia, and Kisumu Districts are severely deficient in P (<5 mg bicarbonate-extractable P kg^{-1} soil), and most are deficient in N when P deficiency is overcome." Because cereal production is particularly constrained by nitrogen and phosphorous deficiencies, maize yields can drop by more than 30% over a 20-year period without nitrogen and phosphorous inputs (Sanchez et al. 1997; Qureshi 1991).

In the past, traditional farming throughout this region normally included land fallowing. However, land is commonly transferred through inheritance resulting in shrinking farms and decreased fallows over time. Moreover, a rising population growth rate resulting in 500-1200 people per kilometer throughout the highlands of western Kenya (Sanchez et al. 1997) has resulted in even smaller landholdings, often making it difficult to take land out of cultivation altogether.

Thus, crop yields cannot be sustained without adequate soil fertility replenishment, which entails "returning to the soil the nutrients removed by harvests, runoff, erosion, [and] leaching" (Sanchez et al. 1997:10; Aune 1993). This requires nutrient inputs from outside a farm. If the inputs come from cattle manure or "green manure" raised on the farm, it is merely nutrient cycling and not replenishment (Sanchez et al. 1997).

Mineral fertilizers provide the highest concentration of nutrients on a dry weight basis. They can be easily transported to and dispersed throughout the field. Yet mineral fertilizers are commonly at least twice their international price throughout rural Africa (Sanchez et al. 1997). Poor infrastructure increases transport costs, as do taxes and import duties.

Over the last decade, a variety of organic input options have been researched and developed, providing farmers with alternatives to mineral fertilizers. Yet their nutrient concentration is far lower than mineral fertilizers on a dry weight basis. This means that very large quantities of organic fertilizers are necessary to provide adequate nutrient replenishment and they can be difficult to transport to and disperse throughout the field.

Improved fallow systems are another option that has been extensively researched and disseminated. Fast growing species of leguminous trees and shrubs, such as *Sesbania sesban*, *Crotalaria grahamiana*, and *Tephrosia vogelii*, have been tested for smallholders as a substitute for nitrogen fertilizers (Amadalo et al. 1998). Because the legumes fix nitrogen from the air and transport it to the soil through its roots, they provide farms with an external, not recycled, source of nitrogen. Improved fallows involve planting the fast-growing shrub or tree species into cropland that is fallowed for at least nine months, including two rainy seasons. The selected species enhance soil fertility by either bringing up nutrients from deeper soil levels and/or by fixing atmospheric nitrogen (Amadalo et al. 1998).

Nonetheless, Quiñones et al. (1997) of the Sasakawa Global 2000 Project maintain that mineral fertilizer use will remain pivotal to increased productivity across Africa while low input technologies, such as organic fertilizers and improved fallows, can only be supplemental. Organic fertilizers, they argue, can increase food production by 2% at best (Quiñones 1997:83; Hayami and Ruttan 1985). Yet agricultural productivity in Africa needs to increase by 5-6% annually in order to exceed its population rate of 3% and assure food security (Quiñones 1997:83).

Data collected in this study show that small-scale farmers in western Kenya are investing in neither mineral fertilizers nor replenishment alternatives to mineral fertilizers. They plant a minimum amount of maize seed over a broad area and apply only minimal quantities of mineral fertilizer. Essentially, they are substituting land for fertilizer and practicing extensive agriculture.

Extensive agriculture can be understood as a food supply system in which a minimum amount of crop is harvested per unit of land, or in which a minimum amount of labor and capital is invested per unit of crop produced. According to Boserup (1981:18), at its least intensive, a food supply system may simply comprise an area used only for gathering. An area planted with one or two successive crops followed by a 15-25 year fallow would represent a more intensive form of land use. If the fallow was shortened to 5 years, the area would then represent a still more intensive form of land use.

The emphasis of Boserup's perspective is on "the frequency with which the land is cropped" (2005:13). Boserup (2005:12) contrasts her perspective with the classical economic conception of agricultural expansion whereby agricultural output is raised in two different ways: "the expansion of production at the so-called extensive margin, by the creation of new fields, and the expansion of production by more intensive cultivation of existing fields." Boserup (2005:12) argues that the classical economic conception of agricultural expansion, which inherently distinguishes between cultivated and uncultivated land, is oversimplified and outmoded because "the classical economists were writing at a time when the almost empty lands of the Western Hemisphere were gradually taken under cultivation by European settlers, and it was therefore natural that they should stress the importance of the reserves of virgin land and make a sharp distinction between two different ways to raise agricultural output." However, the special conditions for agriculture in the Western Hemisphere in preceding centuries cannot be applied to the current conditions for agriculture in developing countries where there is no clear distinction "between the creation of new fields and the change of methods in existing fields" (Boserup 2005:13).

Thus Boserup dismisses from her definition of agricultural growth the classical economic implication that production can be expanded at the so-called extensive margin. In doing so, Boserup redefines the term "extensive agriculture" as an antonym of "intensive agriculture" whereby the latter refers to a food system of greater yields per area of land and time and the latter refers to a food system of lesser yields per area of land and time. That is, extensive agriculture no longer refers to a method of increasing agricultural production. More recently, extensive agriculture, or *extensification*, has been defined as a less intensive use of farming that, using fewer chemical fertilizers and leaving uncultivated areas at the edges of fields, allows lower yields from the same area of farmland (AgricultureDictionary.com).

According to Netting (1993:28), the key characteristic of intensive agriculture is the manipulation of nutrients, water, and sunlight for increased supplies that support more biotic growth for longer periods of time. Naturally, this involves replenishing elements that become exhausted. It is a means of coping with limited space and time (Netting 1993:102). Nonetheless, Boserup (1981:15), and later Netting (1993:56), were careful to distinguish between intensive/extensive and traditional/modern. That is, a very traditional food supply system involving the simplest of tools can be highly intensive while a very modern system involving highly sophisticated technology, such as tractors and combine harvesters, can be extensive and even wasteful (Netting 1993:56). Moreover, lumping together an intensive short-fallow system and an extensive long-fallow system under the category of “traditional agriculture” overlooks the relationship between demographic conditions and methods of food supply (Boserup 1981:15).

According to Boserup (1981), extensive agriculture is a feature of food supply systems characterized by abundant land and/or sparse population. However, western Kenya has neither abundant land nor sparse population. Instead, western Kenya is characterized by one of the highest population densities in the world, a shrinking land supply, and annual cropping/multi-cropping. Naturally, it is now also characterized by declining fertility. Yet curiously, it remains uncharacterized by the use of fertility enhancement technologies.

Nonetheless, Boserup (1981:26) believed the problem of soil fertility would be dealt with by “(1) fallowing, as in sparsely populated countries; (2) industrial inputs, as in high-technology countries; and (3) labor-intensive practices, as in densely populated countries at low technological levels.” This line of reasoning is also found in Hayami and Ruttan’s (1970) theory of “induced innovation” which holds that technical change is “induced by shifts in relative factor prices or by the changes in resource endowments and income distribution that are associated with economic growth (Binswanger et al. 1978:3; Hayami and Ruttan 1970). In the case of western Kenya, it follows that a shrinking land base resulting from population pressure, and declining yields resulting from continuous cultivation, should motivate a technological shift in agriculture towards either labor-intensive fertility enhancement practices (e.g. organic fertilizers and improved fallows) or mineral fertilizer use. Yet Blaikie and Brookfield term this line of reasoning “optimistic.” Instead, they argue that land degradation occurs in a wide variety of social and ecological circumstances and arises even in cases of decreased population densities (Blaikie and Brookfield 1987:4).

In turn, the issue of extensification in western Kenya not only calls into question the applicability of the theory of induced innovation, but also calls into question the efficacy of the Green Revolution. While Norman Borlaug firmly maintains that increased agricultural productivity in Africa cannot be achieved without mineral fertilizers (Thurow and Kilman 2009; Quiñones et al. 1997), it remains unclear how this will take place. Africa has the lowest rates of use in the world (Morris et al. 2007; Crawford et al. 2006; FAOSTAT). In 2002, fertilizer use in sub-Saharan Africa averaged 8 kg/ha compared to 78 kg/ha in Latin America, 101 kg/ha in South Asia, and 96 kg/ha in East and Southeast Asia (Morris et al. 2007:17; FAOSTAT). Africa’s low fertilizer consumption is attributed to its weak bargaining position as a low volume importer and to the high cost of transportation resulting from poor infrastructure (Quiñones et al. 1997). Moreover, the Green Revolution itself has been criticized for its inability to benefit smallholders (Shiva 1991).

Nonetheless, from 1962 to 1982, fertilizer use in sub-Saharan Africa grew at the relatively same rate it did in both Latin America and East and Southeast Asia[1] (Morris et al. 2007:17). Only after 1982 did fertilizer use in sub-Saharan Africa plummet (Morris et al. 2007). Gladwin (1991:197) argues that SAP-mandated fertilizer subsidy-removal programs implemented throughout sub-Saharan Africa during the 1980s resulted in

[1] Fertilizer use grew annually at 8.71% in sub-Saharan Africa, 7.70% in Latin America, 7.64% in East and Southeast Asia, and 13.19% in South Asia during 1962-1982; however from 1982 to 2002, it grew at 0.93% in sub-Saharan Africa, 3.06% in Latin America, 3.39% in East and Southeast Asia, and 4.99% in South Asia (Morris et al. 2007: 17; FAOSTAT).

decreased fertilizer use because smallholders, unable to overcome cash-constraints and access credit markets, could not afford fertilizer at higher prices. However, Minot (2009) points out that fertilizer subsidy removal programs in sub-Saharan Africa had mixed results during the 5-year period following subsidy removal: fertilizer use decreased in some countries (Nigeria, Ghana, Cameroon, Senegal, and Tanzania) and increased in others (Benin, Togo, Mali, and Madagascar). In Kenya, where fertilizer distribution was more market-based than in other sub-Saharan countries, fertilizer consumption continued to increase despite liberalization in the early 1990s (Minot 2009; Crawford et al. 2006). Minde et al. (2008:18) report that small-scale farmers across western Kenya are currently using fertilizer on maize at dose rates of roughly 163 kg/ha annually, comparable to fertilizer use throughout Latin America and Asia. Yet data collected in this study indicate that small-scale farmers across 4 villages in western Kenya applied fertilizer on maize during the long-rains season of 2007 at an average rate of 69 kg/ha. It is unlikely that their annual average dose rate approaches the amount reported by Minde et al. (2008).

Despite the controversy, policy makers have recently reconsidered fertilizer subsidies. Minot (2009) attributes the renewed interest to four factors: 1) Jeffrey Sachs (2005) recommends localized, temporary fertilizer subsidies as a way to jumpstart small-scale agricultural production, particularly in villages where disease and hunger make it difficult for producers to climb out of a poverty trap. 2) In Malawi, where fertilizer markets were never fully liberalized, its Agricultural Input Subsidy Programme is credited with making the country an exporter of maize in 2005. 3) In 2006, the case in favor of fertilizer subsidies was brought up during the Africa Fertilizer Summit held in

Abuja, Nigeria (Morris et al. 2007). 4) In 2008, the upward spike in oil, fertilizer, and food prices focused attention on food production.

Nonetheless, Blaikie and Brookfield argue that the remedies for land degradation "are not found simply in compelling or persuading the immediate land managers to mend their ways" (1987:xix), and scientists "frequently make assumptions about the way in which a society operates and changes in discussing the causes and implications of land degradation" (1987:xx). Arthur Lewis (1954:23), similarly, argued that "cultural inheritance" may affect agricultural productivity. Ultimately, however, there may simply be more profitable alternatives to intensive small-scale farming on degraded land.

According to Ricardo's (1951) theory of rent, when population pressure forces agriculture to move onto marginal land, the price of food must rise to cover the increased costs of production, resulting in an unearned income for labor inputs on land of better quality. This unearned income is termed "rent," and the people who benefit from the unearned income are said to engage in "rent-seeking behavior." A similar process applies to degraded land which, of course, has become marginal land. It has a lower productivity potential that must be addressed with higher labor and/or capital inputs than superior land. Blaikie and Brookfield (1987:1) argue that "land degradation, therefore, directly consumes the product of labour, and also consumes capital inputs into production; other things being equal, the product of work on degraded land is less than that on the same land without degradation."

Arguably, if food prices fail to rise, marginal producers will not invest in these increased costs—which, essentially, are the costs associated with fertility enhancement. Instead, they will cultivate until they degrade the land and must abandon the area or abandon agriculture. Boserup (1981) suggests that without agricultural intensification, densely populated areas must rely on imported food. And that is what is occurring in many African countries where the price of imported maize is lower than the price small-scale farmers can fetch for their marginally-produced maize. Farmers are degrading their land and finding alternatives to farming. Meanwhile, aggregate agricultural productivity remains low.

Consequences of Low Agricultural Productivity

At the household level, low agricultural productivity can translate into higher levels of malnutrition and illness, lower levels of education and health care, and increased urban migration to slum areas already teeming with people and disease. Without a surplus to sell, subsistence farmers have few opportunities for generating the cash needed to pay for additional foodstuffs, agricultural investments, medications, and school fees. Low agricultural productivity renders individuals food insecure and vulnerable (Roberts 2008). Their margin of survival is smaller than that of surplus producers during periods of crisis brought on by drought, war, and pandemics (Tomich et al. 1995; Blaikie and Brookfield 1987:2).

Moreover, the importance of agricultural productivity extends beyond the farm. At the national level, low aggregate agricultural productivity leads to reduced agricultural exports and also leads to a demand for food that requires food imports. Decreasing exports and increasing imports both lead to reductions in foreign exchange and compound the fiscal crises most sub-Saharan countries are already grappling with (Ayittey 2005).

While some economists argue that food imports, *per se*, are not detrimental (Timmer et al. 1990:272), they require already scarce foreign exchange. Multiplying this effect, the opportunity to earn foreign exchange through the sale of surplus food is lost. Again, some economists argue that this is not problematic (Thomson and Metz 1997:22). The theory of comparative advantage, first proposed by David Ricardo, suggests that countries fare better economically by specializing in the commodities they produce best while trading freely for those commodities produced more efficiently in other countries (Roberts 2008:115; Thomson and Metz 1997:22). Yet Lewis (1954) notes that many developing countries have been wrongly advised to allow their fledgling industries to be destroyed by cheap imports because the law of comparative costs is only valid if written in marginal, and not average, terms. That is, one day's labor may produce 3 units of food in a more developed country and 1 unit of food in a less developed country. Yet higher wages in the more developed country will render food production more "expensive" while subsistence wages in the less developed country, where labor is abundant in the subsistence sector, makes it "cheaper" to specialize in food production (Lewis 1954).

Another problem with the application of the theory of comparative advantage is that the majority of farmers in Kenya, for example, know best how to grow maize—a commodity that is under-priced in the international market as a result of subsidies originating in the United States, European Union, and Japan. For instance, in 2005 American taxpayers covered the difference between the $1.85 per-bushel world market price of corn and the $3 per-bushel it cost the United States to grow it —"which, of course, only rewarded [American] farmers for overproducing in the first place" (Roberts 2008:121; Hanrahan et al. 2006). The low international price of maize acts as a disincentive for maize production in countries where IMF and World Bank lending have restricted governments from providing their farmers those same subsidies. On the other hand, growing alternate crops is problematic in developing countries where agricultural extension, infrastructure, and market-demand are limited.

For example, in implementing structural adjustment programs (SAPs) during the 1980s, most of Central America followed the agricultural development advice provided by the United States Agency for International Development (USAID) which included financial support for the development of new non-traditional agricultural commodities, such as broccoli, melons, and flowers (Stonich 1993). Although Central America's producers had no experience farming these cash crops nor was there any prior infrastructure support for their development, USAID provided the funds for their promotion in order to facilitate an increase in agricultural exports throughout the region. Yet the true impetus behind USAID's avid promotion of new non-traditional crops throughout Central America lay in the U.S. Bumpers Amendment to the Foreign Assistance Act of 1961 which prohibits USAID from promoting abroad the development of a crop for export that competes with a similar crop grown in the United States (Farnsworth et al. 1996). Because maize is Central America's subsistence crop, assistance to its producers would have naturally benefited the greatest portion of the rural sector. However, USAID could not promote basic grain production for export in Central America because the United States itself is a major basic grain producer.

The resulting regional emphasis on new non-traditional cash crops replaced support for basic grain production despite its inability to benefit the majority of Central America's rural population. Small-scale producers were unable to substitute basic grains with cash crops because the international market places great emphasis on quality-control—a requirement that is difficult for small-scale producers to meet (Farnsworth et al. 1996). Additionally, the infrastructure was limited and the market for the new crops inadequate and unstable. Once produced, many farmers had trouble both transporting the crops to market and selling them.

Thus, it is doubtful that basic grain producing populations in developing countries will easily switch to cash crops—particularly those not consumed domestically—or increase basic grain productivity in the face of low international prices enabled by subsidies in developed countries. Indeed, agricultural growth over the last half-century has been slowest in Africa (Anderson and Masters 2009:5) where most of the world's predominantly agricultural countries are located. In Kenya, agriculture grew at a rate of 2.3% annually from 1980 to 2004 (Anderson and Masters 2009:9)—yet its total population grew at an average rate of over 3% annually during the same period (Winter-Nelson and Argwings-Kodhek 2009:257). Thus food-production growth rates did not keep up with population growth rates.

Clearly, increased agricultural productivity remains essential to development. Tomich et al. (1995) argue that developing countries must develop their subsistence sectors in order to industrialize. In order to reach the structural transformation turning point, the point "when the absolute size of the agricultural work force begins to decline," developing countries must increase low agricultural labor productivity (output per farm worker) while simultaneously absorbing a significant proportion (4-6%) of the total labor force into the non-agricultural sector (Tomich et al. 1995:9).

Tomich et al. (1995:2) illustrate this point by explaining that countries with abundant rural labor (CARLs) have a large agricultural sector, where more than 50% of the total population is employed, and a small non-agricultural, industrial sector. For example, agriculture's share in employment from 2000-2004 in Kenya was 75%. This means that the industrial capitalist sector is small and the potential for profits, savings, and investment, which lead to capital increase, is also small (Lewis 1951:12). In turn, the potential for the industrial sector's absorption of the rural labor force is limited. Tomich et al. (1995:14) clarify this by indicating that the rate of growth in the nonagricultural work force is mediated by agriculture's initial share of the total labor force and by the rate of growth in the total labor force. Thus the key point is that the rate of growth in the nonagricultural workforce can be stagnant for decades if most of the total labor force is predominantly in agriculture and population rates are high. To overcome these constraints, agricultural productivity must rise for a country to transform its predominantly rural economy to a predominantly industrial economy[2]. This also explains why the structural and demographic characteristics of a developing country constrain its development options (Tomich et al. 1995:2).

Tomich et al. (1995) suggest that the key to encouraging this shift is investment in agriculture and agricultural specialization. Bates (1981) also argues that the key to development lies in providing proper incentives for farming. Similarly, Arthur Lewis (1954) notes industrialization is dependent on agricultural improvement. He argues that

> it is not profitable to produce a growing volume of manufactures unless agricultural production is growing simultaneously. This is also why industrial and agrarian revolutions always go together, and why economies in which agriculture is stagnant do not show industrial development.

[2] Tomich et al. (1995:14) express the *timing* of the structural transformation point with the identity $L'_a \equiv (L'_t - L'_a)\, 1/(L_a/L_t) + L'_n$, where L'_a represents the rate of growth in the agricultural labor force, L'_t represents the rate of growth in the total labor force, L'_n represents the rate of growth in the nonagricultural work, and L_a/L_t represents agriculture's initial share of the total labor force.

> Hence, if we postulate that the capitalist sector is not producing food, we must either postulate that the subsistence sector is increasing its output, or else conclude that the expansion of the capitalist sector will be brought to an end through adverse terms of trade eating into profits. [Lewis 1954:20]

In sum, the consequence of low aggregate agricultural productivity in developing countries is delayed development.

Other Factors Affecting Agricultural Productivity

Therefore, aggregate agricultural productivity is the most important factor affecting development while soil fertility is but one of the many factors affecting agricultural productivity. Yet ultimately, both agricultural production and soil fertility management are determined by price signals. In turn, price signals are affected by macroeconomic policies, trade and export production policies, investment in agricultural research and extension, infrastructure, and banking. Timmer et al. (1990:215) point out that "an unfavorable macroeconomic environment will ultimately erode even the best plans for consumption, production, or marketing." This is why a political ecology perspective encompassing the "interactive effects of these complex relationships" (Blaikie and Brookfield 1987:17) is indispensable in understanding trends in agricultural land management and production.

Macroeconomic Policies

Neo-liberal economic theory holds that government policy alterations of the so-called "macro prices"–wage rates, interest rates, land rental rates, foreign exchange rates, and rural-urban terms of trade—can result in distorted prices that fail to signal the actual abundance (or scarcity) of domestic factors of production to farmers (Timmer et al. 1990). Particularly during the 1960s and 1970s, governments in developing countries often tampered with these "macro prices" in ways that favored urban consumption at the expense of rural production. For example, governments adjusted foreign exchange rates because overvalued domestic currencies resulted in cheaper imports, needed or desired in urban sectors, even if they taxed the agricultural sector by bringing down the domestic price of food. Similarly, they subsidized the development of the industrial sector at the expense of the agricultural sector by providing inadequate prices (below the international value) to growers for their commodities in order to finance the formation of domestic manufacturing firms (Bates 1981).

Normally, an expansion of the industrial sector increases the demand for food and, in turn, the price of food (Lewis 1954:20). Yet urban employees, averse to relinquishing their wages to high-cost food, and industrial firms, averse to raising wages, both pressure governments politically in order to maintain food prices low (Bates 1981:30). Unfortunately, “cheap food, cheap labor” policies tend to lead to agricultural production disincentives that in the long run also retard the industrial sector because the industrial sector is never stimulated by the internal demand of the large subsistence sector (de Janvry 1981). They retard the backward and forward linkages between the subsistence and industrial sectors which are key to industrial expansion and are facilitated with proper incentives for farming and agricultural specialization.

Export Strategies

International trade provides a critical outlet for abundant resources that can be traded for scarce resources. Moreover, exports are the most important source of foreign exchange for any country and integral to its balance of payments. Yet developing countries are often advised to adopt export strategies that do not necessarily support their internal productive and consumptive capacities. Such was the case in Central America when USAID promoted new non-traditional exports that were difficult to produce and to market and had no consumptive value for most of the population. De Janvry (1981) notes that when key sectors only produce export or luxury goods that are not consumed by workers, production and consumption capacities are not in accord; capitalist profits and workers' wages are not rising and falling in sync. The resulting structural condition is what he terms "social disarticulation." In other words, the consumption needs of the population are not linked to or met by its production; wages are not linked to profits.

Emphasizing export production in this manner results in market distortions because scarce resources (credit and extension services) are channeled to a minority of export producers. In turn, finance and technology neglect the needs of the majority of subsistence producers. This results in a bimodal agrarian structure, where a small number of large and mechanized producers crop the majority of total land while most of the population subsists meagerly off a small proportion of total land. Governments in developing countries may favor a bimodal agrarian structure because it is easier for the state to tax output that is concentrated in a few large units than it is to tax many small units (Lewis 1954:17). However, a bimodal agrarian structure makes it difficult to move at least 50% of the rural labor force out of agriculture and into industry and services. Only through a broad-based strategy can the bulk of the rural sector be addressed and the subsistence sector developed. For most developing countries, this means addressing financially and technologically a configuration of abundant labor and scarce land.

The “induced-innovation hypothesis,” developed by Hayami and Ruttan (1971), by drawing on the idea of induced technological innovation introduced by John Hicks

(1932), claims that “economic efficiency of any path to productivity growth in agriculture depends on factor endowments…[and] relative factor endowments, expressed through market prices, [which steer] innovation…” (Tomich et al. 1995:86). According to Tomich et al. (1995), the contrasting development paths taken towards structural transformation by the United States and Japan epitomize Hayami and Ruttan’s hypothesis.

In simple terms, Hayami and Ruttan’s induced-innovation hypothesis claims that relative factor prices (the prices of land, labor, and other factors of agricultural production) reflect relative factor scarcities and, in turn, influence patterns of productivity growth by inducing innovations that save scarce, expensive factors and use abundant, inexpensive factors (Tomich et al. 1995). Hayami and Ruttan’s hypothesis is epitomized by the successful yet contrasting patterns of agricultural productivity growth exemplified by the United States and Japan and their contrasting factor endowments. In short, in the 1880s the United States was endowed with abundant land and scarce labor, while Japan was endowed with abundant labor and scarce land. These scarcities were reflected in the market: in the United States, land was inexpensive and labor was expensive while in Japan, land was expensive and labor was inexpensive. Yet technological innovations responded to market price signals in both cases. In the United States, "the scope for cost reduction was greatest through...technology that substituted for human labor" (Tomich et al. 1995:86). In Japan, it was through technology that substituted for land. Hence, in accordance with market price signals, mechanical innovations in the United States (tractors) and biological innovations in Japan (high-yielding, fertilizer-responsive crop varieties) emerged, allowing each country to increase agricultural productivity.

In Japan, the growth of factor productivity followed a "labor-using, land-saving pattern of agricultural development," based on intensifying production of scarce land. In the United States, productivity followed a "labor-saving, land-using pattern of agricultural development" based on expanding production of abundant land (Tomich et al. 1995:81). The success of each of these countries in achieving structural transformation along different development paths implies that there is no single right path to agricultural development because resource endowments may vary from country to country. Therefore, current-day developing countries should avoid the pitfall of adopting an agricultural development pattern that fails to reflect their actual relative factor endowments and scarcities--such as favoring a small export producing segment of the agricultural sector and neglecting the productive capacity of the bulk of the rural labor force.

Because most current-day developing countries have scarce (and expensive) land and abundant (and cheap) labor, they resemble Japan in its pre-structural transformation years. It makes sense that they should use what resources they have and save what resources they lack, thereby supporting the design of labor-intensive and land-saving agricultural innovations (e.g., high-yielding, fertilizer-responsive crop varieties). Otherwise, they run the risk of “modernizing” (borrowing prototypical means and prescribed ends) or generating foreign exchange at the expense of economic efficiency and/or aggravating poverty by promoting/sustaining a bimodal agrarian structure that responds to a minority and fails to respond to the majority.

Even so, Tomich et al. (1995:160) note “policymakers often believe that when small farms are included in development strategies, there must be a sacrifice of economic efficiency for equity." Yet this is a mistaken notion, stemming from attention to the social advantages of broad-based development. Instead, Tomich et al. (1995:160) contend that "broad-based strategies to promote a unimodal agrarian structure offer bigger economic, as well as social, advantages in [developing countries] than the dualistic approach [where productivity growth is restricted to a narrow range of farms]." Their advocacy of a unimodal strategy of development is not limited to an argument in favor of equity; it is more so based on an argument in favor of efficiency. Tomich et al.'s rationale for this argument stems from the distinction between economic efficiency and technical efficiency. Economic efficiency comprises both technical efficiency and allocative efficiency. Technical efficiency indicates that an operating unit (i.e. a farm) uses the least amount of necessary inputs in order to produce a given output. For example, let us assume there are two farms, each producing an output of 1 ton of plantains and the only input required for each is fertilizer. Farm A produces its 1 ton using 0.5 tons of fertilizer and Farm B produces its 1 ton using 1 ton of fertilizer; therefore Farm A is technically superior to Farm B and Farm B is technically inefficient.

Allocative efficiency means that production decisions are made in such a way that "marginal costs for additional inputs and investments equal the revenue expected from the resulting increase in production (Tomich et al 1995:122). For example, a farm that spends an additional 2 dollars on fertilizer in order to produce an additional pound of output should at least obtain 2 dollars for the sale of the additional pound of product. If the farm only obtains 1 dollar in the sale of the additional pound of product, then the farm is allocatively inefficient. The farm is allocatively more efficient if it produces less output at fewer costs but obtains an equal revenue.

Therefore, the argument made by Tomich et al. implies that a farm can be technically efficient and not economically efficient. According to the authors, arguments made in favor of dualistic strategies are based on the mistaken notion that economies of scale are prevalent in agriculture. That is, the notion assumes that large farms are allocatively and economically more efficient—resulting in policies that favor large farm production.

As mentioned earlier, an additional problem with policies that follow dualistic strategies, especially in order to obtain fast cash through the export of cash crops, is that they de-link domestic production and consumption capacities. De Janvry (1981) explained Latin America's earlier lack of development along these lines, where the demand for exports originated abroad and were de-linked from local consumption demands within Latin American countries. Again, this decelerates structural transformation because the demands of the bulk of the rural sector cannot articulate and stimulate the nonfarm sector, and thus overall development.

Trade Policies

To this day, trade policy remains a hotly debated area. Even amongst economists, there is disagreement about optimal policies for development. While economic theory holds that liberalizing trade is good for welfare and growth, Stiglitz and Charlton (2005:17) argue that "to date, not one successful developing country has pursued a purely free market approach to development." For example, they note that Latin America grew rapidly during the years many of its countries adopted import substitution strategies where only "essential" capital goods were imported and the remainder produced domestically (2005:19). The neo-liberal view maintains that import substitution was the cause of Latin America's economic decline during the 1980s

(2005:21), yet Stiglitz and Charlton (2005:21) point out that according to South Centre (1996:42), the economic decline had less to do with import substitution than it did with the combined effects of global recession, oil price shocks, and debt policies. Stiglitz and Charlton also note that the success of East Asia does not fit the orthodox "laissez-faire" economic model (2005:16). Many East Asian countries protected their industries until they were ready for international competition while governments remedied market failures and provided requisite physical and institutional infrastructure.

State Intervention

The successes enjoyed by the United States and Japan in transforming their agrarian economies resulted from more than just the free hand of the market. In both cases, the state pursued broad-based development strategies, whereby the needs of the collective, i.e. the needs of farmers, determined the direction of research and development. Tomich et al. (1995:67,48) claim that "both countries were pioneers in government action that increased not only the opportunities for farmers but also their ability to seize those opportunities...[and this was critical because] without the right policies, even the richest endowment of natural resources will not lead to structural transformation."

The United States and Japan succeeded because government seized the day and provided an enabling environment for agricultural productivity growth. In both cases, government took the initiative and built key public institutions and infrastructure including rural schools, agricultural research facilities, and extension services. According to Tomich et al., they reached structural transformation by making concrete policy choices supporting the "Six I's": innovations, inputs, incentives, infrastructure, institutions, and initiative. Similarly, Djurfeldt et al. (2005:3) view "the Green Revolution in Asia as a state-driven, market-mediated and small-farmer based strategy to increase the national self-sufficiency in food grains."

For many developing countries, however, the role of the state has been undermined by IMF and World Bank lending conditions. Wherever implemented, SAPs have weakened the role of the state and its ability to act as a key intermediary. SAPs demand decreased government spending, privatization of "parastatals," reduced employment in the public sector, and the removal of food and input subsidies (Gladwin 1991). In western Kenya, for example, government cutbacks have grounded extension services. Insufficient funding prevents extensionists from visiting individual fields and farmers are expected to gain technical knowledge solely at the extension office.

Nyang'Oro and Shaw (1998) note that SAPs have so demised state interventions that civil society has increasingly played a larger role in assuring basic needs throughout developing countries. Technically, reduced state spending should not affect good policy-making—but it does. When SAPs call for privatization and a dismantling of state-sponsored agencies, including agricultural extension agencies, the natural result is that former public institutions become privatized, profit-seeking enterprises. Privately-owned agricultural and development institutions develop technology for whomever can pay for it—namely the wealthy minority. In turn, a dualistic strategy ensues. For this reason, Tomich et al. (1995) emphasize that collective action by farmers often needs publicly operated administrative structures. Otherwise, private entrepreneurs will usually curtail research efforts when they are unable to capture a full return to their investment. Without state intervention, a bimodal agrarian structure will distort the price signals which lead to induced innovations that bank on abundant resources and save on scarce resources.

Infrastructure

Nowhere is the role of the state more critical than in the provision of infrastructure. Where there are no roads, agricultural goods cannot be transported to market and where there are poor roads, the costs of transport make goods expensive. In Kenya, the price of fertilizer doubles, if not triples, from port to farm gate (Sachs 2005; Sanchez et al. 1997). Yet Lewis (1954:13) points out

> roads, viaducts, irrigation channels and buildings can be created by human labour with hardly any capital…even in modern industrial countries constructional activity, which lends itself to hand labour, is as much as 50 or 60 percent of gross fixed investment, so it is not difficult to think of labour creating capital without using any but the simplest tools.

In terms of agricultural development, roads provide high returns to investment. Governmental investment in infrastructure was key to the economic successes enjoyed by the United States and Japan. Sachs (2005:70) notes that Asia's relatively extensive road network has contributed to its rising per capita food production during recent decades while Africa's absence of roads contributes to its declining per capita food production. Tomich et al. (1995:208) also compare Asia and Africa, noting Asia's superior transport networks and access to consumer goods and services and concluding that investment in rural infrastructure is a priority in Africa. Stiglitz and Charlton (2005:15) also attribute Asia's economic success in part to the role of government in providing infrastructure.

Nonetheless, even as a public investment, roads often reflect special interests. This study will indicate that in Kenya, the road system is noticeably better near the capital and regions of commercial agriculture while in decrepit conditions in regions of subsistence agriculture and/or areas populated by ethnic groups lacking in power. In this way, the road network reflects the bimodal agrarian structure adopted by the state as well as its system of patronage.

Neo-patrimonialism

Systems of patronage can be understood as social structures embodying rules and patterns of resource allocation. Orvis (1997:69) argues that rules of reciprocity and redistribution commonly underlie rural social structures in Africa. Reciprocity underpins most social relationships so that "what one party gives will subject the recipient to providing some future good or service" (Orvis 1997:69). Redistribution implies that the wealthy will provide some goods and services to the poor and powerless. Naturally, these relationships are not egalitarian and Orvis (1997:69) notes that patron-client ties frequently exploit the clients. Nonetheless, these relationships or "networks of support" are integral to survival and accumulation (Orvis 1997:75). Constituting more than defense mechanisms, Hyden (Hyden and Peters 1991:305) argues these networks or "economies of affection" are the manner in which people in Africa get ahead. Operating both horizontally and vertically, they have a social logic of their own and are beyond market and state rationalities, particularly because markets and states are weak in Africa (Hyden and Peters 1991).

Beyond the household level, systems of patronage often involve corruption. Lambsdorff defines corruption as "the misuse of public power for private benefit" (2007:16). He distinguishes between "clientilist" corruption and "patrimonial" corruption. The "briber" obtains the higher benefit in "clientilist" corruption while the "bribee" benefits more in "patrimonial" corruption. However, Médard (2002:380) argues that the term corruption cannot be used in the case of traditional patrimonialism, such as identified by

Max Weber, because there is no clear distinction between public and private domains. The term can, however, be used in the case of neo-patrimonialism where the public and private sectors are formally differentiated and corruption occurs when the distinction is disrespected. In Africa, the term neo-patrimonialism is used to characterize the "contradictory processes of bureaucratization and patrimonialization" that developed together (2002:380).

Both Ake (1996) and Médard (2002) explain that corruption in Africa stems from the economically and politically insecure position of African elites after independence. To an extent, this remains the case. State power is the only leverage they control and economic accumulation comes necessarily through the state (Médard 2002; Ake 1996). In turn, political support is accumulated through the redistribution of state resources. Médard (2002:383) argues that

> the art of governing is not only the art of extracting resources, but also of redistribution: it is the only way of legitimizing power, in the absence of ideological legitimacy. In this way, corruption fits into the logic of the accumulation of political-economical goods, within the framework of survival strategies where the economy and politics are closely articulated.

Additionally, both Ake (1996) and Reno (1998) note that political power involves not only accumulating political-economic goods but also denying resources to political rivals. This view would explain why state-sponsored infrastructure seems to rarely make its way to certain regions in Kenya, for example, where ethnicities are divided by territories and political rivalries occur along ethnic lines.

By definition, neo-patrimonialism reduces economic efficiency. As a result, important state-controlled institutions lose credibility and fail to perform the functions they were designed for. For example, Ayittey (2005:282) complains that people resort to saving money under mattresses if they cannot trust banks with their deposits. In turn, banks lack the necessary funds to lend to businesses, and fail to function as "financial intermediaries" thereby slowing the process of economic development. The same applies to currencies. People will keep their savings in physical assets and foreign currencies if they lose confidence in the national currency which in turn leads to inflation (Ayittey 2005:282).

Neo-patrimonialism affects agricultural productivity in the same manner as do price distortions. Factor prices fail to reflect actual resource abundance and scarcity because elite segments of the population direct credit, investments, and infrastructure preferentially. In turn, necessary channels for agricultural production and marketing are distorted or nonexistent. For example, if roads in a particular region are purposely neglected by the state, the region's farmers will have trouble transporting their goods to market and the price of their inputs will be higher as a result of the additional transportation costs associated with poor road systems. Likewise, some farmers may be unable to access privileged lending, extension services, and subsidies. Fertilizer and improved seeds may be subsidized in one region and not another, as western Kenyan farmers have pointed out for this study.

Nonfarm Work

Nonfarm work, which refers to either off-farm nonagricultural activities or nonfarm activities carried on in the homestead (Tomich et al. 1995:201) can impact agricultural productivity both positively and negatively. Tomich et al. (1995:201) cite nonfarm activities as the key link between agriculture and industry. Nonfarm activities can account from 40 to 80 percent of output and employment in the rural economy (Tomich et al. 1995:201). Moreover, nonfarm incomes can smooth total rural household incomes over the year and reduce income inequalities in rural areas (Tomich et al.

1995:203). Orvis (1997) maintains that nonfarm income is critical to agricultural investments, improvements, and expansion.

On the other hand, nonfarm work can reduce available labor for agricultural production. Labor-intensive agricultural activities, such as soil conservation, cannot be undertaken. In Kenya, where off-farm employment is usually reserved for men (Orvis 1997:63), women are left to manage all farm activities on their own. And while labor is usually the most abundant and inexpensive resource throughout developing countries (Tomich et al. 1995), poor farmers often experience household labor shortages and bottlenecks (e.g. Morera 1999; FAO 1998; Ayieko 1995; Zimmerer 1993) for the following reasons.

- Poor farmers cannot afford to hire additional labor during peak seasons when labor demands are very high because cash flows are seasonal, increasing only after a harvest (Morera 1999).
- Young families have more household consumers than producers (Chayanov 1966).
- Labor is tied up in alternate income-generating activities (Morera 1999; FAO 1998; Ayieko 1995; Zimmerer 1993).

Nonetheless, the role of off-farm activities in diversifying, stabilizing, and increasing rural incomes has been given significant attention (de Janvry and Sadoulet 2001; Ruben and Van den Berg 2001; Reardon et al. 2001). De Janvry and Sadoulet (2001) parallel the rising importance of off-farm work with the deep economic changes brought on by trade liberalization, decentralization, elimination of public subsidies and reduction of parastatal services to agriculture. Increased costs of production, decreased access to rural services, and natural resource degradation lead farmers off-farm to generate income through multiple activities (Morera and Gladwin 2006; Morera 1999). In Kenya, where credit service to the rural sector is often channeled to “a narrow, already favored stratum of the farming population" (Gyllstrom 1991:257), off-farm income also substitutes for formal credit (Orvis 1997).

Even so, Ruben and Van den Berg (2001) maintain that the importance of off-farm work has been largely neglected by rural development programs intent on increasing rural incomes through improved agricultural productivity. Land and agricultural labor have often been viewed as the only assets controlled by the rural poor (de Janvry and Sadoulet 2001). In turn, rural poverty has been addressed through the implementation of redistributive land reforms and integrated rural development programs in an effort to raise the productivity of these assets (de Janvry and Sadoulet 2001).

De Janvry and Sadoulet (2001) term this trend the "traditional approach" to poverty reduction and distinguish it from the "new approach" which is instead characterized by its promotion of off-farm income generation. According to the authors, the "traditional approach" has generally failed to resolve poverty while it has become clear that raising the capacity of the poor to participate in non-farm jobs is crucial. The "new approach" is based on findings indicating that 1) off-farm activities are fundamental for the land-poor; 2) nonagricultural incomes are far larger than agricultural wage incomes; 3) off-farm incomes help mitigate income inequalities; and 4) off-farm work helps overcome credit failures and smooth risk management (de Janvry and Sadoulet 2001; Ruben and Van den Berg 2001). Moreover, the "new approach" generally involves the efforts of local organizations (as opposed to state supported programs) applying participatory methodologies (as opposed to the application of economic incentives). It is characterized by a decentralized, demand-driven allocation of public resources (de Janvry and Sadoulet 2001:1).

Yet the development literature's emphasis on off-farm work lacks a discussion of its potential relationship to land degradation and gender. Tradeoffs occur within households when limited labor is applied towards off-farm work. The fruits of off-farm income generation do not flow back to the farm consistently. In cases where men migrate long distances and for long periods, the remittances they send back to the farm may be insufficient to make up for the loss of labor and unfulfilled gender roles their absences constitute. Even though household consumption requirements are lessened by male migration, women are left to undertake all agricultural activities and labor-intensive soil conservation practices are not undertaken if household labor is limited and cash is unavailable for hired labor.

The development literature's emphasis on off-farm work also lacks a discussion of its potential relationship to gender and disease. Tradeoffs within households also occur when families are separated for long periods of time. In Kenya, where polygamy is the norm, men may acquire additional wives during their off-farm migrations. For women, this represents reduced access to men's off-farm income and an increased threat for HIV infection.

Disease

The omnipresence of disease has often been characterized as a symptom of underdevelopment that contributes to the poverty trap. Disease disproportionately affects the poor and the oppressed worldwide. In turn, development is stunted by disease. Sachs (2005:194) attributes Africa's slow economic development in part to disease. He notes that virtually everyone in sub-Saharan Africa contracts malaria at least once a year (Sachs 2005:197). This translates to several days or weeks of absenteeism per worker per year. “Malaria to this day can stop a good investment project in its tracks, whether a new mine, farm region, or tourist site” (Sachs 2005:197).

More devastating still than malaria has been Africa’s HIV/AIDS pandemic. “AIDS is the leading cause of death in sub-Saharan Africa, where over 22 million people are HIV-positive [and] most victims are between 15 and 49 years of age (Hock 2010: 289; UNAIDS/WHO 2007). Because HIV/AIDS affects people in the prime of their lives, Africa is losing its most productive individuals. The costs of the disease are reflected in all sectors of the economy.

> Africa is losing its teachers and doctors, its civil servants and farmers, its mothers and fathers…business costs have soared because of disarray from massive medical costs for workers, relentless absenteeism, and an avalanche of worker deaths. [Sachs 2005:201]

Moreover, the co-occurrence of tropical diseases in Africa compounds the severity of any one infection. Because individuals’ immune systems are impaired, they are more susceptible to additional infections.

The burden of disease impacts agricultural productivity in a number of ways. At the household level, labor availability is reduced, nonfarm income that could otherwise be used for agricultural intensification or education must be diverted towards health care, and productive assets such as cattle must be sold. Over time, a household may also experience technological reversal if it loses its knowledgeable members (Sachs 205:55). At the national level, disease places a greater toll on the health care system and reduces productivity across all sectors of the economy.

Conclusion

This chapter has set the stage for the empirical work to follow in the next four chapters. By synthesizing and analyzing the literature on agricultural productivity and soil fertility management, this chapter has illustrated that without incentives for agricultural intensification, soil fertility enhancement technologies are for naught because farmers rather plant extensively with minimum application of inputs, including soil fertility enhancement practices. If food prices fail to rise, marginal producers will not invest in the increased costs of intensification—which, essentially are the costs associated with fertility enhancement. Instead, they will cultivate until they degrade the land and must abandon the area or abandon agriculture. The chapters that follow will indicate that in western Kenya, farmers are degrading their land and finding alternatives to staple crop production. Land-poor farmers, rather than intensify production, apply their labor towards agricultural wage work or nonfarm work while larger landholders, rather than increase agricultural productivity, substitute kale production for maize and bean production. Thus smallholders do not invest their labor in organic fertilizers or improved fallows while larger landholders do not invest their wealth in inorganic fertilizers. On average, farmers substitute land for fertilizer. Meanwhile, soil fertility enhancement as well as aggregate agricultural productivity remains low in this region of western Kenya, calling into question the theory of induced innovation as well as the efficacy of the Green Revolution and pointing to a need for increased efforts if agricultural research and development are to be successful and structural transformation in Kenya attained.

CHAPTER 3
RESEARCH SETTING: THE LAND AND ITS PEOPLE

Introduction

This chapter describes the ecological and socioeconomic features of the study's research setting. It weaves primary data collected through participant-observation together with secondary data collected from published materials in order to present a current, as well as historical, glimpse into this region of western Kenya. By examining the land, people, and institutions interacting in Shinyalu Division of Kakamega District in the Western Province of Kenya, the chapter provides a context in which the theoretical framework, research methods, and empirical results of this study can be understood.

Ecological Setting

The empirical work of this study took place throughout four villages located within Shinyalu Division of Kakamega District in the Western Province of Kenya. Spanning almost 333 square miles, Shinyalu Division borders the Nandi Escarpment and encompasses a portion of Kakamega Forest National Reserve[1], as illustrated in Figure 3-1. Shinyalu Division's boundaries are illustrated in Figure 3-3. Its land is of high agricultural potential and its population of 103,948 is predominantly *Luhya*, Kenya's second largest ethnic group (Kenya 2001)[2].

The four villages—*Mutsulio, Shikusi, Lugango*, and *Shinakotsi*—are located close to one another within an area that spans from the Yala River in the south to the

[1] Kakamega Forest is Kenya's only remaining tropical rain forest (Müller and Mburu 2009). While it has received government protection since 1933, protection varies by area. Müller and Mburu (2009) note that the region around Kakamega Forest is among the most densely populated in the world and predict that forest clearing will increase particularly in areas with lower protection status, especially near roads and market centers. However, they also predict considerable forest clearing in the strictly protected National Reserve.

[2] The results of Kenya's 2009 census were to be released in August, 2010.

unpaved road in the north connecting Highway A1 to Highway C39 (see Figures 3-1 and 3-2). The geographical coordinates of each village entrance appear in Table 3-1. The area encompassing the four villages lies at an altitude of 1500 to 1800 meters above sea level on Archaean Kavirondian Group rock formations (Kenya 1962) and is characterized by temperatures ranging from 14^o to 26^o Celsius (Mathu and Davies 1996). The area's soil is comprised of Nitisols and Acrisols (Kenya 1982), with nitrogen and phosphorous deficiencies, and its vegetation includes scattered woodlands. Its annual rainfall of 1200 to 1900 millimeters is distributed across two rainy seasons. The first of these is known as the long-rains season, which runs from March through July, and is the more reliable of the two seasons. The second rainy season is known as the short-rains season and runs from August through November. The rains are known to fail periodically.

Socioeconomic Setting

The area encompassing Mutsulio, Shikusi, Lugango, and Shinakotsi villages overlaps what used to be known as Isukha Location, or Isukhaland, an area peopled by the *Abesukha*, a sub group of the Luhya of western Kenya, who are also known as the Western Abaluyia (Nakabayashi 2003). According to oral tradition, the ancestor of the Abesukha, who spoke an *Oluluyia* dialect, moved into this region from eastern Uganda, finding the region unpopulated upon his arrival (Mwayuuli 2003; Were 1967). One of his sons established the Abesukha sub-tribe. Thus all the clans of the Abesukha originated in this region (Were 1967). Moreover, they have not migrated since (Mwayuuli 2003; Were 1967). Abesukha elders interviewed at Isukha Location in 1964 traced their genealogy back 13 generations to their common ancestor (Were 1967). To this day, the people of this region identify themselves as Abesukha.

The Abesukha, like the rest of the Luhya, are patriarchal. Land is passed from the father to the sons, each son inheriting a partition of the original landholding. Sons move into their own houses once they are old enough to marry. However, they inherit their own piece of land only several years after marriage. Thus, when a woman first marries, she moves into her husband's house but cooks meals with her mother-in-law and helps work her father-in-law's land. Only after a period of this cohabitation does the son inherit an individual partition of his father's land and does his wife establish her own household, cooking in her own kitchen and working her husband's land.

According to tradition, Luhya marriages are arranged by the parents of the bride and groom with the help of a "go-between," also known as *Wanjira* (Wako 1985; A list of additional Luhya terms and their translations appear in Table 3-2). A young woman is chosen from a different clan (or different sub-tribe or different tribe) on the basis of her parents' characters and her farming proficiency. If the woman's parents consent to the marriage, the groom's family pays them a bride-price, usually in the form of cattle, which must also be agreed upon. Only then does the bride journey, in the company of her relatives, to the groom's house for the marital feast (Wako 1985).

Surprisingly, many of these traditions remain in place. During my field work season in 2007, I witnessed the distress of a family whose daughter arranged her own marriage. A bride-price was never paid nor a marital feast held in the village. As such, the young woman forfeited her family and community's protection should anything have gone wrong in her marriage.

Also during the field work season of 2007, a young Luhya man explained to me the importance of establishing a family on inherited land. The Luhya consider it shameful for a man to leave idle the land his father has passed on to him. Yet the Luhya also encourage their sons to migrate in search of off-farm work. Thus Luhya men feel social pressure to marry locally and to establish families on their fathers' lands, later leaving their wives to tend the land while they migrate in search of nonagricultural jobs.

It is common for Luhya women to bear entirely the responsibility of farming and feeding their families. Women are responsible for fetching water and firewood, plowing by hand, planting, weeding, and caring for the young—tasks that must be completed on a regular basis. For example, many of the women interviewed for this study walked long distances every day to fetch water from the Yala River and collect firewood from the scattered woodlands[3]. Men are often responsible for managing cash crops, maize harvests, and heavy work such as land clearing, carpentry, and oxen plowing. However, these jobs are often not necessary for long periods of time. Thus most women interviewed in this study actually preferred to have their husbands employed in an off-farm job rather than residing and working on the homestead. Off-farm jobs are usually better paid than agricultural work and although women only receive a portion of the income in the form of remittances, these are an important source of cash that is often applied towards school fees and towards farming and household expenses.

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[3] According to Kenya's 1999 census (2001:xvi), the proportion of households in Western Province which used streams/rivers as their source of water from 1989-1999 declined from 36% to 21%, while the use of other sources of water such as bore holes and roof water increased from 16% to 54%. In most cases, this should have translated as decreased workloads and improved conditions for women. However, Kenya's 2003 Demographic and Health Survey (2004:43) indicates only 13.3% of women interviewed in Western Province enjoyed full or joint decision making in all decisions regarding healthcare, purchases, visits, and cooking. Moreover, illiteracy was 22.5% for women, whereas it was 15% for men (2004:29-30). The Survey presents additional socioeconomic indicators related to women's status. In 2003, infant mortality in Western Province was 80 deaths per 1000 live births and under-five mortality was 144 per 1000 (2004:116). Trends in the nutritional status of children indicate 30% of children under five in Western Province were stunted (2004:167). Data were unavailable at district, division, and village levels.

Agricultural Practices

The farms I visited throughout the villages of Mutsulio, Shikusi, Lugango, and Shinakotsi during the field work season of 2007 averaged a little over a hectare (2.83 acres) in size. Most were cropped predominantly in maize and beans, with smaller portions of the landholdings devoted to sugarcane, napier grass, kale, tea, and cattle. The steeper farms, in Mutsulio especially, had terraces and live barriers of napier grass on their hillsides while many Lugango farms specialized in zero-grazing cattle rearing. During the short-rains season, most farmers left a portion of their maize fields fallow.

Fallowing for soil-nutrient replenishment has long been practiced in this region while terracing for soil conservation as well as zero-grazing for more efficient cattle rearing are relatively new technologies disseminated by institutions such as the Kenya Agricultural Research Institute (KARI), Kenya's Ministry of Agriculture and Rural Development (MoARD), and the International Centre for Research in Agroforestry (ICRAF). Over the years, these institutions have also disseminated planting and fertilizing technologies. During one interview in Mutsulio in 2007, an informant explained to me that prior to KARI and ICRAF's work in his village, farmers broadcasted, rather than spaced, their maize seed and use very little fertilizer.

Kale production, too, is a relatively recent agricultural practice that is increasingly disseminated through extension efforts. Although Kenyan farms have long grown a variety of African vegetables for subsistence, kale (*Brassica oleracea*) is a nontraditional species that is now grown in large quantities for market (Nekesa and Meso 1997). The success of kale production lies in its high domestic consumption. Its local name, *sukuma wiki,* a Swahili term for "push the week" (Parkinson et al. 2006), implies its ubiquity in the diet and, like traditional African vegetables, is typically served with *ugali*, Kenya's staple dish of prepared maize meal. Thus the niche kale has filled existed previously and kale is quickly replacing African vegetables in much the same way that maize has largely replaced the production and consumption of sorghum and millet in this region.

Collaboration with the PLAR Project

The PLAR project, as it came to be known in Mutsulio and Shikusi villages, was a collaborative effort between several institutions to scale up the work on soil fertility enhancing technologies ICRAF had achieved during the 1990s in Vihiga District, a district lying just south of Kakamega District. Together with KARI, MoARD, and the Royal Dutch Institute for Tropical Agriculture (KIT), ICRAF sought to disseminate their soil fertility enhancement technologies in Mutsulio from 1998 to 1999 using the Participatory Learning and Action Research (PLAR) approach (Place et al. 2005; Baltissen et al. 2000). During the year 2000, the technologies were also disseminated in Shikusi (Baltissen et al. 2000).

The PLAR approach, as outlined by Baltissen et al. (2000), involves four phases that include farmer input, farmer-to-farmer exchanges, and farmer interaction with extension staff across all phases. The first phase of the PLAR approach entails diagnosis and analysis. Community representatives are invited to a meeting and asked to outline the territory, organization, and current natural resource management of the village, developing a set of criteria indicative of good soil fertility management. Later, village committees are formed to coordinate and monitor the PLAR process. Members of the committee include both men and women of varying resource bases.

During the second phase of the PLAR approach, extension visits and workshops are organized, introducing farmers to alternative management practices. During the third phase, technologies are experimented with. Key farmers arrange field visits to their demonstration plots in order to share their experiences with the technologies and disseminate them to others. The fourth and last phase of the PLAR approach involves evaluation of the activities implemented at the community level and assessment of experiments carried out by committee members, appraising their successes and failures.

From 1998 through 2000, the PLAR project worked with Mutsulio and Shikusi villagers to disseminate improved fallows, biomass transfer, and their optimal combinations with recommended doses of rock phosphate (Baltissen et al. 2000). As will be explained in Chapter 4, improved fallowing is a soil fertility enhancing agroforestry technology that involves sowing legumes within maize rows during the long-rains season, leaving the maize field fallow during the short-rains season, and turning the legumes back into the soil as the following long-rains season begins (Kamiri et al. 1997). Biomass transfer is another soil fertility enhancing technology that involves cutting the leaves and soft twigs of *Tithonia diversifolia* or *Lantana camara* from hedges and live fences, chopping them into small pieces, carrying them to the field, and incorporating them into the soil as "green manure" (ICRAF 1997). According to Baltissen et al. (2000:8), farmers in Mutsulio conducted 449 experiments with soil conserving and organic soil fertility enhancing technologies over the period of 1998 to 1999. Farmers in Shikusi conducted 55 of these experiments from March to August of 2000.

However, as will be discussed in the following chapters, by my fieldwork season of 2007, improved fallows and biomass transfer technologies had all but vanished from this region. The technologies were discontinued in Mutsulio and Shikusi villages and never reached Lugango and Shinakotsi villages. Farmers from Mutsulio and Shikusi villages interviewed in this study pointed out that although the technologies improved their production of maize, the implementation of the technologies took up too much land and labor.

Nonetheless, the participatory methods and farmer-to-farmer exchanges emphasized by the PLAR project resulted in long-term benefits for its participants that became apparent during my fieldwork season of 2007. As will be discussed in Chapters 5 and 6, PLAR project participants exhibited greater access to social capital, such as labor-sharing and money-saving groups, than did non-participants. A higher number of PLAR project participants than non-participants also reported the sale of cash and staple crops as well as a better quality of life and economy. Finally, PLAR project participants applied fertilizer in greater quantities and purchased maize for consumption in lesser quantities than did non-participants. In Shikusi, for example, fertilizer was applied at an average rate of 88 kg/ha, compared to an average rate of 69 kg/ha applied across all four villages during the long-rains season of 2007. Similarly, while PLAR project participants reported purchasing maize for consumption at an average rate of 3.1 months per year, non-participants did so at a rate of 4.5 months per year. Shinakotsi non-participants purchased maize for consumption at an average rate of 5.3 months per year. Thus the PLAR project, while failing to achieve the long-term adoption of improved fallow and biomass transfer technologies in Mutsulio and Shikusi, seems to have significantly improved the overall wellbeing of its project participants[4].

[4] Moreover, fieldwork visits to farmers' homes dispelled the consideration that PLAR project participants had been economically better off to begin with than non-participants. In fact, the PLAR project targeted

Other Institutions Working in the Surrounding Areas

In addition to the institutions that collaborated to bring the PLAR project to Mutsulio and Shikusi, there are a number of institutions located throughout Kakamega District that provide an array of services for farmers living in Shinyalu and other surrounding divisions. The most frequently mentioned of these during my fieldwork season of 2007 was Kenya Women Finance Trust (KWFT). KWFT is an independent microfinance organization founded to address the financial needs of women. Loans, commonly ranging from 10,000 to 100,000 Kenyan shillings ($150 to $1500), are provided to groups and to individuals, using household items and cattle as collateral. As one KWFT representative pointed out, "KWFT doesn't want you to chattel your land" (KWFT, personal communication). Nonetheless, farmers "still lack information regarding loans and continue to fear them" (KWFT, personal communication). For this reason, KWFT has outreach programs and targets. Perhaps as a result, farmers interviewed for this study had only positive things to say about KWFT.

Another institution working in the surrounding area is the National Cereals and Produce Board (NCPB). Once a government parastatal with "monopoly powers to purchase, store, market and generally manage cereal grains and other produce in Kenya," the NCPB is now "a commercially viable entity, free to make independent commercial decisions" (NCPB). The NCPB was transformed in 1993 when the grain sector of Kenya was fully liberalized. The NCPB continues to purchase, store, and market cereal grains in Kenya but farmers now have the freedom to "dispose [of] their produce to willing buyers at market driven prices for different regions depending on

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more marginal farmers. Participants, on average, had less land and fewer head of cattle than non-participants.

supply and demand" (NCPB). Because the NCPB is located at the outskirts of Kakamega Municipality, farmers interviewed for this study naturally preferred to sell their maize locally, in the Shinyalu area, rather than absorb the transport costs of selling it to the NCPB. Moreover, smallholders find it difficult to meet the standards of quality required by the NCPB. As one NCPB representative explained, "Maize sold to the NCPB must be 13.5% dry, free of foreign matter, and free of disease" (NCPB, personal communication).

Other institutions serving the farmers of Shinyalu Division include Kenya's Agricultural Finance Corporation (AFC), Kenya Farmers' Association (KFA), and various branches and programs of Kenya's Ministry of Agriculture. Nonetheless, many farmers interviewed in this study in 2007 had experienced few exchanges with most of these institutions. Only thirteen percent of the farmers interviewed had ever visited the Shinyalu extension office.

Markets and Infrastructure

Although the roads surrounding the villages of Mutsulio, Shikusi, Shinakotsi, and Lugango are not paved, they constitute important networks for market transactions. Large trucks transporting molasses often traverse the Shinyalu area, traveling along the wider routes and stopping to sell molasses. Village women often sell maize and vegetables at busy junctions. Kiosks that carry bread, tea, soda, candy, etc., can also be found along the roads, even in the interior reaches of the villages.

Despite their importance, the roads in this region have been hard to maintain. During the fieldwork season of 2004, two-wheel drives had a difficult time crossing from A1 to C39 along the unpaved Shinyalu road (see Figure 3-1). From 2004 to 2007, the condition of A1 between Kakamega and Kisumu also worsened. Moreover, while it took me approximately 6 hours to travel by bus from Kisumu to Nairobi in 2004, the same trip took over 8 hours in 2007. Yet certain portions of the route between western and eastern Kenya remained well-paved, such as those surrounding Nakuru and Nairobi.

Additional Livelihood Strategies

In addition to agricultural production, households throughout Mutsulio, Shikusi, Lugango, and Shinakotsi engage in a number of alternate livelihood strategies. The most prevalent of these are agricultural wage work and brewing liquor (*chang'aa*) or beer (*busaa*) for sale. Agricultural wage work is commonly undertaken by younger farmers, men and women alike, as the work is too strenuous for older farmers. On the other hand, chang'aa and busaa brewing are commonly undertaken by women of all ages, though less commonly by men. As such, brewing is an important source of income for women, particularly land-constrained women. Although home-brewing has been illegal in Kenya since Moi took office in 1979, thus providing a marginal livelihood, it is better remunerated than agricultural wage work whose compensation is the lowest in the rural sector. Home-brewing also represents an important form of nonfarm specialization in the rural economy which, according to Tomich et al. (1995:201), is the key link between agriculture and industry.

It is important to note that not all of the ingredients used to brew chang'aa are produced on the farm. Chang'aa is brewed by fermenting maize, millet, and "rock sugar"—which can be obtained locally from pressed sugarcane or, more commonly, purchased in the form of molasses. However, informants interviewed in this study explained that substituting regular sugar for rock sugar or molasses produces a clearer, higher-quality chang'aa. During the fieldwork season of 2007, I confirmed that chang'aa made from sugar fetched a higher price than did chang'aa made from molasses.

Throughout my time in Kenya, I was fortunate enough to catch glimpses of chang'aa being brewed on several occasions. According to one of my informants, 5 liters of chang'aa requires about 4 kg of maize, 1 kg of millet, and 3 kg of regular sugar. The process takes 11 or 12 days. The grains are fermented during approximately 7 days after which the sugar is added and the mixture fermented for another 4 or 5 days. The mixture is then boiled and distilled. I calculated in 2007 that the ingredients necessary to brew 5 liters of chang'aa cost approximately 370 Kenyan shillings. In turn, 5 liters of chang'aa could be sold for 600 Kenyan shillings in Khayega, 1200 Kenyan shillings in Kisumu, and 1700 Kenyan Shillings in Nairobi. The cost of traveling from Khayega to Kisumu, roundtrip, in 2007 was approximately 200 Kenyan Shillings.

Busaa, too, is often brewed with ingredients not produced on the farm, since finger millet—a key component of busaa—is no longer as widely cultivated as it was before the introduction of maize to this region. Busaa, unlike chang'aa which is made with sugar and requires distillation, is made strictly with grains. Thus busaa is a beer, rather than liquor, and has a much lower alcoholic content than chang'aa.

In addition to home-brewing and agricultural wage work, farmers throughout this region also engage in retail in an effort to supplement their incomes generated through agricultural production. The most common forms of retail involve the buying and reselling of maize, vegetables, fish, paraffin, and medicine. Retail is most often undertaken by women.

Effects of Illness on Livelihoods

Illness has affected the agriculture, economy, and social structure of Mutsulio, Shikusi, Lugango, and Shinakotsi in a variety of ways. At the very least, as in the case of malaria, illness annually robs several weeks of work from every farmer in the area.

At worst, as in the case of HIV/AIDS, illness depletes household assets, alters age and sex ratios, and transforms the very fabric of the community. As one representative of USAID's HIV/AIDS Program in Kakamega explained, "Diseases have affected agricultural production in this region because virtually every family has had to deal with disease-related deaths" (USAID, personal communication).

Nonetheless, the effects of disease on farming did not become apparent to me until my fieldwork season of 2007, when I returned to Mutsulio and Shikusi after a hiatus of 3 years. At that time, I began to realize that the composition of many households interviewed in 2004 had evolved. What were once male-headed households, were now female-headed households.

During my first fieldwork season in 2004, I had difficulty locating female-headed households for this study. In fact, the main reason I included Shikusi in the sample was that I could not locate a sufficient number of female-headed households in Mutsulio, one of the villages involved in the PLAR project. Because the study's sample of 120 households was to be disaggregated by both PLAR project participation and gender, I had to include one more PLAR project-involved village in the study in order to randomly select a total of 30 female-headed households from a list that combined households from both villages.

During my second fieldwork season in 2007, however, I had the opposite problem. I returned to Mutsulio and Shikusi, once again combining lists of farmers from both villages in order to randomly select 30 female-headed and 30 male-headed households previously involved in the PLAR project[5]. What I found was that many households

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[5] Qualitative results reflect analysis of data collected during all three fieldwork seasons. Quantitative results reflect analysis of data collected in 2007.

which were male-headed in 2004 had become female-headed by 2007. Many of the initial random selections were discarded when, upon arriving at the homestead, I discovered the husband of the household had passed away.

In addition to the emotional pain and financial costs incurred by medical treatments and funeral arrangements, the loss of a male head of household can translate to a loss of off-farm income, reduced schooling, and increased work load for the remaining household. Because men, more typically than women, work off-farm and pay for their children's school fees, their incomes are particularly important for on-farm improvements and expansion. Thus young *de facto* female-headed households have fewer opportunities than others to achieve food security and the overall betterment of their families.

Sadly, many homesteads visited during 2007 were dotted with graves. The Luhya typically bury relatives at the entrance of the homestead. Thus by the time I entered a household, I was painfully aware of the misfortune endured by the family. One informant had buried six relatives over the last year alone. The only way she could now meet the demands of her farm was through hired labor. This unfathomable loss tragically illustrated the effects of illness on rural productivity.

Conclusion

This chapter has examined the ecological and socioeconomic features that characterize the region in which the research study took place. By describing the nature of the land, the ways of the people, and the institutions that interact in Kenya's Western Province, this chapter has sought to ground the theoretical framework discussed in the preceding chapter as well as contextualize the empirical work to follow in the remaining chapters. Thus the next chapter now turns to the research methods used to examine the nature of soil fertility management in this region and its role in agricultural productivity, investigating how it is affected by technological adoption, gender, off-farm work, and other off-farm factors.

Table 3-1. Geographical coordinates of Lugango, Mutsulio, Shikusi, and Shinakotsi villages

Village	Geographical Coordinates	Kilometers from Khayega tarmac
Shinakotsi	00 º 12.43 N 34 º 47.68 E	2.6
Lugango	00 º 12.24 N 34 º 47.89 E	3.2
Shikusi	00 º 12.22 N 34 º 47.94 E	3.4
Mutsulio	00 º 11.52 N 34 º 48.81 E	5.6

Coordinates recorded at each village entrance using a global positioning system (GPS) receiver

Table 3-2. Agricultural Luhya terms and their English translations

Luhya term	English translation	*Luhya* term	English translation
Amamondo	Money	*Khuraka*	Planting
Amasika	funerals (or tears)	*Khwabitsa*	top dressing
Amasingo	cow dung	*Kikabicchi*	Collards
Amatsi	Water	*I'ngombe*	Cattle
Bandu	many people	*Likhubi*	Cowpeas
Bulimi	agriculture (or farming)	*Likondi*	Sheep
Chichirishi	ox	*Lipata*	Duck
Eshikulu	hill	*Lusuu*	napier grass
Ifula	rain	*Mabere*	milk (or finger millet)
ifula yo murotso	long-rains	*Majani*	Tea
ifula yo mshibwe	short-rains	*Makanda*	Beans
Ikanisa	church	*Matuma*	Maize
Imbolea	fertilizer	*Mbuli*	Goat
Ingokhoo	chicken	*Miro*	African vegetable (produces small white seeds)
Ingulume	pig	*Mukhali*	Wife
Intzu	house	*Mulimi*	field (or farmer)
Ipunda	donkey	*Mundu*	one person
Irotso	long	*Murere*	African vegetable (produces small black seeds)
Isimbwa	dog	*Musatsa*	Husband
Isukari	sugar	*Obulwale*	Illness
Isukuma	kales	*Okhufwa*	Death
Itwasi	cow	*Omuchera*	River
khu birira	second weeding	*Omukhonye*	Sugarcane
khu sembera	first weeding	*Omusala*	tree (or drugs)
Khufuna	harvest	*Omwana*	Child
Khukombola	hiring	*Shibwe*	Short
Khukonera	idle	*Shimiyu*	"during hunger time"
Khulia	eating	*Tsikwui*	Firewood
Khulima	plowing or digging		

Compiled with the assistance of Sarah Anyolo and Mildred Machika

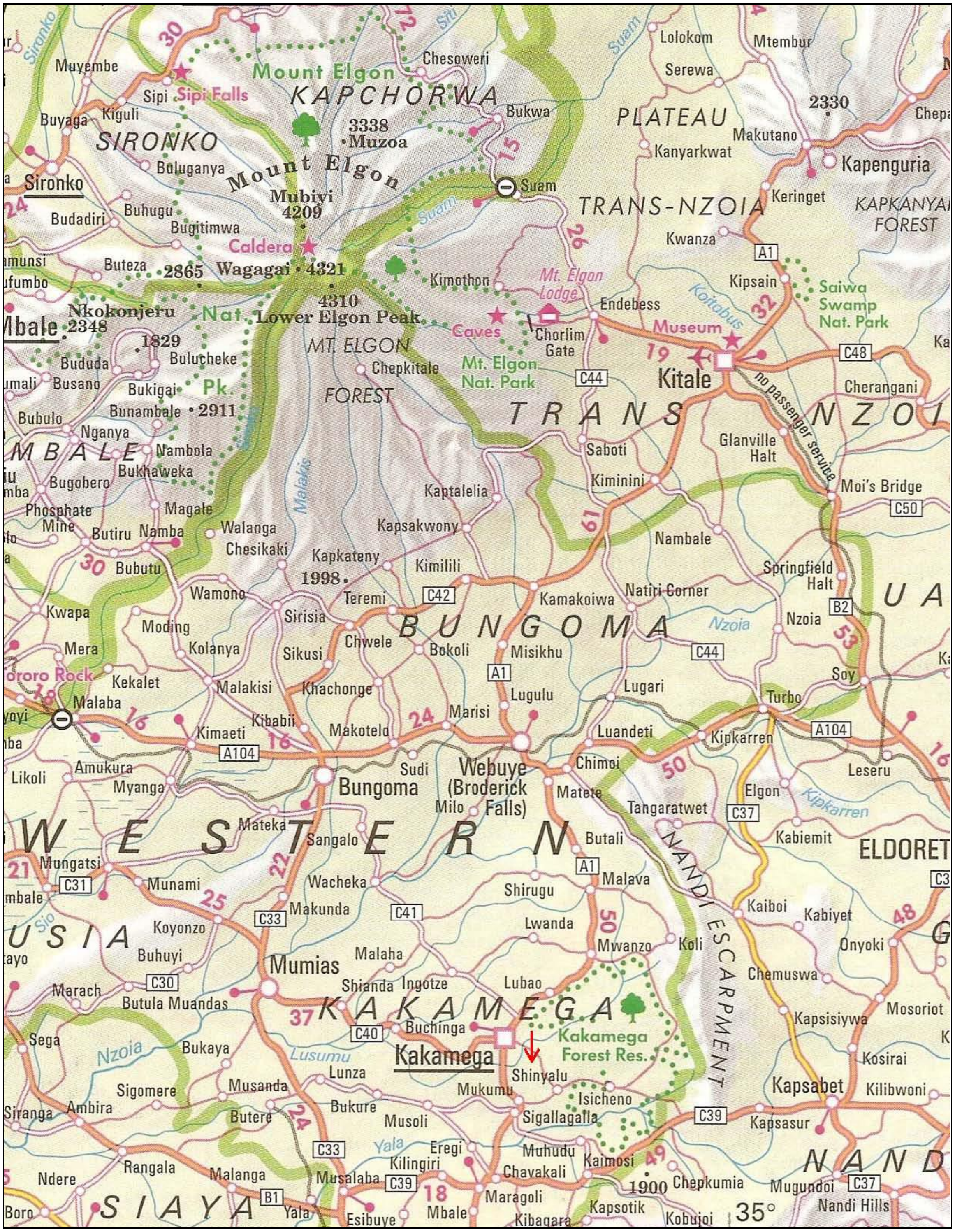

Figure 3-1. Road map indicating location of Shinyalu, adapted from Nelles Map: Kenya (Source: Nelles Verlag 2005)

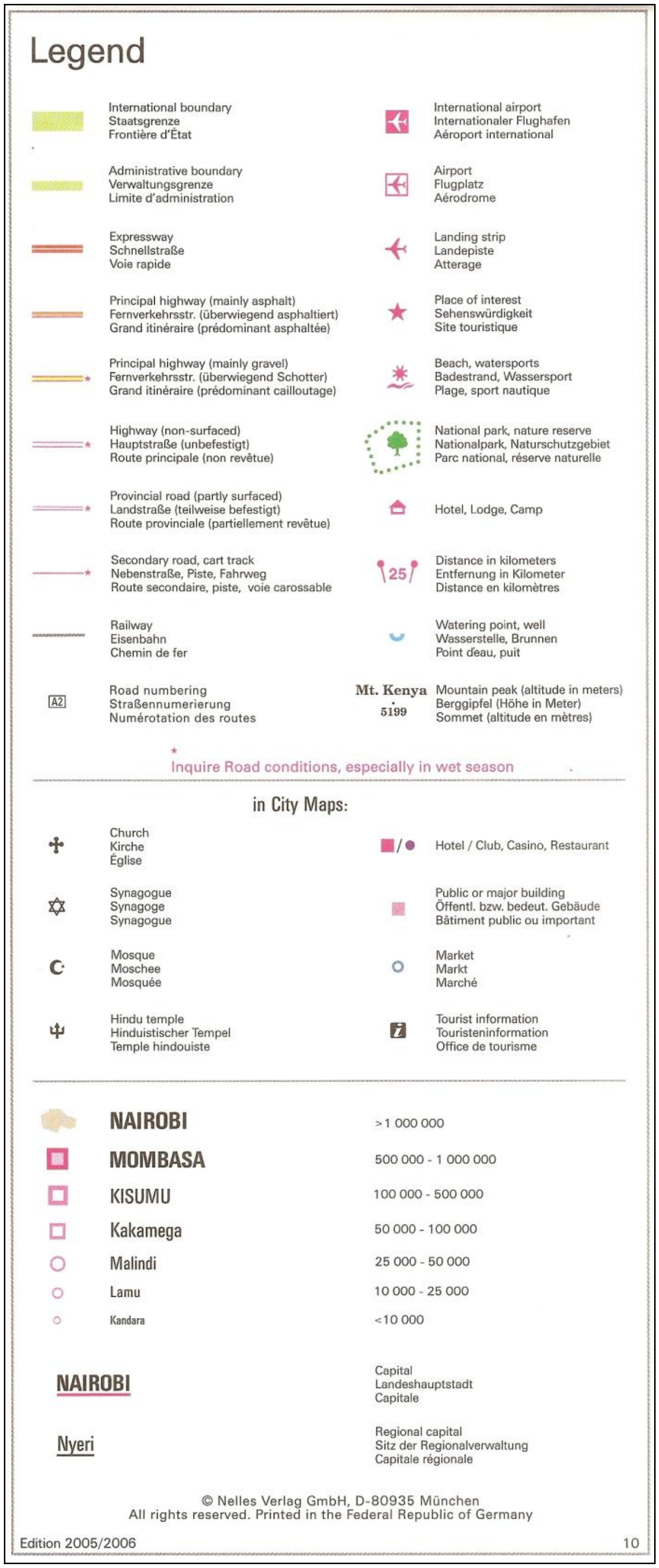

Figure 3-2. Legend for road map indicating location of Shinyalu, adapted from Nelles Map: Kenya (Source: Nelles Verlag 2005)

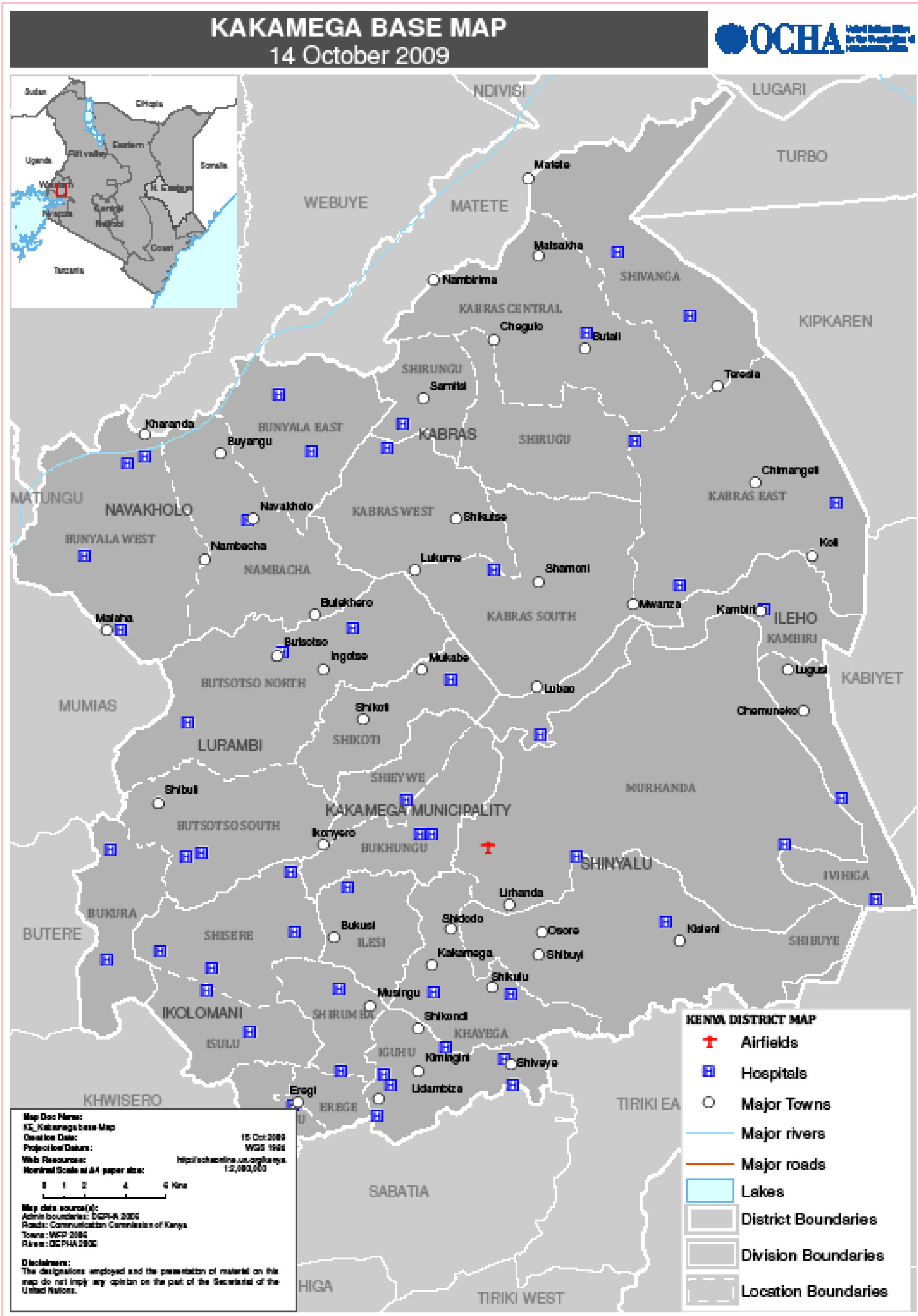

Figure 3-3. Map of Kakamega District indicating location of Shinyalu Division[6] (Source: United Nations 2009)

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[6] Map provided courtesy of the UN Office for the Coordination of Humanitarian Affairs. The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

CHAPTER 4
RESEARCH METHODS: UNDERSTANDING THE OPPORTUNITIES AND CONSTRAINTS AFFECTING SOIL FERTILITY MANAGEMENT

Introduction

The impetus for this study was ignited by a host of publications in which a strong case was made for the replenishment of soil nutrient deficiencies across Africa through the application of improved fallow and biomass transfer systems (Place et al. 2001; Franzel et al. 2000; Pisanelli et al. 2000; Sanchez 1999; Kwesiga et al. 1999; Swinkels et al. 1997; Buresh et al. 1997). Improved fallow systems were built on African farming techniques by improving traditional fallows with fast growing tree or shrub legume species, such as *Sesbania sesban, Crotalaria grahamiana,* and *Tephrosia vogelii*, which fix nitrogen from the air and return it to the soil. Biomass transfer systems were also built on African farming by utilizing hedges around homesteads and traditional live fences of common species such as *Tithonia diversifolia* and *Lantana camara*, for green manure. Together, these systems could provide smallholding farmers with labor-intensive "green," organic soil fertility enhancing alternatives to expensive industrial, inorganic fertilizers. The technologies were extensively researched and disseminated in western Kenya during the 1990s by the International Centre for Research in Agroforestry.

Improved fallows involve sowing legume seeds in maize rows either at planting (if using *Sesbania sesban*) or after the second weeding (if using *Crotalaria grahamiana* or *Tephrosia vogelii*) during the long-rains season (Kamiri et al. 1997). The long-rains season in western Kenya, as the name implies, is the longer of two rainy seasons. The long-rains usually extend from March through July and the short-rains from August through November. Many farmers plant during both seasons. However, improved fallow systems require leaving a field fallow after the long-rains maize harvest and letting the legumes grow during the short-rains season. By the time the next long-rains season is about to begin, the legumes have grown into young shrubs and returned to the soil anywhere from 50 to 150 kilograms (kg) of nitrogen per hectare (Kamiri et al. 1997), at which time the young shrubs should be turned back into the soil.

Biomass transfer involves cutting the leaves and soft twigs of *Tithonia diversifolia* or *Lantana camara* from hedges and live fences, chopping them into small pieces, carrying them to the field(s), and incorporating them into the soil as “green manure” (ICRAF 1997). The mixture should be left to decompose for at least one week before planting a crop (ICRAF 1997:6). In western Kenya, an application on maize fields of 5 tons of *Tithonia diversifolia* (dry matter) per hectare yields comparable results to an application of 50 kg/ha of inorganic P_2O_5 and 60 kg/ha of inorganic nitrogen (ICRAF 1997:7).

The results and publications of ICRAF’S work in western Kenya during the 1990s with improved fallow and biomass transfer systems were compelling. Nonetheless, my own work in Honduras in 1997 (Morera 1999) led me to conclude that economic constraints, particularly resulting from SAPs, inhibit smallholders from investing in labor-intensive, fertility enhancing technologies—despite their proven capacity to ameliorate soil degradation and raise maize yields. Moreover, economic trends in Kenya indicated that the production growth of maize remained lower than population growth, rendering maize an importable commodity even after liberalization from 1992 onward (FAOSTAT 2004). With all of this in mind and amidst a growing concern surrounding Africa’s relatively low consumption of inorganic fertilizer and correspondingly low agricultural productivity, I embarked on my own investigation of farming patterns among smallholders in western Kenya.

Research Objectives and Assumptions

This study set out to identify factors affecting farmers' soil fertility management practices throughout western Kenya and to gauge trends in agricultural productivity. In doing so, the study addressed the following guiding questions: 1) Is agriculture in western Kenya intensifying or extensifying? 2) Does off-farm work lead to an expansion or a contraction of on-farm investments? 3) Does limited resource access, particularly to land and cash, lead to labor-intensive, "greener" farming practices? 4) How does gender affect technological choice? 5) Do research and development efforts to disseminate soil fertility enhancing technologies have lasting effects on farming practices? 6) How do factors originating outside the farm—at both the community and national levels—affect farming decisions?

In order to address these questions using a political ecology approach, the study sought to integrate information from various levels of Kenyan society—local, national, and international. At the local level, primary data were obtained through interviews with farmers, community leaders, and representatives of local government agencies, organizations, banks, and businesses. At the national and international levels, secondary data were gathered from national archives and online publications. The information was used to link farmers' opportunities and constraints to local, national, and international norms, institutions, policies, and events affecting farmers' access to resources. The study assumed that farming decisions are based on farmers' physical and social resource access and this access is embedded within a larger framework of overlapping "trans-actions"—exchanges and interconnections across horizontal and vertical levels of society, facilitated or limited by social rules of varying flexibility. The study gathered both *emic* (insiders') and *etic* (outsiders') accounts of soil fertility management in rural western Kenya in its attempt to view agricultural decisions from the perspective of the farmer while locating those decisions within a general context.

Thus the methods of the study were: 1) to collect household wealth, education, employment, and farming data from 120 West Kenyan households; 2) to statistically test the association between these variables using multiple regression; 3) to collect several farming routines and biographical vignettes in order to elucidate the opportunities and constraints faced by farmers of varying access to social and physical capital; 4) to develop ethnographic descriptions of West Kenyan farmers in order to depict their relationships to their social and physical environments, thereby contextualizing the results of the study; and lastly 5) to collect background information on national and international agricultural policies and trends from Kenyan archives, gray literature at ICRAF, ICRAF personnel, and Kenyan administrative personnel in order to further contextualize the ground-level results of the study.

Research Hypotheses

According to Sanchez et al. (1997), the region of western Kenya has one of the highest population densities in the world and, as a result, shrinking agricultural landholdings and declining soil fertility. Because Boserup (1981) argues that in the face of population pressure, soil fertility is dealt with either through labor-intensive or industrial soil fertility enhancement, it follows that farmers in western Kenya should be either applying green manure (biomass transfer), using improved fallows, or applying mineral fertilizer in order to arrest the decline of agricultural yields. As such, this means farmers in western Kenya should be intensifying agricultural production because, as

Netting (1993:102) notes, the key characteristic of intensive agriculture is the manipulation of nutrients, water, and sunlight for increased plant growth during longer periods of time as well as the replenishment of elements that become exhausted. Intensification is a means of coping with limited space and time. Thus, the following two-part hypothesis incorporating Boserup and Netting's concepts was tested.

- **H1:** Farmers throughout western Kenya are intensifying agricultural production by increasing the availability of soil nutrients to their staple crops, thus increasing crop yields per area:

    a) Farmers' applications of soil fertility enhancement per acre of land (measured in kg of green manure per acre of land, acres of improved fallows per total acres of land, and/or kg of mineral fertilizer per acre of land) will be positively related to landholding size (measured in acres);

    b) Farmers' maize and bean yields (measured in kg per acre of land) will be positively related to landholding size (measured in acres).

On the other hand, rejection of H1 would imply that farmers in western Kenya are extensifying agricultural production. By applying Boserup's conception of intensive agriculture as described in Chapter 2 of this study, which eliminates the classic economic distinction between cultivated and uncultivated land as well as the notion of raising agricultural output through expansion of production at the so-called extensive margin, this study adopts the more recent definition of extensification as a means of decreasing agricultural yields per area (AgricultureDictionary.com). Rejection of H1 would imply that farmers in western Kenya, on average, are decreasing agricultural output per area of farmland through fewer applications of soil fertility enhancements. This would apply to both largeholders and smallholders. That is, H1 would be rejected following a negative association between farmers' yields per area of farmland and landholding size, as well as between farmers' applications of soil fertility enhancement per area of farmland and landholding size.

Because farms throughout western Kenya tend to be less than 2 hectares (4.9 acres) in size (Amadalo et al. 1998), households must supplement farm production with off-farm work in order to subsist (IEA/SID 2001; Orvis 1997; Ayieko 1995). Previous research indicates rural Kenyan households allocate labor in response to soil fertility, rainfall, and cash availability: households with marginal farmland and limited cash flows tend to invest less labor in on-farm production and more labor in off-farm work (Place et al. 2001; Orvis 1997; Ayieko 1995). Consequently, poorer farmers are less likely to apply labor-intensive soil fertility enhancing practices because these represent a risky use of available household labor that can instead be used off-farm to gain immediate cash. On the other hand, research throughout Latin America (De Janvry and Sadoulet 2001; Reardon et al. 2001; Ruben and van den Berg 2001) illustrates correlations between non-farm generated income and on-farm improvements. Similarly, Orvis (1997) correlates ongoing off-farm employment and on-farm re-investment in agriculture throughout Kenya. In either case, however, the findings fail to make the distinction whether off-farm agricultural jobs can generate the same level of on-farm improvements that nonfarm jobs can generate. The distinction is critical for countries whose nonfarm sectors provide for less than 50% of the labor force. Because agricultural jobs tend to yield lower incomes than nonfarm jobs (Tomich et al. 1995), they should result in lower levels of household re-investments in agricultural productivity—such as soil fertility enhancement. Thus, the following two-part hypothesis addressed whether the kind of off-farm income generation results in an expansion or contraction of agricultural productivity.

- **H2:** Nonfarm income generation leads to increased on-farm agricultural investments while agricultural off-farm income generation leads to decreased on-farm agricultural investments:

  a) The greater the number of household members employed in nonfarm work, the more a household invests in one or more of the following: kg/acre of green manure, square meters/acre of improved fallows, kg/acre of mineral fertilizer, days/acre of hired oxen, days/acre of hired labor, and/or kg/acre maize and bean seed;

  b) The greater the number of household members employed in agricultural wage work, the less a household invests in one or more of the following: kg/acre of green manure, square meters/acre of improved fallows, kg/acre of mineral fertilizer, days/acre of hired oxen, days/acre of hired labor, and/or kg/acre maize and bean seed.

Wealth, in general, is often correlated with higher levels of agricultural productivity. Wealthier households can afford to use more agricultural inputs, such as labor, seed, and fertilizer per area than can poorer households. Research throughout Yuscarán, Honduras (Morera and Gladwin 2006; Morera 1999) indicates that resource access is significantly tied to agricultural intensification measures. Research throughout some villages in western Kenya also indicates a positive link between wealth and the uptake of labor-intensive soil fertility enhancing technologies (Place et al. 2005). However, labor-intensive soil fertility enhancing technologies in western Kenya were researched and developed for lower-resource farmers unable to afford mineral fertilizers. The original assumption made by Sanchez et al. (1997) was that the technologies would be of particular importance to land and cash-constrained farmers grappling with declining yields. Nonetheless, the assumption made in this study is that labor-intensive soil fertility enhancing technologies are a form of intensification requiring labor inputs that wealthy— not poor—farmers can better afford. Moreover, because landholding size often denotes wealth irrespective of its direct effect on agricultural inputs and outputs as described in H1, it was incorporated into the following hypothesis as well.

- **H3:** The wealthier a household, the more it invests in agricultural productivity:

  Household wealth indicated by greater landholding size, number of cattle owned, cumulative years of schooling, and the receipt of bank loans leads to greater investment in one or more of the following: kg/acre of green manure, square meters/acre of improved fallows, kg/acre of mineral fertilizer, days/acre of hired oxen, days/acre of hired labor, and/or kg/acre maize and bean seed.

Because several proxies for wealth, such as land ownership, cattle ownership, and off-farm nonagricultural work in Kenya tend to be controlled by men, it follows that wealth-mediated investments in agricultural productivity should be higher for male-headed households than for female-headed households. That is, if it is the wealthier households that can invest in greater inputs of labor, seed, and fertilizer, then these should also tend to be male-headed households. On the other hand, because off-farm nonagricultural work generally involves the out-migration of a household's male(s) (Orvis 1997), *de jure* female-headed households, like wealthy male-headed households, will also have greater resources to invest in inputs of labor, seed, and fertilizer. The overall effect should be such that there is no difference between male-headed and female-headed household investments in agricultural productivity, including technological choice.

- **H4:** There is no difference between male-headed and female-headed household investment in one or more of the following: kg/acre of green manure, square meters/acre of improved fallows, kg/acre of mineral fertilizer, days/acre of hired oxen, days/acre of hired labor, and/or kg/acre maize and bean seed.

An important assumption of this study is that labor-intensive soil fertility enhancing technologies are no more affordable to resource-constrained farmers than are mineral fertilizers because labor inputs, long believed to be abundant, inexpensive, and the only factor of production controlled by the poor (Tomich et al. 1995; Marx 1859) can always be channeled into more remunerative activities if the payoff for labor investments in soil fertility enhancement are uncertain. For this reason, wealthier farmers should be better able to invest in them in the same way they are hypothetically better able to invest in mineral fertilizers. That is why the above hypotheses do not differentiate on the basis of technology—because whether labor-intensive or cash-intensive, where labor and cash units are interchangeable, all forms of soil fertility enhancement represent measures of intensification.

Nonetheless, labor-intensive soil fertility enhancement technologies remain an alternative or complement to mineral fertilizers which farmers may be unaware of. Thus an important objective of this study was to determine whether national or international agricultural institutional efforts to disseminate labor-intensive soil fertility enhancement technologies have been long lasting. Previous research experience in Honduras (Morera and Gladwin 2006; Morera 1999) indicates that technical knowledge is a necessary but insufficient condition of technological adoption. Farmers are often well-versed in labor-intensive soil fertility enhancing technologies but nonetheless choose to channel their labor into alternative livelihood strategies. Because resource access is a limiting factor in the uptake of agricultural intensification measures, there should be no difference in technological practices between nearby villages where agricultural institutions have disseminated labor-intensive soil fertility enhancing measures in some and not in others. Thus the current study tested the following hypothesis where the sample data comprised farmers from two villages where labor-intensive soil fertility enhancement technologies were disseminated 10 years ago as well as farmers from another two villages where labor-intensive soil fertility enhancement technologies were not disseminated.

- **H5:** There is no difference in soil fertility enhancement practices among farmers living throughout nearby villages where labor-intensive soil fertility enhancement technologies have been disseminated in some villages and not in others.

In addition to agricultural institutional efforts to affect farming practices, there are other factors originating beyond the farm that may provide incentives or disincentives to agricultural intensification. The most obvious of these is prices. If input prices are high and output prices are low, a simple mathematical equation will indicate whether an agricultural endeavor is feasible. Moreover, a cursory examination of input and output markets will reveal possible explanations for their prices.

For this study, a simple comparison of agricultural input and output prices during 2004 and 2007 as well as a firsthand comparison of transportation conditions between eastern and western Kenya and documentation of oil prices during the same period provides insight into market circumstances and contextualizes farmers' production patterns. The following two-part hypothesis incorporates basic indicators to gauge the likelihood of intensification or extensification in western Kenya.

- **H6:** If the international price of oil rises and driving time between eastern and western Kenya increases as a result of poor road conditions, the price of imported inputs (i.e. fertilizer) will rise faster than the price of outputs (i.e. maize) and farmers will not invest in the intensification of their maize production through the application of fertilizer.

Data Collection

This study predominantly took place throughout four farming villages in western Kenya, differentially involved in the past with a local soil fertility management project. The project disseminated organic soil fertility enhancement technologies, particularly improved fallows and biomass transfer, to both male and female farmers. The project was collaboratively implemented by the International Center for Research in Agroforestry (ICRAF)—now known as the World Agroforestry Centre--and the Kenya

Agricultural Research Institute (KARI) during the 1990s. Known simply as the "PLAR project," it used a "participatory action and learning approach" to acquaint resource-limited farmers with farming practices that promised to reduce their need for expensive fertilizers (Place et al. 2005). Of the four villages selected, two had been involved with the project. Thus, the villages of Mutsulio and Shikusi were selected for their involvement with the PLAR project while the villages of Lugango and Shinakotsi were selected for their lack of involvement with the PLAR project. All four villages are located near one another within Shinyalu Division in the Province of Western Kenya and share similar ecological and infrastructural conditions. Nonetheless, Mutsulio lies on a somewhat steeper ridge and furthest from the Khayega tarmac, which runs perpendicular to the unpaved road leading to the selected villages, as described and illustrated in Chapter 3.

Village selection was based on the assumption that participation with the PLAR project would have resulted in familiarization with and practice of soil fertility enhancement practices. It was assumed that at least some farmers in Mutsulio and Shikusi would still be practicing soil fertility enhancement practices at the time of this study. On the other hand, it was assumed that a lack of project involvement would have affected knowledge of the technologies, thereby resulting in fewer (although not necessarily significantly fewer) farmers practicing the soil enhancement technologies throughout the other two villages, Lugango and Shinakotsi, which had not participated in the PLAR project.

Data were collected for this study during three fieldwork seasons in order to gain a longer term perspective than would be possible had data been collected during a single consecutive fieldwork season. The first fieldwork season took place during a period of 6 months, from early February through late July of 2004. The second fieldwork season took place during a period of 9 months, from late March through late December of 2007. The third and final fieldwork season took place during a period of 2 months from mid June through mid August of 2008.

The first and second fieldwork seasons focused on household interviews with farmers living in the selected four villages of western Kenya. The third fieldwork season focused on interviews with personnel employed by nearby institutions and organizations affecting the farmers of Mutsulio, Shikusi, Lugango, and Shinakotsi. The third fieldwork season also focused on gathering secondary data from national archives in Nairobi, ICRAF's gray literature, and relevant online publications. The purpose of the third fieldwork season was to contextualize the information gathered from the household interviews.

A stratified sample of 120 households across the four villages was selected. The first selection consisted of thirty male-headed households (MHH) and thirty female-headed households (FHH) randomly chosen from a compilation of Mutsulio and Shikusi farmers' lists. The second selection consisted of thirty MHH and thirty FHH randomly chosen from a compilation of Lugango and Shinakotsi farmers' lists. The lists of farmers were compiled with the assistance of Shinyalu Division's assistant chief and a community leader, both of whom had worked as liaison farmers with the PLAR project and were well-acquainted with Shinyalu's farmers.

The assistant chief and community leader also located two fieldwork assistants who acted as language interpreters for this study during 2004 and 2007, respectively.

The fieldwork assistants were fluent in English, Swahili, and Luhya—Shinyalu's mother tongue—and were familiar with the location of the households to be interviewed. A third fieldwork assistant, independently located in Kisumu, Kenya, was also hired during 2007 for her language proficiency and previous experience working with diverse peoples. She moved to Kakamega, a large town located a few kilometers north of Shinyalu, and commuted each day to the selected villages for the duration of the 2007 fieldwork season. Each of the three fieldwork assistants was paid a wage of 300 Kenyan Shillings per day of fieldwork, which typically stretched from 9 am to 5 pm. The wage was typical for specialized non-rural labor in this area and was negotiated with the help of the assistant chief and community leader. In 2007, the wage was six times the wage for unspecialized agricultural labor.

During the 2004 fieldwork season, I lived in a convent in Mukumu, a small township located within biking distance of the selected villages. The convent was composed of Kenyan and Ugandan nuns, mostly hailing from nearby villages. The large house in which they lived featured spare rooms, electricity, running water, and security. Given my frequent need to work on a laptop, it was recommended I rent a room in the convent and commute by bicycle to the villages. In my spare time, I accompanied the nuns to local events, such as village celebrations, holiday feasts, and church gatherings. These extracurricular activities provided an unexpected source of comradeship and inclusion as well as a privileged view of rural life in western Kenya. On fieldwork days, I took a *boda-boda* (bicycle taxi) from the convent to Shikusi, where the first fieldwork assistant would be waiting. Together we would head out from there by foot to the selected households to conduct interviews.

During the 2007 and 2008 fieldwork seasons, I lived in a convent in Kakamega with the same order of nuns. On fieldwork days, together with the third fieldwork assistant, I commuted by *matatu* (small, privately owned buses serving as public transportation) to the Khayega tarmac which runs perpendicular to the unpaved road leading to the selected villages. From the tarmac, the third fieldwork assistant and I would take two boda-bodas to Shikusi, where the second fieldwork assistant would be waiting. From there the three of us would head out by foot to the selected households to conduct interviews.

Thus, each of the 120 selected households was visited in the company of the hired fieldwork assistants who helped interpret the interviews. Consent forms were obtained for all interviews and research participants were compensated for their time. In 2004, compensation consisted of a small Polaroid family portrait. In 2007, compensation consisted of either a small bag of tea leaves or half a kilogram of sugar.

Three ethnographic field methods were used throughout the individual visits to the 120 selected households: The ethnographic interview, the questionnaire, and participant-observation. These were based on the method employed by Spradley (1979) in *The Ethnographic Interview*. The ethnographic interviews consisted of informal dialogues between the farmers, the research assistants, and me. The interviews conducted in 2004 were in-depth, semi-structured, and open-ended. Heads of households were asked to discuss their experiences with the PLAR project, their sentiments regarding the recommended technologies, farming routines, livelihood strategies, and household dynamics. The first twenty-five interviews conducted in 2007 also took place in this manner. A survey questionnaire having a similar objective was created after approximately 40 such interviews, during the 2007 fieldwork season. The questionnaire was updated whenever new questions arose during a household interview. The questionnaire continued to be refined throughout the entire first half of the 120 household visits. Yet once the questionnaire was developed, interviews became more structured. During the second half of the 120 household visits, the interviews were strictly a survey. When these were completed, the first 60 households were visited a second time in order to elicit any questions not asked during the earlier data collection phase.

Participant-observation also took place during the interviews. On several different occasions, interviews were conducted in the midst of farming activities. Several interviews occurred in the field as the soil was tilled, on the floor of a home as vegetables were prepared for sale, and even on the grass as maize kernels were removed from cobs. The technique involved participating in the activities of the informant and learning while observing (Spradley 1979).

Conceptually, the difference between observation and participant-observation is that the former takes place in the researcher’s terms while, ideally, the latter takes place in the research participant’s terms. Spradley (1979:34) compares these two modes of enquiry as distinguishing “between treating people as actors and as informants,” respectively. Spradley emphasizes that treating people as informants emphasizes the researcher’s desire to understand the informants’ world from the informants’ perspective. Similarly, Harris (1979:32) distinguishes between *emic* or insider’s knowledge and *etic* or outsider’s knowledge. And while the insider’s view of a culture may never be entirely grasped by an outsider, ethnographic interviews and participant-observation are critical in designing meaningful and relevant questions about an informant's reality. That is why treating people as informants is radically different from treating them as actors, or even subjects and respondents (Spradley 1979:34). Bernard (2006:196) notes, "Respondents respond to survey questions, subjects are the subject of some experiment, and informants…well, informants tell you *what they think you need to know* about their culture."

According to Bernard (2006:196) there are two kinds of informants: specialized informants and key informants. Specialized informants "have particular competence in some cultural domain" and can speak knowledgeably about it (Bernard 2006:196). For example, because this study sought to gain an understanding of agricultural decision-making in western Kenya, as a researcher I interviewed western Kenyan farmers. In this case, the farmers interviewed were specialized informants. On the other hand, key informants are "people who know a lot about their culture and are, for reasons of their own, willing to share all their knowledge with you" (Bernard 2006:196). Key informants can explain to an outsider the meaning of a broad range of phenomena in their own culture. Bernard also notes that a researcher does not choose key informants—key informants and the researcher choose each other over time as a result of easy conversation (Bernard 2006:196).

For this study, several individuals graciously served as key informants. The community leader who had worked as a liaison farmer for the PLAR project and helped compile farmers' lists and select research assistants for this study, frequently met with me in order to help me make sense of my surroundings. He explained to me the agricultural technologies PLAR recommended to the farmers during the 1990s. He also provided a history of the area and offered descriptions of its customs. Most importantly, he helped me construct questions in ways that would be locally acceptable. One of the nuns at the convent also ensured questions, such as those regarding income, would not be inadvertently presented in offensive ways and frequently met with me to chat about local traditions. And of course, during the almost 200 visits to farmers' homes throughout the hillsides of Shinyalu Division, I had the great fortune of enjoying many stories from my fieldwork assistants who were pivotal in providing background information regarding Kenyan farming, education, social life, politics, and the economy from a Kenyan perspective.

Data Analysis

Because this study set out to identify factors affecting soil fertility management practices and staple crop productivity in western Kenya, the agricultural inputs invested and outputs yielded by a sample of farmers throughout four western Kenyan villages during a full growing season were each to be measured as dependent variables[1]. These dependent variables were to be calculated in acres or kg per total acres of agricultural land as follows: acres of improved fallows, kg of biomass transfer, kg of chemical fertilizer, days of oxen hire, days of labor hire, kg of maize and bean seed, and kg of maize and bean yields. The independent variables included:

- Gender: Male-Headed Household (MHH) or Female-Headed Household (FHH) (measured as a categorical variable and coded as 1 or 0, respectively)
- Number of household members
- Total household land (measured in acres as a continuous variable)

[1] Measurements were self-reported. Although Bernard (2006:245) notes that self-reported behavior and self-reported measurements of environmental circumstances result in errors, the logistical and budgetary constraints of this study necessitated reliance on informants' reports of socioeconomic data.

- Cattle ownership (measured as a continuous variable)
- Access to credit and bank loans (measured as a categorical variable where an affirmative response was coded as 1 and a negative response was coded as 0)—informants were asked whether they had access to credit or received a bank loan over the last 5 years
- Off-farm employment (measured as a categorical variable and coded according to whether household members were engaged in off-farm agricultural work, on-farm nonagricultural work, or off-farm nonagricultural work)
- Participation in the PLAR Project (measured as a categorical variable)
- Receipt of project incentives (measured as a categorical variable)—informants were asked if they had received payments of any kind in order to experiment with a technology, such as bags of fertilizer or seed
- Receipt of remittances (measured as a categorical variable)
- Months of maize purchase (number of months per year during which maize must be purchased as a result of insufficient household production)
- Membership in community organizations (measured as a categorical variable)
- Cumulative schooling of household head's children (in number of years of schooling per child)

However, by the end of the fieldwork season of 2007, it became clear that none of the sampled households were practicing improved fallows and only three were practicing biomass transfer. This meant that, for improved fallows and biomass transfer, there was no variation in the dependent variable against which the effects of the independent variables could be analyzed. On the other hand, most farmers used at least some chemical fertilizer. Thus, chemical fertilizer use became the only measure of soil fertility enhancement.

Additionally, the long rains season of 2007 became the frame of reference for most of the independent variables. For example, farmers were asked how many kg of diammonium phosphate (18-46-0) (DAP) chemical fertilizer were applied during the long-rains season of 2007, how many agricultural laborer days were hired during the long-rains season of 2007, how many household members were employed in off-farm jobs during the long-rains season of 2007, how many head of cattle were owned during the long-rains season of 2007, how many kg of maize were harvested at the end of the long-rains season of 2007, etc. This was done in an effort to systematize the observations, making them comparable, and to obtain an entire agricultural season of socioeconomic data. The long-rains season was selected because most farmers plant during this period of abundant rainfall whereas not all farmers plant during the short-rains season when rainfall is less dependable.

Multiple Regression Analysis

Multiple regression analysis in Excel was used in order to test the first five hypotheses of this study and determine how much each of the independent variables contributes to the prediction of agricultural inputs invested and outputs yielded in the production of staple crops by the sample of western Kenyan farmers during the long-rains season of 2007. Multiple regression analysis was used because it estimates an equation that accounts for these relationships as well as the interrelationships among the independent variables (Bernard 2006:661), providing the best fitting line between the points of observation. That is, it figures “how much variance in a dependent variable is accounted for by a series of independent variables after taking into account all of the overlap in variances accounted for across the independent variables” (Bernard 2006:661). It also provides a measure of association between the dependent variable and each of the independent variables, holding the other independent variables constant. This type of analysis was feasible because in this study the dependent variable was always a continuous, quantitative variable while the independent variables were either continuous quantitative variables or categorical variables coded as 1 or 0. Had the dependent variable been a categorical variable, multiple regression analysis would have been inappropriate.

The independent variables included in each multiple regression equation consisted solely of those variables theorized to affect the dependent variable, whether or not their associations with the dependent variable resulted significant once the regression was run. Stepwise multiple regression, where the program for statistical analysis "looks for the independent variable that correlates best with the dependent variable and then adds in [independent] variables one at a time, accounting for more and more variance, until all the specified variables are analyzed, or until variables fail to enter because incremental explained variance is lower than a preset value, say, 1%," was not used (Bernard 2006:667). While stepwise regression omits from the multiple regression equation those variables whose associations with the dependent variable are not significant, it can result in omitted variable bias, particularly when independent variables synergistically affect the dependent variable.

To build a multiple regression equation that tested the first hypothesis of this study (H1), which posits that farmers in western Kenya are intensifying agricultural production by increasing the availability of soil nutrients to their staple crops, production and input functions were estimated for each of the staple crops and for each of the main inputs farmers invest in to produce their staple crops, respectively. Therefore, production functions were estimated for maize yield per acre ($Q_{mzyield/acre}$) and for bean yield per acre ($Q_{bnyield/acre}$). Input functions were estimated for fertilizer use per acre ($Q_{fert/acre}$), oxen use per acre ($Q_{oxen/acre}$), labor hired per acre ($Q_{labor/acre}$), maize seeding per acre ($Q_{mzseed/acre}$), and bean seeding per acre ($Q_{bnseed/acre}$)[2].

The independent variables included in the production functions were limited to the inputs western Kenyan farmers required to produce maize and beans, identified through ethnographic interviews. For example, during one interview, a farmer explained that she used part of the funds gained through a bank loan to purchase fertilizer for her maize and beans. In another interview, a farmer pointed out that he improved his maize and bean yields by applying the seeding rates and distances recommended by the PLAR project. Thus "BankLoan," "TotalFertilizer/Acre" and "ProjectParticipation" were all included in the set of independent variables of which maize production and bean production are functions, as illustrated below. The same set of independent variables was used to estimate both functions because maize and beans are grown together. The production function for maize yield per acre ($Q_{mzyield/acre}$) was estimated as:

$$Q_{mzyield/acre} = f\,(MHHorFHH,\ TotalHHMembers,\ ProjectParticipation,\ Mz\&BnAcreage,\ VisitExtOffice,\ TrainingBaraza,\ GroupBorrow,\ BankLoan,\ NonAgOFW,\ AgWageWork,\ Brewing,\ OxenUse/Acre,\ HiredLabor/Acre,\ MaizeSeedingRate,\ BeanSeedingRate,\ TotalFert/Acre)$$

The production function for bean yield per acre ($Q_{bnyield/acre}$) was estimated as:

$$Q_{bnyield/acre} = f\,(MHHorFHH,\ TotalHHMembers,\ ProjectParticipation,\ Mz\&BnAcreage,\ VisitExtOffice,\ TrainingBaraza,\ GroupBorrow,\ BankLoan,\ NonAgOFW,\ AgWageWork,\ Brewing,\ OxenUse/Acre,\ HiredLabor/Acre,\ MaizeSeedingRate,\ BeanSeedingRate,\ TotalFert/Acre)$$

On the other hand, the independent variables selected for each of the input functions were those hypothesized to affect the application of intensification measures,

[2] To increase the availability of soil nutrients to crops, farmers normally increase plowing and seeding rates in addition to increasing fertilizer use or other forms of soil fertility enhancement.

such as gender, project participation, physical and social capital, off-farm work, and the application of other inputs. For example, the input function for fertilizer use per acre ($Q_{fert/acre}$) was estimated as:

$$Q_{fert/acre} = f\,(MHHorFHH,\ TinRoof,\ CattleOwned,\ AcresOwned,\ ProjectParticipation,\ GroupBorrow,\ BankLoan,\ NonAgOFW,\ AgWageWork,\ Brewing,\ OxenUse,\ HiredLabor,\ LaborShareOffFarm,\ LaborShareOnFarm,\ MaizeSeedingRate,\ BeanSeedingRate)$$

The same set of independent variables was included in the functions estimated for oxen use per acre ($Q_{oxen/acre}$), labor hire per acre ($Q_{labor/acre}$), maize seeding per acre ($Q_{mzseed/acre}$), and bean seeding per acre ($Q_{bnseed/acre}$). Moreover, because gender, project participation, physical and social capital, and off-farm work are the subjects of H2 through H5 of this study (listed on pages 6 through 9), in addition to testing H1, the input functions also tested H2 through H5.

Because wealth was hypothesized in H3 to affect soil fertility management and staple crop productivity, an aggregate wealth index based on the visible conditions of a farmer’s house (i.e. building materials, roof, floor, furniture, etc.), land, and livestock was created during the first half of the 2007 fieldwork season and a function estimated for it in order to assess its relationship to agricultural input investments as well as other proxies for wealth. Because gender, social capital, and alternate livelihood strategies were theorized to affect wealth, these were also included in the set of independent variables. The function was estimated as:

$$Wealth = f\,(MHHorFHH,\ TotalHHMembers,\ TinRoof,\ CattleOwned,\ AcresOwned,\ TrainingBaraza,\ BankLoan,\ OxenUse/Acre,\ HiredLabor/Acre,\ TotalFert/Acre,\ NonAgOFW,\ AgWageWork,\ Brewing,\ QMoMzPurch)$$

PLAR project participation was not included in the function's set of independent variables because, as the index was created only for Mutsulio and Shikusi villages, the data set in this case solely comprised project participants.

Additional functions that could be applied towards the entire data set were estimated for land ($Q_{acresowned}$) and cattle ($Q_{cattleowned}$) as wealth proxies in order to assess their relationships to alternate livelihood strategies and socioeconomic indicators. Thus the set of independent variables included the three main alternative livelihood strategies, off-farm nonagricultural work, agricultural wage work, and home-brewing, as well as socioeconomic indicators such as loan receipts and participation in merry-go-rounds and the PLAR project. The following function was estimated for landholding size ($Q_{acresowned}$):

$$Q_{acresowned} = f\,(MHHorFHH, TinRoof, CattleOwned, ProjectParticipation, MerryGoRound, GroupBorrow,$$
$$BankLoan, NonAgOFW, AgWageWork, Brewing)$$

A similar function using the same set of independent variables shown above was estimated for total cattle owned ($Q_{cattleowned}$).

During the course of ethnographic interviewing, several informants pointed out the manner in which income generated from alternative livelihood strategies was used, elucidating the interrelationships between nonfarm work and farming—an important objective of this study. They explained, for example, that remittances received from husbands' off-farm nonagricultural work were often applied towards school fees, while the income generated from the sale of brewed beer and liquor was often applied towards maize purchases. As a result, additional functions were estimated to predict cumulative years of children's schooling and months of annual maize purchase for household consumption. Cumulative years of schooling ($Q_{yrsschooling}$) were estimated as:

$$Q_{yrsschooling} = f\ (MHHorFHH,\ AcresOwned,\ CattleOwned,\ BankLoan,\ NonAgOFW,\ AgWageWork,\ Brewing,\ Mutsulio,\ Shikusi,\ Shinakotsi)$$

Months of annual maize purchase for household consumption ($Q_{monthsmzpurch}$) were estimated as:

$$Q_{momthsmzpurch} = f\ (MHHorFHH,\ TotalHHMembers,\ TinRoof,\ CattleOwned,\ ProjectParticipation,\ TrainingBaraza,\ BankLoan,\ KaleAcreage,\ MaizeAcreage,\ OxenUse/Acre,\ HiredLabor/Acre,\ TotalFert/Acre,\ MzYield/Acre,\ NonAgOFW,\ AgWageWork,\ Brewing)$$

During the course of ethnographic interviewing it also became evident that kale production was an important source of income for many farmers. As an alternative livelihood strategy, it was particularly relevant to this study as it appeared that some farmers were substituting, rather than complementing, their maize production with kale production. It became important to assess what kind of farmer would be more likely to switch from staple crop production to cash crop production. For this reason, the set of independent variables included physical and social capital indicators, such as land, cattle, and participation in training *barazas* and the PLAR project, as well as alternative livelihood strategies, such as off-farm nonagricultural work, agricultural wage work, and home-brewing. Therefore, a function was estimated for the amount of acres devoted to kale production ($Q_{kaleacreage}$) as follows:

$$Q_{kaleacreage} = f\ (MHHorFHH,\ TotalHHMembers,\ TinRoof,\ CattleOwned,\ MaizeAcreage,\ ProjectParticipation,\ TrainingBaraza,\ BankLoan,\ NonAgOFW,\ AgWageWork,\ Brewing,\ EnoughMzHarvest)$$

In sum, while the first set of functions analyzes factors affecting the production of maize and beans, the second set of functions analyzes factors affecting inputs towards maize and bean production, including soil fertility management measures. Together these functions test H1 through H5 of the study. The third set of functions analyzes the role of wealth in soil fertility management and agricultural productivity. The fourth set of functions analyzes the interrelationships between off-farm work, farming, and investment priorities while the final equation analyzes the relationship between cash crop production and staple crop production. In total, the functions estimated characterize the region's patterns of agricultural production and nonagricultural specialization.

Frequency Distributions

Data were also analyzed using frequency distributions in order to capture trends in household nonnumeric responses to semi-structured or open-ended questions. For example, frequency counts were tabulated for household data on social capital, income and expenses, and attitudes towards quality of life, agriculture, and the economy. For data on social capital, frequency counts were tabulated for total households participating in "merry go rounds" (community savings groups), training *barazas* (community workshops on agricultural technologies), agricultural labor-sharing groups, other social groups, and agricultural extension visits. For data on income and expenses, frequency counts were tabulated for the most common sources of income, the most common expenses, the most common crops sold, and whether yields provided sufficient food or whether food had to be purchased to supplement household production. For data on attitudes towards quality of life, agriculture, and the economy, frequency counts were tabulated for households observing either improvements or deterioration in their lives overall, in their agricultural production, and in their country’s economy.

Script Analysis

A script analysis was made of various agricultural routines depicted through farming calendars. Schank and Abelson (1977) define individuals' routine patterns of activities as "scripts." Scripts represent unconscious detailed knowledge that allows individuals to do less mental processing during frequently experienced events. In this case, scripts were elicited in order to explore differences between “good” and “bad” farming practices—an emic distinction informants often made during open-ended ethnographic interviews when commenting on the nature of farming routines. Thus, farming calendars were elicited from several informants and also compiled from the many in-depth and semi-structured interviews conducted throughout all four villages. Normative themes regarding idealized and constrained farming were incorporated into the calendars.

Farm History Analysis

Brief farm histories were elicited from several informants in order to provide a longitudinal backdrop to current agricultural and nonagricultural livelihood strategies observed during 2007. The histories bring to life the farming opportunities and constraints leading to current agricultural practices examined in this study, thereby providing a qualitative context in which quantitative results can be conceptualized. Informants were asked to describe their lives over the last decade with particular reference to changes in agricultural technologies and income generation.

Feasibility Analysis

Three simple calculations were made in order to compare 1) organic and inorganic fertility management practices, 2) on-farm and off-farm livelihood strategies, and 3) 2004 and 2008 input and output prices involved in the production and sale of maize. The first calculation documents the labor required in the biomass transfer of an amount of *Tithonia diversifolia* approximately equivalent to an application of 50 kg/ha of diammonium phosphate (18-46-0) (DAP). The calculation then converts the labor units to cash units and compares the cash cost of biomass transfer to the cash cost of 50 kg of DAP. The second calculation compares the labor and/or cash requirements of three alternatives for obtaining a 90 kg bag of maize using 2007 Shinyalu Division prices. In one scenario, the household purchases the maize. In a second scenario, the household produces the maize using biomass transfer. In a third scenario, the household produces the maize using inorganic fertilizer. Finally, the third and last calculation tests the sixth hypothesis (H6) of this study and compares the prices of inputs and outputs involved in producing and selling maize in Shinyalu Division from 2004. Together the three calculations test the feasibility of soil fertility management and agricultural intensification in western Kenya.

Conclusion

This chapter has discussed the motivations, assumptions, objectives, hypotheses, ethnographic techniques, and analytical tools involved in carrying out the empirical work of this study. By combining quantitative and qualitative methods, the study examined the nature of soil fertility management in western Kenya, investigating its role in agricultural productivity and exploring the effects of technological adoption, gender, off-farm work, and other off-farm factors on both. The study sought to establish whether institutional efforts to disseminate improved fallows and biomass transfer had lasting effects on the region’s farming systems and whether off-farm work and gender affected soil fertility enhancement practices and, in turn, agricultural intensification. The following chapter now turns to the research results themselves.

CHAPTER 5
RESEARCH RESULTS: THE MAKING OF A SUCCESSFUL FARMER

Introduction

This chapter presents the results of quantitative and qualitative analyses of ethnographic data collected from 120 households located throughout the villages of Mutsulio, Shikusi, Lugango, and Shinakotsi in western Kenya. Five sets of analyses were applied to the sample data: 1) multivariate statistics, 2) descriptive and inferential bivariate statistics, 3) script analysis, 4) farm history analysis, and 5) feasibility analysis. Multivariate statistics were used to analyze farmers' quantitative responses to specific ethnographic questions regarding their most recent farming season. Descriptive and bivariate statistics were used to analyze farmers' qualitative and open-ended responses to general ethnographic questions regarding social, financial, and agricultural activities. Script analysis was used to analyze farmers' agricultural routines. Farm history analysis was used to understand the conditions leading up to, and the results obtained from, adopting various technological and livelihood strategies. Lastly, feasibility analysis was used to assess the economic feasibility of several farming alternatives by calculating various costs and benefits derived from each using real world prices.

Statistical analysis was applied to responses elicited systematically of all farmers during the entire fieldwork season. On the other hand, script analysis was applied to agricultural routines compiled early in the field work season from open-ended ethnographic interviews during which farmers commented on their daily routines and nature of farming. Similarly, farm histories were compiled early in the fieldwork season from open-ended, in-depth interviews during which farmers commented on their past experiences and choices leading up to their current lives on the farm. Lastly, feasibility analysis was applied to hypothetical alternatives based on several technological and livelihood options recommended by agricultural institutions or witnessed throughout the fieldwork season.

Together, the five sets of analyses were used to address the six research questions discussed in Chapter 4 concerning agricultural productivity, soil fertility management, technological adoption, and the role of gender, off-farm work, and other off-farm factors on these. Results of multivariate statistics were used to test the first five hypotheses listed in Chapter 4 regarding the effects of landholding size, off-farm work, wealth, gender, and PLAR project participation on the per acre application of soil fertility enhancement measures and other intensification measures as well as on overall maize and bean production per acre. Results of descriptive and bivariate statistics were used to illustrate the effects of gender and project participation on farming activities. Results of script analysis and farm history analysis were used to contextualize and substantiate quantitative results. Results of feasibility analysis were used to test the sixth hypothesis listed in Chapter 4 regarding the effects of off-farm factors on soil fertility management.

Multivariate Statistics: Multiple Regression Analysis

The results of multiple regression analysis are illustrated in Tables 5-2 through 5-19. Each multiple regression corresponds to a linear equation, where

$$y=a+bx_1+bx_2+bx_3+\ldots bx_n+e,$$

and where *e* is an error term. The dependent *y* variables for each of these appear in blue at the top left hand corner of each of the tables. Each of the independent *x* variables are listed in the first column of each table under *X Variables* after *Intercept*. The *b* coefficients for each of the *x* variables are listed in the second column under *Coefficients* for each of the tables. The first of these is the coefficient for the *Intercept*, representing *a* in the equation. As an example, the linear equation corresponding to Table 5-2 is

$$y=269.80-13.87x_1+1.36x_2-58.67x_3-32.94x_4+80.77x_5-45.22x_6+30.85x_7+10.41x_8-0.01x_9-37.72x_{10}-12.08x_{11}+0.25x_{12}+35.59x_{13}+3.37x_{14}+11.08x_{15}+1.47x_{16}+e$$

where y= maize yield per acre cropped in maize and beans, x_1=MHH or FHH, x_2=TotalHHMembers, x_3=Project/NonProject, etc. Table 5-1 provides a legend for the codes used to identify each of the variables included in the multiple regression analyses.

As explained in Chapter 2, because western Kenya reportedly has one of the highest population growth rates in the world (Sanchez et al. 1997), I expected to find households increasing the productivity of their maize and bean farming through the application of soil fertility enhancing measures such as fertilizer, biomass transfer, and improved fallows as well as other intensification measures such as oxen use and hired labor. I also expected to find households with larger landholdings, more cattle, and more nonfarm income relative to agricultural off-farm income to be applying greater amounts of these measures per acre than households with smaller landholdings, fewer cattle, and less nonfarm income relative to agricultural off-farm income. On the other hand, I did not expect to find any differences in soil fertility management and other intensification measures between male-headed and female-headed households or between PLAR participant and non-participant households.

Therefore, I expected multiple regression analysis to result in a significant and positive association between landholding size and each of the intensification measures applied per acre, as suggested in the first hypothesis. I also expected significant, positive associations between each of the intensification measures applied per acre and both on-farm nonagricultural work (*brewing*) and off-farm nonagricultural work (*nonagofw*), as suggested in the second hypothesis. By the same token, however, I expected significant, negative associations between each of the intensification measures applied per acre and agricultural off-farm wage work. As suggested in the third hypothesis, I expected significant, positive associations between intensification measures applied per acre and each of the wealth proxies, measured as acres owned, cattle owned, cumulative years of children's schooling, and the receipt of bank loans. On the other hand, I did not expect multiple regression analysis to result in significant associations between any of the intensification measures and either gender of the household head (MHH or FHH) or PLAR project participation, as suggested in the fourth and fifth hypotheses.

However, it should be kept in mind that while fertilizer use, biomass transfer, and improved fallows were all to be measured as soil fertility enhancement practices, fieldwork revealed that by 2007 none of the 120 sample households were applying improved fallows and only three reported the use of biomass transfer. Instead, most households applied small quantities of fertilizer to their land, their sole means of enhancing its soil fertility. This meant that, for improved fallows and biomass transfer, there was no variation in the dependent variable against which the effects of the independent variables could be analyzed. Thus, the use of improved fallows and biomass transfer could not be included in multiple regression analysis. Fertilizer application per acre was the only measure of soil fertility enhancement which, together with oxen use per acre, hired labor per acre, and seed per acre were measured as indicators of intensification.

Production Equations

Production equations were estimated in order to assess sample household outputs of maize and beans per acre, thereby examining agricultural productivity and determining whether households were intensifying or extensifying staple crop production. As stated in the first hypothesis, I expected farmers to be intensifying their maize and bean production. Therefore, I expected the production regressions to result in significant and positive associations between landholding size and quantities of maize and bean yields. That is, if households were intensifying staple crop production, the larger a household's landholding, the greater the amount of maize and bean yields per acre. However, the production regressions instead resulted in negative associations between landholding size and maize and bean yields per acre, with only the amount of maize yield per acre significantly associated with landholding size. The association between landholding size and the amount of bean yield per acre was not significant.

The results of the production regressions, the multiple regression analyses of household production of maize per acre of land cropped in maize and beans (*y=maize yield per acre cropped in maize and beans*) and household production of beans per acre of land cropped in maize and beans (*y=bean yield per acre cropped in maize and beans*), appear in Tables 5-2 and 5-3, respectively. As noted earlier, each *y-variable* appears in blue at the top left hand corner of each table. *Significance F*, corresponding to the overall significance of each equation, appears towards the center of each table. *X-variables,* whose associations with the dependent variable are significant, are marked in red. *X-variables,* whose associations with the dependent variable are only somewhat significant, are marked in orange.

Maize production

Table 5-2 indicates that a household's per acre yield (*y=maize yield per acre cropped in maize and beans*), the dependent variable, is significantly and negatively associated (P=.04) with land size (*maize and beans acreage*). On the other hand, the table also indicates that a household's crop of maize is significantly and positively associated with oxen used (*oxen used per acre of land cropped in maize and beans*) (P=.004), bean seeding rate (*bean seeding per acre of land cropped in maize and beans*) (P=.03), and fertilizer used (*total fertilizer used per acre of land cropped in maize and beans*) (P=.11). Project participation (*PLAR project participation/nonparticipation*) is somewhat significantly and negatively associated with the dependent variable (P=.18).

Bean production

Table 5-3 indicates that a household's crop of beans (*y=bean yield per acre cropped in maize and beans*), the dependent variable, is negatively but not significantly associated with land size. Instead, a household's crop of beans is significantly associated with project participation (P=.03) and brewing of chang'aa or busaa for sale (*brewing*) (P=.09), in both cases negatively. A household's crop of beans is also significantly and positively associated with the ability to borrow from a group (P=.07). Yet it is only somewhat significantly and positively associated with bean seeding rate (P=.18).

Input Equations

Input equations were estimated in order to assess sample household applications of inputs per acre of land cropped in maize and beans for oxen used, hired labor, fertilizer used, and maize and bean seeding rates. Similar to production equations, input equations were estimated as a way of examining agricultural productivity and determining whether households were intensifying or extensifying staple crop production. Because I expected households to be intensifying their maize and bean production, I also expected the input regressions to result in significant and positive associations between landholding size and quantities of inputs applied per acre. However, the input regressions instead resulted in negative associations between landholding size and quantities of inputs applied per acre, with only fertilizer use (Table 5-5) and bean seeding rate (Table 5-13) significantly associated with landholding size. Oxen use (Table 5-7) and maize seeding rate (Table 5-11) were somewhat significantly associated with landholding size.

The selection of independent variables included in the input equations also allowed me to assess whether the kind of off-farm work affected staple crop production, as suggested in the second hypothesis listed in Chapter 4. Because I expected that greater amounts of nonagricultural off-farm income generation would lead to greater amounts of agricultural inputs applied to staple crop production, I also expected a significant and positive association between off-farm nonagricultural work and each of the inputs applied. On the other hand, because I expected that greater amounts of agricultural wage work lead to smaller amounts of agricultural inputs applied to staple crop production, I expected a significant and negative association between agricultural wage work and each of the inputs applied. The results of the input regressions supported these hypotheses in five cases. Off-farm nonagricultural work resulted significantly and positively associated with oxen use (Tables 5-6 and 5-7) while agricultural wage work resulted somewhat significantly and negatively associated with hired labor (Table 5-9) and with bean seeding rate (Tables 5-12 and 5-13).

Finally, the selection of independent variables included in the input equations also allowed me to assess whether gender and project participation affected the application of soil fertility enhancement practices and other intensification measures. As suggested in the fourth and fifth hypotheses listed in Chapter 4 (the third hypothesis is addressed by the wealth equations discussed further ahead), I expected no gender or project participation differences in the application of soil fertility enhancement practices or other intensification measures. Thus, I expected the input regressions would not yield any significant associations between any of these. However, the input regressions indicate project participation is somewhat significantly and positively associated with fertilizer use (Table 5-4) and significantly but negatively associated with maize seeding rate (Table 5-11). It is also significantly and negatively associated with oxen use. The input regressions also yielded a significant and positive association between female-headed households and hired labor (Tables 5-8 and 5-9). Nonetheless, because none of the 120 sample households were using improved fallows and only 3 were using biomass transfer, the effects of gender and project participation on labor intensive soil fertility enhancement measures were nil.

The results of the input regressions, multiple regression analyses for each of the agricultural inputs farmers used on their fields throughout the growing season in order to produce outputs of maize and beans, appear in Tables 5-4 through 5-13. The five inputs analyzed are: Fertilizer used, oxen used, labor hired, maize seeding rate, and bean seeding rate. Two tables are presented for each input used per acre of land cropped in maize and beans, for a total of 10 tables. The first table for each input presents a multiple regression analysis of all the variables hypothesized to affect the application of that input, including the application of the remaining inputs. That is, the use of one input is hypothetically affected by the use of another input. For example, it is unlikely for a farmer to invest in the mineral fertilization of a field that is not properly plowed. However, it is possible that including highly correlated variables in a multiple regression analysis results in multicollinearity. According to Agresti and Finlay (1997:397), "once certain important predictors are in the model, the addition of other variables often provides only a small boost in R^2"—"the amount of variance accounted for by the independent variables" (Bernard 2006)—particularly when the additional variables have small associations with the dependent variable and are "highly correlated, no one having much unique explanatory power." Thus a second set of multiple regressions was run for each of the inputs analyzed, this time omitting the remaining input variables from the equation in an effort to control for multicollinearity. These are presented in a second table for each input.

Fertilizer use

The results of the first multiple regression analysis for fertilizer use as the dependent variable (*y = total fertilizer per acre cropped in maize and beans*) appears in Table 5-4. Results indicate that a household's fertilizer use is significantly and positively associated with having a tin roof (P=.04), receiving a bank loan (P=.02), with oxen use (P=.02), hired labor (P=.04), participation in an off-farm labor sharing group (*labor share off-farm*) (P=.04), and bean seeding rate (P=01). Fertilizer use is also somewhat significantly and positively associated with project participation (P=.12) while it is somewhat significantly but negatively associated with participation in an on-farm labor sharing group (*labor share on-farm*) (P=.14).

The results of the second multiple regression analysis for fertilizer use as the dependent variable appear in Table 5-5. The results are similar to the first regression analysis except that, in this case, fertilizer use is significantly associated (P=.04) with landholding size (*total acres owned*). The association is negative. As mentioned earlier, the associations between landholding size and each of the inputs applied per acre are negative throughout all the multiple regression analyses. Table 5-5 also indicates that fertilizer use here is significantly and positively associated with cattle owned (*total cattle*) (P=.04) and the ability to borrow from a group (P=.04). However, a household's tin roof does not result significantly associated with fertilizer use in this analysis.

Oxen use

Table 5-6 presents the first of two multiple regression analyses for oxen use as the dependent variable (*y = oxen use per acre cropped in maize and beans*). Results indicate that oxen use is significantly and positively associated with cattle owned (P=.04), the ability to borrow from a group (P=.06), off-farm nonagricultural work (*nonagofw*) (P=.05), maize seeding rate (*maize seeding per acre cropped in maize and beans)* (P=.01), and fertilizer use (P=.02). On the other hand, oxen use is significantly but negatively associated with project participation (P=.07).

Table 5-7 presents the second multiple regression analysis, for oxen use as the dependent variable. The results are similar to those of the previous analysis except that here, oxen use is somewhat significantly and negatively associated with landholding size (P=.15) and tin roof (P=.16). Also, cattle ownership is more highly a predictor of oxen use (P=.01).

Hired labor

The first of two multiple regression analyses for hired labor as the dependent variable (*y = hired labor per acre cropped in maize and beans*) appears in Table 5-8. Results indicate that hired labor is significantly and negatively associated (P=.02) with whether a household head is male or female (*male-headed household or female-headed household*). Because male-headed households were coded as 1 and female-headed households were coded as 0, the negative sign of the coefficient indicates hired labor is significantly and negatively associated with a household head being male but significantly and positively associated with a household head being female. Results also indicate hired labor is significantly and positively associated with cattle owned (P=.01), participation in an on-farm labor sharing group (P=.002), bean seeding rate (P=.02), and maize seeding rate (P=.04). On the other hand, hired labor is significantly but negatively associated with participation in an off-farm labor sharing group (P=.10).

The second multiple regression analysis for hired labor as the dependent variable appears in Table 5-9. The results are the same as those for the previous analysis except that with the other agricultural inputs omitted from the regression, the association between hired labor and cattle owned is highly significant in this case (P=.002). The significance of the association between hired labor and gender of the household head remained the same (P=.02).

Maize seeding rate

Table 5-10 presents the first of two multiple regression analyses for maize seeding rate as the dependent variable (*y = maize seeding per acre cropped in maize and* *beans*). Results indicate that maize seeding rate is significantly and positively associated with oxen use (P=.01) and bean seeding rate (P=.002). Maize seeding rate is also somewhat significantly and positively associated with participation in an on-farm labor sharing group (P=.18) and somewhat significantly but negatively associated with participation in an off-farm labor sharing group (P=.16).

Table 5-11 presents the second multiple regression analysis for maize seeding rate as the dependent variable. With the other agricultural inputs omitted from the regression in this case, the maize seeding rate is significantly and positively associated with the ability to borrow from a group (P=.06) and significantly but negatively associated with having a tin roof (P=.08). Maize seeding rate is somewhat significantly and positively associated with cattle owned (P=.18). Yet it is somewhat significantly but negatively associated with landholding size (P=.11).

Bean seeding rate

The last two input regressions appear in Tables 5-12 and 5-13. Table 5-12 presents the first of two multiple regression analyses for bean seeding rate as the dependent variable (*y = bean seeding per acre cropped in maize and beans*). Results indicate that bean seeding rate is significantly and positively associated with hired labor (P=.02), maize seeding rate (P=.002), and fertilizer used (P=.01). On the other hand, bean seeding rate is significantly but negatively associated with the receipt of a bank loan (P=.06). Landholding size (P=.19), the ability to borrow from a group (P=.15), and agricultural wage work (*agwagework*) (P=.13) are all somewhat significantly and negatively associated with the bean seeding rate.

Table 5-13 presents the second multiple regression analysis for bean seed seeding rate as the dependent variable. With the other agricultural inputs omitted from the regression, the bean seeding rate in this case is significantly and negatively associated with landholding size (P=.02), its best predictor. Bean seeding rate also results somewhat significantly and negatively associated with having a tin roof (P=.14) and somewhat significantly and positively associated with cattle owned (P=.17) in this case. The negative association between bean seeding rate and agricultural wage work remains relatively the same.

Wealth Equations

Wealth equations were estimated as a means of assessing whether wealth indicators were associated with greater applications of soil fertility enhancement measures and other intensification measures, as suggested in the third hypothesis listed in Chapter 4. Because I expected wealth indicators such as landholding size, cattle ownership, and the receipt of bank loans to lead to greater applications of soil fertility enhancement measures and other intensification measures, I expected multiple regression analysis to result in significant and positive associations between each of the wealth variables and the application of agricultural inputs. The previous input regressions, overall, support these hypotheses as does Table 5-14, which treats wealth as an aggregate dependent variable and indicates that it is significantly and positively associated with fertilizer use per acre and oxen use per acre. Table 5-14 also indicates that wealth is significantly and negatively associated with the number of months throughout the year that maize must be purchased.

Moreover, the wealth regressions support the hypotheses regarding nonfarm income generation and agricultural wage work. That is, off-farm nonagricultural work resulted significantly and positively associated with landholding size (Table 5-15) as well as with cumulative years of schooling received by a household head’s children (Table 5-

17). On the other hand, agricultural wage work resulted significantly and negatively associated with landholding size (Table 5-15) and with cumulative years of schooling received by a household head's children (5-17).

In turn, multiple regression analysis of children's cumulative years of schooling also helped clarify the role of husbands' nonagricultural off-farm income received as remittances. Several female-headed households reported that children's schooling was the responsibility of the husband, noting that nonagricultural off-farm income was applied towards school fees. In addition to cumulative years of schooling, off-farm nonagricultural work is only significantly and positively associated with oxen use (Tables 5-6 and 5-7) and landholding size (5-15).

Multiple regression analyses of three measures of wealth appear in Tables 5-14 through 5-16. The first of these measures, "wealth index," is an aggregate measure based on the visible conditions of a farmer's house (i.e. building materials, roof, floor, furniture, etc.), land, and livestock. The measure was created during the first half of the 2007 fieldwork season and corresponds to 54 households interviewed throughout the villages of Mutsulio and Shikusi. On the other hand, the second and third measures of wealth, "total acres owned" and "total cattle owned," are based on household responses and correspond to the entire data set.

Wealth index

The results of multiple regression analysis for "wealth index" as the dependent variable (*y* = *wealth index*) appear in Table 5-14. Results indicate that wealth is significantly and positively associated with fertilizer use (P=.04), oxen use (P=.10), and landholding size (*total acres owned*) (P=.10). It is somewhat significantly and positively associated with participation in training barazas (P=.14). On the other hand, wealth is significantly but negatively associated with the number of months per year maize must be purchased (*quantity of months/year maize is purchased*) (P=.07).

Landholding size

Table 5-15 presents the results of multiple regression analysis for landholding size as the dependent variable (*y=total acres owned*). Results indicate that landholding size is significantly and positively associated with male-headed households (P=.02), cattle owned (P=.0003), and off-farm nonagricultural work (P=.007). It is somewhat significantly and positively associated with the ability to borrow from a group (P=.16). On the other hand, landholding size is significantly and negatively associated with agricultural wage work (P=.08) and brewing chang'aa and busaa for sale (P=.03).

Cattle owned

The results of multiple regression analysis of total cattle owned as the dependent variable (*y=total cattle owned*) appear in Table 5-16. Results indicate that cattle owned is significantly and positively associated with male-headed households (P=.08), landholding size (P=.0003), and the receipt of a bank loan (P=.09). It is somewhat significantly and positively associated with having a tin roof (P=.16) and with brewing chang'aa and busaa for sale (P=.13).

Cumulative years of schooling

The final wealth regression appears in Table 5-17, which presents the multiple regression analysis of cumulative years of schooling received by a household head's children (*y=children's cumulative years of schooling*). Results indicate that cumulative years of schooling are significantly and positively associated with off-farm nonagricultural work (P=.05) and with the receipt of a bank loan (P=.10). It is also somewhat significantly and positively associated with total cattle owned (P=.19).

However, cumulative years of schooling are significantly and negatively associated with agricultural wage work (P=.07).

Additional Equations

Additional multiple regressions were run in order to clarify the factors associated with the production and sale of kale as well as chang'aa and busaa, topics that came up frequently during ethnographic interviews. Informants reported kale, chang'aa, and busaa were their most important sources of cash (see Figure 5-7). Yet kale, on the one hand, constitutes a cash crop while chang'aa and busaa, on the other hand, constitute locally manufactured nonfarm goods. Moreover, the circumstances under which kale production or chang'aa and busaa brewing were undertaken seemed to differ. Informants who reportedly grew kale for sale, tended to be better off overall while informants who reportedly brewed chang'aa and busaa for sale tended to be worse off overall. The results of the following multiple regression analyses, presented in Tables 5-18 and 5-19, support these deductions (as does Table 5-15 which indicates that brewing chang'aa and busaa for sale is associated with smaller landholdings).

Kale acreage

Table 5-18 presents the multiple regression analysis for kale acreage as the dependent variable (*y=kale acreage*). Results indicate that kale acreage is significantly and positively associated with the number of individuals in a household (*total household members*) (P=.02), with off-farm nonagricultural work (P=.07), and with the production of sufficient maize to last an entire year (*enough maize harvest*). It is also somewhat significantly and positively associated with total cattle owned (P=.20) and with participation in training barazas (P=.11). Kale acreage is significantly and negatively associated with maize and bean acreage (P=.09).

Number of months maize is purchased for consumption

Table 5-19 presents the multiple regression analysis for the number of months per year a household purchases maize for consumption as the dependent variable (*y=number of months per year maize is purchased*). Results indicate that the number of months of maize purchase is significantly and positively associated with the brewing of chang'aa and busaa for sale (P=.01) and with the number of individuals living in the household (P=.08). On the other hand, the number of months of maize purchase is significantly but negatively associated with total cattle owned (P=.05), project participation (P=.01), the receipt of bank loans (P=.03), maize and bean acreage (P=.002), and maize yield per acre (P=.07). Of these, maize and beans acreage best predicts, negatively, the number of months per year maize must be purchased for consumption.

Descriptive and Inferential Bivariate Statistics: Frequency Distributions and Two-Tailed t-Test for Difference of Means

Descriptive statistics here provide a concise view of the 120 farming households' qualitative responses to the study's questions regarding farming practices, income and expenses, off-farm work, social capital, and impacts of structural adjustment. More specifically, descriptive statistics are used to summarize the sample data's trends in crop production, cash sources, recurring expenses, social group membership, technological use, farming ideals, investment preferences, and attitudes towards quality of life, farm, and economy. The information is conveyed using bar graphs and pie graphs, illustrated in Figures 5-1 through 5-30. Most trends are presented as an aggregate whole as well as segregated by PLAR project participation and by gender, resulting in three graphs per trend, with numbers of farmers appearing on the y-axes and farmers' responses appearing on the x-axes (Figures 5-1 through 5-28). In these cases, inferential bivariate statistical tests were conducted in order to ascertain any significant differences between project participating households and non-participating households and between male-headed households and female-headed households. Where a two-tailed t-test for a difference of means resulted in a significant P-value ($P \leq .10$), the P-value is illustrated on the bar graph.

Crops Sold

All farmers interviewed were asked what crops they most often sell. Figure 5-1 summarizes in a bar graph their most commonly sold crops. Each bar represents the number of farmers reporting the sale of the crop labeled on the *x*-axis. Nonetheless, each of the crops illustrated are grown for both sale and consumption. Almost 20% of all farmers interviewed produce strictly for consumption.

In Figure 5-2 the crops sold are segregated by PLAR project participation. As shown, a significantly larger number of project participating farmers sell kale, cabbage, and collards (P=.0002), maize and beans (P=.01), and tea leaves (P=.004) than do non-participating farmers. A significantly larger number of non-participating farmers sell no crops at all (P=.009).

In Figure 5-3 the crops sold are segregated by gender. As shown, a significantly larger number of female-headed households sell cowpeas (the leaves) and other green leafy vegetables (P=.06) such as pumpkin leaves and *mirro* (a local leafy vegetable), than do male-headed households. A significantly larger number of female-headed households also sell other crops (P=.002) such as cassava, pineapple, avocado, sweet potato, onion, and papaya.

Household Use of Remittances

All farmers interviewed were asked whether anyone from the household was currently employed outside the farm and sending back remittances. Though not illustrated, nearly all household members working outside the farm were employed in nonfarm jobs. On the other hand, most household members employed in agricultural wage work did not live outside the homestead. Thus remittances were chiefly composed of nonfarm earnings.

Figure 5-4 illustrates the most common expenditures remittances are used for. Each bar represents the number of farmers who apply their remittances to the expenditure listed on the *y*-axis. Figure 5-4 also indicates that almost half of all farmers interviewed were receiving no remittances. Figure 5-6 indicates that most of these were male-headed households. Female-headed households most commonly received remittances from husbands and sons, as it is more common for males to migrate in search of off-farm work.

Figure 5-5 indicates that there is no significant difference between PLAR project participant and non-participant usage of remittances. On the other hand, Figure 5-6 indicates that a significantly higher number of female-headed households apply remittances towards business such as retail and brewing (P=.04), farm inputs (P=.0007), and school fees (P=.06). As mentioned, a significantly higher number of male-headed households receive no remittances (P<.0001).

Most Important Cash Sources

All farmers interviewed were asked to name their most important sources of cash. Figure 5-7 illustrates their most common responses. Each bar represents the number of farmers who mentioned the source of income listed on the *x*-axis as an important source of cash.

Figure 5-8 indicates that a significantly higher number of PLAR project participants than non-participants reported that the sale of kale provides an important source of cash (P=.02). Figure 5-9 indicates that a significantly higher number of female-headed households reported that the sale of bananas (P=.001), leafy greens (P<.10), and retail (P=.006) provide important sources of cash. On the other hand, a significantly higher number of male-headed households reported that the sale of tea (P=.06), milk (P=.06) and paid labor (P=.02) provide important sources of cash.

Most Important Expenditures

All farmers interviewed were asked to name their most important expenditures. Figure 5-10 illustrates their most common responses. Each bar represents the number of farmers who mentioned the expenditure listed on the *y*-axis as an important expenditure.

Figure 5-11 indicates that a significantly higher number of PLAR project participants report that farming inputs are their most important expenditure (P=.01) while a significantly higher number of non-participants report that sugar is their most important expenditure (P=.001). Figure 5-12 indicates that a somewhat significantly higher number of female-headed than male-headed households reported that school fees are their most important expenditures (P=.11).

Social Capital

All farmers interviewed were asked about the social and financial groups they belong to as well as the agricultural groups and training they have participated in. For example, farmers were asked whether they belong to a *merry-go-round*, a local financial group to which members contribute money monthly and each month one member keeps the entire amount contributed. Farmers were also asked whether they belong to other social groups such as funeral groups and widows' groups, from which they can borrow money. They were also asked whether they had ever received a bank loan. Regarding agricultural groups, farmers were asked whether they regularly participated in on-farm or off-farm labor sharing groups. They were also asked about their interactions with local agricultural extension offices in order to clarify whether they had ever been visited by or sought advice from an extension officer. Finally, farmers were asked whether they have ever received inputs such as fertilizer or seed as an incentive to experiment with a technology and whether they currently practice improved fallowing or biomass transfer. Figure 5-13 illustrates all these trends.

Figure 5-14 indicates that a significantly higher number of PLAR project participants than non-participants can borrow from a social group they belong to (P=.04), have participated in a training baraza--a community meeting in which an agricultural technology is explained and illustrated (P=.0004), have received extension visits to their farm (P<.0001), have visited their local extension office (P=.02), and have received seed or fertilizer as an incentive to experiment with an agricultural technology or increase agricultural productivity (P<.0001). On the other hand, Figure 5-14 illustrates that there is no significant difference in the practice of improved fallowing and biomass transfer between PLAR project participants and non-participants.

Figure 5-15 indicates that a higher number of female-headed than male-headed households belong to a merry-go-round (P=.02) and can borrow money from a social group they belong to (P=.09). Figure 5-15 also indicates that there is no significant difference in the practice of improved fallowing and biomass transfer between male-headed and female-headed households.

Technological Dissemination

Figures 5-16 through 5-18 further illustrate farmers' participation in agricultural technology-related activities. Figure 5-16 indicates that while half of all farmers interviewed have been trained in the application of improved fallows and biomass transfer through a training baraza, less than 4% practice the technologies. The graph also indicates that a little over a third of all farmers interviewed have received an extension visit to their farms while approximately only a tenth have visited their local extension office. Figure 5-17 provides a close-up illustration of the significant differences between PLAR project participant and non-participant agricultural technology-related activities also illustrated in Figure 5-14. Figure 5-18 provides a close-up illustration of the lack of significant differences between male-headed and female-headed household agricultural technology-related activities also illustrated in Figure 5-15.

Quality of Life, Farm, and Economy

All farmers interviewed were asked about the current quality of their lives, farms, and national economy as compared to 5 years ago. They were asked to rate each according to whether it was worse, the same, or better. Figure 5-19 captures their responses and indicates that more than half of all farmers feel that the quality of their lives, farms, and national economy are all worse now than 5 years ago. Yet Figure 5-20 indicates that a significantly higher number of PLAR project participants reported that their lives were better now than 5 years ago (P=.06) while a significantly higher number of non-participants reported that their lives were worse now than 5 years ago (P=.01).

Similarly, Figure 5-24 indicates that a significantly higher number of PLAR project participants reported that the national economy was better now than 5 years ago ($P<.0001$) while a significantly higher number of non-participants reported that the national economy was worse now than 5 years ago ($P<.0001$). On the other hand, Figure 5-22 indicates there is no significant difference in the responses made between PLAR project participants and non-participants regarding the quality of their farms now compared to 5 years ago. Figures 5-21 and 5-25 also indicate there is no significant difference between male-headed and female-headed household responses regarding the quality of their lives and national economy. Yet Figure 5-23 indicates that a significantly higher number of female-headed than male-headed households reported that their farms are the same now as 5 years ago.

What Would Improve Your Farm?

All farmers interviewed were asked to name the single most important thing that would improve their farm. Figure 5-26 captures their open-ended responses and illustrates that fertilizer was their most common response. Overall, the frequencies of the responses appearing on the *y*-axis of Figure 5-26 were equally distributed between PLAR project participants and non-participants and between male-headed and female-headed households, as is also illustrated in Figures 5-27 and 5-28. The only significant difference is illustrated in Figure 5-28 where a higher number of male-headed households than female-headed households reported that more land would provide the single most important improvement to their farms ($P=.06$).

Investment Preferences

All farmers interviewed were asked, hypothetically, what they would do with 5000 Kenyan Shillings (approximately $70) if they could obtain a bank loan. Their open-ended responses were grouped into 6 main categories and appear in Figure 5-29. The pie graph is divided according to the percentage of farmers' responses falling into each group. For example, responses such as "buy more fertilizer" and "buy more land" were grouped under "Improve/Expand Farm." Responses such as "buy a cow" and "buy chickens" were grouped under "Livestock." Responses such as "buy and resell fish" and "buy and resell tomatoes" were grouped under "Retail." Responses such as "begin brewing and selling *chang'aa* (a local liquor)" and "begin making and selling *mandazis* (a local pastry)" were grouped under "Industry." Responses such as "plant and sell sugarcane" and "plant and sell kale" were grouped under "Cash Crop." Finally, responses such as "buy sugar" and "pay for school fees" were grouped under "Expenditures." The graph indicates that while almost a third of all farmers would use the loan to improve or expand their farms, 44% would apply it towards nonfarm activities and 60% would invest the funds in alternatives to crop production.

The Making of a Successful Farmer

All farmers interviewed were asked what they believe makes a successful farmer. Their open-ended responses were grouped into 5 main categories and appear in Figure 5-30. The pie graph is divided according to the percentage of farmers' responses falling into each group. Responses such as "money" and "enough fertilizer" were grouped under "Resource Access." Responses such as "proper timing" and "proper weeding" were grouped under "Proper Procedures." Responses such as "grow many crops" and "plant different things" were grouped under "Crop Variety." Responses such as "don't be lazy" and "commitment" were grouped under "Effort." Finally, responses such as "grow tomatoes for market" and "plant sugarcane for sale" were grouped under "Cash Crop." The graph indicates that almost two-thirds of all farmers feel that resource access is the key to successful farming while another 21% feel that proper procedures, whose understanding is often inaccessible, make a successful farmer. Only 7% of all farmers feel successful farming depends solely on effort.

Script Analysis

A script analysis was made of various agricultural routines depicted through farming calendars. Schank and Abelson (1977) define individuals' routine patterns of activities as "scripts." Scripts represent unconscious detailed knowledge that allows individuals to do less mental processing during frequently experienced events. In this case, scripts were elicited in order to explore differences between “good” and “bad” farming practices—a comparison farmers often made when commenting on the nature of farming routines during open-ended ethnographic interviews.

Farming calendars were elicited from several farmers and also compiled from the many in-depth and semi-structured interviews conducted throughout all four villages. Normative themes regarding idealized and constrained farming were incorporated into the calendars. These are illustrated in Tables 5-21 and 5-22. A more generalized, all-encompassing calendar is featured in Table 5-20.

The main difference between the three calendars lies in the timing of farming routines. The “good” farmer undertakes land preparation, planting, weeding, and harvesting early in the farming season. The “bad” farmer undertakes these late in the farming season, sometimes altogether skipping a prescribed farming chore such as a second plowing, gapping (replanting where germination did not take place), or a second weeding. The “good” farmer waits until the price of maize rises before selling. The “bad” farmer sells immediately after the harvest. The “worst” farmers do not plant at all;

they rent out their land. Of course, an underlying and understated factor in the timing of farming activities is resource access, particularly to cash and labor.

Farm History Analysis

Tables 5-23 through 5-25 present the brief farm histories of three farmers living in three of the four sampled villages. The stories bring to life the farming opportunities and constraints examined in this study, thereby providing a qualitative context in which previous quantitative results can be conceptualized. Their stories were selected for farm history analysis because of the varied circumstances of the farmers' livelihood and farming strategies. Yet it is important to note that despite the variations, none of the three farmers practiced labor-intensive soil fertility enhancement strategies. Two of the farmers, "Yohana" and "Mr. James," were familiar with improved fallow and biomass transfer technologies but chose not to apply them. The third farmer, "Mrs. Odhiambo," had never heard of them. Moreover, the role of resource access across the three stories supports the hypotheses of Chapter 4. In the first story, nonfarm remittances and the receipt of a bank loan led to farming improvements, particularly increased fertilizer use and larger harvests. In the second story, sufficient land and maize production go hand in hand with kale production. In the third story, agricultural wage work led to the neglect of on-farm activities.

"Yohana"

Table 5-23 presents "Yohana's" farm history. Her story indicates that her household is female-headed. She receives remittances from her husband who lives and works in Nairobi. She also receives remittances from her sister.   Yohana recently improved her farming through the receipt of a bank loan. Prior to that, she was unable to invest sufficient fertilizer in the production of maize and beans. And although she is familiar with improved fallows and biomass transfer, she does not apply the technologies because she feels they take up too much of her land.

"Mr. James"

Table 5-24 presents "Mr. James's" farm history. His story indicates his household is male-headed. He formerly participated in an agricultural project that disseminated improved fallow and biomass transfer technologies. His fields were used as demonstration plots. He has four fields, two in which he cultivates maize and beans, one in which he cultivates kale, and a fourth on which he keeps cattle. Mr. James is not currently applying improved fallows and biomass transfer. He instead improves the fertility of his soil with fertilizer.

"Mrs. Odhiambo"

Table 5-25 presents "Mrs. Mary Odhiambo's" farm history. Her story indicates her household is male-headed. She has very little land and supplements her maize and bean production with agricultural wage work. However, her wage work results in the neglect of her farm. She has never heard of improved fallows and biomass transfer.

Feasibility Analysis

Tables 5-26 through 5-28 present three calculations that compare the feasibility of various farming strategies using real world prices and labor requirements. In doing so, the calculations clarify why farmers tend to choose inorganic fertilizer over organic fertilizer. By providing the cash equivalents of labor units and illustrating that labor and cash are interchangeable at any time, the results of the calculations illustrate that organic, labor-intensive measures can be more expensive than inorganic fertilizer. The results of the calculations also clarify why farmers tend to substitute land for fertilizer by illustrating that between 2004 and 2008, the price of fertilizer rose far more quickly than the price of maize.

Calculation 1

Calculation 1, illustrated in Table 5-26, was created in order to document the labor required in the biomass transfer of an amount of *Tithonia diversifolia* approximately equivalent to an application of 50 kg/ha of diammonium phosphate (DAP). The calculation also converts those labor units into cash equivalents using 2007 Shinyalu Division prices. The results of the calculation indicate that the labor required to collect an amount of *Tithonia diversifolia* equivalent to a 50 kg bag of DAP is 300 labor days. That is, it would take 1 laborer 300 days to complete the task. If a household lacked the necessary labor, the cash required to hire the labor would amount to 15,000 Kenyan shillings. On the other hand, a 50 kg bag would cost 2000 Kenyan shillings.

Calculation 2

Calculation 2, illustrated in Table 5-27, was created in order to compare the labor and/or cash requirements of three alternatives for obtaining a 90 kg bag of maize using 2007 Shinyalu Division prices. The first alternative involves purchasing the 90 kg of maize and presents the amount of casual agricultural wage work required to raise the necessary cash: 30 labor days to raise 1600 Kenyan shillings. The second alternative involves producing the 90 kg of maize through the application of green manure (biomass transfer) and presents the amount of labor and its cash equivalent required to do so: 60 labor days or 3000 Kenyan shillings to hire the labor. The third alternative involves purchasing the inorganic fertilizer necessary to produce the 90 kg of maize and presents the amount of casual agricultural wage work required to raise the necessary cash: 8 labor days to raise 400 Kenyan shillings.

Calculation 3

Finally, Calculation 3, illustrated in Table 5-28, was created in order to compare the prices of inputs and outputs involved in producing and selling maize in Shinyalu Division from 2004 to 2007. The results of the calculation support the 6th hypothesis listed in Chapter 4, in which I expected a greater rise in the price of fertilizer than in maize, and illustrates the consequences of the international and national factors affecting the price of fertilizer, discussed in the research setting chapter, Chapter 3. Moreover, by illustrating that the price of fertilizer rose 250% during the period between 2004 and 2008 in comparison to a rise of only 80% in the price of maize during the same period, the results of the calculation help explain why farmers use smaller quantities of fertilizer per larger quantities of land, as illustrated throughout the multiple regression results of this study.

Conclusion

This chapter has presented the extensive results of this study. Though various tools of analysis were applied, both quantitative and qualitative, results indicate some important consistencies. Households are no longer applying improved fallows and biomass transfer technologies and the larger their landholdings, the smaller their applications of fertilizer and other inputs. Nonfarm income is associated with on-farm improvements such as increased oxen use, more schooling, and more land yet off-farm agricultural work is associated with less land, decreased on-farm labor, and less schooling. Kale production and brewing emerge as important sources of income, the former associated with wealth indicators and the latter associated with small landholdings. And finally, a comparison of labor requirements and price equivalents for soil fertility enhancement measures and other agricultural inputs substantiates these trends by indicating that biomass transfer is an expensive technology and the price of fertilizer is rising far faster than the price of maize. The following chapter will now turn to the discussion of these results in more detail.

Table 5-1. Key of terms used in multiple regression analyses

AgWageWork:	Whether or not the household head regularly works for wages as an agricultural laborer
BankLoan:	Whether or not the household head or spouse has received a bank loan (within the last 10 years)
BeanSeedingRate:	Bean seeding (in kg) per acre of land cropped in maize and beans
BnYield/Acre	Bean yield (in kg) per acre of land cropped in maize and beans
BorrowFromAGroup:	Whether or not the household head can borrow from one of the social groups he or she belongs to
Brewing:	Whether or not the household head or spouse brews either *chang'aa* or *busaa* for sale
EnoughMzHarvest:	Whether or not the household's maize harvest regularly lasts the entire year without a need to purchase maize for consumption
HiredLabor/Acre:	Amount of hired labor (in number of laborers multiplied by number of days hired) per acre of land cropped in maize and beans
KaleAcreage:	Amount of land (in acres) cropped in kale
LaborShareOffFarm:	Whether or not the household head participates in an off-farm agricultural labor sharing group
LaborShareOnFarm:	Whether or not the household head participates in an on-farm agricultural labor sharing group
MHH or FHH:	Male-headed or female-headed household
MzYield/Acre:	Maize yield (in kg) per acre of land cropped in maize and beans
MerryGoRound:	Whether or not the household head participates in a *merry-go-round*
Mutsulio:	Whether or not the household is located in the village of Mutsulio
Mz&BeansAcreage:	Amount of land (in acres) cropped in maize and beans
MaizeSeedingRate:	Maize seeding (in kg) per acre of land cropped in maize and beans
NonAgOFW:	Whether or not the household received remittances from a household member employed in an off-farm nonagricultural job
OxenUse/Acre:	Amount of oxen used (in oxen set multiplied by number of days hired) per acre of land cropped in maize and beans
Project/NonProject:	Whether or not the household participated in the PLAR project
QMo/YrMzPurchased:	Number of months per year maize is purchased for household consumption
Shinakotsi:	Whether or not the household is located in the village of Shinakotsi
Shikusi:	Whether or not the household is located in the village of Shikusi
TinRoof:	Whether or not the household has a tin roof (as opposed to thatch)
TotalCattle:	Total number of cattle owned
TotalAcresOwned:	Total number of acres owned
TotalFert/Acre:	Total amount of fertilizer and urea (in kg) used per acre of land cropped in maize and beans
TotalHHMembers:	Total number of individuals residing in the household
TrainingBaraza:	Whether or not the household head has participated in a training *baraza* (within the last 10 years)
VisitToExtOffice:	Whether or not the household head has visited the extension office (within the last 10 years)

Table 5-2. Multiple regression analysis for Y = maize yield per acre cropped in maize and beans

SUMMARY OUTPUT

Y=Maize Yield Per Acre Cropped in Maize & Beans

Regression Statistics	
Multiple R	0.650766102
R Square	0.423496519
Adjusted R Square	0.33394258
Standard Error	214.5216768
Observations	120

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	16	3481989.856	217624.4	4.728955	4.55794E-07
Residual	103	4740013.629	46019.55		
Total	119	8222003.485			

X Variables	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	269.8010901	81.96704959	3.29158	0.001365	107.238784	432.3634
MHH or FHH	-13.8725332	46.58715668	-0.297776	0.766474	-106.2671681	78.522102
TotalHHMembers	1.359290071	8.188900473	0.165992	0.868489	-14.88146217	17.600042
Project/NonProject	-58.668043	43.74489468	-1.34114	0.182825	-145.4257218	28.089636
Mz&BeansAcreage	-32.936906	15.49923628	-2.125066	0.035973	-63.67598477	-2.197827
VisitToExtOffice	80.77362589	64.80200246	1.246468	0.21542	-47.74585854	209.29311
TrainingBaraza	-45.2243148	44.40826282	-1.018376	0.310885	-133.2976278	42.848998
BorrowFromAGroup	30.85368977	43.96864937	0.70172	0.484436	-56.34775362	118.05513
BankLoan	10.41855099	74.36451385	0.140101	0.888854	-137.0659189	157.90302
NonAgOFW	-0.0137422	47.07598576	-0.000292	0.999768	-93.37785426	93.35037
AgWageWork	-37.7251915	46.7954445	-0.806172	0.422001	-130.5329161	55.082533
Brewing	-12.0781839	47.72812061	-0.253062	0.800725	-106.7356516	82.579284
HiredLabor/Acre	0.253902941	0.883906351	0.287251	0.774497	-1.499116784	2.0069227
OxenUse/Acre	35.58552755	12.05172431	2.952733	0.003902	11.6837755	59.48728
MaizeSeedingRate	3.374610373	4.112846838	0.820505	0.413823	-4.782251069	11.531472
BeanSeedingRate	11.07975545	4.976464907	2.226431	0.028163	1.210111307	20.9494
TotalFertilizer/Acre	1.472928666	0.9103838	1.617921	0.108738	-0.332602833	3.2784602

Table 5-3. Multiple regression analysis for Y = bean yield per acre cropped in maize and beans

SUMMARY OUTPUT

Y=Bean Yield Per Acre Cropped in Maize & Beans

Regression Statistics	
Multiple R	0.4752253
R Square	0.2258391
Adjusted R Square	0.1055811
Standard Error	12.218974
Observations	120

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	16	4486.157832	280.3849	1.877955	0.030806241
Residual	103	15378.2423	149.3033		
Total	119	19864.40013			

X Variables	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	3.3014268	4.668774061	0.707129	0.481083	-5.957985107	12.560839
MHH or FHH	3.0171867	2.65356518	1.137031	0.258163	-2.245533801	8.2799073
TotalHHMembers	0.2458415	0.466432869	0.527067	0.59928	-0.679218094	1.170901
Project/NonProject	-5.5969235	2.491672332	-2.246252	0.026823	-10.53856774	-0.6552792
Mz&BeansAcreage	-1.0903595	0.882823436	-1.235082	0.21961	-2.841231562	0.6605125
VisitToExtOffice	4.4797455	3.691067444	1.213672	0.227649	-2.840615967	11.800107
TrainingBaraza	-0.0901956	2.529457222	-0.035658	0.971624	-5.106777256	4.9263861
BorrowFromAGroup	4.6313618	2.504417211	1.849277	0.067285	-0.335558904	9.5982825
BankLoan	-4.9253011	4.235740033	-1.162796	0.247599	-13.32589218	3.47529
NonAgOFW	2.2395654	2.681408473	0.83522	0.405527	-3.078375711	7.5575066
AgWageWork	-3.0905491	2.665429079	-1.159494	0.248936	-8.376798885	2.1957007
Brewing	-4.6723285	2.718553524	-1.718682	0.088677	-10.0639381	0.7192811
HiredLabor/Acre	0.0155023	0.050346561	0.307912	0.758771	-0.084348211	0.1153528
OxenUse/Acre	0.3705384	0.68645606	0.539785	0.590511	-0.990885257	1.731962
MaizeSeedingRate	-0.1129899	0.23426429	-0.482318	0.630603	-0.577597848	0.3516181
BeanSeedingRate	0.3842621	0.283455247	1.355636	0.17818	-0.177904491	0.9464287
TotalFertilizer/Acre	0.0674108	0.051854694	1.299995	0.196504	-0.035430711	0.1702524

Table 5-4. Multiple regression analysis for Y = total fertilizer per acre cropped in maize and beans

SUMMARY OUTPUT

Y=Total Fertilzer Per Acre Cropped in Maize & Beans

Regression Statistics	
Multiple R	0.62985659
R Square	0.39671933
Adjusted R Square	0.30300582
Standard Error	22.4934822
Observations	120

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	16	34270.03542	2141.877	4.233321	3.06306E-06
Residual	103	52113.54418	505.9567		
Total	119	86383.5796			

X Variables	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-18.195455	13.00503589	-1.399108	0.164785	-43.98787614	7.5969652
MHH or FHH	1.69333369	5.03723193	0.336164	0.737431	-8.296827508	11.683495
TinRoof	21.5316749	10.43454932	2.063498	0.04158	0.837207893	42.226142
TotalCattle	0.79292036	1.109214415	0.714849	0.47632	-1.406944753	2.9927855
TotalAcresOwned	-1.0420258	1.14119416	-0.913101	0.363322	-3.305315173	1.2212636
Project/NonProject	6.94189691	4.386455792	1.582575	0.116584	-1.757603348	15.641397
BorrowFromAGroup	4.39159472	4.682494435	0.937875	0.350503	-4.89502834	13.678218
BankLoan	17.1864806	7.343033407	2.340515	0.021184	2.623306092	31.749655
NonAgOFW	-1.2492444	5.052788788	-0.247239	0.805216	-11.27025898	8.7717701
AgWageWork	-2.9566587	5.756349406	-0.513634	0.608608	-14.37301977	8.4597024
Brewing	-3.3424933	4.893589016	-0.683035	0.496118	-13.04777263	6.3627861
OxenUse/Acre	2.96615298	1.220940011	2.429401	0.016855	0.544706506	5.3875995
HiredLabor/Acre	0.19956047	0.096021711	2.078285	0.040169	0.00912406	0.3899969
LaborShareOffFarm	19.0714127	9.126862569	2.089591	0.039118	0.970433877	37.172391
LaborShareOnFarm	-11.647617	7.810152862	-1.491343	0.138928	-27.13721233	3.8419791
MaizeSeedingRate	0.41381737	0.418895048	0.987878	0.325527	-0.416962132	1.2445969
BeanSeedingRate	1.39612234	0.502877275	2.776268	0.006533	0.398783894	2.3934608

Table 5-5. Multiple regression analysis for Y = total fertilizer per acre cropped in maize and beans

SUMMARY OUTPUT

Y=Total Fertilizer Per Acre Cropped in Maize & Beans

Regression Statistics	
Multiple R	0.36752146
R Square	0.13507203
Adjusted R Square	0.05572084
Standard Error	26.1813672
Observations	120

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	10	11668.00511	1166.801	1.702205	0.089124698
Residual	109	74715.57449	685.464		
Total	119	86383.5796			

X Variables	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	14.2643867	13.12588255	1.086737	0.27955	-11.75068505	40.279458
MHH or FHH	-0.3367998	5.59697877	-0.060175	0.952126	-11.42982944	10.75623
TinRoof	10.9548593	11.54136605	0.949182	0.344628	-11.91975226	33.829471
TotalCattle	2.45496801	1.182762137	2.075623	0.040282	0.110771983	4.799164
TotalAcresOwned	-2.6725358	1.281718459	-2.085119	0.039394	-5.212860055	-0.1322116
Project/NonProject	2.05390088	4.975147591	0.412832	0.680541	-7.806679602	11.914481
BorrowFromAGroup	10.5533507	5.108150254	2.065983	0.041201	0.429163287	20.677538
BankLoan	15.6980058	8.400608405	1.868675	0.064353	-0.951726403	32.347738
NonAgOFW	-0.0428158	5.734751685	-0.007466	0.994057	-11.4089069	11.323275
AgWageWork	-2.9290699	5.512030706	-0.531396	0.596226	-13.85373519	7.9955955
Brewing	-4.0731249	5.637124438	-0.722554	0.471502	-15.24572193	7.0994721

Table 5-6. Multiple regression analysis for Y = oxen use per acre cropped in maize and beans

SUMMARY OUTPUT

Y=Oxen Use Per Acre Cropped in Maize & Beans

Regression Statistics	
Multiple R	0.60081575
R Square	0.36097957
Adjusted R Square	0.26171426
Standard Error	1.76540544
Observations	120

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	16	181.3401714	11.33376	3.636513	3.1853E-05
Residual	103	321.0156045	3.116656		
Total	119	502.3557758			

X Variables	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-0.1381897	1.030266389	-0.13413	0.893561	-2.181480052	1.9051006
MHH or FHH	0.40688174	0.393528065	1.033933	0.303589	-0.373588339	1.1873518
TinRoof	-0.8517535	0.831489378	-1.024371	0.30806	-2.500816558	0.7973095
TotalCattle	0.18005487	0.085450292	2.10713	0.037535	0.010584375	0.3495254
TotalAcresOwned	-0.0368789	0.089855183	-0.410426	0.682346	-0.215085496	0.1413276
Project/NonProject	-0.6316308	0.342829028	-1.842408	0.068292	-1.311551349	0.0482897
BorrowFromAGroup	0.68124419	0.362916904	1.877135	0.063329	-0.038515873	1.4010043
BankLoan	0.16849769	0.591213495	0.285003	0.776214	-1.004034806	1.3410302
NonAgOFW	0.78857694	0.389002569	2.027177	0.045228	0.017082115	1.5600718
AgWageWork	0.4180548	0.45048709	0.928006	0.355574	-0.47538007	1.3114897
Brewing	-0.361587	0.383290834	-0.943375	0.347697	-1.121753968	0.3985799
HiredLabor/Acre	-0.006119	0.007669013	-0.79788	0.426776	-0.021328631	0.0090907
LaborShareOffFarm	-0.00944	0.7313487	-0.012908	0.989726	-1.459897626	1.4410176
LaborShareOnFarm	0.12064526	0.619450135	0.194762	0.845963	-1.107887945	1.3491785
MaizeSeedingRate	0.08005752	0.032076739	2.495812	0.014154	0.016440876	0.1436742
BeanSeedingRate	0.03341019	0.040785889	0.81916	0.414586	-0.047479002	0.1142994
TotalFert/Acre	0.01827128	0.007520901	2.429401	0.016855	0.003355352	0.0331872

Table 5-7. Multiple regression analysis for Y = oxen use per acre cropped in maize and beans

SUMMARY OUTPUT

Y=Oxen Use Per Acre Cropped in Maize & Beans

Regression Statistics	
Multiple R	0.45637701
R Square	0.20827998
Adjusted R Square	0.13564511
Standard Error	1.91019747
Observations	120

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	10	104.6306491	10.46306	2.867493	0.00327977
Residual	109	397.7251267	3.648854		
Total	119	502.3557758			

X Variables	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1.63609841	0.957666859	1.708421	0.090404	-0.261966112	3.5341629
MHH or FHH	0.35561973	0.408356623	0.870856	0.385747	-0.453729798	1.1649693
TinRoof	-1.1868826	0.842060237	-1.409498	0.161535	-2.855818536	0.4820534
TotalCattle	0.24372275	0.086294548	2.824312	0.005635	0.072689762	0.4147557
TotalAcresOwned	-0.1338302	0.09351442	-1.431119	0.155257	-0.319172769	0.0515123
Project/NonProject	-0.7771195	0.362987704	-2.140898	0.034511	-1.496549278	-0.05769
BorrowFromAGroup	1.04375085	0.372691603	2.800575	0.006036	0.305088231	1.7824135
BankLoan	0.53416848	0.612909969	0.871528	0.385381	-0.680599118	1.7489361
NonAgOFW	0.7578225	0.418408561	1.811202	0.072864	-0.071449637	1.5870946
AgWageWork	0.29364774	0.402158797	0.730179	0.466847	-0.503417893	1.0907134
Brewing	-0.4362535	0.411285659	-1.060707	0.291168	-1.251408301	0.3789013

Table 5-8. Multiple regression analysis for Y = hired labor per acre cropped in maize and beans

SUMMARY OUTPUT

Y=Hired Labor Per Acre Cropped in Maize & Beans

Regression Statistics	
Multiple R	0.57522547
R Square	0.33088434
Adjusted R Square	0.22694404
Standard Error	22.6124908
Observations	120

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	16	26044.08138	1627.755	3.183408	0.000192787
Residual	103	52666.44822	511.3247		
Total	119	78710.5296			

X Variables	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	3.043809	13.19408355	0.230695	0.818009	-23.1235431	29.211161
MHH or FHH	-11.909008	4.928905335	-2.416157	0.017445	-21.68432912	-2.133687
TinRoof	6.96169426	10.68238305	0.651699	0.516047	-14.22429244	28.147681
TotalCattle	2.70314303	1.085650729	2.489883	0.014378	0.550010929	4.8562751
TotalAcresOwned	-0.3780905	1.151263276	-0.328414	0.743266	-2.661349618	1.9051686
Project/NonProject	-0.5627796	4.46260978	-0.12611	0.899891	-9.413313278	8.2877542
BorrowFromAGroup	2.63166187	4.720208549	0.557531	0.578374	-6.72975824	11.993082
BankLoan	-5.8136045	7.553953928	-0.769611	0.443292	-20.79509002	9.1678811
NonAgOFW	-1.6787839	5.078335841	-0.330578	0.741635	-11.75046497	8.3928973
AgWageWork	-7.0062248	5.752939389	-1.217851	0.226063	-18.41582288	4.4033733
Brewing	-0.8049169	4.929970898	-0.16327	0.870626	-10.58235111	8.9725174
OxenUse/Acre	-1.0038876	1.258193213	-0.79788	0.426776	-3.499216991	1.4914418
LaborShareOffFarm	-15.473998	9.242694786	-1.674187	0.097128	-33.80470219	2.8567071
LaborShareOnFarm	23.6118305	7.587093365	3.112105	0.002404	8.564620654	38.65904
MaizeSeedingRate	-0.2346449	0.422469437	-0.555413	0.579817	-1.072513319	0.6032236
BeanSeedingRate	1.20591469	0.510464949	2.362385	0.020036	0.19352789	2.2183015
TotalFert/Acre	0.20167773	0.097040463	2.078285	0.040169	0.009220863	0.3941346

Table 5-9. Multiple regression analysis for Y = hired labor per acre cropped in maize and beans

SUMMARY OUTPUT

Y=Hired Labor Per Acre Cropped in Maize & Beans

Regression Statistics	
Multiple R	0.38478851
R Square	0.1480622
Adjusted R Square	0.06990276
Standard Error	24.8031656
Observations	120

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	10	11654.05384	1165.405	1.894361	0.053413541
Residual	109	67056.47576	615.197		
Total	119	78710.5296			

X Variables	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	21.3044453	12.4349289	1.713274	0.089505	-3.341178811	45.950069
MHH or FHH	-12.727386	5.302350739	-2.400329	0.018075	-23.23647273	-2.2183
TinRoof	1.59471912	10.93382221	0.145852	0.884308	-20.07576038	23.265199
TotalCattle	3.50810862	1.120500889	3.13084	0.002238	1.287312348	5.7289049
TotalAcresOwned	-1.3904923	1.214248097	-1.145147	0.254657	-3.797092485	1.0161079
Project/NonProject	-0.0462656	4.713253094	-0.009816	0.992186	-9.387779678	9.2952486
BorrowFromAGroup	5.83442527	4.839254423	1.205645	0.230565	-3.756819385	15.42567
BankLoan	-4.1749148	7.958395772	-0.524593	0.600932	-19.94819606	11.598366
NonAgOFW	-1.9710885	5.432871212	-0.362808	0.717451	-12.73886225	8.7966853
AgWageWork	-6.7902684	5.221874387	-1.300351	0.196224	-17.13985332	3.5593166
Brewing	0.35641245	5.340383116	0.066739	0.946912	-10.22805294	10.940878

Table 5-10. Multiple regression analysis for Y = maize seeding per acre cropped in maize and beans

SUMMARY OUTPUT

Y=Maize Seeding Per Acre Cropped in Maize & Beans

Regression Statistics	
Multiple R	0.56612889
R Square	0.32050192
Adjusted R Square	0.21494882
Standard Error	5.26605165
Observations	120

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	16	1347.25516	84.20345	3.036405	0.000346219
Residual	103	2856.323903	27.7313		
Total	119	4203.579063			

X Variables	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	8.96706792	2.943725022	3.046164	0.002944	3.128883798	14.805252
MHH or FHH	-1.4276947	1.171520258	-1.218668	0.225754	-3.751128713	0.8957394
TinRoof	-2.5679759	2.479988197	-1.035479	0.30287	-7.486447414	2.3504957
TotalCattle	0.01583123	0.260321949	0.060814	0.951625	-0.500455941	0.5321184
TotalAcresOwned	-0.0951558	0.268085412	-0.354946	0.723356	-0.626840001	0.4365283
Project/NonProject	-1.0224306	1.034449599	-0.988381	0.325282	-3.074017327	1.0291562
BorrowFromAGroup	1.05191151	1.096021107	0.959755	0.339426	-1.121787795	3.2256108
BankLoan	0.95822013	1.76170569	0.543916	0.587675	-2.535707504	4.4521478
NonAgOFW	-0.8855182	1.180061083	-0.7504	0.454724	-3.225891	1.4548545
AgWageWork	-0.5228098	1.348386336	-0.38773	0.699016	-3.19701601	2.1513964
Brewing	-0.0696153	1.14823164	-0.060628	0.951773	-2.346861831	2.2076313
OxenUse/Acre	0.71233363	0.285411533	2.495812	0.014154	0.146287181	1.2783801
HiredLabor/Acre	-0.0127258	0.022912302	-0.555413	0.579817	-0.058166927	0.0327154
LaborShareOffFarm	-3.0797451	2.160343001	-1.425582	0.157013	-7.364275768	1.2047856
LaborShareOnFarm	2.48808241	1.831773636	1.358291	0.177339	-1.144808467	6.1209733
BeanSeedingRate	0.36413508	0.116663828	3.121234	0.002337	0.132759895	0.5955103
TotalFert/Acre	0.02268118	0.022959481	0.987878	0.325527	-0.022853539	0.0682159

Table 5-11. Multiple regression analysis for Y = maize seeding per acre cropped in maize and beans

SUMMARY OUTPUT

Y=Maize Seeding Per Acre Cropped in Maize & Beans

Regression Statistics	
Multiple R	0.31809265
R Square	0.10118293
Adjusted R Square	0.01872265
Standard Error	5.88751486
Observations	120

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	10	425.3304628	42.53305	1.227051	0.281937248
Residual	109	3778.2486	34.66283		
Total	119	4203.579063			

X Variables	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	14.8458503	2.951672771	5.02964	1.95E-06	8.99573105	20.69597
MHH or FHH	-1.3502116	1.258616308	-1.072775	0.285742	-3.844748114	1.1443249
TinRoof	-4.5258494	2.595355837	-1.743826	0.084009	-9.669760184	0.6180613
TotalCattle	0.37187673	0.265972728	1.398176	0.164899	-0.155272559	0.899026
TotalAcresOwned	-0.4625725	0.288225455	-1.604898	0.11141	-1.033825989	0.1086809
Project/NonProject	-1.8465553	1.118782498	-1.650504	0.101718	-4.063945758	0.3708352
BorrowFromAGroup	2.14495689	1.14869137	1.867305	0.064546	-0.131711991	4.4216258
BankLoan	1.25869003	1.889080371	0.666298	0.506629	-2.485405736	5.0027858
NonAgOFW	-0.4494259	1.289597886	-0.348501	0.728136	-3.00536693	2.1065151
AgWageWork	-1.2368659	1.239513677	-0.997864	0.320555	-3.693541642	1.2198098
Brewing	-0.26036	1.267644034	-0.205389	0.837651	-2.772789164	2.2520692

Table 5-12. Multiple regression analysis for Y = bean seeding per acre cropped in maize and beans

SUMMARY OUTPUT

Y=Bean Seeding Per Acre Cropped Maize & Beans

Regression Statistics	
Multiple R	0.63882442
R Square	0.40809664
Adjusted R Square	0.31615049
Standard Error	4.25114417
Observations	120

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	16	1283.397257	80.21233	4.438431	1.38558E-06
Residual	103	1861.439352	18.07223		
Total	119	3144.83661			

X Variables	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	6.34770207	2.400997553	2.643777	0.00948	1.585889848	11.109514
MHH or FHH	0.0932555	0.952486856	0.097907	0.922196	-1.795777478	1.9822885
TinRoof	-2.1479978	2.001261716	-1.073322	0.285635	-6.117028255	1.8210327
TotalCattle	-0.0629915	0.21006312	-0.299869	0.764881	-0.479602138	0.3536191
TotalAcresOwned	-0.2856895	0.214713157	-1.330564	0.186271	-0.711522415	0.1401434
Project/NonProject	-0.4917819	0.837634169	-0.587108	0.558416	-2.153031713	1.1694678
BorrowFromAGroup	-1.2610141	0.880007909	-1.432958	0.154898	-3.006302191	0.484274
BankLoan	-2.6834988	1.399459392	-1.917525	0.057941	-5.45899635	0.0919988
NonAgOFW	-0.4345973	0.954272238	-0.455423	0.649764	-2.32717115	1.4579766
AgWageWork	-1.6646431	1.076891142	-1.545786	0.125223	-3.800402633	0.4711164
Brewing	0.75388472	0.923972413	0.815917	0.416431	-1.078596586	2.586366
OxenUse/Acre	0.19373213	0.236500836	0.81916	0.414586	-0.275311484	0.6627757
HiredLabor/Acre	0.04262177	0.018041838	2.362385	0.020036	0.006840037	0.0784035
LaborShareOffFarm	1.42478069	1.755504461	0.811608	0.418888	-2.056848265	4.9064096
LaborShareOnFarm	-0.0105276	1.491927005	-0.007056	0.994384	-2.969412836	2.9483577
MaizeSeedingRate	0.23730339	0.076028716	3.121234	0.002337	0.086518372	0.3880884
TotalFert/Acre	0.04986798	0.017962232	2.776268	0.006533	0.014244129	0.0854918

Table 5-13. Multiple regression analysis for Y = bean seeding per acre cropped in maize and beans

SUMMARY OUTPUT

Y=Bean Seeding Per Acre Cropped in Maize & Beans

Regression Statistics	
Multiple R	0.33715331
R Square	0.11367235
Adjusted R Square	0.03235789
Standard Error	5.05688343
Observations	120

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	10	357.4809761	35.7481	1.397935	0.190723418
Residual	109	2787.355633	25.57207		
Total	119	3144.83661			

X Variables	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	12.1848836	2.535240333	4.806205	4.95E-06	7.160119802	17.209647
MHH or FHH	-0.6089705	1.081046266	-0.563316	0.574377	-2.751568997	1.533628
TinRoof	-3.3029552	2.229193853	-1.481681	0.14131	-7.721144782	1.1152344
TotalCattle	0.31609105	0.228448355	1.383643	0.169295	-0.136686149	0.7688682
TotalAcresOwned	-0.603557	0.247561588	-2.438007	0.016385	-1.09421596	-0.1128979
Project/NonProject	-1.0205212	0.960940705	-1.062002	0.290582	-2.925074411	0.8840319
BorrowFromAGroup	0.40938773	0.986629928	0.414935	0.679005	-1.546080647	2.3648561
BankLoan	-1.6536366	1.622562229	-1.019151	0.310388	-4.869502062	1.5622289
NonAgOFW	-0.4134717	1.107656854	-0.373285	0.709661	-2.608811528	1.7818681
AgWageWork	-1.7336796	1.064638702	-1.628421	0.106323	-3.843758823	0.3763996
Brewing	0.46867851	1.088800329	0.430454	0.667715	-1.689288277	2.6266453

Table 5-14. Multiple regression analysis for Y = wealth index

SUMMARY OUTPUT

Y=Wealth Index

Regression Statistics	
Multiple R	0.71236655
R Square	0.5074661
Adjusted R Square	0.33065906
Standard Error	0.4896106
Observations	**54**

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	14	9.632458388	0.688033	2.870169	0.004726474
Residual	39	9.349023093	0.239719		
Total	53	18.98148148			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.69095274	0.375722773	1.838996	0.073539	-0.069018295	1.4509238
MHH or FHH	0.10492684	0.170545626	0.615242	0.541969	-0.240034244	0.4498879
TotalHHMembers	-0.0054142	0.02909936	-0.186058	0.853364	-0.064273168	0.0534449
TinRoof	-0.2369304	0.305735646	-0.774952	0.443041	-0.85533916	0.3814783
TotalCattle	0.00653657	0.044426909	0.147131	0.883787	-0.083325329	0.0963985
TotalAcresOwned	0.06112136	0.036594947	1.670213	0.102885	-0.01289891	0.1351416
TrainingBaraza	0.24806943	0.162555293	1.526062	0.135064	-0.080729679	0.5768685
BankLoan	0.0331779	0.26320093	0.126055	0.900336	-0.499196224	0.565552
OxenUse/Acre	0.08309559	0.049350389	1.683788	0.100212	-0.016724995	0.1829162
HiredLabor/Acre	-0.0019967	0.003319825	-0.601459	0.551015	-0.008711718	0.0047182
TotalFertilizer/Acre	0.00639645	0.00305267	2.095362	0.042681	0.00022184	0.0125711
NonAgOFW	0.22490254	0.179075217	1.255911	0.21662	-0.137311275	0.5871163
AgWageWork	-0.1580184	0.174799927	-0.903996	0.371548	-0.511584628	0.1955478
Brewing	0.09987423	0.196559933	0.508111	0.614238	-0.297705762	0.4974542
QMo/YrMzPurch	-0.0519707	0.027685826	-1.87716	0.067991	-0.107970604	0.0040291

Table 5-15. Multiple regression analysis for Y = total acres owned

SUMMARY OUTPUT

Y=Total Acres Owned

Regression Statistics	
Multiple R	0.58022091
R Square	0.33665631
Adjusted R Square	0.27579909
Standard Error	1.95611477
Observations	120

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	10	211.6719515	21.1672	5.531904	1.25931E-06
Residual	109	417.0759652	3.826385		
Total	119	628.7479167			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1.64304073	1.003378504	1.637508	0.104408	-0.345622788	3.6317042
MHH or FHH	0.97711202	0.415243024	2.353109	0.02041	0.154113868	1.8001102
TinRoof	-0.2802497	0.865039873	-0.323973	0.746579	-1.994730506	1.4342312
TotalCattle	0.31495702	0.083252755	3.783142	0.000253	0.149952771	0.4799613
Project/NonProject	-0.4289208	0.370843472	-1.156609	0.249961	-1.163920514	0.3060789
MerryGoRound	0.09415194	0.437841335	0.215037	0.830141	-0.773635327	0.9619392
BorrowFromAGroup	0.60536092	0.423711638	1.42871	0.155947	-0.234421747	1.4451436
BankLoan	0.6434897	0.652223189	0.98661	0.326019	-0.64919542	1.9361748
NonAgOFW	1.14145897	0.416414757	2.741159	0.007157	0.316138485	1.9667795
AgWageWork	-0.738031	0.412653875	-1.788499	0.076474	-1.555897569	0.0798355
Brewing	-0.9068206	0.418209888	-2.168338	0.032307	-1.735698946	-0.077942

Table 5-16. Multiple regression analysis for Y = total cattle owned

SUMMARY OUTPUT

Y=Total Cattle Owned

Regression Statistics	
Multiple R	0.5139552
R Square	0.26415
Adjusted R Square	0.1966408
Standard Error	2.1158884
Observations	120

ANOVA

	df	SS	MS	F	Significance F
Regression	10	175.1754474	17.51754	3.912801	0.000145047
Residual	109	487.9912193	4.476984		
Total	119	663.1666667			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-1.0262782	1.094195563	-0.937929	0.350354	-3.194938185	1.1423818
MHH or FHH	0.8147461	0.453765226	1.795523	0.075341	-0.084601787	1.714094
TinRoof	1.3223425	0.927538169	1.425648	0.156828	-0.516007891	3.160693
TotalAcresOwned	0.368509	0.097408187	3.783142	0.000253	0.175449179	0.5615689
Project/NonProject	-0.2614556	0.402809929	-0.649079	0.517652	-1.059811781	0.5369005
MerryGoRound	-0.3161015	0.472735675	-0.668664	0.505123	-1.253048204	0.6208452
BorrowFromAGroup	0.0083287	0.462590826	0.018004	0.985668	-0.908511247	0.9251687
BankLoan	1.1943298	0.699344835	1.707784	0.090523	-0.191748931	2.5804084
NonAgOFW	0.506846	0.463156231	1.09433	0.276222	-0.411114583	1.4248065
AgWageWork	0.3259081	0.45178398	0.72138	0.47222	-0.569512986	1.2213293
Brewing	0.7017344	0.457107082	1.535164	0.127641	-0.204236975	1.6077057

Table 5-17. Multiple regression analysis for Y = household head's children's cumulative years of schooling

SUMMARY OUTPUT

Y=Children's Cumulative Years of Schooling

Regression Statistics	
Multiple R	0.51913035
R Square	0.26949632
Adjusted R Square	0.19570807
Standard Error	20.0836669
Observations	**110**

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	10	14731.65878	1473.166	3.652293	0.000356963
Residual	99	39932.01395	403.3537		
Total	109	54663.67273			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	22.680741	6.891841881	3.290955	0.001384	9.005831824	36.35565
MHH or FHH	-3.0589982	4.464246448	-0.685222	0.494805	-11.91703144	5.7990351
TotalAcresOwned	1.30249196	1.105745662	1.177931	0.241648	-0.891547269	3.4965312
TotalCattle	1.31050501	0.988589518	1.325631	0.188013	-0.651071022	3.272081
BankLoan	11.4795135	6.853350897	1.675022	0.097086	-2.119021219	25.078048
NonAgOFW	8.94040015	4.549964885	1.964938	0.052224	-0.08771707	17.968517
AgWageWork	-8.3049072	4.558392259	-1.821894	0.07149	-17.34974616	0.7399318
Brewing	0.87142232	4.621674129	0.188551	0.850831	-8.298981597	10.041826
Mutsulio	-3.8038502	5.639682807	-0.674479	0.501579	-14.9942041	7.3865038
Shikusi	-0.70196	5.861103939	-0.119766	0.904911	-12.33166147	10.927742
Shinakotsi	6.88895723	6.62716655	1.039503	0.301103	-6.26077864	20.038693

Table 5-18. Multiple regression analysis for Y = kale acreage

SUMMARY OUTPUT

Y=Kale Acreage

Regression Statistics	
Multiple R	0.46097554
R Square	0.21249845
Adjusted R Square	0.12418052
Standard Error	0.23757045
Observations	120

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	12	1.629569843	0.135797	2.406062	0.00847839
Residual	107	6.039049949	0.05644		
Total	119	7.668619792			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	-0.1108296	0.119778384	-0.925289	0.356898	-0.348276281	0.1266171
MHH or FHH	0.00474815	0.051337174	0.092489	0.926482	-0.09702181	0.1065181
TotalHHMembers	0.0217414	0.008885519	2.446835	0.01604	0.004126898	0.0393559
TinRoof	0.0358311	0.105440754	0.339822	0.734657	-0.173192889	0.2448551
Mz&BeansAcreage	-0.0289917	0.01703501	-1.701889	0.09168	-0.062761615	0.0047782
TotalCattle	0.0137412	0.010575739	1.299313	0.196629	-0.007223972	0.0347064
Project/NonProject	0.01595394	0.047565307	0.335411	0.737972	-0.078338734	0.1102466
TrainingBaraza	0.07642652	0.047206249	1.618992	0.108393	-0.017154358	0.1700074
BankLoan	-0.0870753	0.084626854	-1.028933	0.305832	-0.25483819	0.0806875
NonAgOFW	0.09422571	0.05108891	1.844348	0.067899	-0.00705209	0.1955035
AgWageWork	0.02652489	0.050972808	0.520373	0.603878	-0.074522753	0.1275725
Brewing	-0.0613395	0.052181852	-1.175495	0.242406	-0.16478396	0.0421049
EnoughMzHarvest	0.157678	0.071443078	2.207044	0.029447	0.016050438	0.2993056

Table 5-19. Multiple regression analysis for Y = number of months per year maize is purchased

SUMMARY OUTPUT

Y=Number of Months Per Year Maize is Purchased

Regression Statistics	
Multiple R	0.60047506
R Square	0.3605703
Adjusted R Square	0.28214968
Standard Error	2.65771255
Observations	120

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	13	422.2007817	32.47698	4.597902	3.30196E-06
Residual	106	748.7242183	7.063436		
Total	119	1170.925			

X Variables	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	4.57736164	1.35562177	3.376577	0.001027	1.889709706	7.2650136
MHH or FHH	-0.128997	0.582370129	-0.221504	0.825127	-1.283602428	1.0256083
TotalHHMembers	0.16688548	0.099148661	1.683184	0.095283	-0.029686375	0.3634573
TinRoof	0.26224219	1.184213168	0.221448	0.825169	-2.085575522	2.6100599
TotalCattle	-0.2681365	0.122879044	-2.182118	0.031309	-0.511756163	-0.024517
Project/NonProject	-1.2885906	0.531077943	-2.426368	0.016938	-2.341504254	-0.235677
TrainingBaraza	-0.213281	0.528546541	-0.403524	0.687376	-1.261175937	0.8346139
BorrowFromAGroup	0.05970638	0.530391575	0.11257	0.910584	-0.991846472	1.1112592
BankLoan	-1.9076769	0.872118358	-2.187406	0.03091	-3.636736319	-0.178617
TotalAcresOwned	-0.2983309	0.133213729	-2.239491	0.027212	-0.562440084	-0.034222
TotalFert/Acre	-0.0188723	0.009764252	-1.932791	0.05593	-0.038230834	0.0004863
NonAgOFW	0.66891046	0.587114326	1.139319	0.257138	-0.495100763	1.8329217
AgWageWork	0.50646938	0.574392372	0.881748	0.379908	-0.632319335	1.6452581
Brewing	1.6685667	0.583454613	2.859805	0.005106	0.511811216	2.8253222

Table 5-20. General farming calendar for western Kenya

January:	Plow land by oxen or by hand Burn if grass is high
February:	Second plowing Begin planting Sell cows in order to pay school fees
March:	Continue planting
April:	Easter celebrations; schools closed Circumcisions; weddings Begin first weeding Purchase maize for consumption
May:	Labor Day celebrations Begin second weeding Purchase maize for consumption Top-dress
June:	Begin roasting early maize Begin eating tender beans Second weeding
July:	Bean harvest
August:	Maize harvest Buy and sell maize Schools close for one month Circumcisions Begin plowing the land for short rains season
September:	Continue harvesting maize Dry maize Continue land preparation for short rains season Begin planting maize, beans, cowpeas, and pumpkin for short rains season
October:	Send cards wishing success in exams Form 4 exams Build houses and repair houses in preparation for December holidays Young men over 18 set up their own houses Weeding
November:	Send cards wishing success in exams Standard 8 exams Continue preparations for December holidays Sew dresses in preparation for December holidays Continue selling maize Harvest cowpeas and pumpkin leaves
December:	Short rains harvest Weddings Holidays; feasting Begin preparing land for long rains season at the end of the month

Compiled with the assistance of Sarah Anyolo, Mildred Machika, and Judy Lung'atso

Table 5-21. “Good” farmer’s calendar for western Kenya

January:	Clear and burn land First plowing
February:	Second plowing Begin planting
March:	Gapping (whatever did not germinate is replanted)
April:	First weeding
May:	Second weeding
June:	Top-dress (with urea)
July:	Begin long-rains harvest
August:	Continue harvest Prepare maize for storage Begin plowing the land for short rains season
September:	Begin planting maize, beans, cowpeas, and pumpkin for short-rains season
October:	Weeding
November:	Begin short-rains harvest
December:	Continue harvest Begin preparing land for long-rains season

Compiled with the assistance of Sarah Anyolo, Mildred Machika, and Judy Lung’atso

Table 5-22. “Bad” farmer’s calendar for western Kenya

January:	Continue short-rains harvest
February:	Clear, burn, and plow land
March:	Begin planting
April:	Continue planting
May:	First weeding
June:	Second weeding (if at all)
July:	Bean harvest
August:	Maize harvest Buy and sell maize
September:	Continue harvesting maize Clear and plow land for short-rains season Begin planting maize, beans, cowpeas, and pumpkin for short-rains season
October:	Continue planting
November:	Weeding
December:	Short rains harvest

Compiled with the assistance of Sarah Anyolo, Mildred Machika, and Judy Lung’atso

Table 5-23. Interview with “Yohana” regarding her farm’s history

At the front edge of Yohana’s property stands a half constructed brick house with the top missing. Her husband began its construction years ago but never finished it. I ask Yohana whether her husband, in time, will complete the house but she does not know. She explains that her husband lives in Nairobi with a second wife and Yohana has not seen him in two years. Nonetheless, he sends remittances of 2000 or 3000 Kenyan shillings whenever he is employed. I nod and we continue walking towards the back of the property, arriving at Yohana’s semi-permanent house. It is constructed of clay and dung and has a tin roof. The interior, filled with sofas and chairs, is comfortable. One wall is covered in pasted magazine and newspaper clippings. Two small children greet us. Just to the right side of the house is a small garden, bordered by flowering bushes. Beyond the homestead are her fields, which slope down all the way to the Yala River. Her property sits up high on the hillside with breathtaking views of the countryside, neat fields of maize pouring down into the valley and river.

I begin the interview with a general question about how Yohana learned to farm and how her farming has changed over the last 5 years. She explains that her parents taught her how to farm, planting maize and beans. She continues to use the same tools her parents used, such as *bangas* and *jembes*, yet now she also plants additional crops, such as potatoes, vegetables, and onions. She moved out of her parents’ home at the age of 20, having been in school until then. She is now 42 years old. She notes that her life became better 4 years ago when she called for a 5000 Ksh loan from an agricultural financial institution in Kakamega. Formerly, she “had no food or improvement of material.” Prior to the loan, she used fewer materials, such as fertilizer, and missed out on producing more maize. With the money the loan provided, she was able to invest in her farm. The financial institution allows her to make loan payments in maize, each harvest. Her sister, who used to be a teacher but now runs her own business as a seamstress in Busia, helps her make loan payments if her harvest is not enough. The sister also sends remittances of 1000 to 1500 Kenyan shillings when Yohana asks her for help.

I ask Yohana whether she has ever participated in an agricultural project that teaches new planting techniques and she replies that a few years back a project worked with the community, helping it install terraces, which she implemented on her fields. She has two on the steeper slope and another further below, bordered by a live barrier of napier grass. She walks us out back to the field and shows us the channels and points to the darker shade of green in the center maize and then shows us how the outer maize is not as dark—it is not as “black and healthy”—because she has run out of fertilizer towards that side.

I ask whether Yohana has ever let her land rest and she answers, no, that she plants it continuously. I also ask whether she has ever planted any agroforestry species with her maize and she again answers, no, because the agroforestry species flood the soil and invade the maize and beans. Finally, I ask, “What is the greatest difficulty you struggle with?” and Yohana responds, “Drought.” If there is no rain, there is no harvest. She also has difficulty obtaining fertilizer because its price has gone up over the last few years.

Table 5-24. Interview with "Mr. James" regarding his farm's history

Mr. James is a Shikusi elder whom I was introduced to during a baraza at the beginning of my field work season in 2007. His home is a semi permanent structure of typical size. A calf grazes on his lawn and pigeons move about the kitchen as we sit in his living room chatting. I have a view of his tea bushes from where I am sitting. I ask Mr. James to tell me a little about his farming. He explains that he has four fields. He plows his 1-hectare field near the house by hand, hiring laborers, because it is steep and has terraces bordered by live barriers of napier grass. Yet he plows his two smaller fields with oxen, attaching either 4 small oxen or 2 large oxen to the plow. A ½ hectare, he notes, requires a team of oxen for two days to complete what farmers term "the 1st plowing." Farmers normally plow their fields twice. During the "2nd plowing," Mr. James employs the same amount of oxen. He generally applies 8 kg of maize, 6 kg of beans, and 50 kg of diammonium phosphate per hectare when planting maize and beans. He keeps two of his fields planted in maize and beans and a third in kale. Mr. James keeps cows on his fourth field. "The tea," he remarks as I glance at it through the window, "still belongs to my mother." Before being introduced to Mr. James, I was told he is regarded a good farmer. In the past, Mr. James's fields were used as demonstration plots by the agricultural project that worked in the area teaching farmers about improved fallows and biomass transfer. However, Mr. James no longer practices improved fallows because, as he explains, "the bushes attract caterpillars." Nonetheless, he still has a live fence of *Tithonia diversifolia*, the species recommended for biomass transfer. But most farmers do not use the technologies, Mr. James says, because they "use too much of the *shamba*."

Table 5-25. Interview with “Mrs. Mary Odhiambo” regarding her farm’s history

Mary Odhiambo has been married since 1999. She moved from her parents’ home to her mother-in-law’s home at the age of 17. At her parents’ home, she mentions, the land was very fertile and her family never applied fertilizer. At her mother-in-law’s home, however, applications of both fertilizer and cattle manure together seem unable to improve the land’s fertility. In 2004, she and her husband moved into their own home after her husband inherited a portion of his mother’s land, which originally belonged to his, now deceased, father. I ask whether Mary has ever planted an improved fallow or practiced biomass transfer, applying green manure to her field. However, she replies that she has never heard of the technologies. She adds that an agricultural project worked recently in her community, instead teaching farmers how to keep chickens and plant potatoes and kale. I ask Mary to describe her annual farming routine. She explains that she hoes her shamba twice throughout January and February, plants during March, and weeds during April. However, she often neglects her weeding because April is also a peak month for agricultural wage work, which she undertakes in order to make ends meet. In May, she plants potatoes and vegetables in her garden. Throughout June, she again engages in agricultural wage work, harvesting other farmers’ beans. In July, she begins consuming her maize, still green. During August, she harvests her maize and also works for other farmers helping prepare their maize for storage. Throughout September Mary prepares her own shamba for the short-rains season but again works off the farm throughout October on other farmers’ fields. In November, she engages in domestic wage work, getting paid to wash clothes for other households. Finally, during December, she is hired to help “smear” houses in preparation for the holidays. She explains that people normally touch up the interior walls of their houses during the holiday season by smearing them with a layer of clay and dung. At the end of our interview, Mary notes that if she had enough land, she would not work off the farm. She complains that her maize gets spoiled because rather than re-weeding it, she neglects it while she works on other farmers’ shambas. Mary concludes, “One who works her own farm is better off because an agricultural laborer’s shamba is always lagging behind.”

Table 5-26. Calculation 1: Feasibility of *Tithonia diversifolia* vs. diammonium phosphate (DAP)

According to ICRAF (1997:7), in western Kenya "farmers can obtain a maize yield from an application of 5 tonnes [5000 kg] of *Tithonia* (dry matter) per hectare that is comparable to the yield obtained from applying the recommended rate of inorganic fertilizer—50 kg/ha of P_20_5 and 60 kg/ha of nitrogen." That is, 5000 kg of *Tithonia diversifolia* dry matter enhances the fertility of western Kenyan soil in much the same way as does a 50 kg bag of diammonium phosphate (DAP). Yet ICRAF (1997:3) notes, the leaves of *Tithonia diversifolia* have a moisture content of 84%. Therefore, after drying, 5000 kg of fresh tithonia is reduced to 800 kg of dry matter. Thus, a farmer must collect 31,250 kg of fresh *Tithonia*, chop it, transport it to the field(s), and spread it over a hectare of land in order to obtain a maize yield comparable to the yield obtained from applying a 50 kg bag of DAP. Furthermore, according to ICRAF (1997:11), "it takes about 4 minutes to collect 1 kg of fresh *Tithonia* biomass." Hence, 1 laborer picks approximately 15 kg of fresh *Tithonia* per hour. If the laborer works 7 hours per day, 100 kg of *Tithonia* can be collected per day per laborer. Further calculation indicates that the labor required to harvest 31,250 kg fresh *Tithonia* is at least 300 labor days (or 30 laborers for 10 days). In the Shinyalu Division area in 2007, 30 laborers @ 50 Kenyan shillings per day (plus a meal) for 10 days would cost at least 15000 Kenyan shillings. A 50 kg bag of DAP would cost 2000 Kenyan shillings.

Table 5-27. Calculation 2: Feasibility of three alternatives for obtaining a sack of maize

Trials in western Kenya researching maize yields from continuous maize cropping without fertilization indicate farmers obtain approximately 600 kg/ha of maize in the absence of soil fertility enhancement measures (Amadalo et al. 1998). Thus, a family of 2 adults and 4 children living on a 0.5 hectare plot of land in western Kenya can expect to produce approximately 300 kg of maize annually if the family spends no cash on agricultural inputs and plants maize only during the long-rains season, leaving the land fallow during the short-rains season. However, a family of 2 adults and 4 children can also expect to consume at least 390 kg of maize annually. Therefore, such a family would need to secure at least 90 kg more of maize annually. That is, the family would need to find a way to obtain approximately one more 90 kg sack of maize per year.

If the family chose to purchase the additional sack of maize, in 2007 a 90 kg sack of maize was priced at approximately 1600 Kenyan shillings in the Shinyalu Division area prior to harvest. In order to obtain the cash to purchase the sack, someone in the family would need to engage in agricultural wage work for approximately 30 days @ 50 Kenyan shillings per day.

If the family chose to produce the additional sack of maize through the application of biomass transfer—green manure—to their field, someone in the family would need to collect, chop, dry, and spread approximately 6000 kg of fresh *Tithonia diversifolia*—the nutrient equivalent of applying 10 kg of DAP to raise maize yields by approximately 90 kg (according to Quiñones et al. (1997), a rate of 50kg/ha of DAP generally doubles farmers' yields). According to ICRAF's (1997:11) estimate, it would take one laborer approximately 60 days to collect 6000 kg of fresh *Tithonia diversifolia*. If the family chose to hire the labor required to collect the green manure, it would cost 3000 Kenyan shillings. The labor required to chop, dry, and spread it would be additional.

If the family chose to purchase 10 kg of DAP and apply it to their field in order to raise maize yields by approximately 90 kg, it would cost them 400 Kenyan shillings. To raise that amount of cash, someone in the family would need to engage in agricultural wage work during 8 days.

Table 5-28. Calculation 3: Feasibility of maize production through a comparison of input and output prices during 2004 and 2007 in Shinyalu Division

Most farmers throughout Shinyalu Division apply inputs of animal power, hired labor, seed, and fertilizer in order to obtain outputs of maize. Below are listed the real world prices of inputs and outputs involved in the production and sale of maize. Farmers ideally strive to store maize after harvest in order to sell it at peak pre-harvest prices during May and June. As the tables indicate, the price of fertilizer rose 250% from 2004 to 2008. Yet the price of pre-harvest maize only rose 80%.

Outputs & Inputs	2004 Prices	2008 Prices
Hired oxen:	500 Ksh/day (plus meal)	500 Ksh/day (plus meal)
Hired labor:	50 Ksh/day (plus meal)	70 Ksh/day (plus meal)
50 kg DAP fertilizer:	1600 Ksh	4000 Ksh
90 kg pre-harvest maize:	1600 Ksh	2000 Ksh

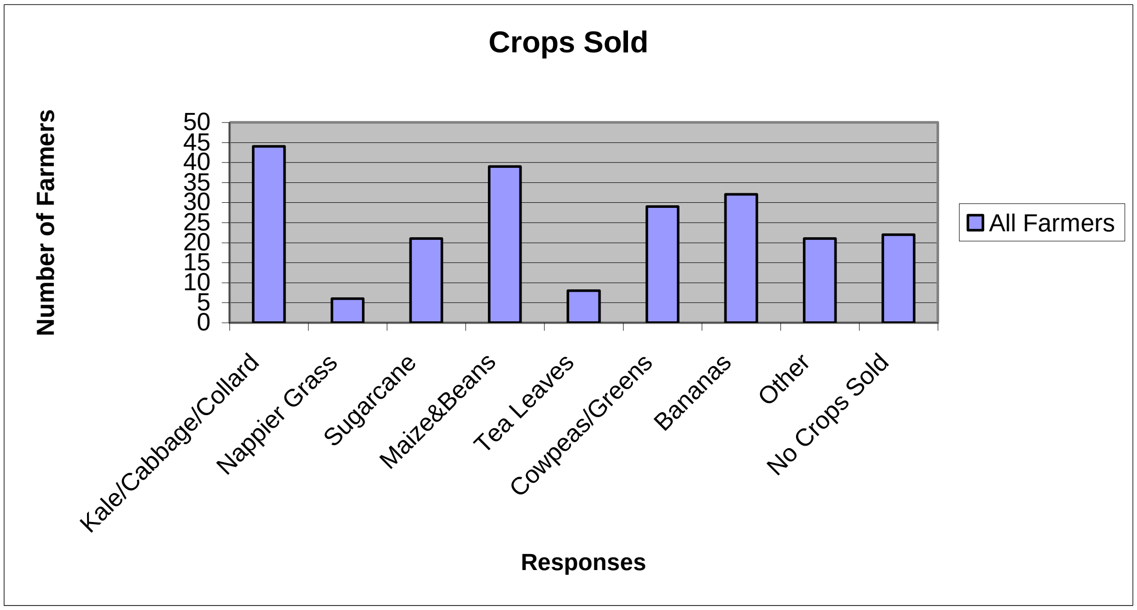

Figure 5-1. Frequency distribution of crops sold by all farmers

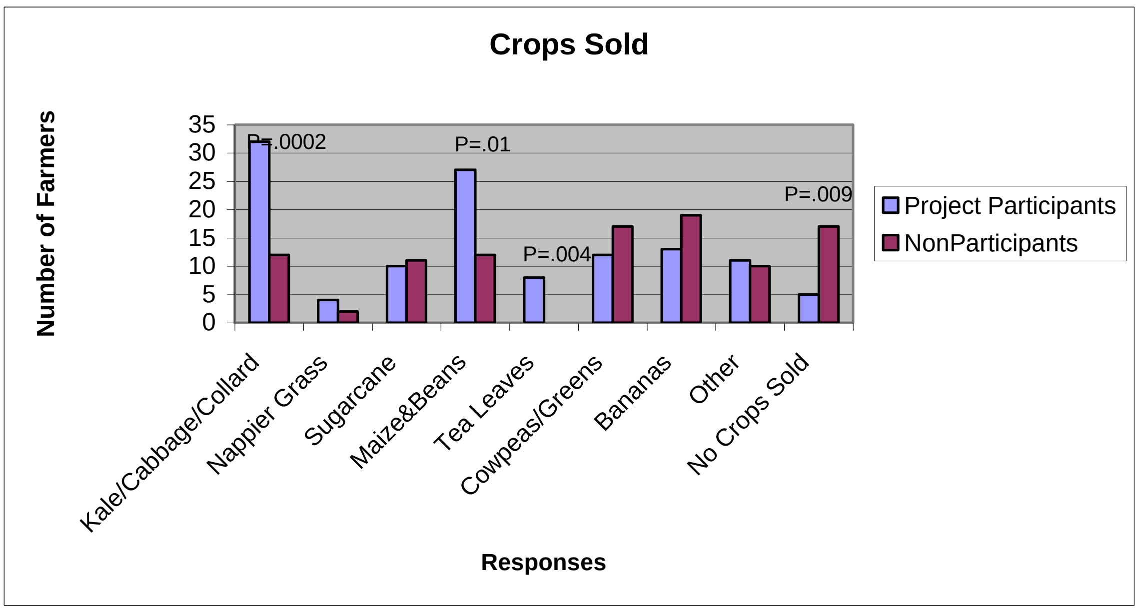

Figure 5-2. Frequency distribution of crops sold by project participants and non-participants

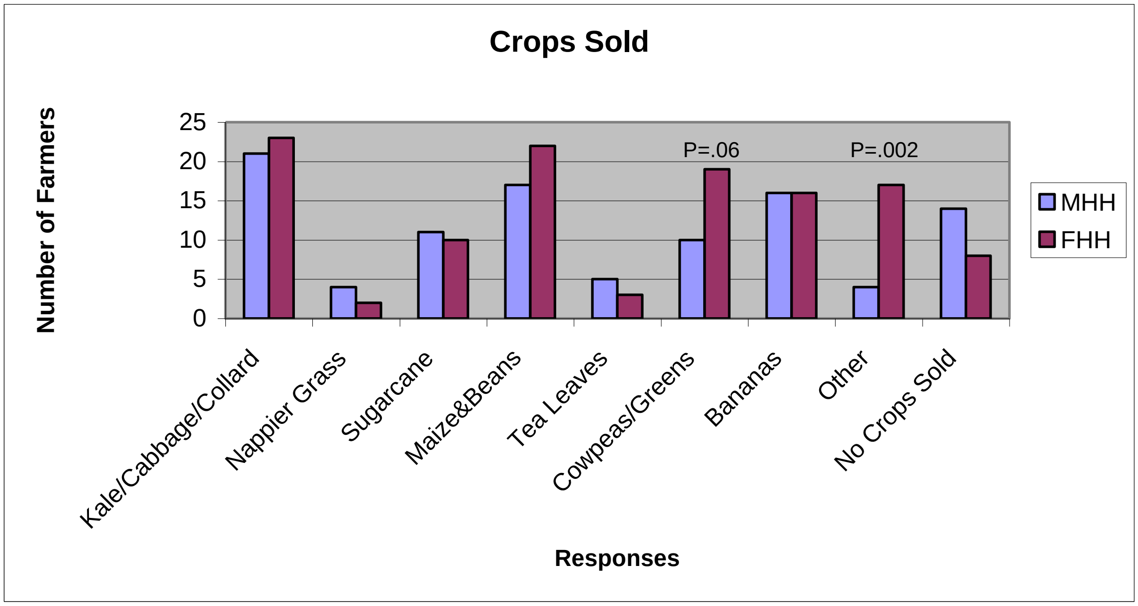

Figure 5-3. Frequency distribution of crops sold by male-headed and female-headed households

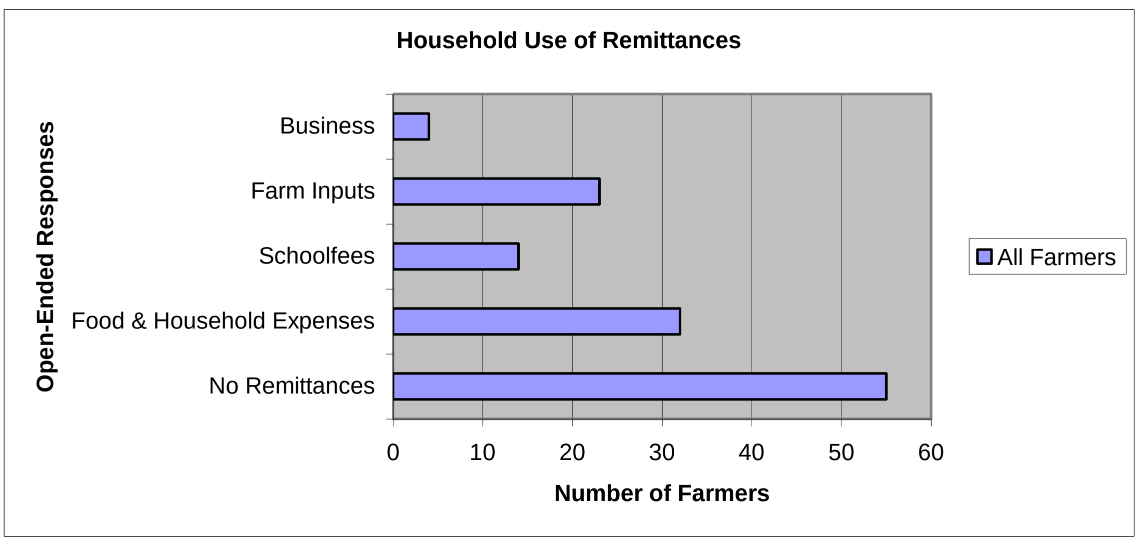

Figure 5-4. Frequency distribution of household use of remittances by all farmers

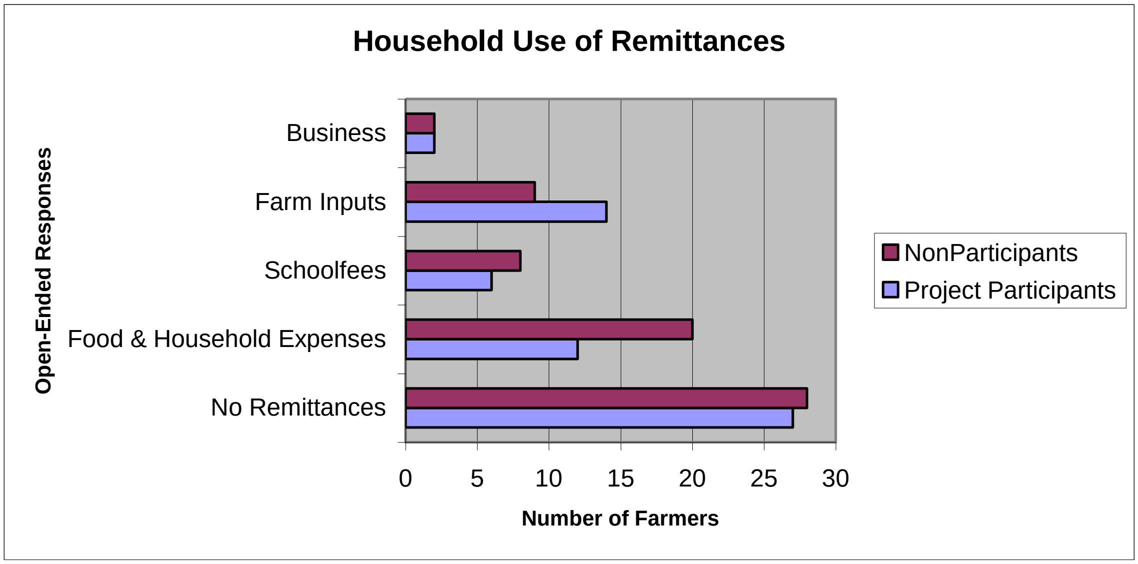

Figure 5-5. Frequency distribution of household use of remittances by project participants and non-participants

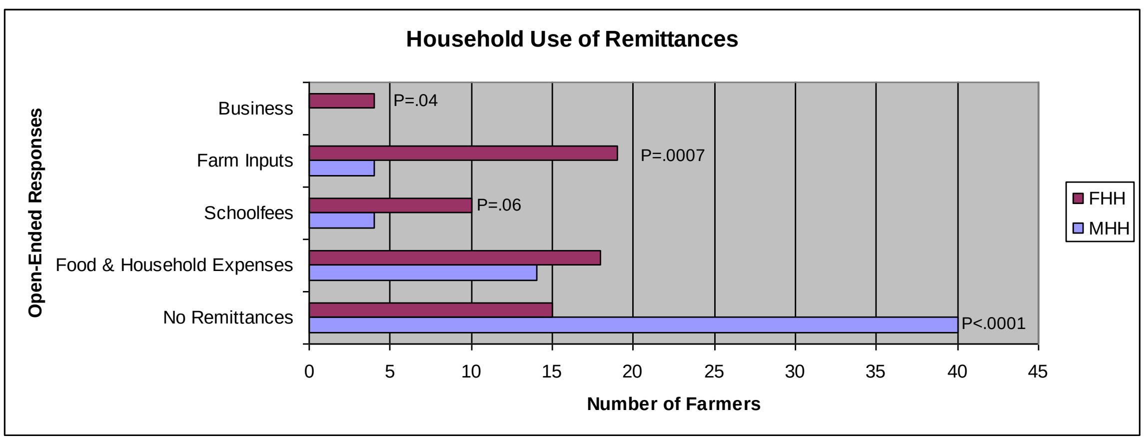

Figure 5-6. Frequency distribution of household use of remittances by male-headed and female-headed households

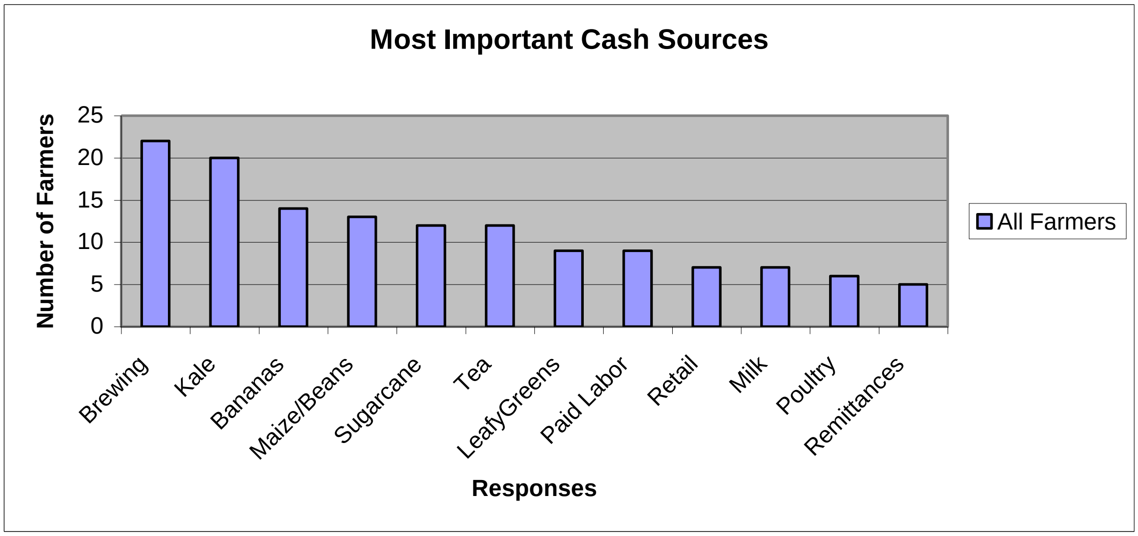

Figure 5-7. Frequency distribution of most important cash sources for all farmers

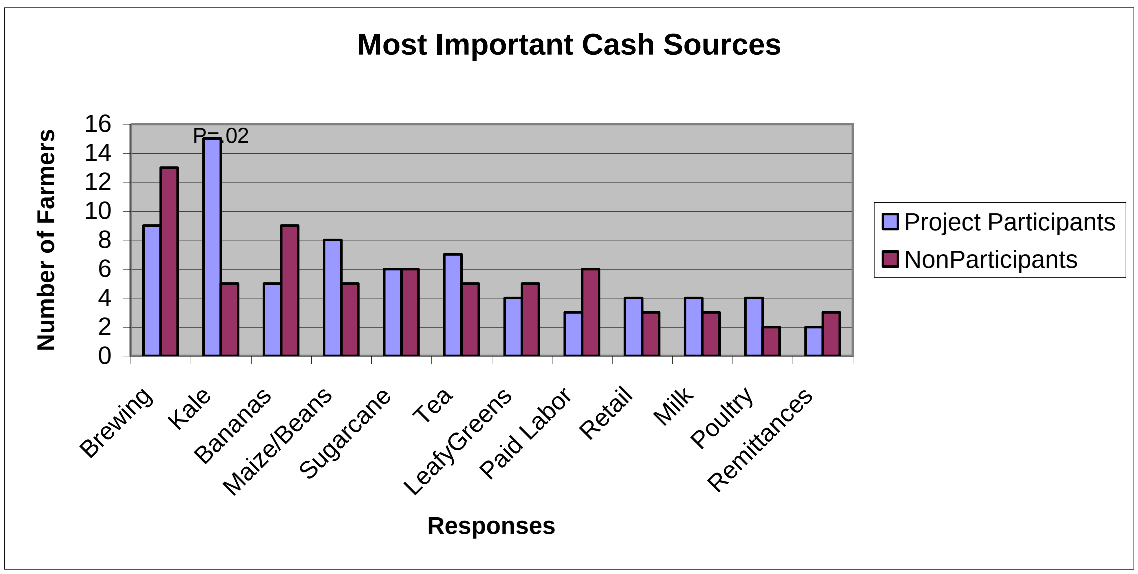

Figure 5-8. Frequency distribution of most important cash sources for project participants and non-participants

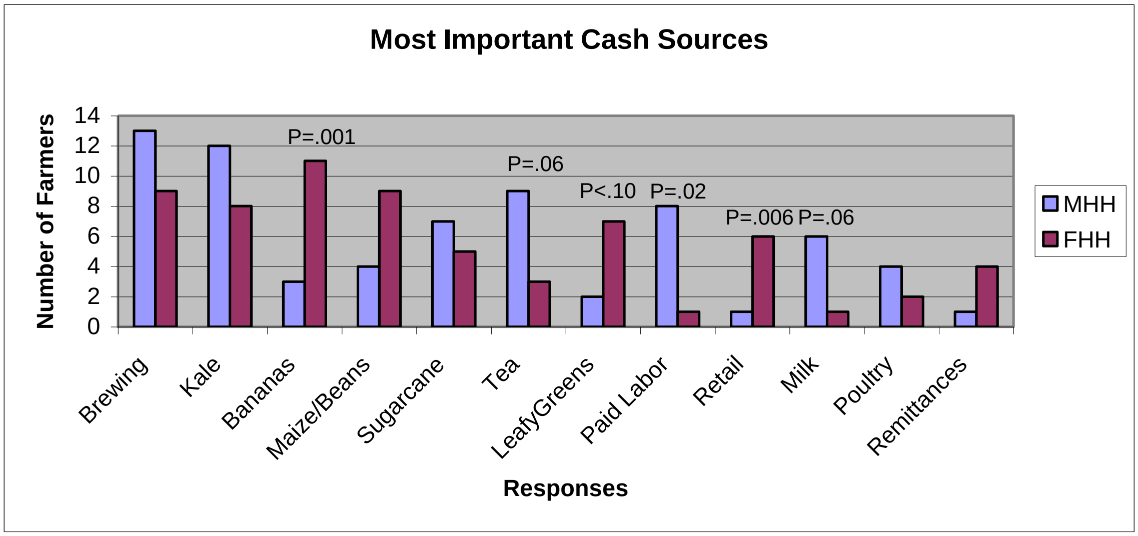

Figure 5-9. Frequency distribution of most important cash sources for male-headed and female-headed households

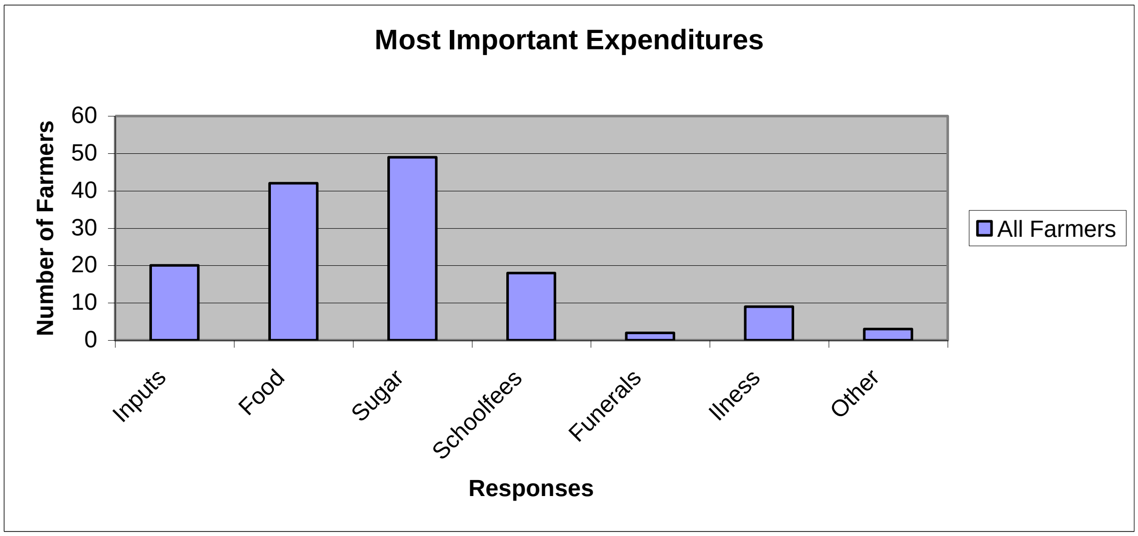

Figure 5-10. Frequency distribution of most important expenditures for all farmers

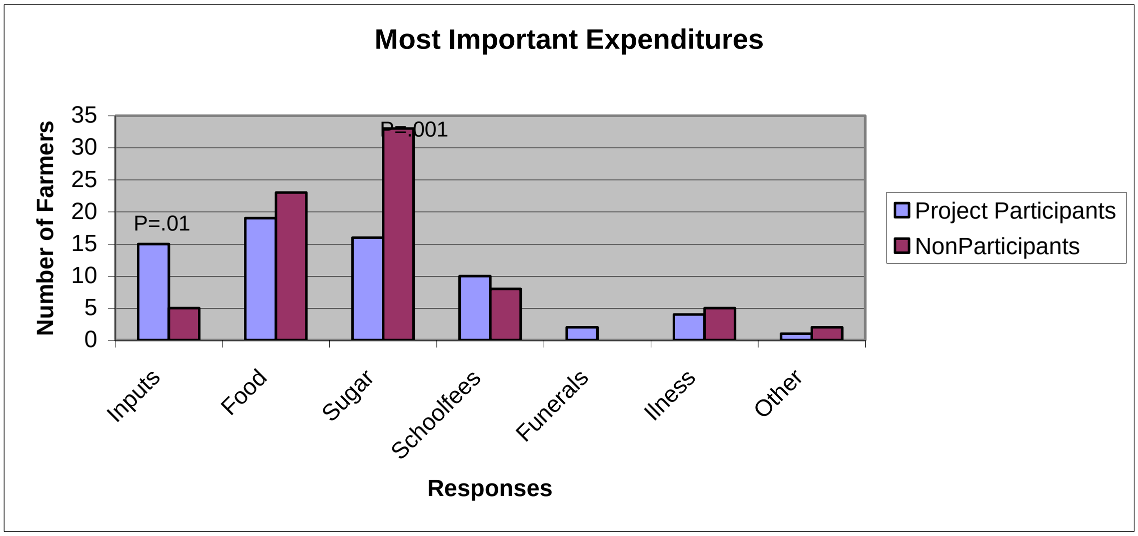

Figure 5-11. Frequency distribution of most important expenditures for project participants and non-participants

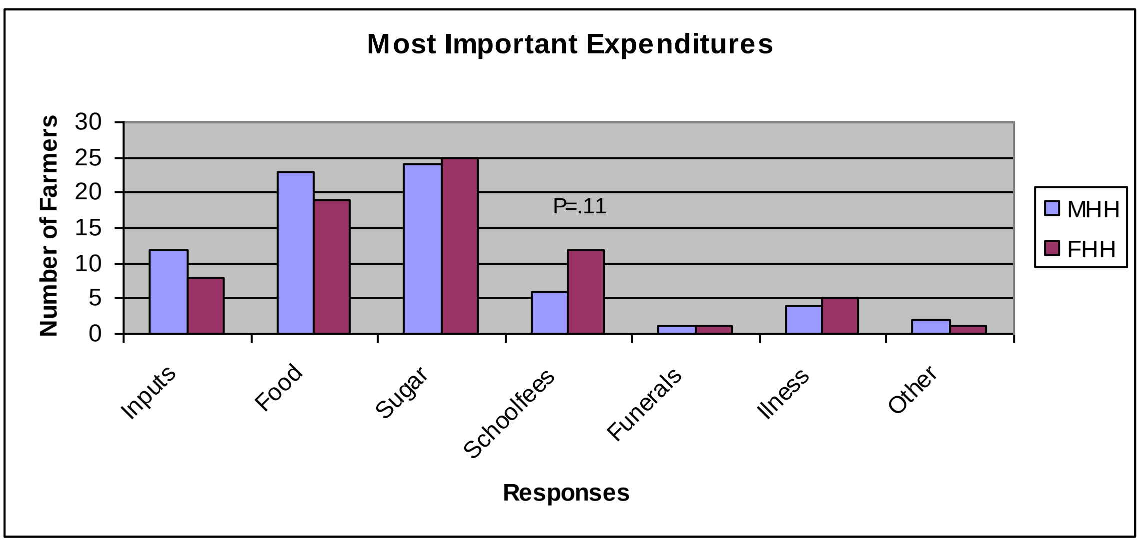

Figure 5-12. Frequency distribution of most important expenditures for male-headed and female-headed households

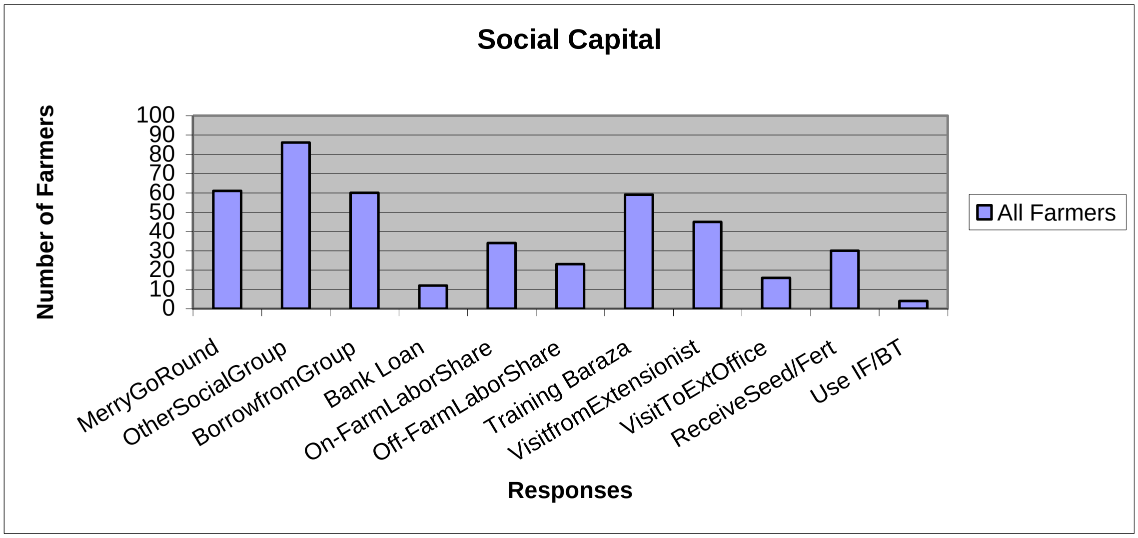

Figure 5-13. Frequency distribution of social capital among all farmers

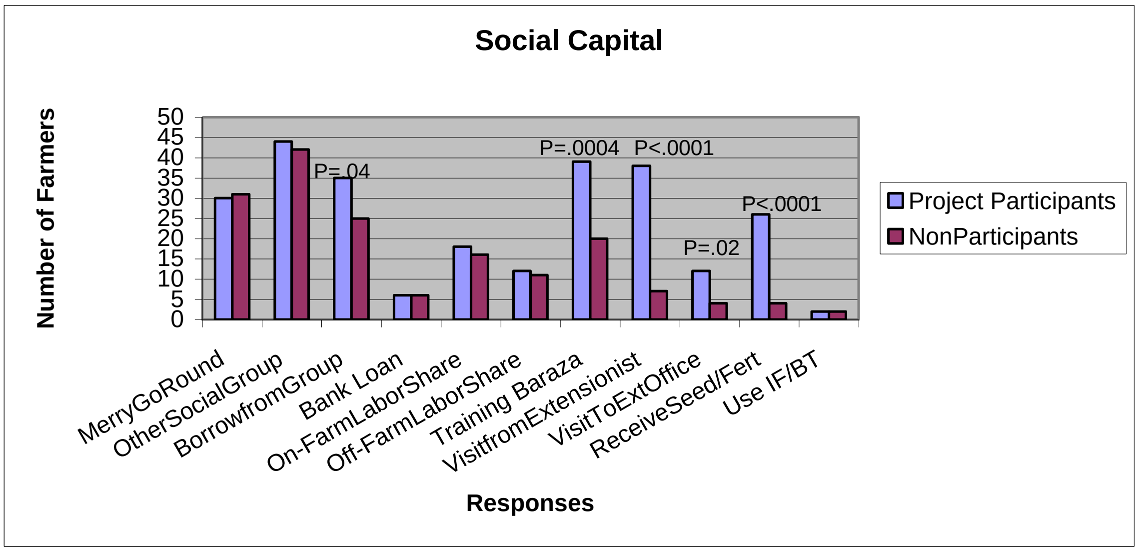

Figure 5-14. Frequency distribution of social capital among project participants and non-participants

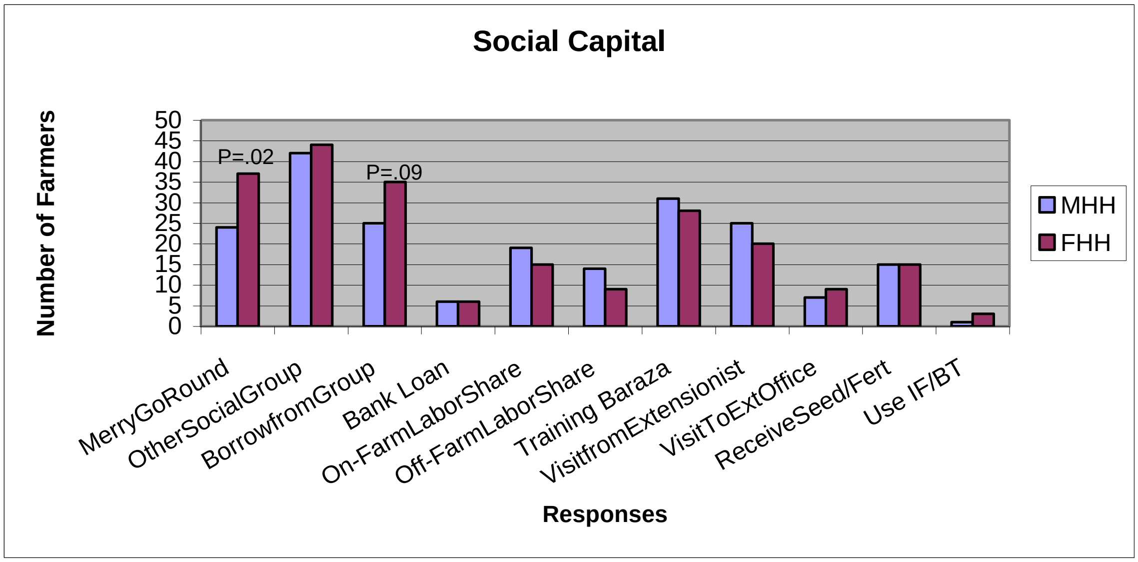

Figure 5-15. Frequency distribution of social capital among male-headed and female-headed households

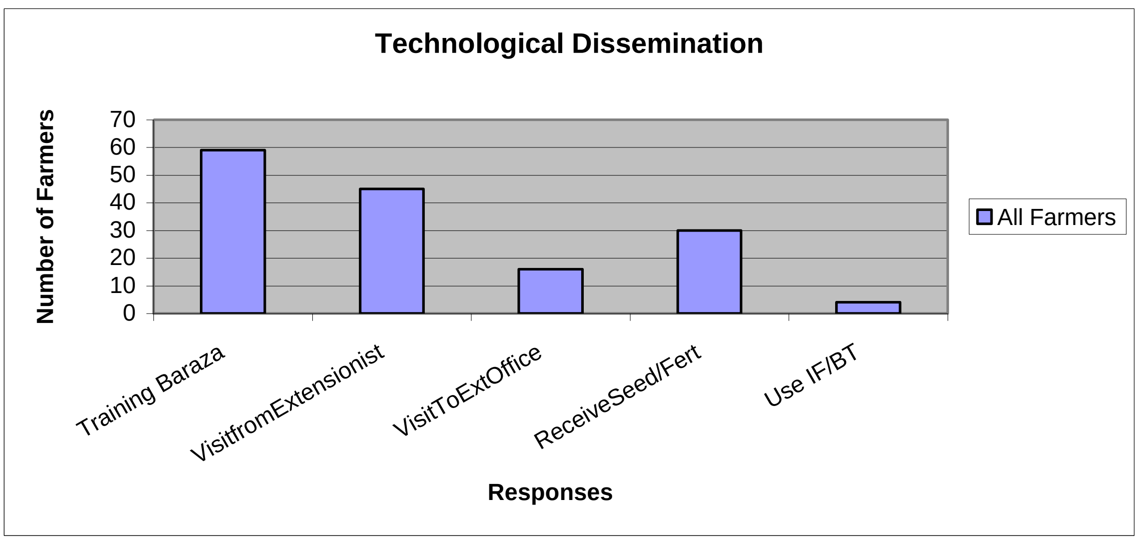

Figure 5-16. Frequency distribution of technological dissemination among all farmers

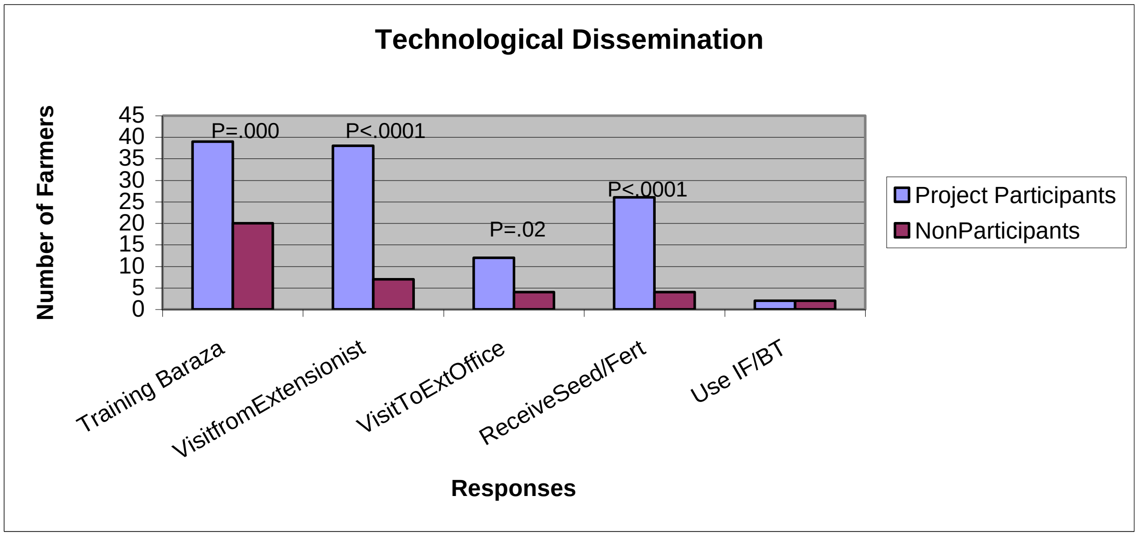

Figure 5-17. Frequency distribution of technological dissemination among project participants and non-participants

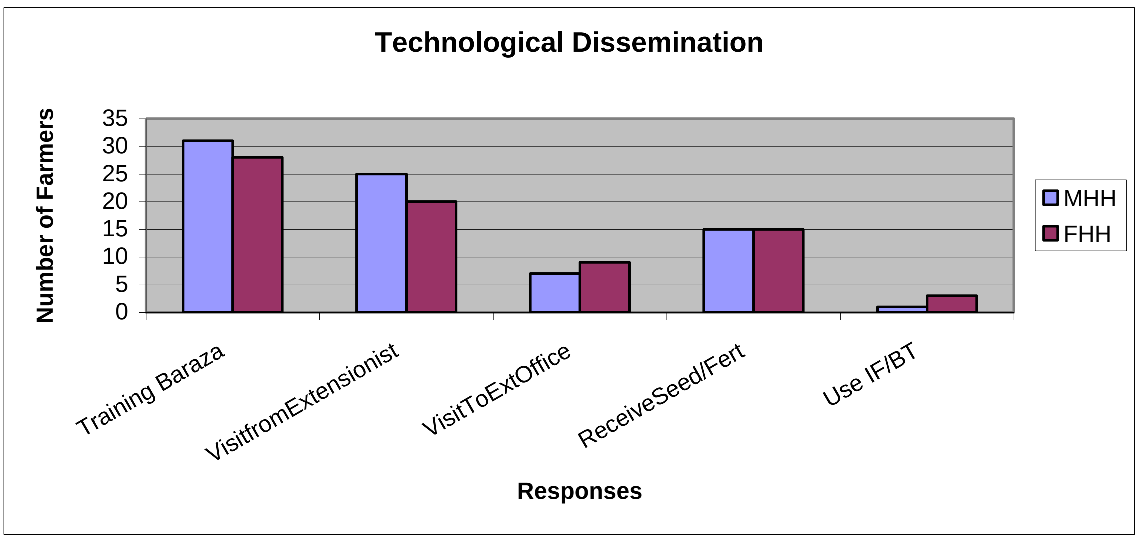

Figure 5-18. Frequency distribution of technological dissemination among male-headed and female-headed households

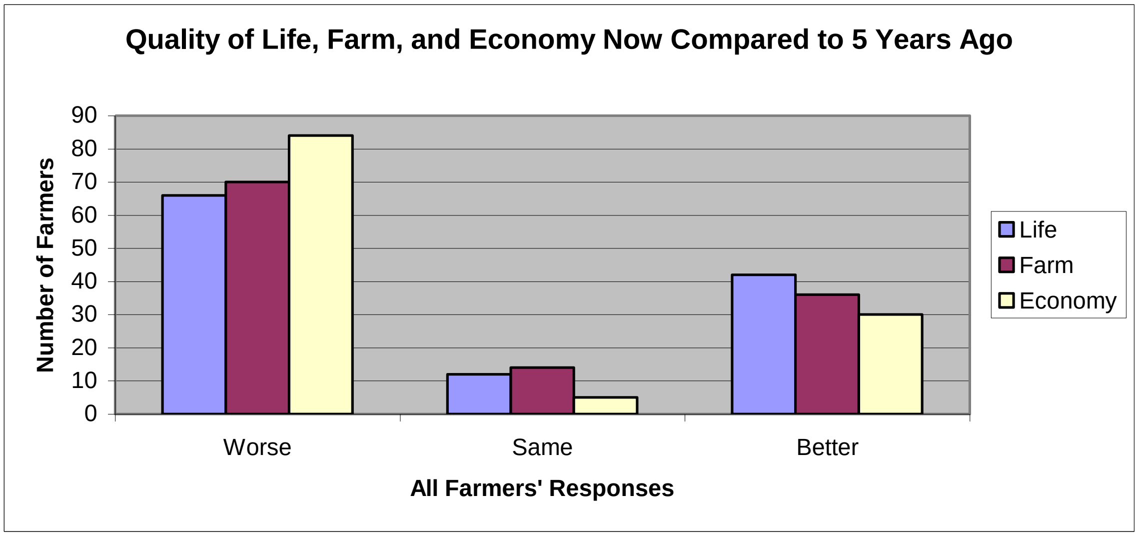

Figure 5-19. Frequency distribution of responses regarding quality of life, farm, and economy now compared to five years ago among all farmers

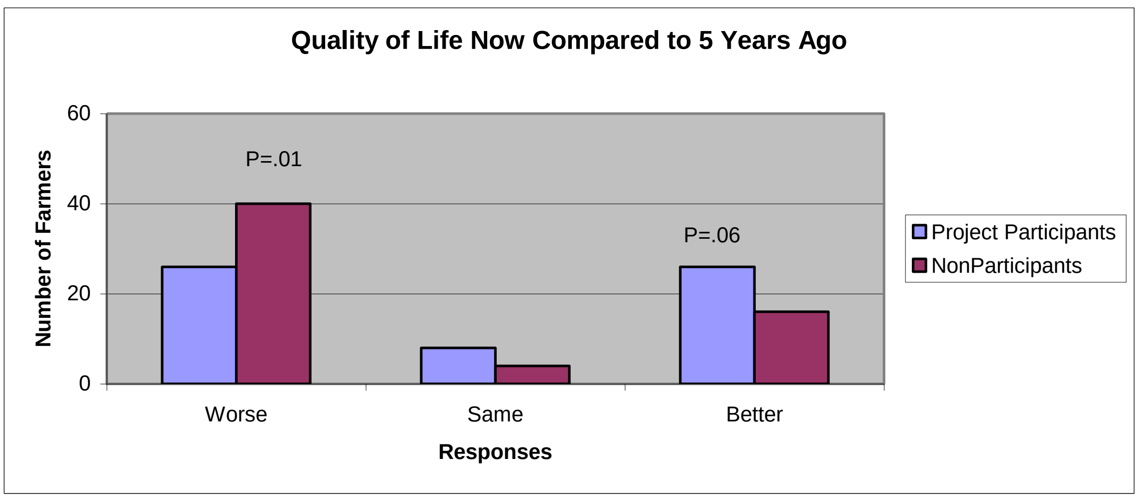

Figure 5-20. Frequency distribution of responses regarding quality of life now compared to five years ago among project participants and non-participants

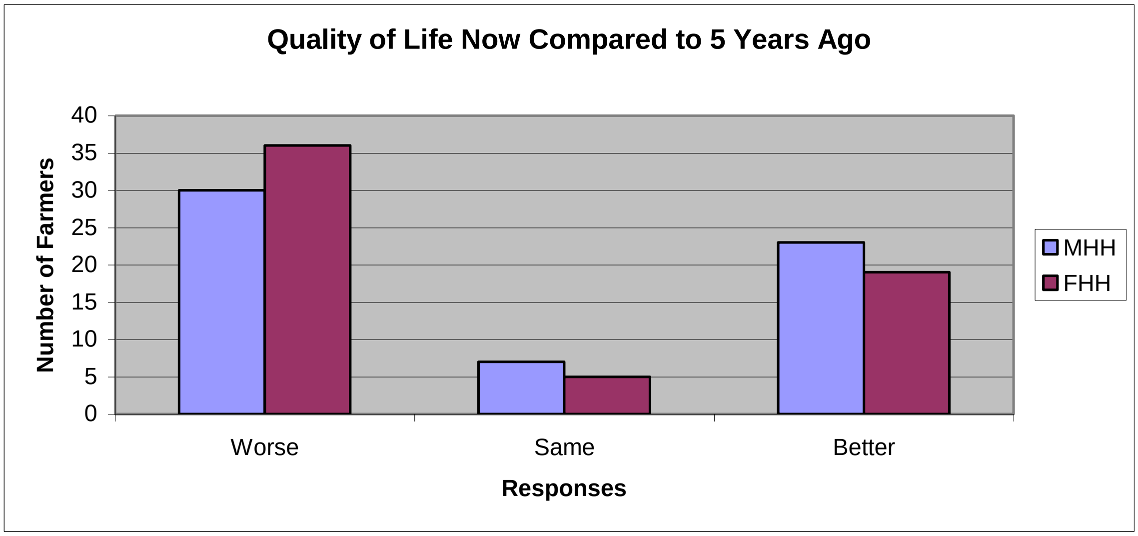

Figure 5-21. Frequency distribution of responses regarding quality of life now compared to five years ago among male-headed and female-headed households

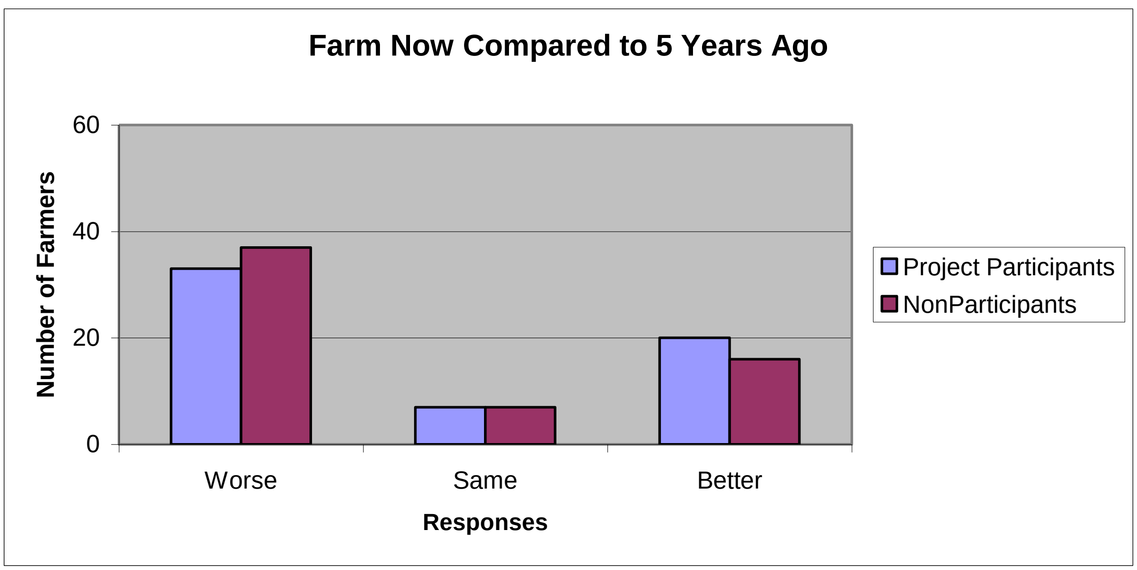

Figure 5-22. Frequency distribution of responses regarding farm now compared to five years ago among project participants and non-participants

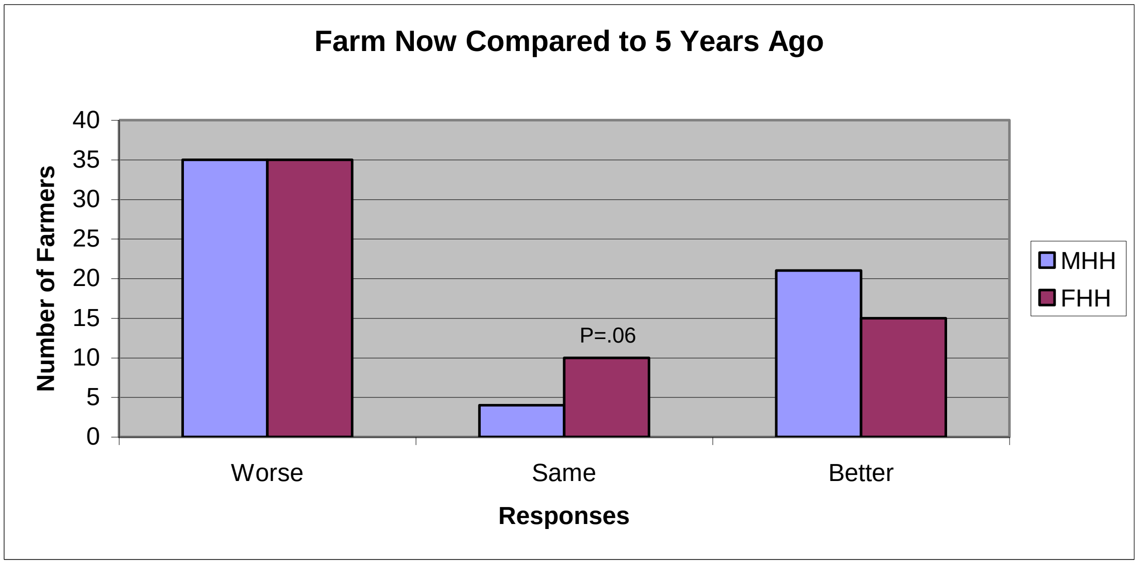

Figure 5-23. Frequency distribution of responses regarding farm now compared to five years ago among male-headed and female-headed households

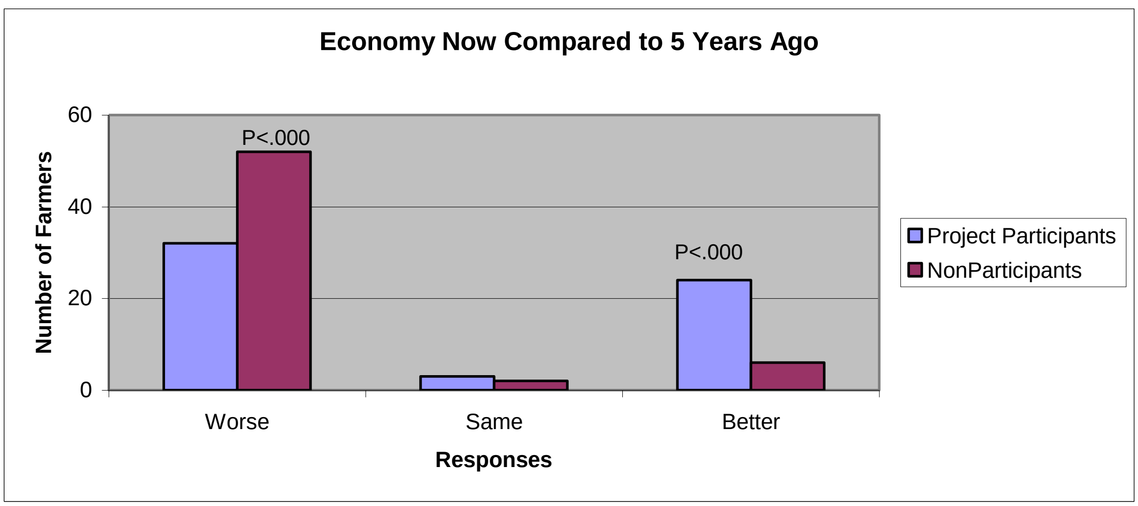

Figure 5-24. Frequency distribution of responses regarding economy now compared to five years ago among project participants and non-participants

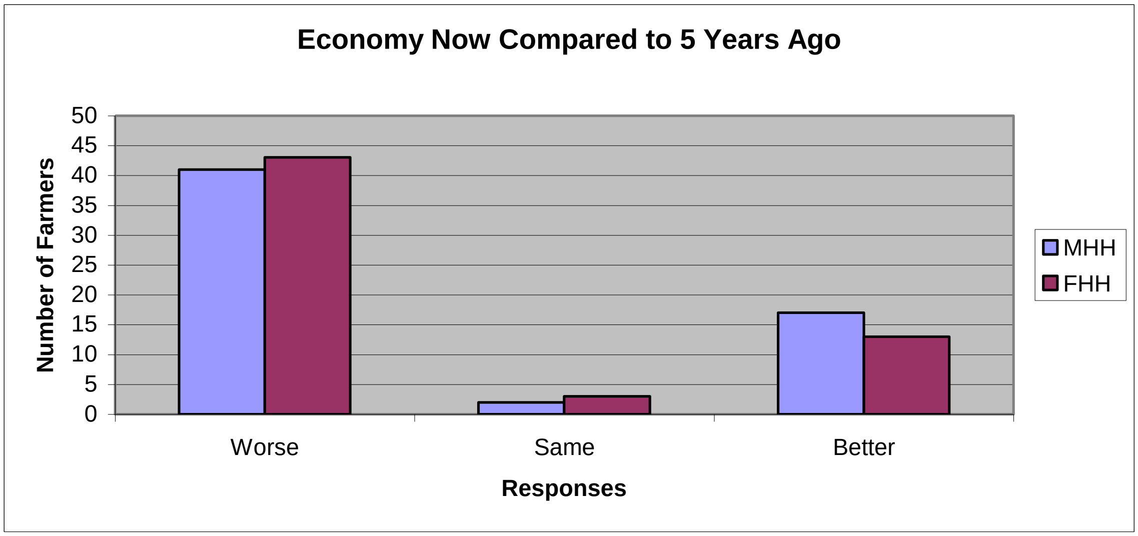

Figure 5-25. Frequency distribution of responses regarding economy now compared to five years ago among male-headed and female-headed households

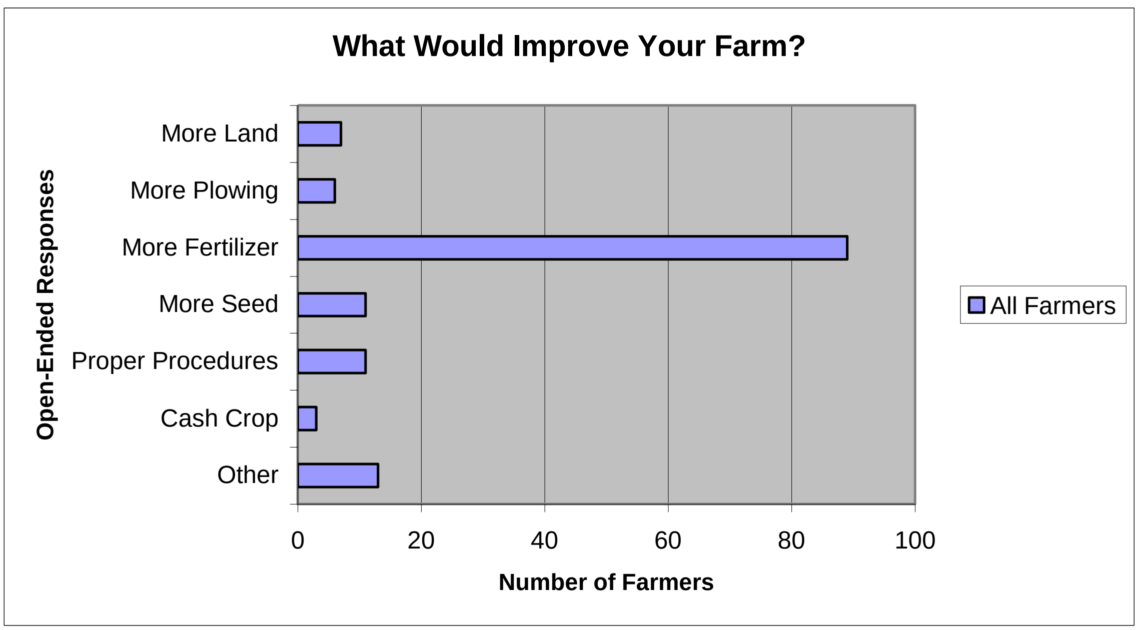

Figure 5-26. Frequency distribution of open-ended responses to the question, “What would improve your farm?” among all farmers

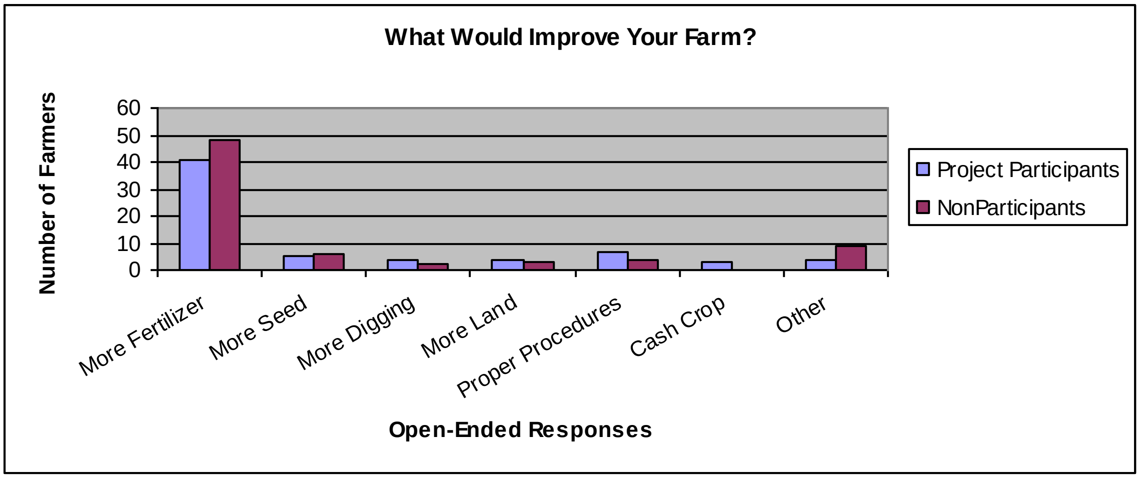

Figure 5-27. Frequency distribution of open-ended responses to the question, "What would improve your farm?" among project participants and non-participants

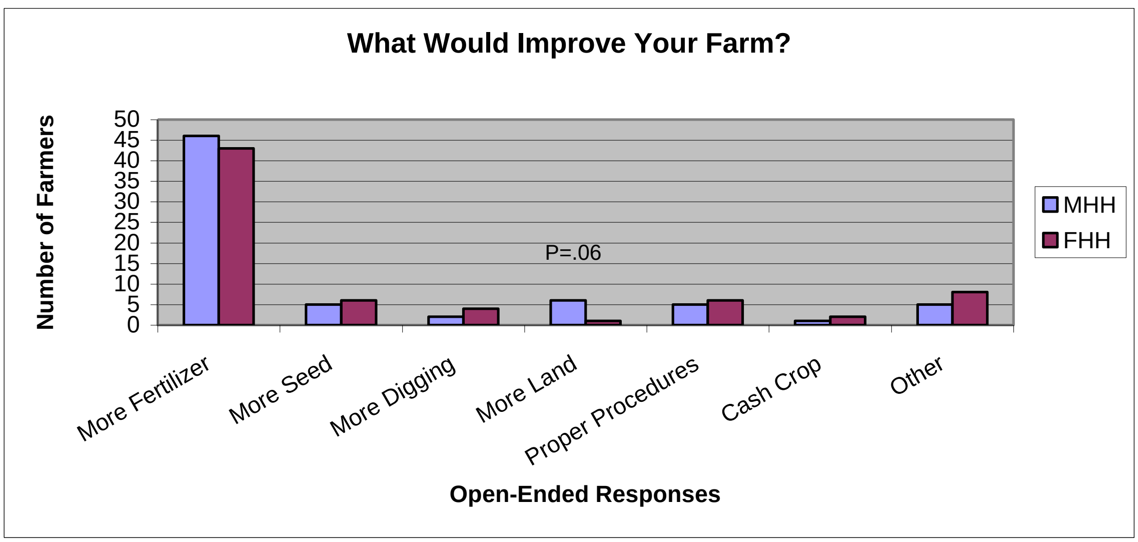

Figure 5-28. Frequency distribution of responses to the question, "What would improve your farm?" among male-headed and female-headed households

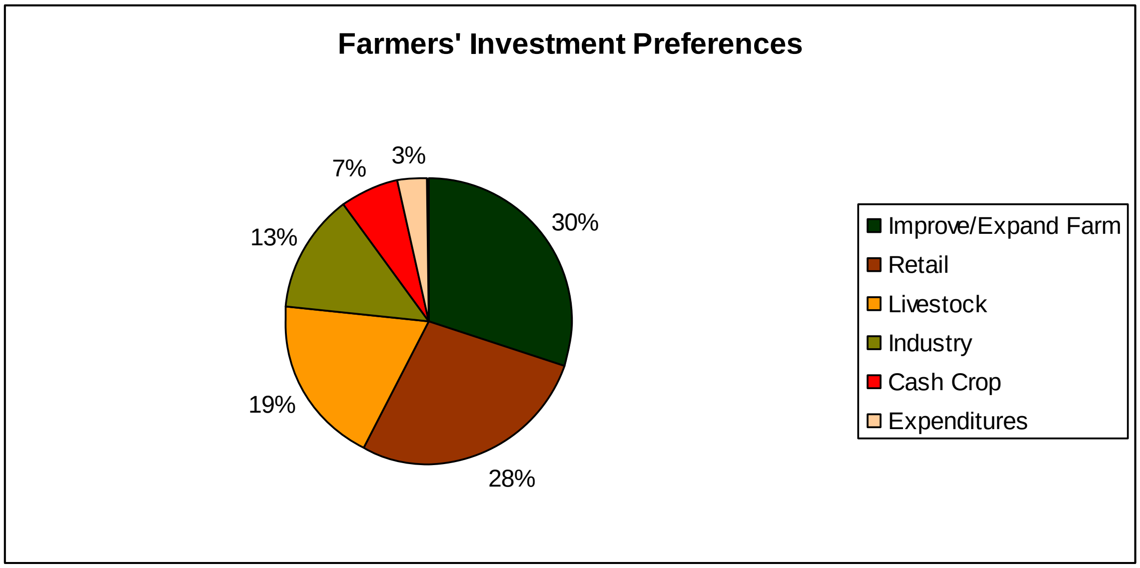

Figure 5-29. Relative frequency distribution of all farmers' responses regarding investment preferences

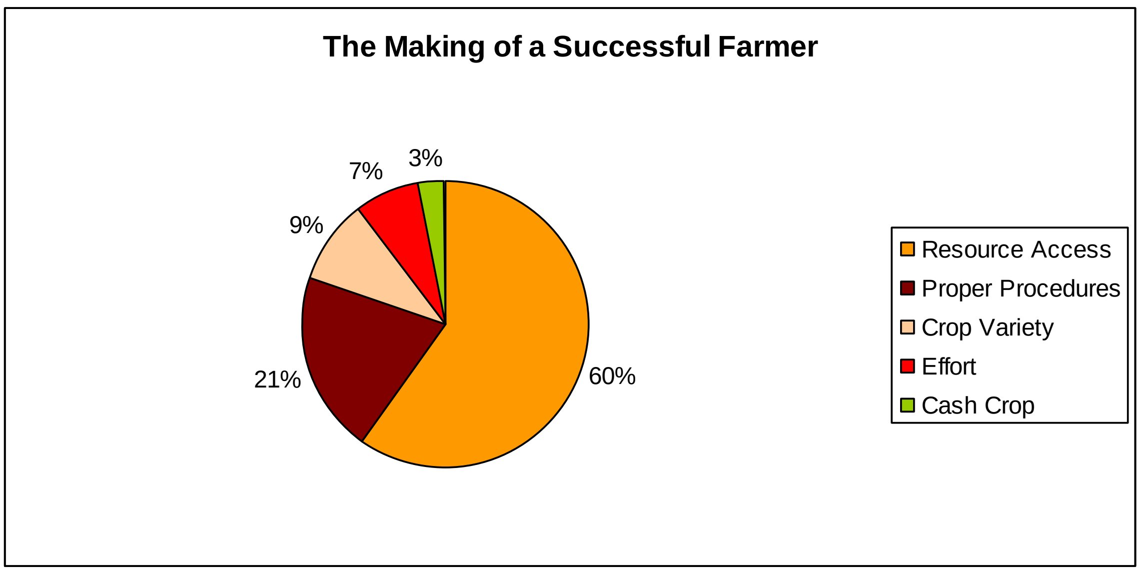

Figure 5-30. Relative frequency distribution of all farmers' responses regarding the making of a successful farmer

CHAPTER 6
DISCUSSION: EXTENSIVE FARMING AND DIVERSE LIVELIHOOD STRATEGIES

Introduction

The results of this study point to five major findings. The first and most important of these is that farmers substitute land for fertilizer. The larger their landholdings, the less fertilizer per hectare farmers apply. Because fertilizer represents the quintessential measure of agricultural intensification, western Kenyan farmers are largely decreasing, rather than increasing, the productivity of their maize and bean agriculture. A second major finding is that despite their inability to invest in fertilizer, farmers have not adopted improved fallows and biomass transfer. Instead of increasing the yield of maize and beans with soil fertility enhancement measures, farmers supplement production with nonfarm work, agricultural wage work, and kale production. Yet a third major finding of this study is that off-farm work differentially affects the farm according to the kind of off-farm work. Off-farm nonagricultural work leads to on-farm improvements while off-farm agricultural work leads to the neglect of on-farm activities. A fourth major finding is that chang'aa/busaa brewing for sale constitutes the most important nonfarm source of income, particularly for land-constrained farmers, while kale production constitutes the most important cash crop, particularly for wealthy farmers. Chang'aa and busaa brewers produce insufficient quantities of maize and beans and, in turn, purchase maize for consumption with cash earned through brewing. Kale farmers produce sufficient maize and beans and, in turn, substitute kale cultivation for maize and bean cultivation on spare land. Finally, a fifth major finding substantiates these trends by comparing the labor and/or cash requirements of soil fertility enhancement measures and other agricultural inputs and illustrates that the prices of some inputs far exceed the value of the additional maize that would be produced.

Extensive Farming Strategies

Given western Kenya's reportedly high population growth rates (Sanchez et al. 1997) and the theories put forth by Boserup (1981) and Netting (1993) which posit that farmers intensify production in the face of decreasing fertility, it was hypothesized in Chapter 4 (H1a and H1b) that households throughout western Kenya would be intensifying the production of their staple crops through soil fertility enhancement measures such as improved fallows, biomass transfer, and fertilizer use and through increased amounts per hectare of oxen use, hired labor, and seeding rate. Thus it was unexpected, although not entirely surprising, that the results of this study reject these hypotheses by indicating households in the study area in western Kenya are producing maize and beans extensively, not intensively. That is, agricultural inputs including soil fertility enhancement measures are negatively associated with landholding size. The larger a landholding, the smaller the amounts of fertilizer applied, oxen used, labor hired, and seeding rate. Moreover, no one is using improved fallows and only three farmers reported using biomass transfer, out of a sample of 120 households.

Extensification is most clearly indicated by the production and input equations (Tables 5-2 through 5-13) presented in Chapter 5. The production regressions (Tables 5-2 and 5-3) indicate that per acre yields of maize are significantly and negatively associated with landholding size. Farmers' per acre yields of beans are also negatively, though not quite significantly associated with landholding size. The input regressions (Tables 5-4 through 5-13) indicate consistently that all agricultural inputs applied per area of land in the production of maize and beans are negatively associated with landholding size. Every single agricultural input is applied at a rate that is negatively associated with the amount of land owned by the household. Fertilizer use (Table 5-5) and bean seeding rate (Table 5-13) are significantly and negatively associated with landholding size. Oxen use (Table 5-7) and maize seeding rate (Table 5-11) are somewhat significantly and negatively associated with landholding size. Only hired labor (Table 5-9) is not quite significantly, yet still negatively, associated with landholding size.

Thus, if households in western Kenya are applying agricultural inputs at rates that are negatively associated with the amount of land they own and are, in turn, producing maize and bean yields that are negatively associated with the amount of land they crop, it can be safely concluded that households in western Kenya are producing their staple crops extensively. Households are not applying their agricultural inputs intensively—particularly fertilizer, *the* soil fertility enhancement measure. Their maize and bean yields are not positively associated with their maize and bean acreage. Farmers in the study area in western Kenya are not increasing the agricultural productivity of maize and bean production. Instead, they are extensifying, rather than intensifying, their staple crop production.

Diverse Livelihood Strategies

Because research (Morera and Gladwin 2006; IEA/SID 2001; Orvis 1997; Ayieko 1995) indicates rural households supplement farm production with off-farm work and this often leads to on-farm labor shortages, it was hypothesized in Chapter 4 (H2a and H2b) that the kind of off-farm work would determine whether off-farm income generation led to on-farm improvements or led to the neglect of the farm. Nonfarm work was hypothesized to lead to greater applications of agricultural inputs and agricultural wage work was hypothesized to lead to fewer applications of agricultural inputs. Overall, the results of this study support these hypotheses.

Off-farm Nonagricultural Work

With the exception of chang'aa/busaa brewing (discussed in the next section) and a few isolated cases of nonagricultural retail (i.e. paraffin, sweaters, and medicine), nonagricultural work was largely carried out at long distances from the farm, with only a fraction of the income it generated reaching households in the form of remittances. Nonetheless, the results of this study indicate that nonagricultural off-farm earnings support households in ways neither agricultural wage work nor brewing can.

Four equations, in particular, illustrate the uses of nonagricultural off-farm income. The first of these is illustrated in Table 5-7 and indicates off-farm nonagricultural work is significantly and positively associated with oxen use per acre of land cropped in maize and beans (P=.07), meaning nonfarm remittances are applied towards maize and bean production. The second equation, illustrated in Table 5-18, indicates off-farm nonagricultural work is significantly and positively associated with kale acreage (P=.07), implying nonfarm remittances are applied towards kale production. The third equation, illustrated in Table 5-15, indicates off-farm nonagricultural work is significantly and positively associated with total acres owned (P=.007), implying nonfarm remittances are applied towards the purchase of agricultural land. Finally, the fourth equation is illustrated in Table 5-17 and indicates off-farm nonagricultural work is significantly and positively associated with children's cumulative years of schooling (P=.05), implying nonfarm remittances are applied towards school fees.

Results of inferential bivariate statistics and farm history analysis also illustrate the importance of nonfarm remittances. Figure 5-6 indicates female-headed households, in particular, apply nonfarm earnings towards agricultural inputs. The case study presented in Table 5-23 illustrates a female household head, which has improved her farming through the receipt of a loan, making loan payments with nonfarm remittances received from her husband and her sister. In sum, quantitative and qualitative results indicate nonfarm income is used towards on-farm improvements and the betterment of the household, supporting H2a, listed in Chapter 4.

On-farm Nonagricultural Work

On-farm nonagricultural work refers to nonfarm entrepreneurial activities that are undertaken on a farming homestead. The most common of these in this study's research site is chang'aa brewing. Farmers, mostly female, produce chang'aa liquor for sale. In most cases, they purchase rather than produce the ingredients that are necessary to brew and distill the liquor. Many farmers, including male heads, report that chang'aa is their household's most important source of income. Busaa beer is also brewed for sale, although not as commonly as chang'aa. The illegality of brewing, however, makes it a marginal enterprise.

The variable most closely associated with chang'aa and busaa brewing is the number of months per year maize must be purchased for consumption as a result of insufficient maize production. The association is significant (P=.005) and positive, as illustrated in Table 5-19. The next variable most closely associated with chang'aa/busaa brewing is acres owned. Again, the association is significant (P=.03) yet negative, as illustrated in Table 5-15. Not surprisingly, chang'aa/busaa brewing is also significantly (P=.09) and negatively associated with bean yield, as illustrated in Tables 5-3. Together, these three equations reveal that chang'aa/busaa brewers are land-constrained. They must purchase maize for consumption because they own very little land and harvest insufficient amounts of maize and beans to sustain them throughout the year. They earn cash through the sale of chang'aa and busaa and purchase maize with the cash. Interestingly, Table 5-16 indicates they also purchase cattle with the cash. Chang'aa/busaa brewing is somewhat significantly (P=.13) and positively associated with total cattle owned. This last equation indicates chang'aa/busaa brewing for sale is relatively lucrative, although clearly not as much so as off-farm nonagricultural work, but more so than agricultural wage work, as illustrated in the next section. Because results indicate that the nonfarm income generated through chang'aa/busaa brewing not only feeds the farm, but expands its assets through investment in cattle, H2a is once again supported.

Off-farm Agricultural Work

The nature of agricultural wage work is best understood by observing that its association with most inputs applied and outputs produced in maize and bean farming is negative, as illustrated in Tables 5-2 through 5-13. In fact, its association with most wealth indicators is also negative, as illustrated in Tables 5-14 through 5-17. It is negatively and significantly associated with total acres owned (Table 5-15; P=.08) and with children's cumulative years of schooling (Table 5-17; P=.07), and it is negatively and somewhat significantly associated with hired labor (Table 5-9; P=.20) and bean seeding rate (Table 5-13; P=.11). Of course, the reason for all these negative associations is that agricultural wage work is both time-consuming and poorly remunerated. Its wages are the lowest in the rural sector.

Agricultural wage work tends to be undertaken by younger farmers as the work is too strenuous for older farmers. Moreover, older farmers usually have older children who contribute to their livelihoods. In turn, younger farmers are more likely to have recently inherited a partitioned, and thus small, landholding whose productive capacity must be supplemented with alternate livelihood strategies. Younger farmers also tend to have young children who are in their early years of schooling.

The results of farm history and script analyses also illustrate the role of agricultural wage work for smallholders. Table 5-25 presents the life story of a woman who neglects her own farming through engagement in agricultural wage work. Her husband's landholding is small and unproductive, forcing her to earn cash through agricultural wage work in order to make ends meet. However, the work interferes with the timing of tasks on her farm and she complains that her farm "lags behind." Similarly, the results of script analysis, illustrated in Tables 5-21 and 5-22 and discussed in Chapter 5, compare the calendars of "good' and "bad" farmers and indicate that proper timing is linked to resource access. These qualitative results, together with the quantitative results discussed above, support H2b, listed in Chapter 4.

The Matter of Wealth

Five equations in Chapter 5—estimated for wealth index, landholding size, cattle owned, cumulative years of schooling, and kale acreage—illustrate the nature of wealth throughout the sampled villages of western Kenya. Four of these are discussed in the section titled "Wealth Equations" in Chapter 5 and illustrated in Tables 5-14 through 5-17. The fifth, estimated for kale acreage, is discussed in the section titled "Additional Equations" in Chapter 5 and illustrated in Table 5-18. Together the equations point out several important features of wealth.

The first important feature of wealth is that fertilizer use per acre is the most significant and positive predictor of wealth index in Table 5-14 (P=.04). The next most significant predictor of wealth, negatively, is number of months per year maize is purchased for consumption (P=.07). That is, farmers who do not produce sufficient maize, such as those who engage in agricultural wage work or brew chang'aa and busaa for sale, are not wealthy. Naturally, total acres owned is positively and significantly associated with wealth index (P=.10). Together these features indicate that wealthier households tend to have more land, use more fertilizer, and purchase less maize annually for consumption than poorer households.

Another important feature of wealth, as indicated by Tables 5-15 and 5-16 , is that total acres owned and total cattle owned, chief proxies for wealth in the countryside, are both controlled by men. For this reason, both are significantly and positively associated with male-headed households (P=.02 and P=.08, respectively). Total acres owned, in Table 5-15, is also significantly and positively associated with off-farm nonagricultural work (P=.007). On the other hand, total acres owned is significantly and negatively associated with both agricultural wage work and brewing (P=.08 and P=.03, respectively, in Table 5-15). That is, large landowners and cattle owners tend to be male-headed households or households receiving nonfarm remittances while smallholders tend to be agricultural wage workers and brewers. Interestingly, brewing is most often undertaken by women.

Reinforcing these results, Table 5-17 indicates that children's cumulative years of schooling, another proxy for wealth, are positively and significantly associated with off-farm nonagricultural work (P=.05) and the receipt of bank loans (P=.10). Children's cumulative years of schooling are also positively and somewhat significantly associated with total cattle (P=.19). On the other hand, schooling is negatively associated with agricultural wage work.

The equation estimated for kale acreage—a cash crop—sheds further light on the characteristics of wealth by indicating that it is positively and significantly associated with the production of sufficient maize (P=.03), as illustrated in Table 5-18. Interestingly, kale acreage is also significantly yet negatively associated with maize and bean acreage (P=.09). This means that larger landholders can afford to substitute kale cultivation for maize cultivation because they produce more than enough maize year-round to begin with. Moreover, kale acreage is positively and significantly associated with off-farm nonagricultural work (P=.07), further reinforcing the important role and lucrative nature of nonfarm income generation.

These five equations provide insight into the role of wealth in this region of western Kenya. In turn, a sixth equation estimated for months of maize purchase, illustrated in Table 5-19 and discussed in the section titled "Additional Equations" in Chapter 5, aptly illustrates what wealth is not. Table 5-19 indicates that individuals who must purchase maize for consumption tend not to have much land, cattle, bank loans, fertilizer, nor participate in projects. Together, the six equations support H3, listed in Chapter 4, which posits that household wealth, indicated by greater landholding size, cattle owned, cumulative years of schooling, and the receipt of bank loans, is associated with greater investment in agricultural inputs and on-farm improvements.

The Role of Gender

The management of the western Kenyan farm is characterized by a gender division of labor. Thus the collection of water and firewood is usually a woman's task while land clearing and cattle herding are often a man's task. Plowing the land by hand is usually undertaken by women while plowing the land using oxen is usually undertaken by men. These culturally assigned gender roles are evident across this study’s sample data, particularly when the data are disaggregated by gender. For example, the significant differences between male and female-headed households in the sale of crops (Figure 5-3) reflect these gender divisions of labor. The sale of fruits and vegetables, such as avocados, bananas, and local greens (including those that are purchased for retail) tend to be carried out by women. Men, on the other hand, because they are more likely to manage cattle, are also more likely to carry out the sale of milk (Figure 5-9). Additionally, men are more likely to benefit from the sale of tea (Figure 5-9) because men are more likely to inherit tea land from their fathers.

The significant difference between male and female-headed households in the receipt of remittances also reflects culturally assigned gender divisions of labor. Males are more likely to migrate in search of off-farm work. Therefore, female-headed households are more likely to receive remittances from husbands working off farm while male-headed households are more likely to receive no remittances at all (Figure 5-6). Yet a significantly higher number of male-headed than female-headed households report that the sale of labor constitutes their most important source of income, reflecting the obvious fact that remittances constitute but a fraction of off-farm earnings. That is, a male’s income generated off the farm is more important to the male than to the female receiving only a portion of it in the form of remittances.

Despite these gender differences in farming activities and income generation, results of multiple regression analysis do not reflect any significant gender differences in the application of most agricultural inputs, including soil fertility enhancement measures such as fertilizer use. Only in the case of hired labor is there a significant difference (Tables 5-8 and 5.9; P=.02) in its application between male and female-headed households. The likely reason for the positive association between hired labor and female-headed households is that oxen use is managed by males. Results of multiple regression analysis also do not reflect any significant gender differences in the production of maize and beans. Thus, overall, results support H4, listed in Chapter 4, which posits no difference between male-headed and female-headed household investment in agricultural inputs.

Achievements and Failures of the PLAR Project

The results of this study indicate that the PLAR project, described in detail in the research setting chapter, provided long-range benefits to its participants despite its failure to achieve long-term adoption of improved fallows and biomass transfer among farmers. Results of bivariate statistical analysis show that a significantly higher number of PLAR project participant farmers sold cash crops and staple crops than did non-participant farmers, as illustrated in Figure 5-2. PLAR project participant farmers also had greater access to social capital, as illustrated in Figure 5-14, and reported a better quality of life and economy, as illustrated in Figures 5-20 and 5-24, . Nonetheless, multiple regression analysis indicates that maize and bean yields are actually negatively associated with project participation (P=.18 and P=.03, respectively, in Tables 5-2 and 5-3) as are oxen use and maize seeding rate (P=.10 and P=.03, respectively, in Tables 5-7 and 5-11). The likely reason for this is that the PLAR project was aimed at marginal farmers. Particularly the village of Mutsulio lies on a steep ridge that constrains farming. On the bright side, project participation is somewhat significantly and positively associated with fertilizer use (Table 5-4; P=.12) and significantly and negatively associated with the number of months per year that maize is purchased for consumption (Table 5-19; P=.02). Thus, project participation seems to have led to increased application of a soil fertility enhancement measure and, perhaps consequently, fewer months of maize purchase for consumption.

Ultimately, however, project participation did not lead to the adoption of improved fallows and biomass transfer despite significant gains in agricultural extension activities. Figure 5-17 indicates that a significantly higher number of project participant farmers than non-participant farmers participated in training barazas ($P=.0004$), received visits from extensionists ($P<.0001$), visited their extension office ($P=.02$), and received seed or fertilizer as an incentive to experiment with a technology ($P<.0001$). Yet the same table shows absolutely no difference between participant and non-participant farmer adoption of either improved fallows or biomass transfer. Furthermore, farm history analysis in Tables 5-23 and 5-24 provides two examples of the progression by which farmers participated in the PLAR project, experimented with improved fallows and biomass transfer, and later rejected the technologies. Thus, overall, quantitative and qualitative results support H5 in Chapter 4, which posits that there is no difference in the soil fertility enhancement practices of project participant and non-participant farmers.

The reason for the PLAR project's failure to achieve long-term adoption of improved fallows and biomass transfer is partially explained by the results of feasibility analysis, particularly Tables 5-26 and 5-27. These indicate that the labor requirements of biomass transfer are so large as to render the technology expensive, especially when one considers that labor and cash are interchangeable units in the rural economy of western Kenya. Labor-constrained households would need to pay more for biomass transfer than for mineral fertilizer. Moreover, households with abundant labor would need to think twice before investing in biomass transfer—which would still not guarantee a harvest given the inherent risks of farming and its vulnerability to the vagaries of weather and pests—when wage labor provides instant remuneration.

This reasoning also helps to partially explain why farmers are substituting land for fertilizer and producing maize extensively, rather than intensively. Although Tables 5-26 and 5-27 indicate that fertilizer use is more feasible than biomass transfer in raising maize yields, Table 5-28 nonetheless indicates that fertilizer prices have been rising far faster than maize prices over the last 5 years. As Chapters 2 and 3 explain, the international rise in the price of oil coupled with the degeneration of infrastructure between eastern and western Kenya have contributed to the rising price of fertilizer. Yet maize prices have not risen proportionally, explaining why farmers are unwilling to invest in the agricultural inputs necessary for its intensification. Thus, the results of feasibility analysis support H6 as listed in Chapter 4, which posits that farmers will not invest in fertilizer use if the international price of oil and driving time between eastern and western Kenya increase, causing fertilizer prices to rise faster than maize prices.

Conclusion

The results of this study have important implications for resource conservation and agricultural development efforts in Kenya. Because farmers in this region of western Kenya are producing maize and beans extensively through the application of inadequate amounts of soil fertility enhancement measures, it can be safely concluded they are degrading their lands and failing to increase the agricultural productivity of their staple crops. Land-poor farmers, rather than intensify production, apply their labor towards agricultural wage work or nonfarm work while larger landholders, rather than increase agricultural productivity, substitute cash crop production for maize and bean production. Thus smallholders do not invest their labor in organic fertilizers or improved fallows while larger landholders do not invest their wealth in inorganic fertilizers. Instead, all farmers substitute land for fertilizer. Meanwhile, soil fertility enhancement as well as aggregate agricultural productivity remains low in this region of western Kenya.

A more subtle implication of the results of this study is that no amount of agricultural extension can achieve long-term farmer adoption of soil fertility enhancement practices when macro policies provide disincentives for agricultural intensification. Without incentives for agricultural intensification, soil fertility enhancement technologies are for naught because farmers cannot afford to apply them. In this case, a combination of international factors, such as the price of oil, and domestic factors, such as poor infrastructure, conspire to raise agricultural input prices faster than maize prices—rendering staple crop production less attractive than alternate livelihood strategies, such as kale and liquor production.

In and of itself, substituting kale and liquor production for staple crop production is not a problem. The demand for kale and liquor in Kenya is domestic, indicating that the needs of the population are in sync with the production of these commodities. Moreover, the production of kale and liquor represents specialization, an important facet of agricultural development. Nonetheless, increased aggregate agricultural productivity—by definition the intensification of a population's staple crop production—remains essential to structural transformation and hence economic development. If food prices fail to rise, marginal producers will not invest in the increased costs of intensification—which, essentially are the costs associated with fertility enhancement. In most cases, they will cultivate until they degrade the land and must abandon the area or abandon agriculture. In this region of western Kenya, results imply that farmers are degrading their land and finding alternatives to staple crop production. In turn, the consequence of staple crop extensification is low aggregate agricultural productivity and delayed economic development. Because aggregate agricultural productivity remains the most important factor affecting Kenyan development, increased efforts to intensify staple crop production will be necessary if structural transformation of Kenya's economy is to be achieved.

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BIOGRAPHICAL SKETCH

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