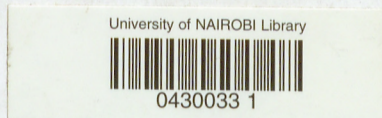


DECLARATION

**AGRICULTURAL PRODUCTIVITY, ENVIRONMENTAL
CONSERVATION AND POVERTY: THE CASE OF KENYA**

JANE WANJIKU KABUBO-MARIARA
B.A., M.A. (Econ), NAIROBI



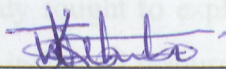
**Thesis Submitted in Fulfillment of The Requirements for the Degree of
Doctor of Philosophy in Economics, University of Nairobi, Kenya**

2003

DECLARATION

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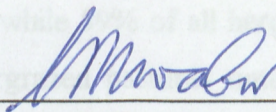
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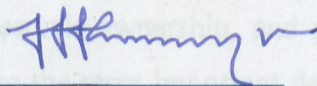
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Professor Germano M. Mwabu

Signed



Professor Peter K. Kimuyu

2003

AGRICULTURAL PRODUCTIVITY, ENVIRONMENTAL CONSERVATION AND POVERTY: THE CASE OF KENYA

ABSTRACT

This study examines the link between environmental conservation practices and agricultural productivity in a fragile ecological environment in Kajiado district, Kenya. The study was carried out against the background of growing concern that declining agricultural productivity and increasing poverty are a cause as well as a consequence of environmental degradation. The study sought to explore mechanisms for escaping from a poverty trap where poverty leads to increased resource degradation, which in turn leads to low productivity and to more poverty.

The study uses panel data to examine the nexus between environmental capital, farm productivity and profitability for the period 1998-2000. Both descriptive and econometric procedures are employed to that end. Descriptive statistics indicate that 69% of the respondents held land under private property, while the rest farmed crops and grazed livestock under common property regimes. About 43% of farmers engaged in at least one environmental conservation practice, while 59% of all herders migrated both in search of pasture and water, and to give overgrazed pastures time to recover. The data further shows that land conservation is more likely under private property than under communal tenure systems.

Property rights, availability of labour, livestock ownership, and perceptions concerning the value of environmental conservation are the most important determinants of adoption of land and environmental conservation practices. All forms of environmental conservation practices exert positive impacts on farm productivity. In addition, property rights, land ownership, technology, and availability of biomass at the village level are important determinants of productivity per acre. Our simulation results confirm the importance of well-specified property rights, environmental conservation and increased biomass on productivity. Moreover, favourable policy changes in these variables reduce poverty.

This study shows that environmental conservation practices reduce poverty through increased agricultural production. Provision of incentives for environmental conservation is the first step towards poverty reduction in the district. In contrast to earlier studies, our results suggest the need to speed up privatization of group land in order to encourage adoption of environmental conservation and increase farm productivity and household welfare. Other important policy implications include making labour markets more competitive, educating producers on the benefits of environmental conservation and about the need to conserve biomass.

Research Consortium, the Beijer International Institute of Ecological Economics and the Resource Accounting Network for Eastern and Southern Africa (RANESA) for giving me an opportunity to participate in their training and research workshops, which in many ways equipped me with new ideas and techniques and helped refine the thesis. The AERC-International Monetary Fund scholarship program enabled me to review literature at the World Bank Library in Washington D.C. I am most grateful to the two institutions.

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This thesis also benefited from presentation and discussion of related working papers at various research workshops. In particular, I would like to thank participants of two research workshops held in Swaziland and Namibia in 1999 and participants of the Environment and Development Second International Conference held in Stockholm, 2000. Thanks also to participants of two Beijer Advanced Workshops on Property Rights and Environmental Resource Management held in Egypt, 2001 and South Africa, 2002.

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CHAPTER ONE

BACKGROUND AND CONTEXT

1.1 Introduction

Kenya experienced a relatively stable economic environment in the 1960s and early 1970s. The growth rate of GDP stood at 6.5% per annum between 1964 and 1971. The situation however changed drastically starting in the early 1980s when the economy entered into a phase of macro economic instability, and experienced falling per capita incomes, declining consumption and increasing poverty.

The macroeconomic problems were aggravated by other exogenous developments such as the droughts of 1970-80 and 1984, which adversely affected agricultural production and led to massive food imports. Other shocks which adversely affected the economy included the boom and bust cycle in coffee and tea prices in 1976-79, the break up of the East African Community in 1977 and the second oil shock in 1979. The attempted military coup of 1982 also led to capital flight and adversely affected investment. This resulted in mixed performance with fluctuations in the growth of gross domestic product, fiscal deficits and inflation. The economy recovered in the late 1980s, recording an average growth rate of about 5% between 1987 and 1989. Further, deterioration occurred in the early 1990s with poor performance in almost all the sectors of the economy. However, with renewed reform efforts in 1993, the economy began to recover, attaining an average growth rate of 4.2% in 1994-96. Another recession was however experienced towards the end of the 1990s with the growth rate declining to 1.8% in 1998.

The government reacted to the weak macro economic performance of the late 1970s by reforming domestic price regimes, trade and exchange rate regimes and seeking external finances whose general policy conditionalities were spelt out in the 1974-78 Development plan and the 1975 Sessional Paper no. 4 on *Economic Prospects and Policies*. Domestic price regulation was expected to increase producer prices of formerly regulated commodities and because these commodities are major food and export crops,

it was believed that their deregulation would increase production and lead to rising agricultural incomes. But the rising output in rural areas was bound to lead to an increased demand for rural workers, which in turn would lead to rising rural wages and declining urban and rural income disparities. The expected impact of deregulation was not achieved but instead, the gross domestic product fell, terms of trade worsened while the budget deficit went up.

The trade and exchange rate reforms were designed to remove distortionary trade taxes and exchange controls in order to make exports competitive at the world market. But if that were successful, it would have shifted resources including labor to production for exports. Depending on the skill intensity of the successful exports, workers with different skills would be affected differently. The success of trade policy reforms have been sporadic with periods of significant progress followed by slower movement and even reversal, due to lack of proper coordination with macroeconomic policies (O'Brien and Ryan 2001).

Public sector reforms were aimed at making the sector efficient through reduction of waste and encouragement of effort. Part of this was to be achieved through reduction of personnel and paying those retained better in addition to privatizing public corporations, all of which have affected workers wages and reduced employment. The result of retrenchment has been to increase growth and employment of the informal sector as new retrenchees start up informal sector activities (Republic of Kenya, Economic Survey, 2001). Although sectoral reforms commenced in the early 1980s and two agricultural sector adjustment loans were given in 1980 and 1990, it was not until 1993 when liberalized market policies for the agricultural sector became prominent.

The government effected changes in macroeconomic management, which resulted in mixed impacts on the agricultural sector. For instance, removal of foreign exchange controls enhanced agricultural growth by providing incentives to producers in the form of high producer prices while trade liberalization had a dampening effect on agricultural food crop production. Custom duty and value added tax rates have been continually

revised downwards favoring the agricultural sector, but the tariff schedules on agricultural inputs seem to discriminate against smallholders encouraging large-scale production.

In other words reform policies adopted by the Kenyan economy did not do much to increase incomes and therefore reduce poverty due to a combination of unfavourable factors including weather conditions, rising input costs, high domestic interest rates, power shortages, dilapidated physical infrastructure, pre-election violence, and other institutional setbacks, which led to a decline in investments, tourism and trade opportunities, thus worsening the poverty situation. The reforms failed to restore growth of gross domestic product of the 1960s and 1970s. With slow economic growth, the incidence of poverty has increased since 1980 and social indicators have shown negative trends (World Bank 1994). At the same time, poor productivity of agriculture, exacerbated by low levels of use of external inputs and extensive use of land has led to higher levels of poverty among agricultural households (Republic of Kenya 2000a). With unfavorable macroeconomic policies, smallholders are therefore forced to exploit their land resources in order to make up for declining incomes. The increased productivity resulting from this exploitation is however only short-term as the resources eventually become degraded. One of the major causes of low productivity and poverty is therefore land degradation, which is most severe in more marginal agricultural lands.

Available evidence for instance, indicates that the African continent is undergoing rapid rates of land degradation and conversion, with 25% of the world's degraded land being located in African countries, and 22% of the vegetated land in Africa being classified as degraded (Barbier 1999). Overgrazing accounts for nearly half of the human-induced soil erosion, while agricultural activities account for one-quarter. Deforestation and wood harvest account for nearly 15% of the degradation. Overgrazing and crop farming are therefore the main causes of land degradation. Many African pastoralists and farm households respond to declining land productivity by abandoning existing degraded pasture and cropland and moving into new lands. Even if rural households choose to stay on degraded land, declining productivity cannot support the growing rural population.

Thus some households will be forced to abandon existing agricultural areas in search of new land. Without additional investment in soil conservation, this process will repeat itself. Eventually, overgrazing and over cultivation will lead to land degradation, and the search for new pasture and cropland will begin again (Barbier 1999).

The same scenario is observed in Kenya, where about 25% of the poorest people live in marginal agricultural areas. These less favorable agricultural lands, with lower productivity potential, poor soils and physical characteristics are easily prone to land degradation due to over cropping, poor farming practices and inadequate conservation measures. Such households have only land and unskilled labour as their principal assets and are dependent on their farms as their main source of income. However, given the poor land quality, and limited land holdings, these households engage in low-productivity farming practices that often exacerbate problems of land degradation. Moreover, although improved land and resource management as well as investment in appropriate inputs and farming systems are necessary for sustained agricultural development of poor rural areas, the poverty of smallholder farmers severely constrains their ability to manage the scarce resources at their disposal. On the other hand, land degradation and the associated loss of productivity impose high private costs to the farmer, in-terms of materials and equipment required to halt degradation and forgone output or loss of output resulting from degraded lands.

This thesis is motivated by the concern that declining agricultural productivity and poverty are due to environmental degradation. The study is therefore an attempt to shed light on the linkage between environmental conservation, farm productivity and the poverty reduction policies suggested by this linkage.

1.2 Statement of the Research Problem

At independence, the Kenyan government identified poverty, ignorance and disease as the major constraints to socio-economic development. Although the commitment to growth and poverty reduction has remained unchanged over the years, the poverty situation in the country has worsened (Republic of Kenya, 2000a).

Previous studies indicate that poverty is most prevalent and severe in rural areas where the bulk of the population resides deriving its livelihood from agriculture and related activities (Mwabu et al. 2000). This is consistent with Barbier's (1997) argument that in developing countries, poor rural households often live in marginal agricultural areas where land productivity and thus household income is stagnant or declining. Furthermore, the poorest groups in rural Kenya are concentrated on low-potential lands (defined as resource- poor or marginal agricultural lands) where inadequate or unreliable rainfall, adverse soil conditions, high fertility and poor topography limit agricultural productivity and increase the risk of chronic land degradation. A large proportion of the poor live in low potential lands deriving their incomes from ecologically fragile environments (Holden et al. 1998). Given this scenario, local resource management by poor rural households is a crucial factor in addressing the poverty problem in Kenya.

Land degradation in Kenya, as in most other developing countries, has manifested itself in rapid rates of natural capital depletion, exemplified by forest degradation and soil erosion especially in river basins. The situation is worse in the dry lands where there is serious environmental deterioration largely due to rapidly increasing human and animal population pressure. The crisis has manifested itself in resource depletion and declining production (Darkoh, 1994). Republic of Kenya (1999) attributes this degradation to poverty. The poor engage in activities such as poor farming practices, overgrazing and burning of trees to make charcoal. These practices have negatively affected the environment and have reduced the land potential especially in the arid and semi arid areas making the struggle for survival hard and leading to over exploitation of land and water resources.

Available evidence indicates that there are two overall aspects of poverty-environment linkages at the rural household level critical to the process of land degradation in developing countries. First, poverty is not a direct cause of environmental degradation, but is a constraining factor on rural households' ability to avoid land degradation or to invest in mitigating strategies. Second, poor households are unable to compete for

resources, including high-quality and productive land, such that they are often confined to unproductive areas, which further perpetuates poverty (Barbier 1998).

Furthermore, fertility decisions are influenced by the poverty profile of the household as well as by the household's access to resources (Dasgupta and Mäler 1995). Population growth is therefore endogenous and land degradation may over time affect the fertility of poor households. Hence, although rapid population growth rates may create greater pressure on fragile land, the feedback effects between population, land degradation and rural poverty may be more difficult to trace.

The joint occurrence of a growing rural population, rural poverty and degradation of the natural resource base used by the poor has however led to the conclusion that population growth and poverty are the major causes of natural resource degradation. Three main arguments are advanced to support this conclusion:

- Poverty leads to short planning horizons, which prevent poor households from investing in conservation to protect their natural resource base. High rates of time preference make rural households to discount the future heavily and thus degrade resources today.
- High levels of poverty and population growth put pressure on fragile natural resources in low potential areas. With low levels of income, satisfaction of present demand at the cost of the future results in depletion of the environment. Barbier (1998) indeed argues that there is evidence that rural poverty, coupled with rising populations and demand for agricultural land is an important factor in the "cumulative causation" process of land degradation and conversion in many African countries.
- Poor rural households live in marginal agricultural areas where land productivity is stagnant or declining. With limited access to capital or to alternative economic opportunities they extract short-term rents through resource degradation resulting

in expanded agricultural activity on frontier forests and other marginal lands, resulting in further degradation.

According to Chopra and Gulati (1998), analytical and empirical arguments maintain that poverty results in environmental degradation of the above nature, while high rates of population growth compound the adverse environmental impact. The authors however also argue that the link between population and environmental degradation is not linear, but is mediated by the institutional context within which it takes place. Other studies concur that institutions such as property rights affect productivity and degradation. For instance, Pinckney and Kimuyu, (1994), cite literature which argues that individual property rights spur growth through increased credit resources, higher security of investment and the increase in land area controlled by the most efficient farmers. Furthermore it is argued that traditional institutions that control the use of land not only regulate resource use at efficient levels but also adapt to changing exogenous conditions so as to preserve efficiency, Chopra and Gulati (1998).

Barbier (1998) argues that the reason why we observe a cumulative causation link between land degradation and conversion is related to the role of poverty in influencing the economic incentives and behavior of many poor rural households. The way markets and institutions operate determine economic incentives that face even the poor rural households, while on the other hand, markets and institutions are in turn affected by public policies and investments. Barbier therefore argues that we can find ways of overcoming rural poverty and land degradation provided we analyze carefully the institutional and policy failures that exacerbate such problems and improve our understanding of why certain policies and investments have succeeded where others have not. He concludes that land degradation is not an environmental problem separate from the core development concerns of reducing widespread poverty.

These arguments notwithstanding, studies on poverty in Kenya have ignored the impact of environmental degradation on farm productivity and links to poverty (Greer and Thorbecke 1986, Mwabu et al. 2000). Empirical investigation of the links between

productivity and environmental conservation would shed light on how policy can effectively address poverty reduction in fragile ecological environments. Our study aims at filling this research gap. The study addresses the following question: What is the relationship between the state of environmental capital, agricultural productivity and poverty? More specifically, the study is concerned with the following issues: What factors explain environmental conservation? What environmental conservation practices would be most suitable in order to ensure sustainable agricultural productivity? What role do institutions such as property rights play in environmental conservation and poverty reduction?

1.3 Objectives of the Study

The general objective of the study is to analyze the linkages between agricultural productivity, environmental conservation and the implications of these linkages for poverty reduction strategies in rural Kenya, with particular reference to Kajiado district.

The specific objectives of the dissertation are:

- To investigate and determine the impact of land institutions controlling for other factors on environmental conservation.
- To investigate the linkages between environmental conservation and agricultural productivity.
- To simulate the impact of policy changes on productivity and on the base poverty rate.
- Draw policy conclusions and recommendations for poverty reduction strategies from study findings.

1.4 Justification of the Study

The link between poverty and environmental degradation is a contentious one. Many authors argue that the poor degrade the environment in their endeavours to satisfy their present needs. Others argue that it is poor environmental quality that leads to poverty. Developing countries are therefore said to have an environmental equivalent of a “low-level equilibrium trap”: poverty leading to increased resource degradation, then leading to

low productivity and to more poverty (Lopez 1997b, Mäler 1997, Dixon 1997). Barbier (1998) further notes that many poor rural smallholders across Africa often find themselves caught in a vicious cycle of debt, poverty and land degradation. Although dependent on limited land holdings for agricultural income, these households engage in low-productivity farming practices that often exacerbate problems of soil fertility decline and land degradation. Not only are poor smallholders unable to finance investments in land improvements; they are also often forced into debt just to finance essential inputs. The more these households borrow, the more indebted they become and the more they degrade their lands further as they try to raise incomes to repay their debts (Barbier and Lopez 1998).

Our study offers important policy prescriptions, concerning poverty reduction strategies, which could enable Kenya to break out of the “low-level equilibrium trap” and the vicious cycle of land degradation and poverty. Furthermore, it also adds to the scarce empirical knowledge on poverty and environmental degradation in Kenya.

1.5 Limitations of the Study

Three main problems were encountered when carrying out this study. In the first place, the study relies on cross-sectional time panel primary dataset, which necessitated that the same households were visited several times, specifically three times. Problems of non-response and sample attrition were encountered in successive waves of the study. The main reason for this was hostility in some households and also because some respondents migrated in search of pasture. However, since the drop in responses was not systematic across time periods, it is unlikely to bias our results.

Another data collection problem relates to the culture of the community studied. The *Maasai* are deeply rooted in their traditional beliefs, which in a way affects the accuracy of data collected from them. For instance, they believe that actual enumeration of children or livestock would cause death to them. During one of our field visits, we had been denied entry into a certain cluster in Loitokitok division as the area residents complained that in the previous year, some researchers went to the cluster and asked for

details on number of children, which (they believe) resulted in death of two children in mysterious circumstances. Respondents may thus have given rough figures for the number of household members and livestock. In one instance, we were interviewing a herdsman who claimed that he had about 20 heads of cattle, but before the interview was over, his sons drove in with about 50 heads of cattle. The understatement of such numbers is however likely to have been random across households and should not bias our results.

Finally, the identification problem was encountered at the estimation stage, given the joint determinants of environmental conservation and productivity. It is virtually impossible to find variables that theoretically affect environmental conservation without also affecting productivity. To solve the problem, a number of instruments were chosen to identify the environmental conservation equation.

1.6 Organization of the Thesis

The remainder of the thesis consists of seven chapters and two appendices organized as follows: Chapter two discusses the relationship between agricultural institutions, environment and poverty. Chapter three presents a review of relevant literature. The first section of this chapter discusses literature on the role of institutional factors in resource use; the second section discusses literature on the productivity-environmental linkage, focusing mostly on literature from developing countries. Chapter four presents the analytical framework. In that chapter we derive a discrete choice model for predicting environmental capital, after which we analyze productivity functions, which relate average revenue to institutional and environmental factors. This is followed by a discussion of econometric problems and how we have addressed them. The last sub section of the chapter presents definition and measurement of variables used in the analysis. Chapter five discusses data and sample statistics. The first section presents a discussion of data collection methods and a brief description of the study area, the second section presents a detailed description of the primary data and the chapter ends with a brief description of the secondary data.

Chapters six and seven present the empirical findings of the study. In chapter six, we discuss results for environmental conservation practices derived using the fixed effects instrumental variable method. Reference is also made to results derived using multinomial and logit binary models. In chapter seven, we discuss the determinants of productivity. In the first section, we present the second stage estimates of productivity derived from the fixed effects instrumental variable model for the full sample. We also make reference to results from alternative specifications presented in appendix 1. Among other determinants, we use the environmental capital variables to explain productivity variations across households. In the last section, we simulate the impact of policy changes on productivity and poverty. Chapter eight presents conclusions and policy recommendations of the study and suggests areas for further research.

Given the size of the agricultural sector in the economy, its growth will remain the key factor in stimulating rapid economic growth and the attainment of higher incomes for the country's rural population. The contribution of the manufacturing sector, on the other hand, depends much on the growth of the agricultural sector given the strong linkages between agriculture and industrial growth. For instance, expanding agriculture allows more raw materials to be marketed and processed and requires more inputs for farming, thus stimulating these sources of growth. Other than for the manufacturing sector, most policy documents underplay the linkage between agriculture and other sectors. It is important to note that the sector also has strong linkages with trade and services as evidenced by the amount of transactions between these sectors (Republic of Kenya, Economic Surveys, various issues). Such linkages are evident from the inputs purchased by the agricultural sector from other sectors, the most important being fuel and power. Other important categories include fertilizers, manufactured feeds and purchased seeds (see Table 2.1).

CHAPTER TWO

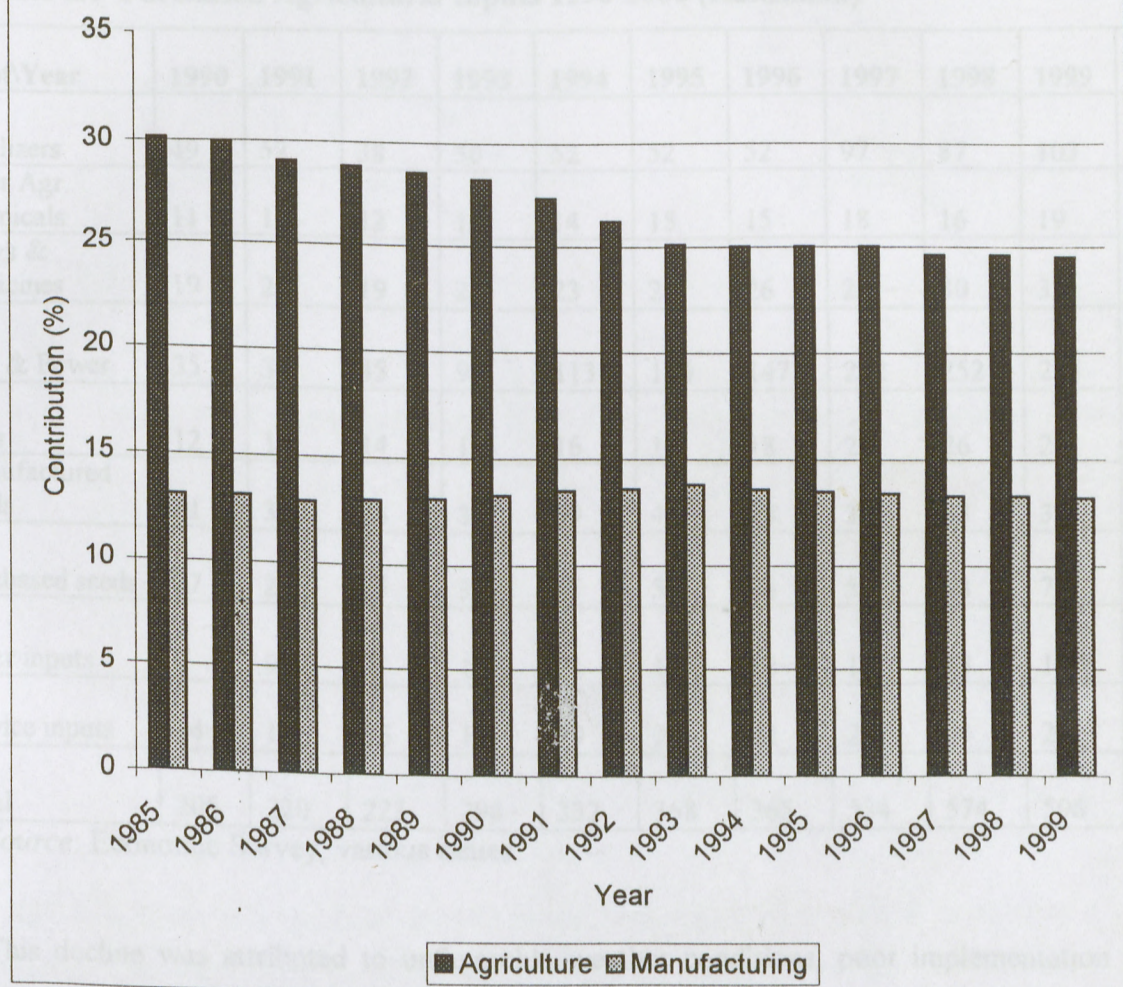
AGRICULTURAL INSTITUTIONS, ENVIRONMENT AND POVERTY

2.1 Role of Agriculture in the Economy

Agriculture continues to be the leading sector in the Kenyan economy in terms of its contribution to real GDP. During the period 1964-74, the sector contributed 36.6 percent of GDP, 33.2 percent in 1974-79, 29.8 percent in 1980-89, and 26.5 percent in 1990-95 and 24.5% between 1996 and 2000. Over the same period the manufacturing sector recorded a growing contribution to GDP of 10%, 11.8%, 12.8%, 13.6% and 13.3% respectively. Between 1993 and 1998, however, the contribution of agriculture to GDP stagnated at 25% while that of manufacturing declined from 13.8% to 13.3% (Figure 2.1a).

Given the size of the agricultural sector in the economy, its growth will remain the key factor in stimulating rapid economic growth and the attainment of higher incomes for the country's rural population. The contribution of the manufacturing sector, on the other hand, depends upon sustained growth of the agricultural sector given the strong linkages between agriculture and industrial growth. For instance, expanding agriculture allows more raw materials to market and process and requires more input for farming, thus stimulating these sources of growth. Other than for the manufacturing sector, most policy documents underplay the linkage between agriculture and other sectors. It is important to note that the sector also has strong linkages with trade and services as evidenced by the amount of transactions between these sectors (Republic of Kenya, Economic Surveys, various issues). Such linkages are evident from the inputs purchased by the agricultural sector from other sectors, the most important being fuel and power. Other important categories include fertilizers, manufactured feeds and purchased seeds (see Table 2.1).

Fig 2.1a: Contribution to Gross Domestic Product by Major Sectors
(%): 1985-99



The decline in the contribution of the agricultural sector to GDP is also reflected in the fluctuations in the sector's growth rates. Figure 2.1b shows the growth rates of the sector for the period 1985–1999, and shows that the growth of GDP per capita fluctuates with the fluctuations in the growth rates for the agricultural and manufacturing sectors. Between 1987 and 1988, the declining growth rate was attributed to lower prices for cash crops and unfavorable weather conditions. The growth rate however recovered in 1989 due to better weather conditions and better prices for some commodities, liberalization of

cereals marketing and growth in livestock and livestock products. In the early 1990's, there was a steady decline in the growth rate reaching the lowest level of minus 4.1% in 1992.

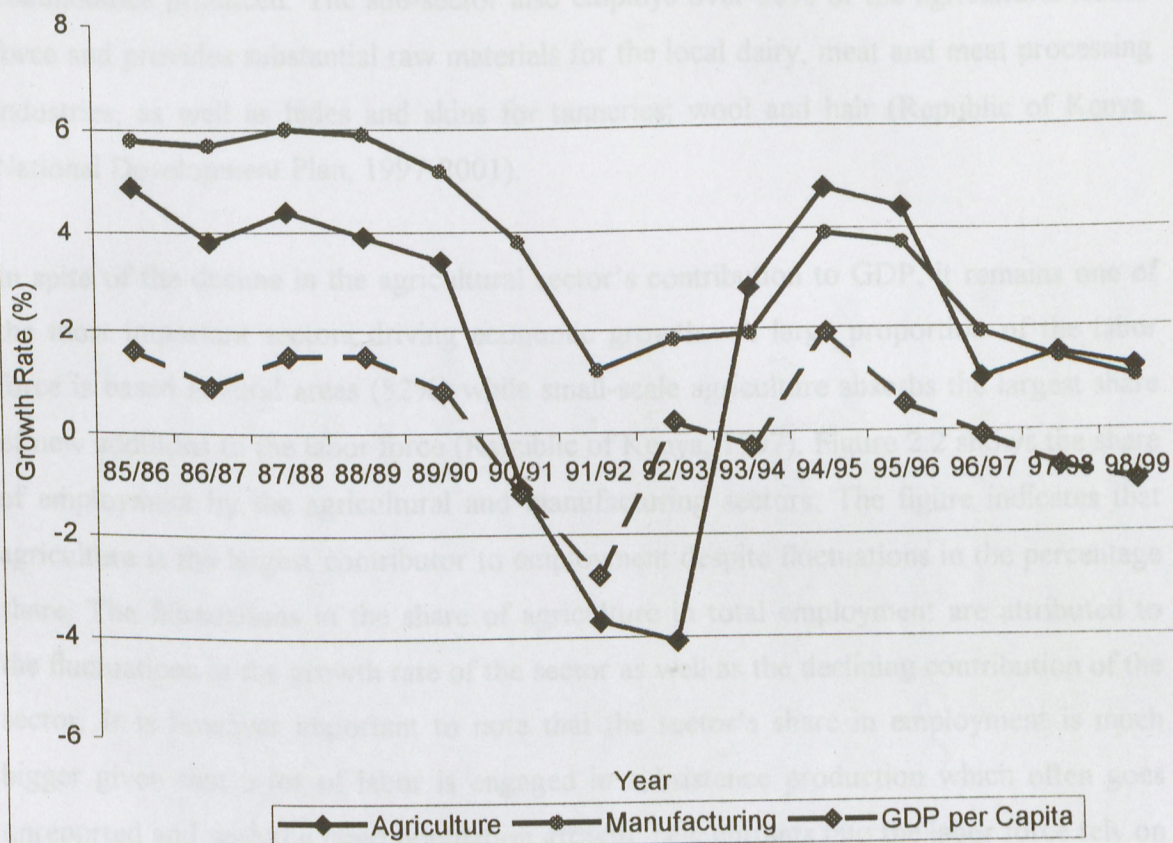
Table 2.1 Purchased Agricultural Inputs 1990-2000 (K£Million)

Input\Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Fertilizers	49	52	38	50	52	52	52	97	87	103	94
Other Agr. Chemicals	11	13	12	14	14	15	15	18	16	19	17
Drugs & Medicines	19	20	19	22	23	24	26	29	30	32	29
Fuel & Power	35	36	45	93	113	136	147	242	252	274	286
Bags	12	13	14	15	16	17	18	24	26	23	25
Manufactured Feeds	31	32	34	37	39	41	38	36	38	38	37
Purchased seeds	27	29	35	39	45	50	46	54	88	73	84
Other inputs	9	9	9	10	11	11	12	12	13	11	12
Service inputs	14	16	16	18	19	20	22	23	24	25	24
Total	205	220	223	298	332	368	365	534	574	596	607

Source: Economic Survey, various issues.

This decline was attributed to unfavorable weather conditions, poor implementation of reform, and deteriorating terms of trade between agricultural exports and imports. Other factors included rapid population growth coupled with a shortage of land in high and medium potential areas of agricultural production and a decline in public investment in agriculture in real terms. Furthermore withholding of aid by International Monetary Fund (1991-92) made the country unable to finance imports of agricultural inputs and investments. The tribal clashes of 1991-92 also disrupted farming activities in the Rift Valley, one of the country's major grain producing areas.

Figure 2.1b: Growth Rate of Gross Domestic Product by Major Sectors:
1985-99



In 1994, there was increased growth in the sector after four years of successive decline, which was attributed to implementation of agricultural reforms coupled with good weather conditions. In 1997, the growth rate declined again due to the drought in late 1996 and early 1997. In 1998, a slight improvement was experienced due to the boost in the production of tea, sugarcane, maize and wheat caused by the abnormal *El nino* rains (which started in the late 1997) and by an increase in crop prices. This was also attributed to reduced import duties on major agricultural farm inputs like fertilizers and poor quality seeds, creation of foreign exchange retention accounts and foreign currency auctions initiated to motivate farmers to increase coffee and tea production.

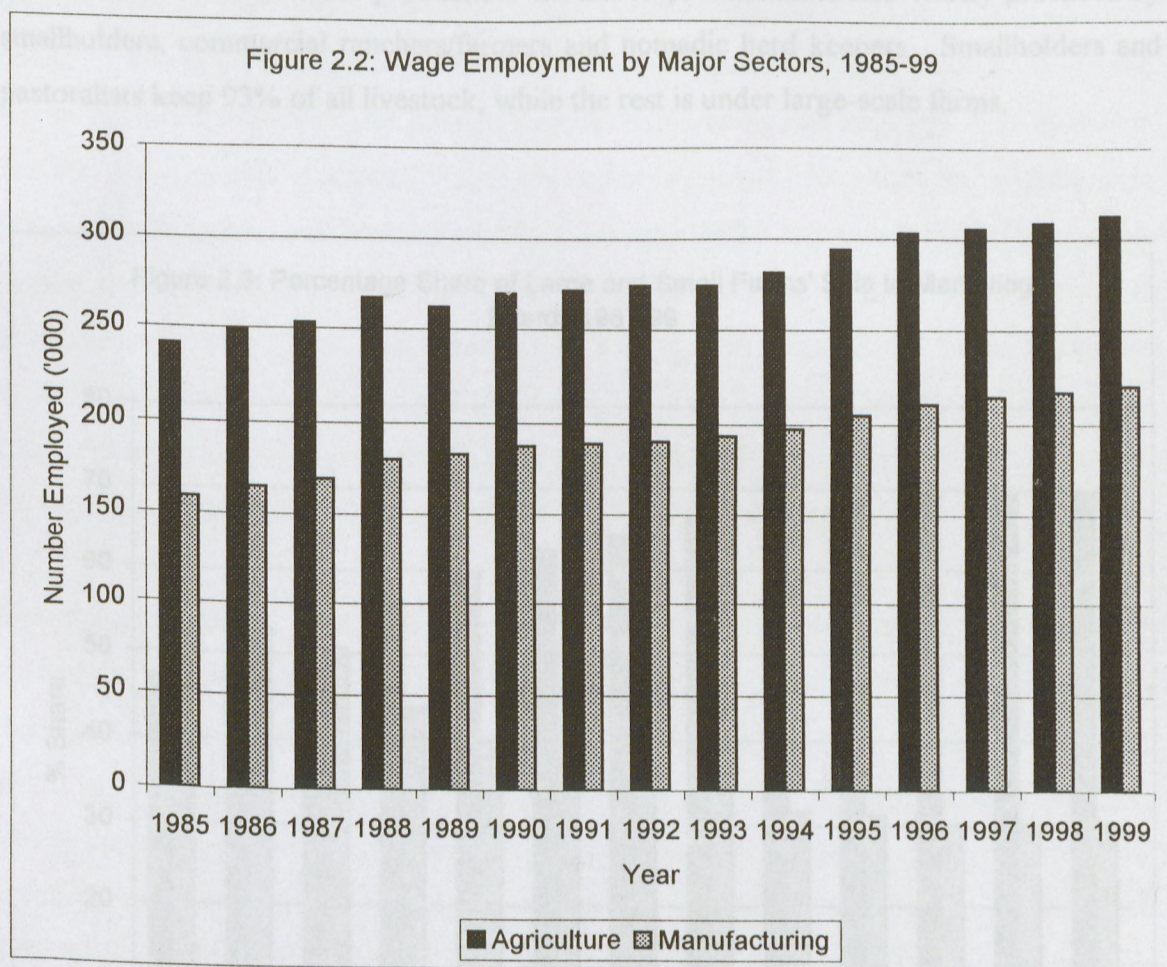
Crop agriculture dominates the sector accounting for 90% of the agricultural GDP and 70% of the farm gate value of commodities produced. The livestock sub-sector contributes the rest (10%) of the agricultural GDP and 30% of the farm gate value of commodities produced. The sub-sector also employs over 50% of the agricultural labour force and provides substantial raw materials for the local dairy, meat and meat processing industries, as well as hides and skins for tanneries; wool and hair (Republic of Kenya, National Development Plan, 1997-2001).

In spite of the decline in the agricultural sector's contribution to GDP, it remains one of the most important sectors driving economic growth. A large proportion of the labor force is based in rural areas (82%) while small-scale agriculture absorbs the largest share of new additions to the labor force (Republic of Kenya, 1997). Figure 2.2 shows the share of employment by the agricultural and manufacturing sectors. The figure indicates that agriculture is the largest contributor to employment despite fluctuations in the percentage share. The fluctuations in the share of agriculture in total employment are attributed to the fluctuations in the growth rate of the sector as well as the declining contribution of the sector. It is however important to note that the sector's share in employment is much bigger given that a lot of labor is engaged in subsistence production which often goes unreported and with the rapid population growth, new entrants into the labor force rely on subsistence agriculture. The agricultural sector accounts for about 70% of export earnings, with food and beverages constituting over a half of the total export earnings. These foreign exchange earnings are used to import foods when temporary shortfalls occur and to cover intermediate needs until increased production can reduce chronic deficits.

Agriculture is also responsible for providing food security for both the rural and urban populations. However, rapidly expanding population, rapid urbanization and the shortage of high potential arable land cause occasional imbalances between the national demand for food and its supply. Concurrently, due to vagaries of weather and migration to marginal lands, a large proportion of people living in these areas experience recurrent temporary food shortages. This leads to importation of food, which drains the country of

its meager foreign reserves. It therefore calls for accelerated growth of the sector in order to ensure food self-sufficiency and balance.

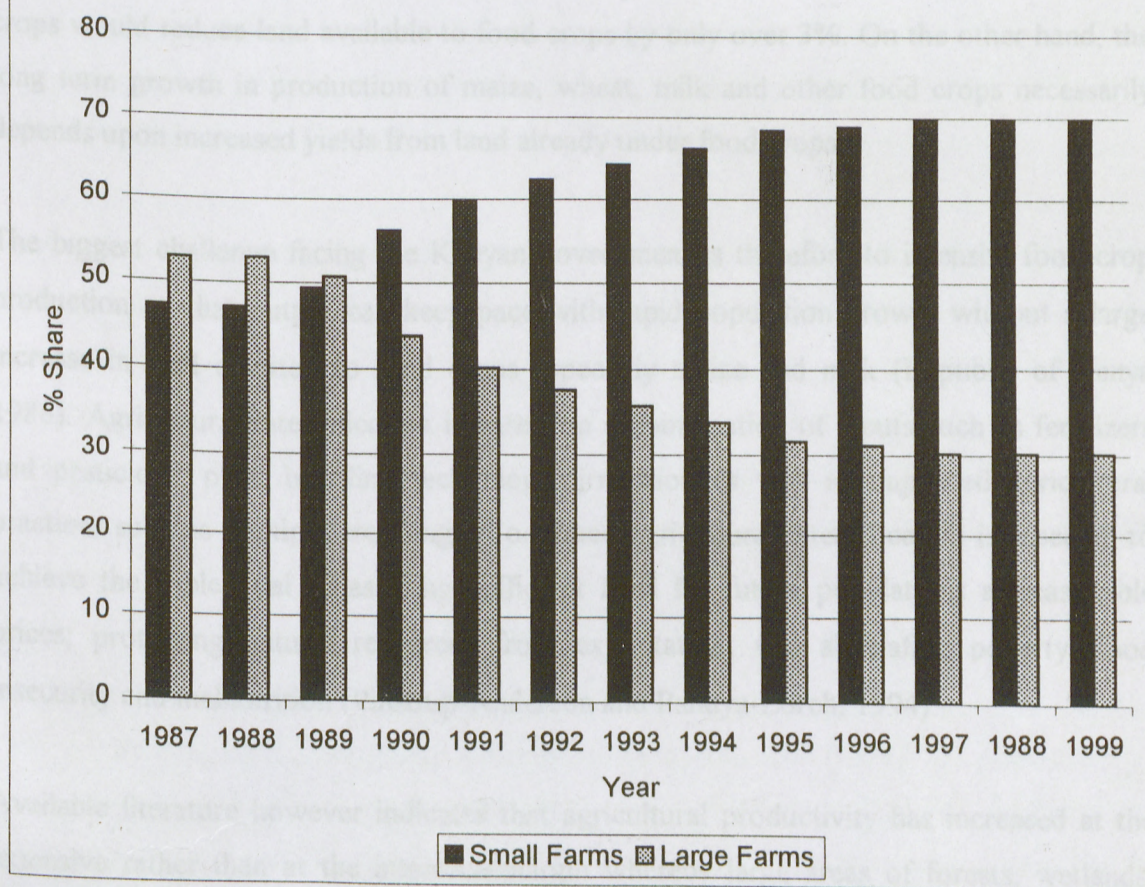
Figure 2.2: Wage Employment by Major Sectors, 1985-99



The agricultural sector is composed of a traditional subsistence sub-sector comprising both smallholder and pastoral producers and a commercial sub-sector, which includes both large-scale farming and smallholder production. Since 1990 small-scale production forms the bulk of agricultural production as evidenced by the sales to marketing boards. For instance, between 1990 and 1998, sales to marketing boards by smallholders increased from 56.2% to 69.8% while that of large farmers declined from 43.8% to

30.2%. The rate of change in output is also higher for small-scale production than for large-scale production (Figure 2.3). The large-scale sub-sector has declined overtime due to continuous subdivision of large farms into small farm units, as well as increased monetization of smallholder production. Livestock production is also widely practiced by smallholders, commercial ranchers/farmers and nomadic herd keepers. Smallholders and pastoralists keep 93% of all livestock, while the rest is under large-scale farms.

Figure 2.3: Percentage Share of Large and Small Farms' Sale to Marketing Boards:1987-99



In Kenya, of the total area of 580,367 Km², only 20% is considered to be high and medium potential for farming or intensive livestock production. The rest 80% are classified as arid and semi arid lands (ASALs). The high and medium potential lands are devoted to crop and milk production, while much of the ASALs are largely used for extensive livestock production such as ranching and pastoralism, as well as being the habitat for wildlife both in and outside national parks and game reserves. It is estimated that the ASALs support about 25% of the nation's human population and slightly over 50% of the livestock population (Republic of Kenya 1999). The two major export crops, (coffee and tea) are grown on less than 5% of the agricultural land, while the rest is devoted to all other crops. This implies that a 70% expansion of area under those two crops would reduce land available to food crops by only over 3%. On the other hand, the long term growth in production of maize, wheat, milk and other food crops necessarily depends upon increased yields from land already under food crops.

The biggest challenge facing the Kenyan government is therefore to intensify food crop production so that output can keep pace with rapid population growth without a large increase in land devoted to food crops especially maize and milk (Republic of Kenya 1986). Agricultural intensification is based on a combination of inputs such as fertilizers and pesticides, plant breeding technology, irrigation as well as improved agricultural practices such as multiple cropping. Continued agricultural intensification is essential to achieve the triple goal of assuring sufficient food for future populations at reasonable prices; protecting natural resources from exploitation; and alleviating poverty, food insecurity and malnutrition (Pinstrup-Anderson and Pandya-Lorch, 1994).

Available literature however indicates that agricultural productivity has increased at the extensive rather than at the intensive margin whereby large areas of forests, wetlands, river valley bottoms and grassland savanna have been converted into farmlands with adverse environmental implications. Furthermore inappropriate farming practices in the marginal areas lead to low productivity and land degradation (Migot-Adholla et al. 1994). This is because the sustainability of many resource poor farming and pastoral systems has

been undermined by a number of interacting exogenous and endogenous factors. The exogenous factors include government policies, which are often biased against the interests of the marginal poor in rural areas. For instance, government controls on agricultural prices, overvalued domestic currencies and heavy taxation of agricultural exports. Depressing agricultural prices reduces farm productivity and diminishes incentives to improve land productivity through investments in soil conservation. On the other hand, increasing farm prices and land values is thought to drive extensive cultivation of more fragile lands. Secondly, lack of affordable low-input technology for improving the productivity of traditional varieties and less favorable environmental conditions is another factor. This is aggravated by the neglect of rural infrastructure and extension services. Finally, encroachment by large-scale commercial interests pushes the rural poor to marginal land resulting to environmental degradation. In Kajiado district, the expansion of mechanized agriculture and quarrying onto traditional semi-arid grazing land continue to push the pastoralists to more arid zones.

According to Barbier (1998), the endogenous factors undermining productivity include demographic pressures (both human and livestock), which accelerate the environmental degradation-poverty process; patterns of land ownership, incomes, access to on-farm and off-farm employment, level of skills and education, cultural and ethnic origins. Others include cultural perceptions of the environment, gender and other socio-economic factors, which have a direct bearing on farming systems and environmental conservation practices.

2.2 Agriculture and Poverty

Given the continued dependence on agriculture by the majority of the population, the downturn in performance of the sector has meant insufficient food and declining rural incomes in Kenya. Household budget surveys suggest that the major cause for low incomes in rural areas has been stagnating agricultural production. This is due to the fact that even when the rural based poor are not engaged in their own agricultural activities, they rely on non-farm employment and income that depend in one way or another on agriculture. The sector's linkages to the non-farm economy generate considerable

employment, income and growth in the rest of the economy. According to Pinstrup-Anderson and Pandya-Lorch (1994), very few countries have experienced rapid economic growth without agricultural growth either preceding or accompanying it. On the other hand, economic growth is strongly linked to poverty reduction. Agricultural growth has two major indirect benefits to the poor. The most important is the impact of expanded food production in reducing food prices in the cities. Since the poor spend a large proportion of their incomes on food, a reduction in food prices increase their real incomes. The other benefit results from consumption by farmers of products and services made in the cities. An expansion in farm income resulting from increased agricultural production stimulates demand for non-farm products, which on the other hand boosts the incomes of producers of non-farm products.

Lagging agricultural growth therefore perpetuates rural poverty and food insecurity, which in-turn impedes the onset of the demographic transition to lower fertility rates. Declining rural incomes imply that rural communities continue to have increasing food and income poverty.¹ For instance during the adjustment phase, it became evident that Kenya ranked for the first time among the 20 poorest countries in the world. In the 1970s, it was estimated that poverty affected 25-44% of the total population (households) with urban poverty standing at 15% of the population. Poverty among the rural smallholder households was estimated to be 33-39% (Republic of Kenya, Economic Survey, 1997). In the 1980s and 1990s, rural absolute poverty was estimated to afflict 46% of the population, while urban absolute poverty was about 30% (Mwabu et al. 2000). The poor tend to be clustered into eight social categories, namely, the landless, the handicapped, female headed households, households headed by people without formal education, pastoralists in drought prone districts, unskilled and semi casual laborers, AIDS orphans, street children and beggars (Republic of Kenya, 2000a). Income inequalities had also widened substantially by the early 1990s. By 1992, it was estimated that the bottom 40% of the rural population received only about 11% of the total income,

¹ Food poverty is defined as a condition of lacking the resources to acquire a nutritionally adequate diet. A household is food poor if it is unable to provide its members with the recommended daily allowance of calories. Overall poverty is defined as the inability to attain a certain predetermined minimum level of consumption at which basic needs are assumed to be satisfied (see Mwabu et al. 2000).

while the top 20% received 61% of the total income. In the case of urban areas, the bottom 40% received 10% of the total income while the top 20% received 59% of the same (Manda, 1997).

Available literature attributes the increasing levels of poverty and inequality to inadequate access to employment opportunities, physical assets, rural infrastructure, markets, human capital and destruction of natural resource endowments (Hanmer et al. 1996, World Bank, 1997). These factors inhibit agricultural development, resulting in declining productivity and thus increased poverty. For instance limited access to physical assets limits a farmer's ability to engage in improved land use practices such as terracing, planting of resistant vegetation and blocking of soil erosion outlets, which could enhance the productivity of farmers. In other words, these constraints act as a disincentive for environmental conservation whose end result is low agricultural productivity.

2.3 Agricultural Sector Policies

Over the years, a number of goals and policies have been designed and implemented to ensure that agriculture continues to play an important role in Kenya's economic development. For instance, in the Sessional Paper No. 1 of 1986, the goals for the sector included providing food security and generating farm family incomes that grow by at least 5 percent a year. Other goals included: absorbing new farm workers at the rate of over 3 percent a year with rising productivity, increasing agricultural exports and stimulation of the growth of productive off farm activities in rural areas. To achieve these goals, the government implemented strategies to encourage farmers to adopt more productive practices, through pricing, marketing and institutional policies, as well as extension services. The government also promoted research into new varieties and encouraged diversification of crop production, focusing on crops that generate more employment per hectare.

The policies pursued in the sector can be classified into those involving government controls and those that relate to liberalized markets. During the era of controls (1963-1980), direct government participation dominated agricultural production, marketing and

investment activities. In the 1960s and early 1970s, the policies implemented were mainly on land reforms, agricultural pricing and marketing and public investments in infrastructure, research, extension and other services. Soon after independence, the government introduced a major land redistribution program. A large amount of land in the high and medium potential areas (belonging to European settlers) was redistributed to small-scale farmers. This was done through programs such as the Million-acre scheme whereby over 35,000 families were settled on 470,000 hectares and the Haraka scheme whereby 14,000 families were settled on 105,000 hectares. This land redistribution resulted to increased monetization of smallholder sector, thereby increasing the marketed production by the sector (Republic of Kenya, Development plan; 1974-1978).

However in mid-1970s, the performance of the sector started to decline due to inefficiencies in crop pricing and marketing, limited development and use of unfamiliar technologies, limited arable land, restrictions on private trade and processing of agricultural commodities, and poor maintenance of infrastructure. This was aggravated by the oil crises of the 1970s, which led to inflation and a decline in Kenya's terms of trade.

As from 1980, there was a major shift in policies towards liberalized markets. This involved reduction of the state's intervention in the economy with an emphasis on market friendly strategies. Initial policy reforms emphasized liberalization of the grain market and removal of price controls for all agricultural commodities. Although the government also agreed to align export crop prices to the world market prices, reforms in the grain marketing system proved difficult to implement.

In 1986, the government officially spelt out a wide range of policy reforms for the whole economy (Sessional Paper No. 1 1986). The specific reforms included removal of government subsidies on extension, research, veterinary and other services. Other policies involved deregulation of markets to provide a market based incentive system to channel resources into the most productive uses, liberalization of trade and marketing policies and removal of price controls to make the economy more competitive.

Substantial implementation of agricultural reform policies started in 1993. This however gave rise to controversies due to a general feeling that implementation of the reforms did not take into account the interests of all the stakeholders especially small farmers.

To improve livestock productivity, especially in arid and semi-arid lands, the government has focused on measures to improve the breeding of sheep and goats, to develop stock routes and water supplies, and to control livestock diseases. On the other hand, crop research and development has focused on drought-resistant crops and suitable grasses to prevent soil erosion. Other policy measures included improvement of rural access roads, encouragement of private sector investments in slaughterhouses in livestock production areas with refrigerated transport of meat and development of both service and ground water sources for both agriculture and livestock.

Policy interventions have important implications on land management and therefore on productivity and environmental conservation. In Kenya, the trend in the growth rate of the agricultural sector as well as growth rate in employment can be attributed to policy shifts. Rising levels of poverty resulting from such policies will have adverse effects on land management. For instance, coffee and tea farmers have rioted several times over the last few years due to unfavorable pricing and marketing policies (Republic of Kenya, Economic Survey 2001). The result has been abandonment of production of cash crops leading to declining productivity and incomes.

Available evidence also indicates that policy intervention impact on demographic forces and institutional factors such as land rights. Government policy also affects information and available technology through extension services and public and community investments in land management. Finally, policy interventions may impact on ecological conditions such as through over cultivation resulting from price incentives. The outcome of these impacts is to determine the household decision concerning products to be produced, production techniques, landscape investments and maintenance. The household could then choose to make one of four decisions namely: land enhancing intensive production, land degrading intensive production, land enhancing extensive

production or land degrading extensive production patterns each of which has differing impacts on natural resource outcomes (Scherr and Yadah 1996).

2.4 Poverty and the Environment

Poverty and Environmental Degradation

Incidence of poverty and squalor in Kenya is most severe in the rain-fed semi-arid regions, where the land is environmentally degraded (Republic of Kenya, 2000a). Improving the life of the poor demands a regeneration of the environment in which they live, improved productivity of land and provision of drinking and irrigation water. Moreover, since the poor reside primarily in rural areas of developing countries and are dependent on the land for their livelihood, rural poverty and land degradation are closely related. Through their agricultural activities, people seek to husband the available soil, water and biotic resources so as to harvest a livelihood for themselves. Environmental degradation depresses the poor's ability to generate income through two channels. First, it requires the poor to divert an increasing share of their labor to routine household tasks such as fuelwood collection; and second; it decreases the productivity of those natural resources from which the poor wrest their livelihood (Mink 1993).

The interaction of social, economic, demographic and even climatic factors has pushed many marginal groups onto low-productivity areas. The result is a fundamental process of cumulative causation of poverty, environmental degradation and underdevelopment (Barbier 1997). Poor people in their struggle to survive are driven to doing environmental damage with long-term losses. Their herds overgraze, their shortening fallows on steep slopes and fragile soils induce erosion, their need for off-season incomes drives them to cut trees and sell firewood, they are forced to cultivate and degrade their land. In other words, without adequate livelihood opportunities, the resource - poor households will be caught in a poverty trap that induces them to over exploit existing resources just to survive.

Livestock husbandry tends to have adverse effects on the environment (widespread destruction of ground cover, erosion and depletion of water reservoirs) and therefore on poverty. Estimates show that overgrazing causes 35% of all human-induced soil degradation worldwide and 49% in Africa (Haen 1993, Pinstруп-Anderson and Pandya-Lorch 1994). Such overgrazing is caused by increased population pressure, curtailment of nomadism (due to privatization of land), losses of grazing lands to agriculture, limited mobility due to political insecurity, open access problems and absence of mechanisms for smoothening number of stocks through the seasons. Another indirect effect of livestock husbandry is felling of trees for firewood. During droughts, the herds shrink and expenditure on food rises. The pastoralists are then forced to turn to other sources of income such as production of charcoal for the urban market, leading to a reduction in the bush and tree stocks (Bayer et al. 1999). The overall effect of these practices is to lower productivity and thereby increase poverty.

Evidence from Kenya indicates that livestock activities have contributed to environmental degradation (Republic of Kenya, 1999). The ASALs are characterized by a limited natural resource base and low carrying capacity. This implies that a relatively small increase in the population can result in the over-exploitation of resources. Overgrazing has therefore resulted from increases in livestock numbers, changes in grazing patterns (resulting from privatization of land rights) and provision of centralized services such as watering points, encroachment of dry areas by cultivators and insecurity.

Institutions, Productivity and Environmental Degradation

Institutions can be defined as the humanly devised constraints that shape human interaction. They structure incentives in human exchange, whether political, social or economic and reduce uncertainty by providing a structure to everyday life (North 1990). There are three basic categories of institutions: constitutional order, institutional arrangements and normative behavioral codes. The constitutional order refers to the fundamental rules about how society is organized. Institutional arrangements are created

within the rules specified by the constitutional order. These arrangements include laws, regulations, associations, contracts and property rights. The third category, normative behavior codes, refers to the cultural values, which legitimize the arrangements and constrain behavior. While constitutional order and normative behavioral codes evolve slowly, institutional arrangements may be more readily modified (Feder and Feeny 1991, Feder and Noranha 1987).³ However, distinction between the three categories of institutions is not easy to draw in a given society as constitutional order and normative behavior codes are embedded in institutional arrangements.

Property rights as a social institution implies a system of relations between individuals. It involves rights, duties, powers, privileges and forbearance of certain kinds. Property rights may also be defined as a bundle of characteristics: exclusivity, inheritability, transferability, and enforcement mechanisms. There are four basic categories of property rights in land: open access (none), communal property, private property, and state (or crown) property. Under open access lack of exclusivity implies the lack of an incentive to conserve and therefore often results in degradation of the scarce resources. Under communal property, exclusive rights are assigned to a group of individuals and the management of resources is governed by normative behavior codes. Under state property, management of the land is under the authority of the public sector. In private property, an individual is assigned the rights. All or some of these categories of property rights may exist in a single society for different tracts of land; while the same tract or land may also be categorized under more than one regime (Feder and Feeny 1991).

Institutional arrangements and changes are seen as important determinants of land use practices and thus productivity and environmental degradation. Customary land tenure systems were found historically to provide considerable security of tenure on land

³ Folkes and Berkes (1995) define property institutions as part of the cultural capital by which societies convert natural capital (resources and ecological services) into human made capital. This cultural capital is said to include social and institutional capital and also how people view the natural world, values, and ethics, including religion, along with culturally transmitted knowledge of the environment [see also Ensminger (1996b), Balland and Platteau (1996) and Ostrom (1990), for definitions of institutions].

brought into farming through customary rules of community land ownership and allocation of use rights to members of the community. However, customary tenure systems lead to environmental degradation where traditional mechanisms and controls on individual access breakdown under demographic pressures, encroachment on the resource base by large-scale commercial concerns, the introduction of new technology and other innovations. The result is often an open-access problem, where each individual user is only constrained by his ability to exploit the resource (Cleaver and Donovan 1995).

Economic theory however suggests that the relationship between land rights, and productivity can be hypothesized to proceed as follows. Increased individualization of rights gives the farmer a greater incentive to invest in land improvements, since there is then greater certainty that the land will belong to him and to his descendants in the future. This leads to a greater demand for land improvements as well as for complementary inputs due to a lower perceived risk and favorable access to institutional credit. These mechanisms interact to increase investments in land conservation and improvement, which in turn lead to increased productivity. With greater access to credit and investment, farmers are in a better position to participate in environmentally friendly land use practices, which increase the productivity of land. It is also argued that more efficient farmers have a higher marginal return to land than less efficient farmers. Assuming that the only value of land is its agricultural use and that no other impediments to increasing scale exists, more efficient farmers should be able to buy out their less efficient neighbors in a transaction that is beneficial both for farmers and society as a whole. Over time, productivity in the agricultural sector will rise as a result of these transactions which are only possible when individuals have the right to both buy and sell land (Pinckney and Kimuyu 1994).

There are however three reasons why agricultural productivity may not improve as hypothesized by theory. First, farmers' investment demand may be weak for reasons other than security of tenure. For instance, farmers maybe unfamiliar with technological options, investment may be risky or unprofitable. Second, financial constraints may prevent farmers from exercising investment demand even if it were enhanced. Third,

more land improvements may not necessarily improve yields, as this may not be the households target (Place, Roth and Hazell 1994).

2.1. Introduction

Market and other policy failures⁴ also play an important role in the link between productivity and environmental degradation. For instance, poor functioning credit markets constrain cash crop farmers from investing in more profitable cash crops, leading to lower productivity and incomes (Patel et al. 1995). Price incentives are crucial in influencing the shift from subsistence to cash crop production and many smallholders are confined to subsistence production despite having the necessary resources for cash crop production due to imperfections in factor and product markets. For instance smallholder farmers may work on their land as much as their family labor allows while as they could hire extra labor. The major problem is their inability to pay for such services given the uncertainty and delays in crop payments. However, on the other hand, price incentives could lead to intensification and extensification of agriculture and thus result to environmental degradation. For instance, if capital and labour markets function better, farmers could replace trees/forests with crops and therefore increase the potential for environmental degradation (Patel et al. 1995).

⁴ In this context, market is defined as an institution that makes available to interested parties the opportunity to negotiate courses of action. Taken together, market and policy failures are referred to as institutional failure (Dasgupta and Mäler 1995).

CHAPTER THREE

LITERATURE REVIEW

3.1 Introduction

This chapter presents a review of studies on institutions, poverty and the environment. The literature is divided into two sections. Section 3.1 presents literature that relates institutions to resource use. In this section, we first review studies that argue for common property resource arrangements and then proceed to review studies that advocate for private property arrangements. Section 3.2 presents a review of studies that relate productivity and poverty to the environment, focusing on divergent views of the factors that condition this link.

3.2 Role of Institutions in Resource Use

The debate on the role of property right institutions in resource use was popularized by the seminal works on the “tragedy of the commons” theory by Hardin (1968). Hardin argued that any commonly held and collectively owned resource that is exploited by individuals will be overused as no incentive operates for individual users to reduce their use levels. The benefits of reducing one’s use level will be passed on to the neighbours, whereas the costs are in the hands of the individual user. Following the work of Hardin (1968), two major schools of thought have emerged to explain the role of property rights in resource use. One strand of the literature argues that in general, common property resources may be more degraded than private property (Mäler 1997, Barbier 1997). Another strand of the literature argues that common property is not necessarily the only cause of overgrazing or “tragedy of the commons” (Jodha 1985, 1993, Ostrom 1990).

Common property resources represent a part of the institutional adaptations, evolved and inherited by village communities against the strains and stresses generated by agro-climatic conditions in the dry tropics (Jodha 1985). Literature that favor traditional common property systems argues that such systems have several advantages. First, they embody a variety of implicit entitlements that enable the resource users to make up for deficient markets. Second, they correspond to a complex set of rights and obligations embedded in long term inter-personal relationships that promote informal cooperation

(McCay 1993). Third, common property institutions provide a method of promoting economic activity through economies of scale operations and therefore sustain the rural poor (Quiggin 1993, Jodha 1985, 1993, Dasgupta and Mäler 1995).

The use and management of common property resources is governed by norms and culture. Moral norms are expectations about one's own action and/or that of others, which express what action is right, or what action is wrong. A person faces a moral decision whenever the welfare of one or several other persons depends upon his actions. According to McCay (1993), norms in any society are shaped by culture (the realm of people's expectations about nature, themselves and each other). Culture includes the values and beliefs people hold about social and ecological relationships, how they are prioritized and linked to each other and how these affect the behavior of the people. Morality manifests itself as a principle of reciprocity that provides that you must not always contribute towards public goods, but that you must not take a free ride when other people are contributing (Baland and Platteau 1996).

Several studies have documented the impact of norms on resource use (Baland and Platteau 1996, Ensminger 1996a, McCay 1993, Kituyi 1990, Ostrom 1990, Quiggin 1993). These studies argue that culture and moral norms play two important roles in society: First, they structure individual expectations and foster mutual trust, and therefore act as a binding constraint especially in use of common pool resources. Second, they play an important role in shaping and modifying individual preferences to accommodate group interests. For instance, Kituyi (1990) argues that among the Maasai, the primary institution for the resolution of conflict and enforcement of social accountability is a council of elders from a given locality (*enikutoto*). The range of affairs dealt with include conflict between local residents, access to communal resources and interpretation of proper conduct (norms).

Proponents of common property resources argue that this is the most ideal system for fragile ecological environments. For instance Jodha (1985,1993) use evidence from Rajasthan (India) to argue that well-intentioned public programs like land reform can

deprive a region of its comparative advantage in livestock farming because privatization raises the cost of livestock raising and hence erodes the regions comparative advantages. The author also argues that common property resources are important as they are a part of the institutional adaptations evolved by communities against the stresses generated by agro-climatic conditions in the dry tropics. These arguments are supported by Quiggin (1993), who argues that common property institutions provide a method of capturing economies of scale and thereby the efficiency of small-scale proprietorship in competition with large-scale production based on wage labour. He recommends promotion of patterns of development which maintain the egalitarian values inherent in common property institutions and encourage the emergence of common property systems adapted to the needs of modern and modernizing societies. Ensminger (1996a) argues that while traditional property rights may remain because transaction costs are often prohibitive, the development of capital markets has not lived up to expectations. However, new property rights would reduce the rights of many over the customary system while enhancing those of the single fitted household's head.

In support of this view, Pinstrup-Anderson and Pandya-Lorch (1994), argue that it is difficult to privatize property rights in circumstances of dependence on key spatially concentrated resources, such as waterholes, or when it could lead to "parcelisation" of resources. So while private land ownership may be expected to be most effective in achieving food security, alleviating poverty, and sustainability goals in many cases, it should not be assumed that it is always superior to common ownership. Place and Otsuka (2002), argue that customary land tenure institutions do not impede the investment in trees and subsequent management activities in Uganda. However, they found evidence that fallowing was less likely under the customary land system than under other forms of land ownership. Otsuka (2001) supports this argument and demonstrates that the communal tenure institutions provide incentives to plant and manage trees, which enhance efficiency of land use and reduce the incidence of poverty in marginal areas. Brasselle et al. (2002) also argue that in Burkina Faso, where it exists, traditional village order provides the basic land rights required to stimulate small-scale investment. Using evidence from Ghana, Besley (1995) argues that land rights should not be viewed as the

panacea for problems of low growth and investments before the process determining the evolution of rights is properly understood. Otsuka et al. (2003), also argue that while the strength of *ex ante* land rights would have a positive effect on tree planting, its effect is not of overwhelming importance. The traditional land tenure institutions are generally not inefficient with respect to the decision to plant trees. Shiferaw and Holden (2001) argue that private economic gains to small farmers from undertaking conservation investments are minimal due to the yield penalty introduced by the reduced effective area planted, their technical efficiency to curb soil erosion and high initial labour costs.

These arguments notwithstanding, available evidence indicates that traditional common property regimes have failed due to several reasons; one, the general development patterns have brought changes, which have marginalized the role of group action, and customary practices that guided the community's action against biophysical stress in the past (Jodha 1993). Ostrom (1990, 1993) supports this argument, noting that over use, conflict and potential destruction of natural resources is likely to occur where individuals act independently. But if those who directly benefit from a resource can communicate/agree on norms, monitor each another and sanction non-compliance on agreements, overuse, conflict and destruction of natural resource can be substantially reduced. Two, population changes, technological progress, unreflective public policies, predatory governments and privatization of land among other causes have resulted into erosion of the commons (Dasgupta and Mäler 1995).

Three, economic growth has increased the gains from dismantling the commons while also making it harder to reach agreement about how to distribute these gains. Sedentarization has increased the costs of maintaining common grazing while growing economic diversification within the society has created interest groups that want very different property rights (Ensminger 1996b). Four, external pressure and transformation in political parameters have changed the existing ideologies and preferences concerning fair distribution of property. Five, breakdown in institutions such as patriarchy, clans and marriage increase the costs of engineering consensus and thus failure of collective action (Ensminger 1996b).

To ensure maximum gains and conservation of common property resources the literature makes several recommendations: First, promotion of patterns of development, which maintain the egalitarian values inherent in common property institutions and encouragement of the emergence of common property systems adapted to the needs of modern and modernizing societies. Second, protection and development of common property resources as they promote economic activity of the region, sustain the rural poor and ensure the use of arid lands according to their capabilities (Jodha 1993). Third, maintaining small groups as the degree of inefficiency resulting from common ownership depends crucially on the number of agents operating on the commons. The smaller the number of agents, the greater the extent to which they can take into account the negative consequences of their actions on the productivity of the common property (Baland and Platteau 1996). The authors argue that village communities are able to use their resources efficiently provided the state does not interfere and especially so if such communities are small and interactions among group users are frequent.

Be it as it may, these studies reach the consensus that common property resources are the best means of allocating resources. However, we need to bear in mind that such institutional structures may only be ideal where the population is small relative to land and the egalitarian rule operates. Furthermore differences in climate, topography and general quality of land will have important impacts on ownership and productivity.

Proponents of private property argue that institutional failures such as lack of well-defined property rights and poorly functioning markets constitute the main force driving overgrazing, soil degradation and over fishing as no single individual can be held responsible for the effect of collective activities on land, soil or fish stock (Mäler 1997, Barbier 1997). A weak structure of property rights may completely negate the value of environmental resources with potentially devastating effects on small local communities.

Ensminger (1996b) presents evidence of the corrosive effects of the market on social institutions with specific reference to the Orma community in Kenya. The author argues

that the Orma society disintegrated in the wake of increasing market relations; such that pastures once held in common were gradually privatized, social norms broke-down, family herding cooperatives gave way to wage contracting herding, while the moral economy collapsed. On the other hand, commercialization has favoured larger economies of scale in livestock production and eroded the economic base for the poor. Ensminger however ignores the impact of the emerging market on resource use and allocation.

Baland and Platteau (1996) concur with Ensminger and argue that the most glaring effects of market integration is that it enhances economic, social and geographical mobility. This produces numerous effects that affect collective action capabilities at the village level. For instance, it gradually detaches individuals from their traditional community settings and since traditional rights and obligations are not tradable on a perfect market, they are led to neglect or overexploit their resources. The authors further argue that market integration modifies the rate of time preference in favour of present consumption such that individuals may be tempted to overexploit their resources or to grant exploitation licenses.

Effective property rights are argued to be essential for economic success in several respects: One, when property rights are not completely specified or enforced, people may be giving up gains from cooperation. Two, in the case of pastoralists, lack of well-specified property rights give each herder an incentive to overgraze the land and ultimately leads to environmental degradation (Ensminger 1996b). Three, institutional constraints such as the structure of property rights and institutional distortions such as lack of markets for scarce resources are argued to be directly linked to the problem of environmental degradation. Duraiappah (1998) also presents evidence that market and institutional failures are the main incentives driving agents to degrade their land as well as to adopt unsustainable deforestation activities. However, the provision of secure individual property rights requires not only social rules for allocation of land-rights, but also adequate implementation and enhancement mechanisms. In the absence of such mechanisms, uncertainty regarding land ownership rights will generate inefficiencies in the allocation of resources (Feder and Feeny 1991)

holding activities (Duraieppah et al. 1998). This explains why in many pastoral
Kebede (2002) argues that investment is crucial to arrest or slow down the process of desertification of common pool resources and that a necessary condition for making long run investments is security of land ownership. He further argues that lack of security of tenure plays an important role in the type of decisions farmers make, such as introduction of fertilizers and irrigation which have a long term impact on productivity. Further, he argues that privatization of land is only a necessary, not a sufficient condition for rural development and suggests that money raised through privatization could be used to cover costs of privatization as well as strengthening of markets.

Stevenson (1991) departs from these studies in that he examines the performance of common property in comparison to private property, using a series of econometric models to test for differences in milk productivity for Alps managed under the two systems. All the models indicate lower average milk production for common property. His results also show that the productivity of many private property right types that are not pure, owner-operated private, such as operations involving rented land, private operations that accept many animals from others, and so forth, is lower than those of pure, owner-operated private.

Proponents of individual ownership therefore assume that efficiency and productivity of resources can be enhanced by privatization of resources held in common. However such literature fail to acknowledge the fact that privatization may not be ideal for ecologically fragile environments as it would confine herders and their livestock in limited geographical areas, which would be economically unsustainable and eventually lead to overgrazing. For ecologically fragile environments, common property resources are therefore still more ideal than individual ownership. Some studies also provide evidence that the hypothesis that security of tenure leads to higher yields through its effect on credit, inputs and land improvements is not supported by research findings (Migot-Adholla et al. 1994). Evidence from Kenya indicates that land reform policies which were initiated to sedentarize the Maasai have set into motion a series of events which would eventually lead the Maasai into poverty and force them to adopt unsustainable

herding activities (Duraiappah et al. 1998). This explains why in many pastoral communities, security of tenure has not changed the traditional methods of resource use and common grazing continues (Kebede 2002).

In the light of this literature, this thesis hypothesizes that changes in institutional structures governing traditional property rights impact negatively on the environment. Most of the literature reviewed under this section suffers a limitation in that the arguments are not based on empirical evidence. Our study departs from this in that we model the impact of institutions on resource use.

3.3 Productivity, Poverty and the Environment

Different frameworks have been proposed and utilized to analyze the poverty environment nexus resulting in different policy conclusions. The main arguments found in the literature indicate that on one hand, environmental degradation leads to low productivity and poverty. On the other hand, it is argued that poverty leads to environmental degradation, which then leads to low productivity and poverty. Ligthelm and Wilsenach (1993) argue that environmental degradation is often a result of economic development and widespread poverty while simultaneously, environmental degradation in its many forms constitute a threat to economic development, growth and poverty reduction. In support of this, Shiferaw and Holden (1999) argue that coupled with growing populations, falling per capita food production and worsening poverty, loss of productive land due to degradation undermines rural livelihoods and national food security.

On the other hand, Broad (1994), uses evidence from the Philippines to refute the traditional paradigm of poor people as environmental destroyers. In a country with severe poverty rates and significant environmental degradation, the author shows that the society has been transformed from environmental destroyers to environmental protectors. Bardhan et al. (2002), also provide evidence from Nepal to refute the poverty environmental hypothesis. Their study shows that after controlling for household characteristics, village fixed effects and censoring of firewood collection, there was no

evidence of the need to reduce poverty to ease pressure on forest because growth in living standards did not necessarily reduce firewood collection.

Pinstrup-Anderson and Pandya-Lorch (1994), argue that rural poverty, combined with increasing population density and inadequate agricultural intensification, is responsible for much of the forced exploitation and consequent degradation of environmentally fragile lands and the breakdown of indigenous institutions for managing common property resources. They observe that the relationship between poverty and environmental degradation is driven in the first instance by poverty itself, but also by loss of entitlements by the poor or by loss of capacity of the poor to sustainably support themselves.

However, the general consensus in the literature is that poverty acts as a constraint on incentives to control land degradation. For instance the Bruntland Commission report argues that amelioration of poverty is a central condition of any effective program to deal with environmental problems. Those who are poor and hungry will often destroy their immediate environment in order to survive: They will cut down forests; their livestock will overgraze grasslands; they will overuse marginal land; and in growing numbers, they will crowd into congested cities (World Commission on Environment and Development 1987). In other words, the report argues that "poverty reduces people's capacity to use resources in a sustainable manner; it intensifies pressure on the environment." World Bank (1992) also argues that the poor degrade the environment through cutting trees for fuel in attempts to meet their short-term needs. Jalal (1993) argues that environmental degradation, rapid population growth and stagnant production are closely linked to the rapid spread of acute poverty in developing Asia. Pinstrup-Anderson and Pandya-Lorch (1994) note that while technological change in agriculture may cause natural resource degradation, the most serious environmental threat in low-income developing countries comes from poverty. Deininger and Minten (1999), also use evidence from Mexico to show that poverty is associated with higher levels of deforestation.

Emerging literature however argues that more complex set of variables govern the links between poverty and environmental degradation. Reardon and Vosti (1995) argue that the level, type and distribution of poverty conditions the poverty-environment nexus. On the other hand, the type of environmental problem conditions the links such that poverty and soil degradation interact differently from the way poverty and rural pollution do. Pinstrup-Anderson and Pandya-Lorch (1994) argue that poverty need not lead to environmental degradation. It is the combination of poverty, population increases, land constraints and lack of appropriate production technology that results in environmental degradation. The factors governing the links between poverty and environmental degradation include demographic, cultural, and institutional factors (Duraiappah et al. 1998). Reddy (1995) argues that the main factors which may be instrumental in changing the perceptions of the people towards environment and achieving sustainable agricultural development and thus poverty reduction are literacy, market forces, technologies and institutional change in terms of agrarian reforms.

Market and institutional failures are some of the major factors driving poverty and environmental degradation (Deininger and Minten 1999, Barbier and Lopez 1998, Gavian and Fafchamps 1996). These failures limit the ability and willingness of poor households to invest in improved land management or adopt new farming systems through several channels. In the first place, lack of well-developed insurance and capital markets has two effects. It limits access to credit by farmers and thus inhibits their ability to finance agricultural inputs and hire enough labour to engage in improved land use practices. This results in declining soil fertility and crop yields further exacerbating poverty and increasing their dependency on land (Lopez et al. 1995, Mäler 1997, and Mink 1993).

Where markets are absent or undeveloped, or where there are constraints to market access, the ability of poor households to make farm and non-farm capital investments as well as land improvements (and intensification) to protect soils is limited. This makes the household to resort to extensive farming, implying the need to push into fragile lands (Reardon and Vosti 1995). Place and Otsuka (1997) argue that increased market integration is important as this benefits crop yields without adverse effects on tree cover.

Fafchamps (1998) argue that the existence of non-market output and sources of 'on-the-job' satisfaction contribute to over accumulation of stocks and hence to livestock cycles. Two distinct forces are argued to be capable of inducing producers to hold on to livestock even when they anticipate losing most of their animals. The first force is the desire to smooth consumption when livestock make an essential contribution to the household income and other assets are not available. The second force is the realisation that, if demand for livestock products is inelastic, producer revenues rise when aggregate supply is low and prices are high. Producers may then be inclined to risk physically losing livestock to reap higher prices when livestock supply dries up. Migot-Adholla et al. (1994), Pinckney and Kimuyu (1994) argue that the main constraints on agricultural productivity have to do with infrastructure, market efficiency and production technology.

Fafchamps (1998) also argues that setting up institutions to ensure that externalities are minimised could significantly contribute to the welfare of millions of people. He therefore advises African governments to promote better management of pasture resources such as by reinforcing the institutions of pastoralists and other rural communities.

In the second place, lack of well-developed insurance and capital markets make domestic animals an extremely important asset. But because such animals are vulnerable during periods of scarce rainfall (and in the absence of mechanisms for smoothening stock levels), farmers and nomads carry extra cattle as insurance against drought imposing an additional strain on grazing lands, especially during drought (Mäler 1997, Barbier 1997, Mink 1993). Reardon and Vosti (1995) note that poverty alleviation can reduce resource degradation where poverty is driving extensification into fragile lands but not where the only insurance available is investment in livestock and insurance demand increases with household income. Byiringio and Reardon, (1996) also argue that programs and policy efforts to encourage and enable farmers make soil conservation investments, to use fertilizers and to participate in cash cropping of perennials will have big pay offs in productivity. They recommend development of land markets to allow farmers to buy land for long term investments.

Second, agricultural pricing policies, trade liberalization and rural wages play an important role in resource allocation. For instance, depressing agricultural prices diminish incentives to invest in soil conservation and more land is likely to be put under cultivation to meet given income expectations. On the other hand, increasing prices drive extensive cultivation of more fragile lands as farmers hope to reap the benefits of the price incentives (Deininger and Minten 1999, Duraiappah 1998, Lopez and Niklitschek 1991, Barbier and Burges 1992, Lopez 1997a, 1998, Ahuja 1998, Barbier and Lopez 1998, Reardon and Vosti 1995, Braun 1992). Available evidence from Colombia also demonstrates that the use of land and labor in Colombia has been driven in highly inefficient directions by a variety of agricultural land and rural finance policies and programmes. These have reduced employment opportunities in the sector, leading to an increasing concentration of poverty in rural areas and increased resource degradation on hillsides and on the Amazon frontier (Heath and Binswanger 1996). Acevedo, Barry and Rosa (1995), note that macroeconomic policy has turned relative prices sharply against agriculture, exacerbating the plight of the rural poor, through the limited access to land and other assets. The result has been accelerated environmental degradation in El Salvador.

Third, well specified property rights are said to act as incentives, which enhance productivity and the well being of the poor (Norton 1998, Gavian and Fafchamps 1996). The impact of property rights on productivity is through the incentives created for investment in land improvements which are widely dissipated in the literature (Besley, (1995), Brasseur et al. (2002), Place and Otsuka, (2002), Migot-Adholla et al. (1994). Strasberg and Kloeck-Jenson (2002) found land access in Mozambique to be closely linked to key welfare indicators such as income and calorie availability, and a weak nonfarm economy to heighten the importance of land for the welfare of rural families. Chopra and Gulati (1997) argue that the creation of institutions aimed at enforcing property rights on common property resources corrects the imbalance between the rural and urban environment. Once property rights are well defined, out migration is decelerated and inputs of labour for environmental protection start coming in, income

from local resources change, a high level of consumption becomes possible with a greater degree of certainty and changes the relative attractiveness of the local area and affects the migration decision. Vainio (1998) argues that insecure, unclear or non-existent property rights explain why people suffer from or cause environmental degradation. The author argues that by better defining property rights, poverty can be alleviated and the environment improved. Governments therefore have a special responsibility to provide collective action in the presence of negative externalities because only governments can establish and enforce legal frameworks for regulating the use of environmental resources.

In an analysis of the implication of property rights for joint agriculture-timber productivity in the Brazilian Amazon, Otsuki et al. (2002), find provision of private land title to positively affect the technical efficiency of agricultural production and joint agricultural-timber production. Their results suggest that land title policies may ultimately increase agricultural yields and reduce the amount of cleared land needed to produce a given quantity of agricultural output. They conclude that these policies encourage too much agricultural production and too little timber production, which may either benefit or harm the economic development of the region and the conservation of forestland.

Barbier and Lopez (1998) argue that institutional problems such as lack of land title security reduces the capacity of farmers to collateralize, increases the risk for lenders and translates into higher costs of credit. Mink (1993) notes that evolving land tenure systems favour those with greater political clout and leave the weak with no choice but to overexploit their natural resources. Gavian and Fafchamps (1996) provide robust evidence that tenure insecurity incites farmers to divert scarce manure resources to more secure fields. They however conclude that formal markets for land and other factors of production may not totally eliminate allocative inefficiency as such efficiency is influenced by farm size and other household characteristics. Reardon and Vosti (1995) argue that land tenure institutions can influence the perceived incentive and risk facing the poor, weighing the decision to invest in land improvement. Li et al. (1998) argue that in China, the right to use land for long periods of time encourages the use of land saving

investments, though long term use rights do not appear to affect the incentive of farmers to use short term current inputs

However, Migot-Adholla et al. (1994) use evidence from Ghana, Kenya and Rwanda to show that land rights have a weak relationship to crop yields implying that the effect of indigenous tenure institutions through their effects on land rights does not appear to constrain agricultural productivity. On the other hand, the authors found plot size to be negatively related to yields implying diminishing returns to scale and presence of inefficient factor markets. Atwood (1990) also argues that land titling and registration may not have the intended impact due to differences in factors such as transaction costs, credit sources, productivity, security and access to formal and informal institutions faced by different people. Deininger and Minten (1999), in a study for Mexico find no evidence to support the hypothesis that communal land tenure arrangements would increase environmental degradation. Place and Otsuka (2002) found land tenure in Uganda to have no impact on productivity. Place and Otsuka (2000) argue that land tenure is linked to land use and tree cover change but it is not necessarily the most important factor determining land use and tree planting. Stevenson (1991), using milk productivity as a proxy for overgrazing provide empirical evidence to refute the hypothesis that private and common property could perform as well as each other, given the theoretical arguments about limited entry, limitations on individual inputs and assurance between participants in common property. He concludes that commons are inferior economic performers than private property.

Fourth, the local community has a crucial role in the poverty-environment link. Reardon and Vosti (1995), argue that intracommunity distribution of wealth conditions the level and incidence of poverty as well as its impact on the environment. For instance, community investments in infrastructure affect economic opportunities for the poor by its effect on demand levels for the poor's farm products. On the other hand, community complementary infrastructure in a watershed, such as culverts and dams or trucks for transportation affects the cost of natural resource management investments by the poor.

The authors also argue that the level and distribution of wealth in the community can affect the enforceability of regulations to control access to the commons.

Effective community controls are essential in regulating the use of common agricultural land (Ahuja 1998, Lopez 1997a, 1998). Ahuja (1998) uses evidence from Cote d'Ivoire to link land degradation, agricultural productivity and common property. His study investigates the effectiveness of community controls in regulating the use of common agricultural land and tests for factors such as group size, ethnic and heterogeneity of the group, income and resource stock levels in explaining the variation in effectiveness across communities. His results indicate significant deterioration in community controls and call for a comprehensive policy framework towards agriculture in general and land tenure in particular. The study also finds that smaller and ethnically homogeneous communities are better able to coordinate their actions, thereby internalizing a higher proportion of the value of land as a factor of agricultural production than their large ethnically heterogeneous counterparts. Such coordination is however only possible in the absence of institutional failure. However, Place et al. (2002), in an assessment of the factors underlying differences in group performance found that group size matters, and that middle-sized groups tend to perform better than very small or very large groups. Group heterogeneity was found to be unimportant in determining group performance.

Jodha (1998) argues that traditionally, local communities were able to evolve and enforce nature-friendly management systems, which ensured resource protective/regenerative social system-ecosystem links (thus preventing the operation of the poverty-environment linkage), but present day systems have led to rapid degradation of the fragile natural resource base. These foundations of the traditional system of natural resource management included: one, the community's sustenance driven collective or integrated stake in the health and productivity of the natural resources. Two the local control over local resources and adherence to social sanctions empowered the community to protect and enhance community stake in its natural resources, and enforce measures which helped in balancing supply and demand aspects of resource use in the community context. Garcia-Barrios and García-Barrios (1990) use evidence from Mexico to show

that emigration and proletarianization have led to shortage of labour and consequently, to the weakening of indigenous institutions that regulates collective action in agriculture. Because these institutions are required to maintain practices that preserve and reinforce the political equilibrium and resource sustainability in the area, local farming now suffers from chronic environmental degradation and productivity stagnation.

Other factors driving poverty and environmental degradation include poverty in assets, cash liquidity constraints, and high rates of time preference (high discount rates), which imply that the poor are less likely to invest in environmental conservation (Mink 1993, Mäler 1997, Chopra and Gulati 1998, Holden et al. 1998, Shiferaw and Holden 1999). Mink (1993) argues that such short time horizons are not innate characteristics but are the outcome of institutional and social failures. Pinstруп-Anderson and Pandya-Lorch (1994) note that when survival is at stake, it may be perfectly rational for poor people to consume capital (reduce future productive capacity). When they have exhausted their arsenal of coping strategies and mechanisms, conservation of natural resources for the future generations takes on a lesser importance, particularly when the poor cannot assure that their children will in fact benefit from such conservation.

Further, rapid population growth directly contributes to environmental degradation and poverty. For instance, population pressure can result in an extended period of land over-use resulting in an unsustainable shortening of fallow periods, deforestation and cultivation and grazing on marginal lands (Place and Otsuka 2000, Mäler 1997, UNEP et al. 1997, Heath and Binswanger 1996, Darkoh 1994, Simonis 1992). Darkoh (1994) argues that the rapid changes taking place in African dry lands including increasing human and livestock populations in conjunction with the effects of drought lead to stress on soil, forests, water and grazing resources. Reardon and Vosti 1995 argue that the population growth rate determines pressure on land and fuels degradation if there are no income alternatives or technical change available to relieve the pressure. Pinstруп-Anderson and Pandya-Lorch (1994) argue that population growth is a key catalyst of poverty-led environmental degradation as it diminishes farm sizes and ultimately pushes people off the land to search for land and employment opportunities elsewhere. The

authors give an example of Kenya where they say increased population in the highly fertile highlands forced people to move to drier areas to settle near dependable water sources and farm land that is more suited for pastoralism. Pastoralists are in turn forced to compete for land and water, which leads to overuse and degradation of resources. These arguments however contradict Boserup (1965) who has shown that population growth triggers agricultural intensification, improved natural resource management and increased income of the rural poor.

According to Boserup, "as population grows, land and other natural resources become scarcer relative to labour and access to markets improves. As a result, agricultural intensification occurs, relative prices change and food prices increase as demand for food rises. This process generates the need for new institutions such as private property rights which emerge, these facilitate adoption of better technologies which increases yields; the natural resource base improves as it becomes more valuable..." The Boserup hypothesis is considered as a benchmark for analysing poverty and environmental degradation as her model has been found consistent with certain evidence (Lopez 1997a, Tiffen et al. 1994, Heath and Binswanger 1996). However most studies that support the Boserup hypothesis lack empirical evidence from fragile ecological environments.

Place and Otsuka (1997) use evidence from Malawi to show that although population pressure induces land conversion (into agriculture), neither population density nor growth necessarily leads to decreased yields or tree cover. Increased environmental degradation through reduced vegetation impact negatively on productivity (Lopez 1997a, 1998, Ahuja 1998). Lopez (1997a) estimates a production function that accounts for the effects of biomass as a factor of agricultural production and tests the hypothesis that farmers efficiently exploit biomass, a resource held in common property. The empirical evidence suggests an over exploitation of biomass through a more than optimal level of land cultivated; thus the stock of the environmental resource is below the socially optimal levels. The study further demonstrates the quantitative importance of agricultural prices, rural wages and population pressure as a source of biomass degradation. In a related study for Cote d'Ivoire, Lopez (1998) extends the same theoretical model to determine

the level of land cultivation that maximizes village income, at a village level where an important part of the land is under common property. The author argues that expansion of the cultivated land diminishes the extent of forestlands or reduces the length of fallow periods and hence reduces the amount of natural vegetation. This has a direct output increasing effect at the cost of reducing natural capital and agricultural productivity. The results show that farmers do not internalize even a small fraction of the external cost of biomass in their land allocation decisions, leading to large income losses at the village level.

Larson and Bromley (1990) develop a dynamic farm household model to examine household incentives for resource use under private and common property arrangements. They argue that this model provides a natural framework for analyzing the links between agricultural production and resource degradation under various property regimes. The authors address directly the authority and composition axioms that give rise to the presumed optimality of individual property in natural resources and the correlated indictment of group management regimes. They show that the household's decision problem under common property does not automatically suggest that resources are more likely to be degraded under common than private property. The model is offered primarily to identify how poor resource endowments, low income as well as high discount rates tend to decrease the household's endogenous value of the environment.

3.4 Overview of Literature

The literature reviewed above indicates that a complex set of factors determine environmental degradation and productivity. Shiferaw and Holden (1999) for instance, argue that smallholders' production and land conservation decisions are likely to be influenced by factors related to their dual nature as units of consumption and production. While proponents of individual ownership argue that efficiency and productivity of resources can be enhanced by privatization of resources held in common, some studies provide evidence that security of tenure does not necessarily lead to higher productivity. The literature however suggests a paucity of empirical studies on the link between environmental conservation practices and poverty especially in Africa. Our study seeks to

fill this important research gap and also to add to available literature on this subject. This thesis hypothesizes that changes in institutional structures governing traditional property rights impact on the environment conservation strategies and therefore affect productivity and poverty.

The literature also indicates that there is no general consensus on the direction of causation between environmental degradation, productivity and poverty. However, these studies imply that the direction of causation between poverty and environmental degradation is conditioned by the interaction of several factors, which include environmental variables, market and institutional policies, population growth, community controls, literacy and technology among others. Although a number of studies have investigated the impact of market and institutional variables on productivity in Kenya (Migot-Adholla et al. 1994, Pinckney and Kimuyu 1994), we are not aware of any study that has incorporated environmental conservation variables as determinants of productivity. This study therefore attempts to fill this gap. The thesis takes the view that adoption of environmental conservation practices, along with other factors increases agricultural productivity, which in turn translates into lower levels of poverty as incomes and consumption expenditures of households rise.

CHAPTER FOUR

ANALYTICAL FRAMEWORK

4.1 Introduction

This chapter specifies frameworks for analyzing environmental conservation practices and farm productivity. We first discuss the theory and assumptions relating conservation practices to productivity. This is followed by specification of multinomial and binary logit models relating environmental conservation practices to a range of determinants, from which environmental capital variables are predicted. We then proceed to specify the average revenue function following the meta production function approach as in Lopez (1997a, 1998), Stevenson (1991), and Place and Otsuka (2002). The average revenue function is specified with the predicted variables for environmental conservation as explanatory factors, along with other conventional determinants. This is followed by a discussion of estimation procedures and econometric problems and details how such problems have been addressed. The chapter ends with definition of the variables used in various models. We note here that we base our theory of environmental conservation on available literature rather than deriving it from a simple theoretical model. We argue that the objective of the producer is to maximize revenue subject to the environmental conservation practices adopted. From the theory of agent behaviour, adoption of environmental conservation practices is constrained by among other factors, institutional factors such as property rights. Deriving first order conditions for the optimization problem make these factors arguments of the environmental conservation practice model (Singh, Squire and Strauss, 1986).

4.2 Theory and Assumptions

Farm Level Environmental Conservation Practices

Faced by increasing land pressure and adverse ecological conditions, households are forced to adopt various strategies to increase their productivity. We hypothesize that households that adopt environmental conservation practices improve the productivity of their land and are therefore less poor than those that do not adopt any practice.

Households in our sample were found to adopt one or more of three different farm level conservation practices: blocking of soil erosion outlets such as by the use of thrush lines (where the after harvest material is arranged along lines to prevent soil runoff) or by building gabbions; land terracing and planting drought resistant vegetation. This vegetation could act as terrace stabilizers and regenerates as soon as rains resume following a drought. The first two practices have a direct impact on crop productivity because they reduce soil erosion. The planting of drought resistant vegetation also increases crop productivity through the same channel but in addition raises livestock productivity as the drought resistant vegetation is used as fodder.

We first hypothesize that adoption of any of these techniques will be encouraged by secure land rights. Available literature argues for a positive link between land rights and investments in environmental conservation. For instance, Demsetz (1967) articulated the traditional view of freedom from expropriation whereby individuals do not invest if the fruits of their investments can be seized by others. This is particularly the case when long-term investments such as planting trees and drought resistant vegetation are concerned. The other argument is on the link between security of tenure and credit markets (Barbier and Lopez 1998). If better rights make it easier to use land as collateral, then constraints on funding investments can be diminished (Besley 1995).

Other factors hypothesized to favor farm level conservation practices include the proportion of total land planted. It is expected that the higher the proportion of total land planted, the higher the probability that a household will adopt environmental conservation practices in order to take advantages of economies of scale in labour and capital inputs. Availability of labour and improved technology proxied by expenditure on farm tools are also expected to favour adoption of these techniques. Blocking soil erosion outlets and land terracing are particularly labour intensive. Income flows (transfers and rent incomes) give a household better access to basic social services including education and information and also enable the household to pay for inputs such as seeds, labour and capital. Wealthier households are therefore more likely to invest in environmental conservation practices than their less wealthy counterparts. Age comes with experience in

agricultural practices and is therefore expected to positively influence the decision to adopt environmental conservation practices. Producers who are better educated are expected to be more knowledgeable about the importance of conserving the environment as well as appropriate methods of doing so. Lastly, perceived benefits of environmental conservation are expected to motivate households to adopt conservation practices.

Migration with Livestock as an Environmental Conservation Practice

Evidence from Kenya indicates that livestock activities have contributed to environmental degradation. The arid and semi-arid lands are characterized by a limited natural resource base and low carrying capacity, such that a relatively small increase in the population can result in the over-exploitation of resources (Republic of Kenya, 1999). The increase in livestock population needed to support larger human numbers, is often unsustainable, leading to environmental stress, increased vulnerability to drought, and to food insecurity. Overgrazing has therefore resulted from increases in livestock numbers, changes in grazing patterns and provision of centralized services such as watering points, encroachment of dry areas by cultivators and insecurity. Marginal lands must therefore be utilized in a way that minimizes land degradation but still provides economic returns to the users.

Our field observations indicated that overgrazing in the study area has led to encroachment of inedible bush. The bushes suppress the growth of grass, resulting in a downward spiral whereby the rangeland becomes less productive. In addition, invading thorn bushes require more water than the original woody plants, leading to a drop in the ground water level. Flexibility and mobility of stock grazing and herding is therefore a priority, both in space and time to reduce environmental degradation. Mobility is an effective tool for range improvement as it provides the herder flexibility to modify herds and access alternative pasture areas. Available literature argues that migratory patterns are traditionally part of the coping mechanism for nomadic pastoralists and represent a well-established, risk-minimizing and functional relationship with a fragile but dynamic environment (Ekbom and Bojö, 1999).

Movement with livestock in search of pasture and water could be seen as a form of rotation scheme, albeit less strictly organized. The movement allows regeneration of natural vegetation. This increases biomass, biotic diversity of both fauna and flora and increases the moisture-holding capacity of the soil. If the movements are too short, they lead to insufficient growth of natural vegetation and consequently to low soil fertility and soil instability. The vegetation that grows in the fallow period is a form of capital that accumulates and is eventually used when the pastoralists return home with their livestock. If a herder does not move with his livestock to avoid overgrazing, the natural vegetation is reduced. Thus overgrazing has a direct short-term output-increasing effect at the cost of reducing the natural capital and thus reducing productivity (López, 1997a, 1998).

Assuming that herders' objective function is to maximize revenue from grazing, our study hypothesizes that migration with livestock would enhance environmental capital (mobility contributes to pasture sustainability and improvements) and improve production inefficiencies in order to increase production and incomes, which in-turn leads to a reduction in the degradation of the land. We argue that mobile pastoral systems are more economically efficient than sedentary systems, with higher overall returns per hectare but lower productivity per animal.

Constraining revenue by the quality of the environment is well documented by Lopez (1997a, 1998 who focuses on productivity under shifting cultivation) and Ahuja (1998) among other studies. Our study takes into account the fact that the basic constraints in an arid land household unit differ from those in the community Lopez focuses on. While farmers under shifting cultivation attempt to maximize productivity subject to the growth rate of village biomass, households in an arid land setting seek to maximize productivity subject to the prevailing environmental conditions and the technological constraints they face.

Migration with livestock is however dependent on several factors. Lack of well specified property right institutions, policies and infrastructure favourable to herders may not only slow the evolution of pastoral systems but may lead to environmental degradation. For

instance, it is argued that private property rights are necessary to give individuals the long-term incentives to invest in resources and use them efficiently. Common property resources are therefore seen as a constraint to intensification and investment, especially where information costs are low and markets (credit and insurance) are perfect. We expect that privatization of land will make herders more sedentary and therefore less likely to migrate. The quality of land is also expected to influence the migration decision, whereby holding other factors constant, better quality land is expected to reduce the propensity to migrate relative to poor quality land. In our analysis, we use the total land available as an inverse of land quality as it is evident that in the more arid zones, households own much more land than in the less arid areas.

Interactions of social and economic factors also influence mobility with livestock and the efficiency of production systems in fragile ecological environments. An increase in total expected income (including transfers and non-farm incomes) reduces the propensity to migrate. Such income flows could reduce the propensity to migrate in search of pasture and water as more wealthy herders may not have to rely on livestock for survival compared to their poorer counterparts. On the other hand, wealth could encourage herders to migrate in search of pasture and therefore forgo income from farming. Markets determine the capacity for growth and efficiency. Improved transport, convenient markets and provision of feed supplies could encourage pastoral people to increase production from individual animals rather than from large unproductive herds. But in many parts of the region, markets barely exist, or if they do exist, operate inefficiently, leaving many pastoralists outside or only loosely connected with the marketing system. On the other hand, the pastoral communities continue to be marginalized in terms of access to education and other essential services. Numerous agencies have programmes in the pastoral areas, but these are primarily focused on emergency relief, with inadequate attention to development, and there is little coordination.

Increasing human populations, water scarcity and the expansion of cultivated areas have contributed to the diminishing quantity and quality of productive rangelands. This, combined with poor animal and human health, places enormous stress on traditional

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pastoral land management practices. A substantial portion of the pastoral population is consequently food insecure due to low productivity even in normal rainfall years. Consequently, herders with more cattle are expected to be more mobile than their counterparts with less livestock due to more severe shortage of pasture on one hand and due to economies of scale in moving on the other.

Further we expect that expenditure on livestock inputs will influence the migration decision as the herder endeavors to mitigate the high cost of maintaining herds by avoiding any losses of livestock to drought. Older herders are expected to be less likely to migrate than their younger counterparts. Migration with livestock is a male affair and so gender is expected to affect the probability of migration. We observe that where male household heads cannot migrate with livestock, *morans* (young men) are hired to do the job. Marital status is also expected to have an important impact on the probability of migration. It is expected that married herders are more likely to migrate than the unmarried as their wives could be left behind taking care of the home and farm. Education is expected to reduce the probability of migration as it is expected to broaden alternative income earning opportunities, relative to no education at all.

From the foregoing discussion, holding the interaction of other social and economic factors constant, three interrelationships between degradation, migration and productivity can be identified. In the first place, increases in herds and human population exert pressure on available pasture and water. Second, such pressure forces the herders to move out in search of more pasture and water. Third, the movement allows regeneration of vegetation, which increases productivity in subsequent periods. In the next section we formalize these relationships using statistical models.

4.3 Empirical Model

Predicting Environmental Capital

The logit technique facilitates the quantification of the effects of predictor variables, which may be quantitative or categorical, on a dichotomous response variable. A household contemplating whether to engage in environmental conservation has to make two decisions. The first pertains to whether such a venture is worth taking or not, the other pertains as to what practice to adopt. Underlying the decision to engage in any environmental conservation practice is a random profit function, whereby a producer engages in environmental conservation in order to maximize expected profits. The economic choice of a given producer is based on a set of parameters or attributes which describe the expected returns of the decision taken, thus affecting productivity. Environmental conservation (which increases environmental capital) is an indicator variable assigned the value of one if the farmer engages in certain land use practices and zero for not engaging. Though these practices are observable, environmental capital is unobservable. For instance, a farmer can adopt practices that improve the quality of the soil, which is not directly observable. Protection of water catchment areas will improve the quality of water (not observable) and also ensure long-term availability of water.

If we let P_1 denote the probability that a farmer will adopt environmental conservation practice i , so that $1 - P_1$ denotes the probability that the farmer does not adopt the practice, the odds favoring adoption are:

$$\frac{P_1}{1 - P_1} = \exp(X\beta + \varepsilon) \dots\dots\dots(1)$$

Where the left hand term denotes the odds ratio and the right hand side denotes the logit index; β is a vector of parameters that measure the effect of vector X on the logit index (McFadden 1987). In a double log specification of equation (1), the vector β would represent effects of the vector X on the log-odds ratio (rather than on the logit index).

If we let $Z = X\beta + \varepsilon$, then we can express the odds ratio as

$$\frac{P_1}{1 - P_1} = \exp(Z) \dots\dots\dots(2)$$

From this equation we can solve for P_1 to get, $P_1 = \frac{\exp(Z)}{1 + \exp(Z)}$ which is based on the cumulative logistic distribution function and can be restated as:

$$P_1 = F(\alpha + \beta X_i) = \frac{1}{1 + \exp\{-(\alpha + \beta X_i)\}} \dots\dots\dots(3)$$

If a farmer adopts n practices, the adoption probability becomes

$$P_1 = \frac{1}{1 + \exp(-Z_2) + \exp(-Z_3) + \dots + \exp(-Z_n)} \dots\dots\dots(4)$$

where n represents a finite set of choice alternatives.

More generally, the probability that a household will engage in a certain land use practice rather than in another can be specified as:

$P_i = F(Z)$, where $F(.)$ = general cumulative distribution function and

$$Z = \alpha + \beta_0 Ppr^j + \beta_1 X^j + \beta_2 W^j + \beta_3 Trf^j + \beta_4 famy^j + \beta_5 K^j + \beta_6 L^j + \beta_7 H^j + \beta_8 V^j + \beta_9 LST^j + \beta_{11} P^j + B_{12} \Phi^j + \beta_{13} \theta^j + \varepsilon \dots\dots\dots(5)$$

Where,

Z is the logit index;

Ppr^j is property right regime facing household j ;

X^j is the amount of total land owned by household j ;

W^j is total hired labour input employed by household j ;

Trf^j is the amount of transfers/remittances received by household j ;

$Famy^j$ is rent income accruing to household j ;

K^j is a vector of capital employed by household j ;

L^j measures the total family labor available to household j ;

H^j is a vector of household characteristics for household j ;

V^j is a vector of village level infrastructure facing household j ;

- LST^j is total livestock owned by household j ;
- p^j is a vector of product prices facing household j ;
- Φ^j is the perceived impact of conservation on productivity by household j ;
- θ^j is amount of biomass available to household j ;
- ε is a stochastic error term for which a distribution is unspecified.

Equation (5) is estimated separately for farmers and herders. The multinomial logit regression method is used to study the determinants of farm level environmental conservation, where farmers are choosing from multiple practices. In the case of herders, a binary logit version of equation (5) is used because they face only two choice alternatives.

Impact of Environmental Conservation on Productivity

To investigate the impact of environmental factors on productivity, we estimate the parameters of the average revenue function. There are different approaches to analyzing the link between productivity and environmental conservation. Some studies have used productivity as a proxy for environmental conservation (Stevenson 1991). However, increased productivity is also argued to increase consumption and therefore to reduce poverty (Barbier and Lopez 1998). The innovation in our case is to follow the standard revenue maximization approach, but to constrain the maximization problem by the requirement that a certain resource stock be used to stop land degradation. In the same vein, Lopez (1998) and Ahuja (1998) consider a representative household farmer who maximizes revenue (R^j) conditional on given land inputs and prices as given in equation (6).

$$R^j(w^j, x^j, \theta^j, p^j, k^j) = \underset{y^j, l^j}{\text{Max}} [p y^j - w l^j : F(y^j, l^j, \theta^j, k^j, x^j) = 0] \dots\dots\dots (6)$$

Where:

- p^j is a vector of output prices facing household j ;
- w^j is a vector of wage rates paid by household j ;
- x^j is land cultivated by household j ;

θ^j is the stock of village level biomass⁵ per hectare for household j ;

k^j is capital employed by household j ;

y^j is a vector of output quantities produced by household j ;

l^j is labor used by household j ;

$F(.)$ is production possibilities set.

The function R^j satisfies all the conditions of a variable profit function in p and w and is increasing and concave in θ , x and k (Lopez 1998).

Lopez (1998) has shown that the rate of extraction of biomass under shifting cultivation is proportional to the rate of land cultivation. Shifting cultivation relies on the natural fertility of land, which in turn relies on the stock of biomass in the village. This is because at the time land is brought under cultivation, the standing vegetation is burnt and the ashes incorporated into the soil as fertilizer. Thus, for a given area under biomass, a higher density of natural vegetation contributes more to the natural fertility of the given plot owing to higher quantities of organic material and the denser root system of the standing biomass. At the same time, a higher area under biomass contributes more towards prevention of flooding and soil erosion, thus contributing positively to land productivity at the village level.

Stevenson (1991), uses a simple model (equation 7) to compare the productivities of private and common property regimes

$$Y = \gamma_1 R + \beta_1' X_1 + \mu_1 \dots \dots \dots (7)$$

where, Y is average milk production (liters/cow/day), R is a dummy variable for property right regimes, which equals to 1 if land tenure is private, and otherwise equals to 0. X_1 is a vector of exogenous variables other than the land rights system that might affect productivity; γ_1 and β_1 are unknown coefficients and μ_1 is a stochastic disturbance term.

⁵ Biomass is the amount of vegetation cover available at a given place at a given time. It is estimated through satellite images similar to measures of forest canopy.

The author argues that milk production can be used as a proxy for the extent of utilization of pasture, because less degraded pastures will yield more milk per cow per day, controlling for the characteristics of the pasture and other factors.

Following this approach and Lopez (1997a,1998), we specify a productivity model as

$$R^j = f(W^j, X^j, P^j, Ppr^j, V^j, L^j, H^j, ECP^j, \theta^j, \varepsilon^j) \dots\dots\dots (8)$$

Where R^j is revenue per acre for household j ; ECP^j is a vector of probabilities of environmental conservation for household j predicted from equation (5)⁶ and all other variables are as defined earlier.

Equation (8) is a well-behaved average revenue function, which relates average revenue of a given household to the conventional inputs, product prices, environmental capital, village level characteristics and other institutional factors.

In compact panel data form, the estimable variant of equation (8) can be expressed as:

$$Y_{jt} = \alpha + X_{jt}\beta + v_j + \varepsilon_{jt} \dots\dots\dots (9)$$

Where j denotes the j^{th} household; t denotes the time period ($t= 1,2,3$) Y_{jt} is the average revenue for household j at time t , α is a constant term and β is a vector of coefficients to be estimated. X_{jt} is a vector of determinants of productivity specific to household j at time t ; $v_j + \varepsilon_{jt}$ is the residual where v_j is the household specific residual, which differs among households but is constant for any household over time; ε_{jt} is white noise with the usual properties (mean zero, uncorrelated with itself, uncorrelated with X , uncorrelated with v_j , and homoscedastic).

⁵ Bindlish and Evenson (1993) employ similar methodology in agricultural extension. Logit models are used to determine farmer participation in training and visit exercises. The results obtained are used in a meta production function to test for the impact of extension services on agricultural productivity.

In this thesis, we estimate equations (5) and (9) using pooled data set. We use panel data models as they yield better results than cross-sectional models, since the former control for unobserved heterogeneity due to farmer specific factors and are based on more informative data; give more variability, less collinearity among the variables, and more efficient results. Presenting results for both panel and cross sectional analysis makes explicit the errors in the later.

In panel data studies, equation (9) can be modified and estimated either as a fixed effects or a random effects model. In the fixed effects models, v_i is assumed to be a fixed parameter to be estimated. Although the fixed effects model is useful when we are confident that the difference between units can be viewed as parametric shifts of the regression function, it suffers a number of shortcomings: it is costly in terms of degrees of freedom lost as $(N-1)$ extra parameters are estimated, which reduces precision of the estimates and has too many dummies that could aggravate the problem of multicollinearity among the regressors. Lastly, it sweeps out all fixed effects and therefore cannot estimate the effect of any time invariant variable such as sex, schooling, race, religion, or union participation (Baltagi 1995). Due to these shortcomings, the random effects model is more attractive than the fixed effects model. The random effects model (also referred to as the variance-components or the error components model) treats all individual effects as random variables. However, the fixed effects approach has one advantage over the random effects: there is no justification for treating effects as uncorrelated with other regressors and the random effects treatment may therefore suffer from the inconsistency due to omitted variables (Greene, 1997). In order to choose between the two specifications, the Hausman specification test for random effects is employed. If the test rejects the random effects model, the fixed effects specification is adopted (Baltagi 1995).

4.4 Estimation Issues, Hypotheses and Variable Definitions

Estimation Issues

In estimating the impact of environmental conservation practices on productivity, it is important to note a number of issues that arise in this type of analysis. The main issue is the possibility of encountering the problem of endogeneity. The problem is that most variables that influence environmental conservation practices also determine productivity. It is difficult to find good identifying variables that determine environmental conservation but theoretically do not influence revenue per acre. On the other hand, it is possible to have feed back effects between environmental conservation practices and productivity. Under such cases, the standard procedure for estimation is two or three stage estimation. However, such methods require appropriate instrumentation so that the separate equations can be properly identified.

To illustrate the procedure, assume that a household adopts a certain environmental conservation practice and consider the following system of equations, where Y_1 is dichotomous and Y_2 is an observed continuous variable:

$Y_1 = f(R) + \varepsilon_1$(10)

$Y_2 = g(Y_1, M) + \varepsilon_2$ (11)

Where Y_1 represents the adoption of the environmental conservation practice and takes a value of 1 if the household undertook that practice, otherwise 0. Y_2 represents revenue per acre. R and M are distinct vectors of exogenous variables and ε_1 and ε_2 are uncorrelated residuals in the environmental conservation and revenue functions.

The standard procedure for estimating equations (10) and (11) is to derive the reduced forms of these structural equations as in Maddala (1983):

$Y_1^* = \lambda_1 X + \tau Z + v_1$(12)

$Y_2^* = \lambda_2 X + \gamma Y_1^* + v_2$ (13)

where X includes all the exogenous variables determining environmental conservation and revenue per acre, Z is a set of exogenous instruments and v_1 and v_2 are stochastic disturbance terms. The next step is to estimate equations (12) and (13) using appropriate methods. The productivity equation (Y_2) and the environmental conservation equation (Y_1) can be properly estimated using instrumental variables (IV) and two stage methods. In the IV procedure, equation (12), which has a dichotomous dependent variable is specified as a linear probability model and estimated using OLS method, which is also used to estimate equation (13). However, in a two stage procedure, equation (12) is specified as logit (or probit) model and estimated using maximum likelihood methods. In the full and farmers sub samples, equation (12) is specified as a multinomial logit whereas in the herders sub-sample, a binary logit model is estimated.

It should be noted that in two stage least squares, consistency of the second stage estimates does not spring from getting the first stage functional form right. Using a linear regression for the first stage estimates generates consistent estimates even with dummy endogenous variables. Moreover, using non-linear first stage to generate fitted values for the second stage equation does not generate consistent estimates unless the non-linear model happens to be exactly right, which makes the danger of misspecification high. Instead, fitted values from a non-linear model can be used as instruments provided a linear model is used to generate first stage predictions of the practices from the fitted values and all other exogenous covariates in the second stage (Angrist and Krueger, 2001). In this light, we use the linear probability model to obtain the fitted values of each practice in the first stage regressions, then plug these into the second stage to estimate the revenue (productivity) equation. We however compare results from the multinomial and binary logit models to the first stage regression results obtained from the instrumental variable equation in order to assess the extent of misspecification.

The alternative to the two stage least squares, which confirms the robustness of this method, is to use the instrumental variable method where environmental conservation and productivity are determined simultaneously, controlling for endogeneity of conservation

through appropriate instrumentation. This method is identical to the two stage least squares only that it runs the regression in two stages from one estimation command. The two methods provide consistent estimates in the presence of measurement errors in explanatory variables and overcome omitted variable problems in estimates of causal relationships while taking care of simultaneity (Angrist and Krueger, 2001). This estimation procedure accounts for the simultaneity of the feedback relationship between environmental conservation, productivity and poverty.

Another estimation issue in our analysis that is worth mentioning is the possible endogeneity of property rights. Available evidence indicates that farmers are more willing to invest in environmental conservation when they have security of land tenure. On the other hand investments in environmental conservation could enhance security of tenure, as an individual strengthens claim on a parcel of land once he has made significant land improving investments such as planting trees (Brasselle et al. 2002, Besley, 1995, Atwood, 1990). Property rights could also be endogenous to productivity as it may be argued that productive land is more likely to be privatized than less productive land (Platteau, 2000). In our sample, however, we assume that land rights may not be endogenous as the decision to privatize land is made at the group level and not at the individual level. For instance, in some of the existing group ranches, members have agitated for subdivision of land for a long period of time, yet this has not been done due to non-coöperation and misappropriation of funds by the management. We therefore assume that there is no feed back effect between property rights and any of the dependent variables and so we do not model property rights.

Hypotheses

Two hypotheses are tested in this thesis. The first hypothesis is that “an improvement in environmental capital has no effect on productivity”. This hypothesis is tested by estimating the average revenue function. It is expected that an improvement in environmental capital (proxied by an increase in the probability of adopting a particular land conservation practice) would improve agricultural productivity. The second hypothesis is that “the quality of the environmental capital is unaffected by institutional

factors". This hypothesis is tested by examining the impact of institutional variables controlling for other factors on environmental conservation practices. Farmers engage in different environmental conservation practices, which impact differently on the environment. Better environmental conservation practices imply improved environmental capital, which increases productivity thereby reducing poverty. Estimation of the participation in environmental conservation equations facilitates the testing of this hypothesis.

Definition and Measurement of Variables

In this sub-section, we define the dependent and independent variables using the notations employed in the estimating equations.

Dependent variables

R^j (gross average revenue) is defined as the revenue per acre. Gross revenue per acre is used as a proxy for productivity. The assumption here is that if we hold prices constant, changes in gross revenue will spring from changes in productivity⁷. Separate equations are estimated for revenue from livestock and farming (and from a combination of the two).

For each household we define a particular environmental conservation practice. For the farmers, we define a practice variable, which takes values ranging from 1 to 3 for the three practices adopted and a reference category of non-adoption, which takes a value of zero. The three practices are blocking soil erosion outlets, terracing and planting drought resistant vegetation. These practices are expected to enhance productivity by reducing land degradation. For pastoralists, migration facilitates the growth of vegetation, which not only prevents soil erosion but also increases the depth of topsoil. The dependent variable in the migration equation assumes a dummy value of 1 if the herder migrated with livestock, and a value of zero otherwise.

⁷ A meta production function also allows gross revenue/profit to be used as a measure of productivity (see Evenson and Mwangi, 1998 and Blindish and Evenson, 1993).

Independent variables

In this sub-section, we define variables used as explanatory factors for both the participation equation for environmental conservation practices and for the productivity equation. The variable definitions, measurement and expected impacts on environmental conservation practices and on productivity are presented in Table 4.1. The first column of the table presents variable notation as in the estimating equation, the second column presents the definition and measurement of each variable. Columns three and four present the expected impact of each explanatory variable on conservation and productivity respectively. The expected impacts are based on the discussion in sections 4.2 and 4.3 and literature in this area (Lopez, 1998, Evenson and Mwabu, 2001, Stevenson, 1991, Place and Otsuka, 2002). The blanks in columns three and four indicate that the variable in question does not enter into the estimating equation as an explanatory factor. In this respect, the last four cells in column four represent the instruments for identifying environmental conservation. These four variables are expected to have a direct impact on environmental conservation but not on productivity.

Variable	Definition and measurement	Expected impact on Conservation	Expected impact on Productivity
V_{it}	Village level characteristics		Positive
H_{it}	household level characteristics		
D_{it}	distance to source of water (Km)	Negative	Negative
M_{it}	distance to markets (Km)	Negative	Negative
LSP_{it}	Total livestock owned by household	Negative	Positive
P_{it}	Product prices faced by household		
P_{1it}	market price per kg of maize	Positive	Positive
P_{2it}	market price per kg of beans	Positive	Positive
P_{3it}	market price per head of cattle	Positive	Positive
P_{4it}	market price per head of sheep	Positive	Positive
W_{it}	Amount of money available at village level (kg per acre)	Positive	Positive
T_{it}	Transfers received by household (KSh)	Positive	
Y_{it}	Real income (KSh)		
K_{it}	Value of capital equipment owned at market price (KSh)	Positive	
δ_{it}	Perceptions of household's economic benefits from environmental conservation (1-increase in perceived benefits)	Positive	

Table 4.1 Independent Variables

Variable	Definition	Expected Impact on	
		Conservation	Productivity
Ppr ^j	Property right regime (1= private, 0= otherwise)	Positive	Positive
X ^j	Total land owned by household j (acres)	Positive	Positive
L ^j	Total family labour (proxied by household size)	Positive	Positive
W ^j	Total hired labour units by household j	Positive	Positive
H ^j	Household characteristics (i) age (ii) education -three dummies - primary (1=yes,0= otherwise) - secondary (1=yes,0= otherwise) - post-secondary (1=yes,0= otherwise) (iii) sex (1= male, 0= female) (iv) Marital status (1=married, 0=not married)	Indeterminate Positive Positive Positive Indeterminate Indeterminate	Indeterminate Positive Positive Positive Indeterminate Indeterminate
ECP ^j	Predicted probability that household adopts - blocking soil erosion outlets - land terracing - planting drought resistant vegetation - livestock migration	- - - -	Positive Positive Positive Positive
V ^j	Village level characteristics facing household j - distance to source of water (Km) - distance to markets (Km)	Negative Negative	Negative Negative
LST ^j	Total livestock owned by household j	Negative	Positive
P ^j	Product prices faced by household j - market price per kg of maize - market price per kg of beans - market price per head of cattle - market price for head of sheep/goat	Positive Positive Positive Positive	Positive Positive Positive Positive
θ ^j	Amount of biomass available at village level (kg per acre)	Positive	Positive
Trf ^j	Transfers received by household j (Kshs)	Positive	-
famy ^j	Rent income (Kshs)	Positive	-
K ^j	Value of capital equipment (valued at market price) (Kshs)	Positive	-
φ ^j	Perceptions of household j concerning benefits from environmental conservation (1=increases output, 0=decreases output)	Positive	-

CHAPTER FIVE

DATA AND SAMPLE STATISTICS

5.1 Introduction

This chapter presents a brief description of the study area, sampling procedures, methodology of data collection and a descriptive analysis of the data. Section 5.2 presents a brief description of the study area and focuses on location, topography, climate, soils and agro-ecological zones. Section 5.3 discusses the sampling procedures, data types and sources. Section 5.4 presents a detailed description of the primary data, focusing on household characteristics, economic activities and details related to land tenure and environmental conservation practices. The last part of this section presents an analysis of infrastructural facilities in the district. Section 5.5 discusses secondary data.

5.2 The Study Area

Kajiado district, with an area of 21,105Km², is one of the arid and semi arid districts in Kenya. It lies within the Rift Valley and is characterized by undulating plains interrupted by several hills and valleys (Republic of Kenya, 1997). The district comprises a large area extending from the foothills of Kilimanjaro and the boundary of Kenya with Tanzania to the South and Nairobi - Mombasa railway line to the North. Southwest Kajiado comprises the volcanic ridges and uplands surrounding Kilimanjaro. In the Northeast are Chyulu Hills, also volcanic, while in between are predominate lava flows, which have been covered recently by piedmont plains. The sedimentary rocks formed as a result of volcanic hills' and mountain degradation since quaternary times. From Chyulu hills, piedmont plains dominate the Amboseli, while around Lake Amboseli are sedimentary rocks that have formed as a result of repeated changes in lake levels. The result of these processes are the moderately fertile soils that occur in the Chyulu hills, while the Northern Kajiado consists of soils of non- dissected erosion plains. In general, soils in Kajiado are of low to moderate fertility and make the ecosystem fragile and easily degradable- especially if human activities such as agriculture are allowed to intensify.

The district has a bimodal rainfall pattern. The short rains fall between October and December while the long rains fall between March and May. However, the bulk of the district is part of Kenya's "*Nyika Region*" with low and moderate rainfalls. Rainfall is highest in the section of Mt. Kilimanjaro, which lies in Kenya (around Loitoktok) where it ranges from 400mm to more than 1000mm. The same rainfall gradient is experienced along the western franks of Chyulu hills in the Northeast. Rainfall on the foothills of Kilimanjaro and Chyulu hills is fairly reliable. However, along the plains, the rainfall is quite unreliable making the ecosystem even more fragile and unable to sustain intensive human agricultural activity. The majority of the vegetation is low to medium savanna at Amboseli National Park and the entire plains. Montane vegetation only occurs on the highest ridges of Chyulu hills and the lower flanks of Kilimanjaro. About 80% of the district can be classified as low savanna and arid/semi-arid. In bio-diversity terms any increase in range stock and /or wildlife capacities could lead to acute land degradation and rapid destruction of fauna and flora habitats (King'oriah 1995).

The district consists almost entirely of ranching zones (90%) except on the Ngong hills, up the Chyulu hills and on the lower flanks of Kilimanjaro where good cropland is available. The land spans between agro-ecological zones III through VI. Zone III is the semi-humid climate where mixed agriculture can be sustained. This represents a small proportion of the area and is concentrated around Magadi division. Zone IV is arable semi-humid/semi-arid climate zone, which is shared by Central, Magadi, Ngong and Loitoktok divisions. Zone V, which is semi-arid climate (ranching land), is the most widespread and is represented in every division of Kajiado district. Zone VI is arid climate (pastoral land) and is also represented in all divisions except Ngong. Economic activities are therefore largely dependent on livestock and wildlife.

5.3 Sampling Procedures, Data Types and Sources

This thesis uses both primary and secondary data to achieve the study objectives. The secondary data were collected by the National Oceanic and Atmospheric Administration (NOAA) using remote sensing methods. The data were translated from digital form into biomass in kilograms per acre by the Department of Resource Surveys and Remote

Sensing (DRSRS) using Geographical Information Systems (GIS). The data images were only available for the first two phases of the study and the previous season (short rains – October to December 1998) due to a breakdown in equipment used to receive the satellite images. We therefore used the value of biomass for the previous season. We assume that this would capture the actual effect of biomass because biomass available this season would affect the health of livestock this season, but the full productivity effect will be realized in subsequent seasons.

The primary data were a time panel collected from a cross section of households in Kajiado district over the period March 1999 to May 2000. The data were collected in three phases. In phase one were data collected for the long rains (March-May 1999); phase two for short rains (October- December 1999) and phase three for the long rains (March- May 2000). Through field visits, data were collected concerning economic activities and tenure systems. Other basic information about the households and villages were also collected during the field visits.

The household sample was based on the National Sample Survey and Evaluation Program (NASSEP III) frame. The NASSEP frame has a two stage stratified cluster design for the whole country. First, enumeration areas are selected using the national census records, with the probability proportional to size of expected clusters. The number of expected clusters are obtained by dividing each primary sampling unit into 100 households. The clusters are then selected randomly and all the households enumerated (Republic of Kenya 1996). From each cluster, 10 households were drawn at random.

Our sample was drawn from the 26 clusters used by the government for the 1997 Welfare Monitoring Survey (WMS) Survey, comprising a total of 312 households. However 5 of the clusters were discovered to fall in urban areas of the district and were therefore dropped from the sample. The questionnaire used to collect the requisite data is attached as appendix 2.

5.4 Primary Data

Household Characteristics

A sample of 220 households were targeted with a response rate of 202 (35%), 192 (34%) and 176 (31%) households in phases one, two and three respectively, making a total of 570 observations. This shows an attrition rate of 5% and 14% in the second and third phases respectively⁸. These households comprised a total of 3879 members: 1377, 1310 and 1192 in the three phases respectively. The reduced number of household members is attributable to the prolonged drought, which led to a lot of migration⁹. Other than for key household characteristics, we base the descriptive statistics and empirical analysis on the sub-sample of adults aged 18 years and above. In total, 51% of the respondents were male and the rest were females. The key household characteristics are presented in Table 5.1. One important highlight in this table is the large household size (maximum household size was 38) where the largest households were found to be in polygamous households. We also note that the overall mean household size in our sample (9.4) is twice as high as the mean household size for the entire district and for Kenya at 4.8 and 4.6 respectively (Republic of Kenya 2000b).

The data indicates that more men than women were single, while more women than men were in polygamous marriages. A higher percentage of women were also found to be in widowhood compared to their male counterparts (Table 5.2). In the final analysis, we collapse the marital status variable to simply distinguish between whether the respondent is married or not. For the full sample, 69% of the respondents were married. Out of 812 women, 76% were married, compared to 63% of their male (788) counterparts. Majority of the households were male-headed (86%).

⁸ Since the variations in the sample are not systematic, we assumed that sample attrition does not bias our results. The software used (Stata) also takes care of unbalanced panels automatically.

⁹ Household members were defined as the usual members and excluded those in boarding schools; living with relatives or working away from home. Due to the prolonged drought, most Maasai had given away their children to live with relatives and friends while others were away looking after livestock.

Table 5.1 Key Household Characteristics

Variable	Phase I N=1377		Phase II N=1310		Phase III N=1192		All Phases N=3879	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Age (yrs)	19.7	17.0	20.1	17.5	19.6	17.1	19.8	17.2
Sex /gender (1= male)	0.47	0.50	0.50	0.50	0.50	0.50	0.49	0.50
Household size	9.3	5.9	9.6	6.7	9.2	5.3	9.4	6.0
Marital status (1 =married)	0.73	0.44	0.69	0.47	0.67	0.47	0.69	0.46
Can read and write (1=yes)	0.51	0.50	0.56	0.50	0.49	0.50	0.52	0.50
Ever attended school (1=yes)	0.50	0.50	0.55	0.50	0.50	0.50	0.52	0.50
Number of years in school	3.7	4.3	3.0	4.0	2.8	4.0	3.2	4.1

Table 5.2 Marital Status by Gender

Marital Status/Sex	Female		Male		Full Sample		
	Freq.	Percent	Freq.	Percent	Freq.	Percent	Household size (mean)
Single	125	15.39	277	35.15	402	25.13	8.9
Married-monogamous	345	42.49	360	45.69	705	44.06	6.5
Married-polygamous	270	33.25	134	17.01	404	25.25	11.9
Separated	13	1.6	5	0.63	18	1.13	7.8
Widowed	59	7.27	12	1.52	71	4.44	5.3
Respondent is married	615	76	494	63	1109	69	8.5
Total	812	100	788	100	1600	100	8.4

Literacy of the respondents was proxied by whether one could read and write or whether one had ever attended school. 52% of all household heads could read and write, while the overall mean number of years in school for all the entire population was 4.7 with a standard deviation of 4.9 years, and a maximum of 19 years. Only 20% of all respondents had more than 10 years of schooling. The mean numbers of years of schooling for men was 5.5 years with a standard deviation of 4.9 years, while that of their female counterparts was 3.89 years with a standard deviation of 4.8 years. The data also indicates that there were a lot of disparities in education among men and women in the district. For instance, 60% of the women had never been to school compared to only 36%

of their male counterparts (Table 5.3). The percentage of respondents who had never attended school in our sample was 48.5 compared to a national average of only 17% and a district average of 40% (Republic of Kenya, 2000b).

Table 5.3 Highest Grade Attained by Gender

Grade\sex	Female		Male		Full Sample	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Pre-school	7	0.86	0	0	7	0.44
Std 1-8	130	16.01	206	26.14	336	21
Sat for KCPE/CPE	54	6.65	106	13.45	160	10
Form 1-4	76	9.36	92	11.68	168	10.5
Sat KCE/EACE	42	5.17	61	7.74	103	6.44
Post-sec. education	13	1.60	15	1.90	28	1.75
University education	1	0.12	4	0.51	5	0.31
Other education	4	0.49	17	2.16	21	1.31
No education at all	485	59.73	287	36.42	772	48.25
Can read and write	328	40.00	507	64.00	825	52.00
Total	812	100	788	100	1600	100

This study also collected information on the main and secondary occupation of the respondents. A tabulation of the main occupation by gender is presented in Table 5.4. The table shows that the main occupation of the respondents was livestock production (37%), followed by farming (27%), wage employment (12%) and general business (8%). Surprisingly, women dominate livestock production (42% compared to 31% of their male counterparts). This is because most women were either in farming or livestock production compared to men, who own livestock and still take up wage employment, leaving their wives to take care of the livestock. There were no notable differences in the distribution of men and women across the secondary occupation.

Table 5.4 Main Occupation of Respondent by Gender

Occupation\sex	Male		Female.		Full Sample	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Farming	181	22.97	246	30.3	427	26.69
Livestock production	245	31.09	340	41.87	585	36.56
Stock traders	12	1.52	0	0	12	0.75
General business	80	10.15	45	5.54	125	7.81
Employed	154	19.54	41	5.05	195	12.19
Student	63	7.99	29	3.57	92	5.75
Other (specify)	45	5.71	89	10.96	134	8.38
None	8	1.02	22	2.71	30	1.88
Total	788	100	812	100	1600	100

Economic Activities

Fieldwork results further indicated that the main economic activity in the district is livestock production, with the traditional cattle as the main breed raised. The data indicates that out of 1600 respondents 95% (1518) kept livestock compared to only 73% (1172) who were crop farmers. 70% (1114) kept livestock and produced crops at the same time. The main crops produced were maize and beans, mostly for home consumption. Tomatoes and onions (other crops) production for the market were found to be concentrated in Loitoktok division, mostly under irrigation.

Data on the main economic variables is summarized in Table 5.5. The data indicates that the maximum number of acres cultivated was 51 with a mean of 2 and a standard deviation of 4.5. The large standard deviation implies that there are a lot of variations in the number of acres cultivated. For instance, 30% of all households did not cultivate at all, while 53% of all households cultivated less than 3 acres. The low acreage is partly attributable to the poor climatic conditions and partly to the way of life (pastoralism) of the community under study.

Table 5.5 Selected Economic Activities (Last Season)

Variable	Sample size	Mean	Std. Dev.	Min.	Max.
Acreage planted	1172	2.1	4.5	0	51.0
Value of maize harvested (Kshs '000)	1172	2.31	7.46	0	84.0
Value of beans (Kshs '000)	1172	3.22	8.76	0	97.2
Value of other crops (Kshs '000)	1172	3.53	21.84	0	322.5
Value of livestock (animals) (Kshs '000)	1518	522.58	1175.2	0	9586
Value of livestock products (Kshs '000)	1518	29.56	83.55	0	1621.8
Number of cattle owned	1518	37.4	103.4	0	902.0
Ratio of sheep and goats to cattle	1518	3.5	8.3	0	93.0
Value of equipment (Kshs '000)	1600	6.21	10.80	0	97.65
Value of farm inputs (Kshs '000)	1172	2.45	5.09	0	43.95
Value of livestock inputs (Kshs '000)	1518	7.004	16.4	0	253
Price of maize (kg)	1600	20.70	6.36	12	40
Price of beans (kg)	1600	42.73	13.24	20	80
Price per cow (Kshs '000)	1600	7.64	3.54	2	17
Price per sheep/goat (Kshs '000)	1600	1.44	0.54	0.4	3
Wages (Kshs '000)	1600	3.15	7.56	0	91.80
Family labor (number)	1600	3.1	1.9	0	12.0
Total land owned (acres)	1545	108.0	147.9	0	800.0
Credit (Kshs '000)	66	55.12	59.63	3	200
Transfers /remittances (Kshs '000)	346	9.91	19.68	0.04	100
Non agriculture income (Kshs '000)	754	23.93	51.89	0.18	420

An analysis of the number of cattle owned indicate that on average, 28% of all households did not own any cows at all while 12% owned more than 37 cows¹⁰. Although this figure is way above the national average of about 3, it compares closely with the average cattle holding of 35.4 by non-poor households in the district (Republic of Kenya, 2000b). The mean number of cows fell from 33 to 29 with the maximum number falling from 565 to 310 in phases 1 and 3 respectively. Investment in technology was captured

¹⁰ Number of cattle refers to standard cattle units owned, taking into account the age and sex of the animal. Price per cattle unit is obtained as an average price of cows and bulls (see Chopra and Gulati, 2001).

by the value of equipment, farm inputs and livestock inputs. The results indicate that on average, producers in the district had made investments of about 6,200 shillings with a standard deviation of about 11,000 shillings worth of physical capital. The mean value of farm inputs was however a low of 2,453 shillings per season compared to a high of 7000 shillings worth of livestock inputs. The high standard deviations indicate that there were a lot of inequalities in terms of investment in productivity enhancing technologies. For instance, only 15% of the investors reported investments of more than 11,000 shillings, while 69% reported less than the mean (Ksh.6,200) investment. Crop farmers reported a higher mean investment in physical capital than herders.

The highest mean prices for maize and beans were reported in phase 2 (22 and 43 shillings per kilogram respectively), while the highest mean prices for livestock were reported in phase 1 (9271 and 1751 shillings per cow and sheep/goat respectively). On the other hand, the highest maximum livestock prices were reported in phase 2, while for maize and beans, the highest maximum prices were reported in phase 1 and 3 respectively.

Wages paid averaged 3100 shillings per season with a standard deviation of 7600 shillings. However, 52% of all households did not hire any labour at all. Of those that hired, 50% paid wages of less than 2500 Kshs., while only 17% paid more than the mean wage. The data further indicates that there might be some correlation between the wage paid and revenue, implying that more successful producers were more likely to hire labour than their unsuccessful counterparts. The mean land size owned was 98 acres with a standard deviation of 145 acres. Only 13 % of the households owned more than 200 acres and these were found in the remotest pastoral clusters. For instance in Loitokitok division, which is a major farming zone, the mean land owned was only 27 acres, while in the more arid divisions of Namanga and Mashuru, the mean land size was 253 and 174 acres respectively (Table 5.6). The total land owned by scheme members was obtained by dividing the total group land by the number of scheme members.

An analysis of credit use indicated that 96% of all respondents did not use any credit. 41% of the recipients sourced credit from cooperatives, 15% from churches, 22% from friends (11%) and the Agricultural Finance Corporation (another 11%), 7% from local traders, and another 7% from banks. The maximum credit received was Kshs. 2 million with a mean of Kshs. 4066 and a standard deviation of Kshs. 65,791. However, excluding the outlying household, the maximum credit received was Kshs.200,000 with a mean of Kshs.55,124 and a standard deviation of Kshs. 59,634. 83% of the respondents reported that they did not need any credit, 13% were unable to obtain any credit while the rest 4% received less than they needed. Most of those who reported that they did not need any credit indicated that they would not borrow, as they would be unable to repay. Credit was mainly used for agricultural inputs such as purchasing livestock (33%) and chemicals (11%). The rest of borrowers reported having used credit to either purchase fertilizers and machinery or for multiple uses. Due to the limited number of households who had obtained any credit, the credit variable is not used in the empirical analysis.

The mean amount of transfers received from other households was 9,910 shillings for all phases combined with a standard deviation of Kshs.19,680. This high standard deviation indicates that there were a lot of disparities in the amount of transfers received. For instance, 77% of the households did not receive any transfers at all, while only 2% received more than 20,000 shillings per month. The rest 98% reported a mean of 1030 shillings per month. As for non-agricultural income, only 48 % of all households received any, with only 19% reporting a high mean of more than 10,000 shillings, and the rest reporting a low mean of 1420 shilling per month. Although most households reported non-agricultural income from wages, the majority of households with high non-agricultural income mostly reported property income (housing rents) and income from quarrying.

Table 5.6 Land Ownership by Division (acres)

Division	Sample size	Mean	Std. Dev.	Min.	Max.
Loitoktok	485	27	44	0	305
Mashuru	202	174	128	0	750
Magadi	133	38	37	0	88
Ngong	441	90	175	0	800
Central	164	121	79	1	301
Namanga	175	253	194	1	772
Full sample	1600	98	145	0	800

Property Right Regimes

Republic of Kenya (1997) indicates that there are three categories of land tenure in the district under study. First there is trust land on which most of the game reserves and national parks (Tsavo and Amboseli) are found. Two, group ranches (common property resources) are found in most parts of the districts, where the main economic activity is livestock keeping. Finally, private ownership is mainly in Loitoktok and Ngong divisions, where the main economic activity is small-scale farming and livestock production. Our findings confirm this ownership structure. An analysis of the data shows that 69% of all households held land under individual ownership, 25% under communal (scheme) ownership, 2% occupied government land, while 4% are tenants. However, since the latter two categories were negligible, we categorize property rights into only two, private ownership (73%) and common property resources (27%) (Table 5.7). 45% of all private landholders were found in Ngong (23%) and Loitoktok (22%) divisions. On the other hand, 8% of all common property landholders were found in Magadi where all respondents in the two clusters held land under common property. In Central division, virtually all land were under private property and only 4% of all households in our sample (for this division) held land under common property.

Out of the households that held land under private ownership, 35% reported that their ownership had changed from common to private within the last 5 years. 41% of this category reported that such privatization had enabled them to increase productivity, 23% felt that privatization had led to a decrease in productivity, while the rest of the sample

argued that privatization had not affected output. Most of those who did not seem to favour privatization were herders with very large herds who felt constrained in-terms of pasture.

Table 5.7 Property Right Regimes by Division

Division	Sample size	Private (%)	Common(%)
Loitoktok	485	76	24
Mashuru	202	73	27
Magadi	133	0	100
Ngong	441	79	21
Central	164	96	4
Namanga	175	86	14
Full sample	1600	73	27

Some of the remaining ranches were still in the process of subdivision while in others, respondents had been allocated individual parcels for farming, but grazing land was yet to be subdivided. However, for those households still holding land under schemes, 65% reported that they would want the schemes to be subdivided, 30% reported that they did not favor subdivision while the rest, 5% were indifferent. The reasons given by ordinary group land members for the need to privatize land ownership was that group land benefited mostly the elders (who take loans, bursaries and relief food in the scheme's name) and those with large herds.

A probe on the perceived constraints of the present system of land ownership indicated that the most serious constraint was shortage of land (29% of all households under common property) and water and climatic conditions (35% of all households under private ownership). Only 6% of those who held land under common property felt that water and climatic conditions were a problem.

Environmental Conservation Practices

Farmers in the sample practice three main environmental conservation practices. However, only 44% of the farmers reported to have engaged in any conservation practice at all. The most widely adopted practice was planting drought resistant vegetation (24%), followed by blocking soil erosion outlets (10%) and land terracing (10%). About 70% of those who engaged in various land conservation practices reported that environmental conservation practices increased output, but 30% thought that practices had no impact on output (Table 5.8). 25% of all farmers reported that land tenure influenced adoption of conservation practices.

Table 5.8 Environmental Conservation Practices

Variable	Sample size	Yes=1 (%)	No=0(%)
Farmer engaged in any environmental conservation practice	1172	43	57
Farmer engaged in blocking soil erosion outlets	1172	10	90
Farmer engaged in land terracing	1172	10	90
Farmer engaged in planting drought resistant vegetation	1172	24	76
Perceived effect of land use practice on output (1 = increases, 0 = decreases output)	1172	30	70
Farmer intend to introduce new practice	1172	24	76
Effect of land ownership on adoption of practices	1172	25	75

The data further show that farmers holding land under private property are more likely to engage in environmental conservation than their common property holding counterparts. For instance, 49% of private property holders engaged in different environmental conservation practices, compared to only 27% of their common property holding counterparts (Table 5.9).

An examination of the effect of the system of land ownership on environmental conservation practices indicate that 75% of the respondents thought the system of ownership discouraged adoption of conservation practices, while the rest, 25%, felt that the system of ownership encouraged conservation. Most of those who reported that they were discouraged were those holding land under tenancy arrangements and under

schemes. The concern was that once the tenant improved the land, the landlord would take it over, while under schemes, the respondents indicated that they could not build permanent houses, plant trees or engage in any other long-term practice as they were not sure which parcel of land would eventually be their own.

Table 5.9 Conservation Practices by Property Right Regime

Regime/Practice	Private Property		Common Property	
	Frequency	Percent	Frequency	Percent
Farmer engaged in blocking soil erosion outlets	85	9	36	15
Farmer engaged in land terracing	111	12	11	5
Farmer engaged in planting drought resistant vegetation	257	28	19	8
Farmer did not engage in any practice	476	51	177	73

Pastoralists are known to migrate during the dry season in search of pasture and water. Table 5.10 presents a summary of the migration variables. The results show that herders under private property are less likely to migrate (55% migrated) than their counterparts in common property (69% migrated). In general, 59% of all livestock keepers migrated. Most of those who did not migrate were those who lived in Ngong and Loitokitok divisions where there are a lot of inhabitants who are not indigenous *Maasai*. Of those who migrated, 73% only returned home during the rainy season while the rest commuted with livestock and returned home daily. Cross tabulations indicate that of the households that commuted, 28% did so often while 52% commuted only during the dry season. Similarly, of the respondents who migrated, 79% migrated only during the dry season while the rest migrated frequently.

An analysis of the distance migrated indicates that private property herders migrated for shorter distances (43 kms), than common property herders (51 kms). The results also show that most households migrated for less than 100 kilometers (90%) while only 10% traveled between 100-300 kilometers away from home. Some households reported to have migrated as far as Tanzania. The average distance migrated by all producers was 65 kms with a standard deviation of 48 kms.

Table 5.10 Migration Patterns by Property Right Regime

Variable	Private property		Common property		Full sample		
	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. Dev.	No.
Whether household migrated (1=yes)	0.54	0.50	0.68	0.47	0.59	0.49	1518
When household migrated (1= dry season, 0 =other)	0.74	0.44	0.72	0.45	0.73	0.44	889
Distance migrated (Kms)	42.81	51.01	50.91	52.77	64.67	47.92	891
Ratio of migrants to adults	0.33	0.43	0.56	1.75	0.250	0.803	891
Ratio of commuters to adults	0.05	0.16	0.04	0.12	0.041	0.214	253
Perceived impact of migration on output (1=positive)	0.53	0.50	0.58	0.59	0.57	0.50	1518

The ratios of commuters to household members have low means indicating that only a small proportion of household members commuted in search of pasture as the herd size may not determine the number of herders required (due to economies of scale in grazing). For instance, a cross tabulation of the number of cattle owned and the ratio of commuters to adults showed that the households with very large herds reported very low ratios. However, ratio of distant migrants to household members is high indicating that distance migration may require that more members migrate. In such cases, the herder may migrate with one of the wives and her small children. Of all the households that migrated, 34% reported that it was children who were the migrants, 25% reported that it was the household heads, 19% reported that the migrants were workers and 12% were other relatives. 57% of all herders felt that migration increased productivity, while the rest, 43%, felt that migration either decreased or had no impact on productivity. This latter category argued that migration was associated with livestock diseases, which either wiped out whole herds, or required a lot of expenditure to cure. Such perceptions were found to be stronger for common property owners (58%), than for herders under private land tenure (53%).

Accessibility to Village level infrastructural facilities

An analysis of accessibility to infrastructural facilities is presented in Table 5.11. The table shows that except for distance to schools and to source of water, other facilities were located more than 7 kilometers away from the homesteads. Water was within 4 kilometers for most households and only about 31% of the households indicated that they traveled for over 3 kilometers in search of water. The results further imply that on average 27% of the households were within easy reach to source of water (less than 0.5 kilometers), which compares closely to an average of 21% and 29% of households that take less than 10 minutes to collect water in the entire district and country respectively (Republic of Kenya, 2000b). 45% of all households reported traveling more than 9 kilometers to the food markets, with a maximum of 40 kilometers. Livestock markets were located in more or less the same distance from the homestead as food markets.

Table 5.11 Distance (Kilometers) to Nearest Infrastructural Facilities by Division

Division	Sample Size	Livestock Markets	Food Markets	Health Facility	Primary School	Source of Water
Loitoktok	485	11.3	11.1	11.6	4.6	5.4
Mashuru	220	8.1	8.6	5.8	4.9	3.2
Magadi	133	15.3	16.9	5.5	1.7	2.5
Ngong	441	12.0	9.6	3.3	2.5	1.7
Central	146	20.5	23.5	6.5	3.8	5.1
Namanga	175	9.4	9.0	9.1	4.6	2.3
All divisions	1600	12.0	11.7	7.3	3.8	3.5

Respondents reported that distance to the market had an adverse effect on production especially for tomatoes and onion production in Loitoktok division (with a mean of about 11 kilometers). In some cases, producers complained that their produce would either go to waste before it reached the market or they would be forced to pay high transport costs to get the produce to the market faster. However, the most inaccessible division in-terms of market was Central division with a mean distance of 24 kilometers and a standard deviation of 13 kilometers. The livestock markets in this division were also inaccessible,

with the highest mean of 21 kilometers and a standard deviation of 14 kilometers. The reason for inaccessibility is that the district is large, very dry, and quite under-populated.

5.5 Secondary data

Biomass was sourced from secondary data and were available both in digital form and in kilograms per acre. A summary of the distribution of biomass is presented in Table 5.12. The data shows that in-spite of variations in biomass at the divisional level, the mean level of biomass for all divisions was the same in phases one and three, but was much higher for phase two. Generally, the highest mean level was observed for Ngong division, while the lowest was observed for Loitoktok division across the three phases.

Table 5.12 Village Level Biomass by Division (Kilograms per Acre)

Division	Phase 1		Phase 2		Phase 3		Full sample	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Loitoktok	1416	152	1926	109	1456	224	1603	287
Mashuru	1532	117	1919	322	1482	328	1619	328
Magadi	2561	395	3436	35	2743	55	2920	440
Ngong	3418	150	3125	236	3118	182	3221	239
Central	2246	295	2411	205	1541	122	2173	395
Namanga	2691	702	2893	580	2875	481	2817	606
All divisions	2218	839	2529	643	2218	839	2301	782

CHAPTER SIX

PARTICIPATION IN ENVIRONMENTAL CONSERVATION

6.1 Introduction

In this chapter, we seek to answer the question of what factors explain environmental conservation. The main hypothesis of this thesis is that environmental conservation practices determine productivity. However, to test this hypothesis, we first test for the endogeneity of the environmental conservation practices. The correct estimation procedure is to first perform the Hausman specification test for endogeneity of practices using the two stage least squares method (FE-2SLS- Hausman; Wooldridge, 2002). The procedure involves first the derivation of residuals from predictions based on linear probability models for various practices, and then using these residuals as regressors together with the original values of practices in the second stage to explain productivity. If the coefficients on residuals of predicted practices turn out to be significant, the model passes the Hausman specification test for endogeneity and calls for methods to remove its effects, otherwise, the OLS method is the efficient estimation procedure.

In our analysis, we use the fixed effects two stage least squares (FE-2SLS) and the fixed effects instrumental variable methods (FE-IV) to control for the effect of endogeneity arising from joint determination of practices and revenue and to account for the endogeneity effect due to unobserved farmer specific factors which are fixed over time and which would otherwise be swept into the error term and be a source of bias and inconsistency of OLS estimates. The FE-2SLS involves obtaining predicted values of the environmental conservation practices from the linear probability models for participation, then using these predicted values in the second stage to estimate the impact of the practices on the revenue function. The FE-IV method estimates the participation and revenue models simultaneously using fixed effects instrumental variables procedure in STATA (StataCorp., 1999). In the first stage, we derive the parametric estimates for practices and in the second stage explain productivity, instrumenting the practice variables simultaneously. Except for the standard errors, the FE-IV and FE-2SLS yield identical results so long as the models are correctly specified. In panel data modeling, we

chose the fixed effects estimator rather than the random effects estimator since the Hausman specification test rejects the random effects model, implying that important individual effects, which are correlated with the right hand side variables, may be present in our data.

The Hausman endogeneity test is inconclusive as to whether practices are endogenous, (see appendix 1 Tables A4 to A6) and so we use the fixed effects regression in order to control for unobserved heterogeneity due possible other omitted factors such as measurement errors and simultaneity. In this chapter, we discuss the first stage regression results from the fixed effects instrumental variables model (FE-IV). That is, we focus on the environmental conservation model. The second stage FE-IV results are presented in appendix 1 (Tables A4 to A6). In the first instance, we explain the determinants of the practices adopted by farmers; namely: blocking soil erosion outlets, land terracing and planting drought resistant vegetation, which are the dominant strategies adopted to improve land quality and to prevent land degradation. Non-adoption is treated as the reference option. We then present similar results for herders, whose environmental conservation is through migration of livestock to areas with better pasture. The sample statistics of the variables used in this chapter are presented in appendix 1, Tables A1 and A2.

6.2 Determinants of Conservation Practices

Conservation Practices Among Farmers

Descriptive statistics in chapter five indicate that farmers participate in various environmental conservation practices in order to conserve the environment. In this section, we discuss the determinants of adoption of practices based on the first stage regressions results of the FE-IV model. The estimated results are presented in Table 6.1. However, before discussing these results, we note that the standard approach for explaining three practices for which the decision to adopt could be jointly determined is the multinomial logit method. We therefore use this method to derive the parametric estimates of adoption of the three practices relative to non-adoption. In such an approach,

we assume independence of irrelevant alternatives, implying that the error terms of the logit index for each practice are uncorrelated, following the dominant econometric literature in this area (relaxing this assumption would otherwise require that the model is specified as a nested logit as in Sahn et al., 2003). The estimated results are presented in appendix 1 Table A8. The results show that without controlling for unobserved heterogeneity, the multinomial logit model results fit the data better judging from the Chow test and the R-squared. The results seem stronger in terms of larger coefficients, higher levels of significance and general consistency of explanatory variables across practices.

Turning back to Table 6.1, the results indicate that the coefficient for the land tenure system dummy (1=private, otherwise =0) is positive and significant in the case of land terracing but is negative for blocking soil erosion outlets and positive and insignificant in the case of drought resistant vegetation. The general implication of the results is that private ownership acts as an incentive for farmers to invest in environmental conservation practices. This is consistent with our *a priori* expectation that private landowners are more likely to conserve land as they are assured of retaining the long-term gains from investments in conservation. Total land owned does not seem to be an important determinant of adoption of environmental conservation practices.

Total hired labour available to the farmer has a positive impact on blocking soil erosion outlets and on planting drought resistant vegetation implying that, as expected, availability of labour will encourage environmental conservation. This expectation is however not supported by the coefficient for terracing and by household size, which is a measure of family labour available to the household. Household characteristics are represented by household size, sex, marital status and the highest grade attained by family members. Our results do not uncover any important impact of household characteristics on adoption of any environmental conservation practices.

Table 6.1: Fixed Effects Instrumental Variable First Stage Regression Results:
Dependent Variable is Choice of Farm Conservation Practices
(Standard Errors in Parenthesis) [∇]

Variable	Blocking soil erosion outlets	Land terracing	Planting drought resistant vegetation
	Parameter estimates	Parameter estimates	Parameter estimates
Property right regimes (1=private, 0=common)	-0.031 (0.022)	0.034** (0.018)	0.032 (0.027)
Log of total land owned (acres)	-0.002 (0.006)	0.004 (0.005)	0.010 (0.007)
Log of hired labour inputs	0.005 (0.002)	-0.003 (0.002)	0.004*** (0.003)
Log of household size	-0.008 (0.028)	-0.093* (0.023)	0.015 (0.034)
Log of age of household member	0.008 (0.023)	0.002 (0.019)	-0.012 (0.027)
Sex (1=male, 0=female)	-0.005 (0.013)	-0.003 (0.011)	0.009 (0.015)
Marital status (1=married, 0=not married)	-0.004 (0.021)	0.002 (0.017)	0.021 (0.025)
Primary school education (1=yes, 0=no)	0.013 (0.022)	0.014* (0.018)	-0.019 (0.026)
Secondary school education (1=yes, 0=no)	0.006 (0.027)	-0.005* (0.022)	0.016 (0.032)
Post secondary education (1=yes, 0=no)	0.025 (0.042)	0.049 (0.034)	0.004 (0.050)
Log of price of maize (Kshs/kg)	-0.116* (0.049)	-0.014 (0.040)	0.425* (0.058)
Log of price of beans (Kshs/kg)	0.334* (0.044)	-0.025 (0.036)	-0.369* (0.052)
Log of distance to market (kms)	-0.118** (0.065)	0.008 (0.054)	0.038 (0.078)
Log of distance to source of water (kms)	0.129 (0.085)	0.016 (0.070)	-0.090 (0.102)
Log number of cattle owned	-0.008 (0.009)	-0.017* (0.007)	0.004 (0.010)
Log of biomass (Kg/acre)	0.048 (0.043)	-0.055 (0.035)	0.255* (0.051)
Log of transfers received (Kshs)	-0.002 (0.002)	0.003*** (0.002)	-0.003 (0.003)
Log of rent incomes (Kshs)	0.004** (0.002)	0.001 (0.002)	0.004*** (0.003)
Log of value of farm equipment (Kshs)	0.002*** (0.001)	0.0004 (0.001)	-0.0002 (0.001)
Perceptions of practicing conservation practices on output (1=increases output, 0=decreases output)	0.070* (0.018)	0.209* (0.015)	0.381* (0.022)
Constant	-1.052 (0.388)	0.721 (0.318)	-1.852 (0.464)
Number of Observations	1600	1600	1600
F (20, 1352)	5.8*	12.44*	26.91*
R ²	0.0790	0.1553	0.2846

[∇] Dependent variable is equal to 1 if farmer adopted the particular practice and equal to 0 if otherwise.

*, **, *** Significant at 1%, 5% and 10% respectively.

Output prices seem to have different impacts on adoption of environmental conservation practices relative to non-adoption. Maize prices are particularly important for the planting of drought resistant vegetation but not for other practices, while higher prices of beans are important for blocking soil erosion outlets. Distance to markets turn out to be important only for the case of blocking soil erosion outlets, while distance to source of water is not an important determinant of adoption of any environmental conservation practices.

The coefficients for livestock ownership imply that farmers who own more cattle are less likely to block soil erosion outlets and to terrace their land. Though the coefficient for planting drought resistant vegetation is insignificant, the positive sign implies that farmers who own more cattle are more likely to adopt this practice, which supports field observations that most drought resistant vegetation is used as fodder for cattle. Farmers with more livestock may therefore have a higher incentive to plant drought resistant vegetation than their counterparts. The impact of cattle on terracing is however negative but insignificant. Amount of biomass available at the village level exerts a positive impact on blocking soil erosion outlets and planting drought resistant vegetation.

Rent incomes exerts a positive and significant impact on all practices, though insignificant for terracing, implying that households that receive more income from assets are more likely to engage in conservation practices and vice-versa. This result confirms our expectation that such income could also be used to pay for labour and other inputs required for conservation. Though transfers exert a negative but insignificant impact on adoption of blocking of soil erosion outlets and planting of drought resistant vegetation, the coefficient for terracing is positive and significant as expected.

As expected *a priori*, increased investment in physical capital (fixed technology) favour environmental conservation relative to non-conservation. This is portrayed by the positive impact of the value of farm equipment on the adoption of blocking soil erosion outlets and land terracing. The impact of this asset on adoption of planting drought resistant vegetation is negative but insignificant.

Perceptions on the benefits of environmental conservation on output was captured by asking farmers what they felt was the impact of practices on output (the responses were coded as equal to 0 if perceived to decrease output and equal to 1 if otherwise. Favourable perceptions exert a strong positive impact on adoption of all environmental conservation practices. For instance, increasing the proportion of farmers with positive perceptions by 1% would increase the likelihood of land terracing by 0.21%. We note that controlling for unobserved heterogeneity in our data makes coefficients of most of our identifying instruments statistically significant. Perceptions turn out to be good instruments for all practices. Rent income is particularly important for explaining adoption of soil erosion prevention practice, and use of drought resistant vegetation, while transfers explain the practice of terracing.

Conservation Practices Among Herders

For livestock producers, environmental conservation is through movement of livestock to areas with more pasture and water. The first stage FE-IV results are presented in Table 6.2, while the alternative logit specification results are presented in appendix 1 Table A10. The results in this table indicate that failure to control for unobserved heterogeneity in the sample result in overstatement of the impact of the determinants of the decision to migrate. For instance, all education dummies exert negative significant coefficients implying that more educated herders are less likely to migrate with livestock than their less educated counterparts. The chow test and the pseudo-R-squared also imply a better fit for this specification than for the specification generating the results in Table 6.2.

Turning to Table 6.2, the results indicate that property right regimes negatively and significantly influence the decision to migrate with livestock in search of pasture and water. This result shows that those who hold land under private property arrangements are less likely to migrate with their livestock compared to those who hold land under common property. This could be explained by the fact that most private landholders are more sedentary and are also likely to engage in other non-herding activities, which reduce their propensity to migrate. On the other hand, this result implies that with privatization of land, it is not possible for herders to move their livestock and keeping large herds

would therefore result in degradation of the pasture. This result supports Kebede (2002) who argues that with increases in population and privatization of land, cattle population diminishes due to diseases and shortage of land, which would clearly be the case if the herder cannot migrate with livestock.

Land exerts a positive impact on migration relative to non-migration. Those who own more land are therefore more likely to migrate in search of pasture and water than those with less land because in most cases, it is only in the more arid zones that individuals own large tracts of land. Such herders are therefore more likely to have deficiencies of pasture as compared to their counterparts with less but more productive land. The coefficient on total hired labour is positive but insignificant.

Household size exerts a strong positive impact on migration. A 1% increase in household size will increase the likelihood of migration with livestock by 0.09%. This impact of larger households on productivity is through increased supply of labour. Given that most households are labour constrained, an increase in total labour available will increase income and therefore increase the welfare of the household. Age has a negative and significant impact on migration implying that elderly herders are less likely to migrate than their younger counterparts. The coefficient for marital status has a negative impact, implying that herders who are married are less likely to migrate than those who are not. Education does not seem to be an important determinant of livestock migration.

Table 6.2 FE-IV First Stage Regression Results for Herders: Dependent variable is Choice of Conservation Practices[∇]

Variable	Coefficient	Std. Error	T statistic
Property right regimes (1=private, 0=common)	-0.127*	0.027	-4.650
Log of total land owned (acres)	0.011	0.007	1.560
Log of hired labour inputs	0.004	0.003	1.240
Log of household size	0.086*	0.038	2.260
Log of age of household member	0.046	0.028	1.620
Sex (1=male, 0=female)	-0.018	0.016	-1.130
Marital status (1=married, 0=not married)	-0.051	0.026	-2.000
Primary school education (1=yes, 0=no)	-0.004	0.026	-0.170
Secondary school education (1=yes, 0=no)	0.0001*	0.033	0.010
Post secondary education (1=yes, 0=no)	-0.041	0.050	-0.830
Log of price per cow (Kshs)	-0.135*	0.023	-5.770
Log of price per sheep/goat (Kshs)	0.071*	0.028	2.560
Log of distance to market (kms)	0.140*	0.078	1.800
Log of distance to source of water (kms)	-0.017	0.101	-0.170
Log number of cattle owned	0.061*	0.011	5.790
Log of biomass (Kg/acre)	0.083***	0.052	1.580
Log of transfers received (Kshs)	-0.010***	0.006	-1.570
Log of rent incomes (Kshs)	0.001	0.003	0.310
Log of value of farm equipment (Kshs)	0.005	0.008	0.650
Perception of conservation practices on output (1=increase output, 0=decrease output)	0.093*	0.022	4.270
Constant	-0.077	0.519	-0.150
Number of Observations	1518		
F (20, 1352)	6.02*		
R-squared	0.0860		

[∇] Dependent variable equals 1 if herders migrated with livestock and equal to 0 otherwise
*, **, *** Significant at 1%, 5% and 10% respectively.

Livestock prices seem to have different impacts on migration. Price per head of cattle has a negative impact on migration, implying that the higher the price, the lower the likelihood that a herder will migrate. This could be interpreted to mean that herders may opt to sell their cattle rather than migrate in search of pasture if prices were favourable. Price per head of sheep/goat however exerts a positive impact. The greater the distance to livestock markets the higher the likelihood of migration. The implication here is that if livestock markets were not available, herders would be forced to migrate in search of pasture rather than sell their cattle in periods of drought. We do not observe an important impact of the distance to source of water on migration.

Number of livestock owned has the expected positive coefficient. A 1% increase in number of cows owned increases the likelihood of migrating by 0.06%. The coefficient for biomass is positive and significant. This implies that contrary to expectations, availability of biomass at the village level will increase the likelihood of herders migrating in search of pasture. Although this is not what was hypothesized *a priori*, it could be interpreted as implying that herders will open graze around the village, instead of paddock grazing if biomass is available at the village level. Increasing kilograms of biomass per acre by 1% raises the likelihood of migration by 0.08%.

Transfers have a negative impact on migration implying that as such incomes rise, herders become less likely to migrate with livestock, probably because they may not have to rely on livestock production for survival. A 1% increase in transfers reduces the likelihood of migrating by 0.01%. The coefficients for value of equipment and non-farm incomes (rent) are positive but insignificant. However, herders with positive perceptions concerning the value of migration have a 0.09% higher probability of migrating. We conclude that transfers and perceptions influence productivity via their impacts on migration of livestock.

To conclude, we note that the analysis in this chapter shows that well-specified property rights, availability of labour, livestock ownership, transfers and rent incomes, perceptions on the benefits of conservation and biomass level are the most important factors

influencing farm level environmental conservation practices. The positive impact of property right regimes on environmental conservation practices support results for Ethiopia by Alemu (1999) who found security of tenure to have a positive impact on the decision to invest in soil conservation. The results for transfers and rent income also support findings by Alemu (1999) whose results indicate that asset ownership is an incentive for environmental conservation. Roth et al. (1994) also found the effect of land title in Uganda to be significantly and positively related to investment in fencing, use of manure and mulching, but to have little effect on long-term investments. Besley (1995) found better land rights to facilitate investments in some regions of Ghana and not in other regions. However, Brasselle et al. (2002) found that controlling for the endogeneity bias between land rights and investments, increased land rights do not appear to stimulate investment.

Well-specified property rights, availability of labour, livestock ownership, distance to markets and perceptions on the benefits of conservation are the most important determinants of environmental conservation practices for herders. Controlling for unobserved heterogeneity, capital investments, perceptions on the benefit of environmental conservation, rent income and transfers are important instruments for identifying farm level environmental conservation practices. On the other hand, perceptions and transfers are good instruments for identifying environmental conservation by herders. In the next chapter, we analyze the impact of environmental conservation practices on productivity, controlling for other covariates.

CHAPTER SEVEN

DETERMINANTS OF FARM PRODUCTIVITY

7.1 Introduction

This chapter presents the empirical results for productivity analysis. We use average revenue as a measure of productivity. Holding prices constant, any factor that increases output will increase average revenue. For instance, education could enhance productivity directly by improving the quality of labour, which increases output and hence productivity. We seek to answer the question whether environmental conservation practices improve productivity, which we proxy with average revenue per acre. We first discuss the results for the determinants of productivity for the full sample, then use these results to simulate the impact of policy changes on productivity and on the base poverty rate. The sample statistics of variables used in this chapter are presented in appendix 1 Table A3.

7.2 Regression Results and Discussion

This section presents and discusses the regression results for the determinants of productivity. We base our discussion on FE results for the full sample (Table 7.1). The property right regime dummy has the expected positive and significant coefficient, implying that well specified private property rights will increase productivity holding other factors constant. This is consistent with our earlier findings on conservation practices, which indicated that well-specified private property rights encourage conservation and would therefore translate to higher output and productivity, other factors held constant. This supports the literature that argues that well specified private property rights will act as incentives for increased productivity (Barbier and Lopez 1998, Norton 1998, Gavian and Fafchamps 1996 and Stevenson 1991). This finding calls for the need to privatize common property resources in order to boost productivity. The result however contradicts Migot-Adholla et al. (1994) who found no relationship between cross-sectional variations in land rights and productivity. Further in contrast to what we find, Pinckney and Kimuyu (1994) also found that land titling in Kenya and Tanzania did not act as an incentive for boosting farm productivity. Differences between

our findings and those from the literature with respect to effects of property rights on productivity are likely due to better estimates from the new estimation methods that we use.

Total land owned has a positive impact on productivity, implying that herders with larger land holdings are likely to report higher productivity than their small land holding counterparts. An increase in land holding by 1% increases productivity by 0.25%, holding other factors constant. Total hired labour inputs also have the expected positive impact on productivity, implying that households with greater access to hired labour report higher productivity than those who hire less labour. Household size (a proxy for family labour) has the expected positive coefficient and indicates that increasing family labour by 1% would increase productivity by 0.77%. This result supports findings by Evenson and Mwabu (2001), Boserup (1965), Tiffen et al. (1994) and Ahuja (1998), and are consistent with the results for the total hired labour input.

The positive household size elasticities of average revenue may have important policy implications for productivity. Demographic and health surveys indicate that there is a demographic transition with fertility in the district declining as the level of education increases. This implies that in the long run, productivity could fall due to scarcity of labour. To counter such an effect, labour markets in the district need to be made more competitive to ensure that hired labour from other regions could substitute for family labour if there was to be a deficiency in the latter. We do not observe age, gender and marital status to be important determinants of productivity though the coefficient for age indicates that productivity declines with age.

Table 7.1 Fixed Effects Regression Estimates: Average Revenue for Farmers and Herders; Dependent Variable is Log of Revenue per Acre

Variable	Coefficient	Std. Error.	t-statistic
Property right regimes (1= private, 0= common)	0.741*	0.168	4.4
Log of total land owned	0.256*	0.042	6.02
Log of hired labour inputs	0.051*	0.019	2.74
Log of household size	0.774*	0.218	3.55
Log of age of household member	-0.132	0.176	-0.75
Sex (1=male, 0=female)	-0.027	0.099	-0.27
Marital status (1=married, 0=not married)	0.006	0.158	0.04
Primary school education (1=yes, 0=no)	0.027	0.167	0.16
Secondary school education (1=yes, 0=no)	0.142	0.206	0.69
Post secondary education (1=yes, 0=no)	0.277	0.317	0.87
Log of price of maize (Kshs)	0.261	0.381	0.69
Log of price of beans (Kshs)	-0.119	0.343	-0.35
Log of distance to market (kms)	-0.460	0.499	-0.92
Log of distance to source of water (kms)	1.034	0.651	1.59
Log number of cattle owned	0.385*	0.066	5.85
Log of biomass (Kgs/acre)	1.042*	0.320	3.26
Farmer engaged in blocking soil erosion outlets (1=yes, 0=no)	0.434**	0.212	2.04
Farmer engaged in land terracing (1=yes, 0=no)	0.502**	0.243	2.07
Farmer engaged in planting land resistant vegetation (1=yes, 0=no)	0.386**	0.164	2.35
Constant			1600
Number of Observations			(19,1354) = 10.43*
F-statistic ¹¹			0.1277
R-squared			

*, **, *** Significant at 1%, 5% and 10% respectively

¹¹ For all estimates in our analysis, the chow test results indicate that the models fit the data better than the intercept only model, and that the variables are jointly significant in explaining variations in the dependent variable. For the OLS specifications, diagnostic tests indicated the presence of heteroscedasticity, and so we corrected the standard errors for this problem using White's general method (Gujarati, 1995). We also performed diagnostic tests for multicollinearity and omitted variables using the variance inflation factors and Ramsey reset tests respectively. The results indicated no presence of collinearity, but implied the presence of omitted variables.

We further explore the impact of gender on productivity in order to test the hypothesis whether it matters who (man or woman) adopts environmental conservation practices. This is achieved by constructing variables interacting gender and each of the farm level environmental conservation practices and using them as explanatory factors for productivity (appendix 1 Table A7). The results do not support the joint importance of gender and environmental conservation as determinants of productivity. Education dummies have the expected positive coefficients but they are insignificant. However, the results indicate that, productivity increases with the level of education. The statistical insignificance of education coefficients is not unexpected in an agricultural environment with static farming technologies (Schultz, 1975).

From theory, product prices are expected to increase average revenue through their impact on profits, holding other factors constant. Favourable prices reflect competitive markets, which enhance productivity. Our results for prices of beans contradict this expectation as portrayed by the negative coefficient. However the price of maize has the expected positive coefficient implying that favourable product prices increase revenue. The coefficients are however statistically insignificant.

Distances to markets exert a negative but insignificant impact on revenue. The result supports findings by Evenson and Mwabu (2001) who argue that investments that make market centers broadly available to farmers would improve productivity because distance from market centers reduce farm yields. This result also finds support in Mwabu and Thorbecke (2001) who argue that inadequate infrastructure is a major barrier to rural poverty reduction as it impedes market integration, limiting opportunities for wage employment and for trade in essential commodities. Distance to source of water has a positive impact. Livestock ownership exerts a strong positive impact on revenue, implying that as would be expected, households with large herds will report higher revenue than their counterparts with smaller herds, holding other factors constant. Increasing the number of cattle owned by 1% increases revenue by 0.39%.

Environmental conservation is captured by the three dummy variables for adoption of various land use practices. Controlling for unobserved heterogeneity, all farm level conservation practices exert strong positive effects on productivity. The log of a farmer's revenue increases by 0.4% if he adopts blocking soil erosion outlets or plants drought resistant vegetation. The effect is slightly higher for terracing at 0.5%. Controlling for other covariates, biomass exerts a positive and significant effect on productivity. A 1% increase in biomass increases revenue by 1.04%, implying that the elasticity of productivity with respect to the amount of biomass available in kilograms per acre is about unity. This is consistent with findings by Lopez (1998), and Ahuja, (1998), who found that environmental conservation through leaving land fallow will increase natural vegetation (biomass) which translates to higher productivity. Our results could also be interpreted as supporting results obtained by Evenson and Mwabu (2001) concerning the positive effect of fallow land on productivity. Leaving land fallow is another form of environmental conservation (synonymous to migration) as it enhances the productivity of land through enriching the fertility and depth of the soil.

The thesis also sought to explain the determinants of productivity among farmers on one hand and herders on the other. The results are presented in appendix 1 Tables A4 and A5. The results for farmers are consistent with those for the full sample (see the FE results). Property right regimes, hired labour, post secondary education and environmental conservation influence productivity. Contrary to expectation, total land owned exerts a negative significant impact on productivity. This implies that bringing more land under cultivation is likely to constrain productivity through lack of intensification and implies diminishing returns to land (Evenson and Mwabu, 2001). Resource constrained farmers are more likely to intensify farming on small plots of land compared to larger plots. The coefficient for age indicates that farmer productivity increases with age. Households headed by men and married farmers seem to suffer a productivity disadvantage. The coefficients are however insignificant.

Consistency of the results is also observed for the herders sub sample. Property right regimes, total land owned, hired labour, number of livestock owned and availability of biomass affect productivity. Migration with livestock also exerts a strong positive impact on productivity implying that environmental conservation among herders increases productivity. For all models, product prices do not seem to be significant determinants of revenue as evidenced by the conflicting coefficients. For instance, price per kilogram of maize and per sheep/goat exert negative significant impacts on revenue in the farmers and herders sub samples respectively, while price per kilogram of beans and per cow have positive impacts. These results confirm our earlier observations from the full sample concerning uncompetitiveness of output markets in the district.

In summary, the analysis in this section indicates that controlling for unobserved heterogeneity, property right regimes and environmental conservation are important determinants of productivity for all sub-samples in the study district. Also important, is availability of labour, and the amount of village level biomass. Our results indicate that failure to control for endogeneity of environmental conservation practices tends to overstate the impact of individual practices on productivity. In the next section, we simulate the impact of various policy changes on productivity.

7.3 Policy Simulations

Kenya is endowed with land resources, which if properly managed could induce and sustain economic development. Methods of cultivation necessitated by activities and demands of a rapidly growing population have resulted to loss of productivity and various forms of environmental degradation. Land degradation and the associated loss of productivity lead to lagging agricultural growth, rural poverty and food insecurity. Environmental conservation would therefore increase productivity and reduce income poverty, which would then enable the producer to increase consumption (hence reduce food poverty).

In this section, we use our empirical results to simulate effects of various policies on productivity, holding other factors constant. We seek to answer the question concerning what factors should be changed in order to increase productivity. The next sub-section presents and discusses the impact of policy on productivity. Holding other factors constant, any policy option that increases productivity would be expected to increase the welfare of the household. The final sub-section simulates the impact of the same policy changes on the proportion of poor household (head count ratio) in the study district.

Impact of Policy Changes on Productivity

We simulate the impact of policy changes on average revenue using the FE regression results in Table 7.1 and the means of the relevant variables (appendix 1 Table A3). We explore the impact of policies that focus on changing property rights, adoption of environmental conservation practices and increased availability of biomass at the village level. In each case, we simulate the effect of a 10% change in each policy measure on productivity. The results are presented in Table 7.2.

Our simulation results confirm that clear property rights act as incentives that enhance productivity and the well being of the poor (Norton 1998, Gavian and Fafchamps 1996). Our results show that holding other factors constant, increasing proportion of land held under private property regimes by 10% would increase productivity by 0.68%. Privatization of common property resources could be seen as a way of increasing assets owned by producers, as it would facilitate independent decisions on use of land and is therefore similar to increasing the amount of land owned. Asset ownership is in theory expected to reduce poverty (Reardon and Vosti 1995), which confirms our conclusions on privatization. The low elasticity of average revenue with respect to privatization of land finds support in Kebede (2002) who argues that productivity differentials may not be observed in the short-run if returns to investment resulting from privatization have long-term impacts. In this respect, the impact of privatization is to strengthen security of tenure and minimizing the uncertainty related to who gets the future returns from investment.

Investment and land use strategies of rural households affect the links between environmental degradation and poverty (Reardon and Vosti 1995). Our results confirm this argument as we find that environmental conservation practices result in higher productivity. If an extra 10% more farmers were to plant drought resistant vegetation, productivity would increase by 0.09%. If another 10% more of farmers were to either terrace their land or block soil erosion outlets, productivity would increase by 0.04% in each case. If 10% more farmers were to adopt all three practices simultaneously, productivity would increase by 0.18%. A 10% increase in biomass per acre would increase productivity by 10%. Productivity is therefore unitary elastic with respect to biomass. These results imply that policies that conserve biomass such as migration with livestock and leaving land fallow should be encouraged in order to boost productivity (Lopez 1997a, 1998) and Ahuja (1998). A combination of all these policy changes would increase productivity by 11%, all other factors held constant.

Compared to other variables, the elasticities of average revenue with respect to adoption of environmental conservation practices are quite low. This is however expected given that they are short-run elasticities and yet the full impact of a conservation practice adopted today will have its full impact realized in the future through the gradual improvement in the quality of the soil. In the short run, adoption of a given environmental conservation practice could impact negatively on productivity if the farmer has to invest a lot of resources in conservation, yet the benefits of the practice would be realized later leading to strong positive long run elasticities. Alemu (1999) concurs with this argument as he found that in Ethiopia, soil erosion investments had long-term benefits but their short run benefits were negative. Shiferaw and Holden (2001) also concur with the idea that gains from conservation may be limited especially where there are high input costs. Given data limitations, our study does not estimate long-run elasticities of average revenue with respect to adoption of environmental conservation practices.

Table 7.2 Simulating Impacts of Policy Changes on Average Revenue

Base Average Log Revenue = 7.929		
Policies	Policy Outcomes	Mean Log Revenue Per Acre
1) Increase proportion of land held under private property by 10%	New mean revenue Absolute change Relative change Elasticity	7.983 0.054 0.68% 0.068
2) Increase proportion of farmers terracing their land by 10%	New mean revenue Absolute change Relative change Elasticity	7.932 0.003 0.04% 0.004
3) Increase proportion of farmers planting drought resistant vegetation by 10%	New mean revenue Absolute change Relative change Elasticity	7.936 0.007 0.09% 0.009
4) Increase proportion of farmers blocking soil erosion by 10%	New mean revenue Absolute change Relative change Elasticity	7.932 0.003 0.04% 0.004
5) Policies 2, 3, and 4	New mean revenue Absolute change Relative change Elasticity	7.943 0.014 0.18% 0.018
6) Increasing biomass by 10%	New mean revenue Absolute change Relative change Elasticity	8.722 0.793 10.00% 1.0
7) Policies 1,2,3,4 and 6	New mean revenue Absolute change Relative change Elasticity	8.791 0.862 10.87% 1.1

Impact of Policy Changes on Poverty

To simulate the impact of policy changes on poverty, we use the policy effects on productivity derived in Table 7.2. We argue that any change in policy that raises productivity by a given percentage will increase incomes by the same percentage. We therefore assess the impact of this change in income on the percentage of households below the poverty line¹². We focus on policies that favour privatization of land, encourage environmental conservation and increase availability of biomass at the village level. To do so, we first compute the FGT base poverty line (head count ratio) from our sample and find 21% of the households to fall below the poverty line.

The simulation results are presented in Table 7.3. With a head count of 21%, a 10% increase in the proportion of total land held under private property reduces the head count ratio by 2.06%. Other factors held constant, increasing the proportion of farmers adopting any of the three environmental conservation practices by 10% would reduce the head count ratio by 1.4%. A combination of all these policy changes would reduce the head count ratio by 2.2%. Increasing the availability of kilograms of biomass per acre by 10% would reduce the head count ratio by 2.5%. We note that in spite of differences in elasticities of revenue with respect to different policy changes in Table 7.2, the changes in head count ratio are not as pronounced, which could be explained by the fact that this methodology does not take into account the distribution of the poor households below the poverty line. These results are consistent with the simulation results reported for the revenue equation. The low elasticities of revenue with respect to environmental conservation reported earlier imply that in the short run, adoption of environmental conservation practices will only have a minimum impact on the base poverty rate. This result demonstrates the importance of policy simulations and shows that basing policy conclusions on signs and magnitude of coefficients would grossly exaggerate the impact of explanatory variables on the variable of policy interest.

¹² We use absolute poverty line (Kshs. 825) derived for the province by Mwabu et al. (2000). We assume absolute poverty to be fixed over time and space so that we need not adjust the poverty line to reflect the standard of living in the sample period. We note here that our head count ratio is consistent with those found by Mwabu et al. (2000) where the cost of basic needs and food energy intake head count ratios ranged from 20.45 to 26.52 using the national poverty line.

To conclude, the analysis in this chapter has enabled us to answer the question concerning the policy options that we need to address in order to increase productivity and reduce poverty. Controlling for other factors, privatization of common property land, and encouraging adoption of environmental conservation practices are some of the most important policy options for increasing productivity. We note that although most studies of the link between environment and poverty are not empirical, our results support qualitative arguments in such literature.

**Table 7.3 Impacts of Policy Changes on the Head Count Ratio
(Benchmark Poverty Rate = 21%)**

Policy Measure	New Head Count Ratio (%)	% Decline in Head Count Ratio
1) Increase proportion of land held under private property rights by 10%	18.94	2.06
2) Increase proportion of farmers terracing their land by 10%	19.56	1.44
3) Increase proportion of farmers planting drought resistant vegetation by 10%	19.55	1.45
4) Increase proportion of farmers blocking soil erosion by 10%	19.56	1.44
5) Policies 1, 2, 3, and 4	18.81	2.19
6) Increase biomass by 10%	18.50	2.5

CHAPTER EIGHT

SUMMARY AND CONCLUSIONS

8.1 Summary

This thesis empirically examines the link between environmental conservation practices and agricultural productivity and then derives the implications of this link on poverty in fragile ecological environments in Kenya. The study was motivated by the growing concern that like many other developing countries where poverty is mostly a rural phenomenon, Kenya has been caught in an “environmental equivalent of a “low-level equilibrium trap” whereby poverty leads to increased resource degradation, which in turn leads to low productivity and to more poverty.

Our study uses a time panel dataset for Kajiado district to test the study hypotheses. Primary data were collected from households using a detailed questionnaire. A sample of 220 households were targeted for interviews in the three phases. In the first phase, 202 households responded to questions satisfactorily, compared to 192 and 176 in the second and third phases respectively. Secondary data was accessed from the Department of Resource Surveys and Remote Sensing (DRSRS), whereby biomass was estimated from satellite images using Geographical Information Systems and recorded in kilograms per acre for each cluster.

In order to test for endogeneity of the environmental conservation practices and to explain productivity while controlling for endogeneity and unobserved heterogeneity due to farmer specific factors, we use a combination of the fixed effects instrumental variable estimation method (FE-IV), fixed effects two stage least squares (FE-2SLS), the new fixed effects two stage Hausman specification test (FE-2SLS-Hausman) (see Wooldridge 2002) and the fixed effects regression methods (FE). We also run multinomial logit and binary logit models for adoption of environmental conservation practices as well as OLS models for productivity for the pooled dataset in order to emphasize the importance of controlling for unobserved heterogeneity.

Descriptive statistics indicate that 69% of the respondents held land under private property. Of all the farmers, 44% engaged in at least one conservation practice 10% engaged in blocking soil erosion outlets, another 10% engaged in land terracing and the rest (about 24%) planted drought resistant vegetation. The results also show that producers holding land under private property are more likely to adopt land conservation practices (49%) compared with their counterparts under common property (27%). 59% of all herders migrated in search of pasture and water; of these, 27% held land under private property and the rest, 32%, held land under common property.

Based on the FE estimation, the econometric results for environmental conservation indicate that property rights, availability of labour (both hired and household labour), livestock ownership and biomass are the most important factors influencing farm level environmental conservation practices. Moreover, the results indicate that transfers, rent incomes and perceptions on the benefits of conservation are significant instruments for adoption of environmental conservation practices. Household characteristics are not observed to be important determinants of adoption of environmental conservation practices. Results based on the multinomial logit estimation technique indicate that failure to control for unobserved heterogeneity overstates the impact of the regressors on adoption of environmental conservation.

For herders, well-specified property rights, availability of labour, livestock ownership, distance to markets and perceptions on the benefits of conservation are important determinants of environmental conservation. Investment in capital equipment, rent incomes, perceptions on the benefits of conservation and transfers are observed to be good instruments for the conservation equation among herders. Unlike for farmers, the property right dummy exerts a negative impact on migration, implying that privatization could discourage environmental conservation through confinement of large herds on a given plot.

The results for the determinants of agricultural productivity indicate that property right regimes have a positive impact on productivity for all sub samples (farmers, herders and full sample). This result is consistent with the findings on the impact of property rights on environmental conservation. An increase in total land held under private property by 1% would increase productivity for all producers by 0.74%, other factors held constant. The impact of privatization on revenue is found to be much more important for farmers than for herders, probably because privatization encourages environmental conservation, and other land improvements which have a long-term positive impact on productivity. Moreover, field work observations indicated that there were cases where land had been demarcated, yet herders still grazed as though under common property so that one household could take care of the herd at a particular time especially when under migration. This result is supported by Kebede (2002) who found that in some areas of Ethiopia, though individuals owned resources privately, they had a common pool resources character in many aspects.

Land ownership has a positive impact on productivity except for farmers, which supports findings of previous studies (Lopez 1997a, 1998, Ahuja 1998, among other studies). Consistent with results for determinants of environmental conservation, household characteristics are not observed to be significant determinants of productivity, except for post secondary education for farmers (Weir, 1999). Household size has a positive impact on average revenue, which implies that the larger the household, the more the labor available, which translates into higher productivity (Ahuja 1998, Boserup 1965 and Tiffen et al. 1994). Product prices report conflicting impacts, reflecting uncompetitive markets in the district. In all sub-samples, the impact of infrastructural facilities (markets) is negative implying that productivity will fall with distance to these basic facilities. Distance to source of water display unexpected impacts. Except for the farmers sub-sample, total livestock owned exert significant positive impact on productivity. For farmers, the implication of the negative coefficient is that farmers may have less time to concentrate on crop production, the larger the size of the herd, and therefore have less crop productivity.

Availability of biomass at the village level is an important determinant of productivity. The elasticity of average revenue with respect to biomass is unity implying that doubling the amount of biomass in kilograms per acre available would double productivity. This latter result is consistent with findings on the importance of biomass in determining productivity (Lopez 1997a, 1998 and Ahuja 1998). All forms of environmental conservation practices exert positive impacts on productivity.

Holding other factors constant, privatization of common property regimes, environmental conservation and availability of biomass are important incentives for increased productivity. Simulations however show rather low elasticities of average revenue with respect to policy changes in these variables. For instance, a 10% increase in farmers adopting all environmental conservation practices lead to a 0.18% increase in average productivity for all producers. We argue that short run elasticities are likely to be low as the full impact of environmental conservation is long term in nature. This finding shows the need to subsidize environmental conservation investments in order to give farmers incentives to make such investments, given the long payback period. Other variables however report higher average revenue elasticities. A 10% increase in the level of biomass available would for instance increase productivity by 10%, while increasing the proportion of households holding land under private property by 10% would increase productivity by 0.68%. These results are consistent with previous literature in this area (Kebede 2002, Shiferaw and Holden 2001, Alemu, 1999).

Simulations on the impact of policy changes on the base poverty rate confirm that clear property rights and environmental conservation have important policy implications on the level of poverty. To carry out these simulations, we first estimate the FGT base poverty rate assuming an absolute poverty rate that is fixed over time and space. With a base poverty rate of 21%, increasing the proportion of farmers adopting any environmental conservation practice by 10% would reduce the percentage of household below the poverty rate by only 1.4%, while increasing the proportion of farmers holding land under private property and adopting each practice by 10% would reduce the base poverty rate by only 2.2%. These simulations reinforce the simulation results for average revenue.

Moreover, the results indicate that the low elasticities of average revenue with respect to environmental conservation imply that the base poverty rate would only change by a small proportion resulting from a policy change in each of the conservation methods. This represents an important methodological contribution: simulations reveal the actual impact of a policy change, which would otherwise be exaggerated if based on magnitudes of the estimated coefficients.

8.2 Policy Conclusions

This thesis has demonstrated that environmental conservation has important implications on the level of poverty through increased agricultural productivity. Since poverty reduction and agricultural sector growth have for a long time been elusive policy goals for Kenya, it is important for the policy makers to address all the factors that govern the link between agricultural productivity, environment and poverty. First we need to address the determinants of environmental conservation. The results indicate that well specified property right regimes would encourage environmental conservation practices, which implies that to enhance conservation, we need to ensure that farmers have secure land rights. Fieldwork observations confirm this as group land members argued that they could not develop the land they occupy as they did not know whether the land will eventually be theirs. Moreover, privatization of land would have similar impacts as increasing the total land owned as farmers would be able to make independent decisions on land. In support of this, Kalabamu (2000) uses evidence from Botswana to show that the multiplier effects of a capitalistic oriented land market would boost the economy, encourage housing development and promote peace and order in communal land settlements.

However, for herders, we note that the results are based on the assumption that migration is a way of conserving the environment. Previous studies suggest that leaving land fallow, which is synonymous to migration will allow soil and vegetation to recover and therefore lead to higher productivity in subsequent periods (Lopez 1998). On the other hand, migration could also be a result of environmental degradation (Chopra and Gulati, 1997, 1998, Ekbom and Boj  1999). For instance, Chopra and Gulati (1998:37) argue

that the increased capacity of resources to sustain populations work as disincentives to migrate, which can only hold if resources are not degraded. In this light therefore, there is no biophysical evidence that migration leads to environmental conservation, and migration could actually take place because the land is degraded.

Availability of labour (both hired and domestic) has been found to be an important determinant of environmental conservation and on productivity, implying the need to make labour markets more competitive in order to ensure availability of hired labour. Another implication of our study is the need to improve farm technology (equipment) as the research findings indicate that technology has a significant positive impact on environmental conservation practices. This can be done through provision of credit to the farmers so that they can acquire the technology needed to engage in or to intensify environmental conservation practices (Place and Otsuka, 2002). For herders, improving technology would ensure that they have access to inputs such as livestock drugs, which could encourage them to migrate without the fear of losing their herds to diseases. In this respect, credit markets also need to be developed in order to encourage the local community to use credit facilities to develop their farms. Our study found that only 4% of the households in our sample reported to have obtained any credit at all. Most households reported that they never needed any credit, yet they had no funds to buy modern farm inputs. This calls for policies that boost other sources of incomes such as transfers and rent income, which would also encourage environmental conservation and therefore have long-term effects on productivity. This policy implication finds support in Place and Otsuka (2002), who recommend that to increase the profitability of long term investment in Uganda, it is important to improve input and output markets, improve access to credit, and new agricultural technology.

The findings also imply that it is vital to educate the farmers in the district on the benefits of environmental conservation, so that they can change their attitudes if productivity growth and poverty reduction are to be achieved. This supports Reddy (1995), who argues that the main factors which are instrumental in changing the perceptions of the people towards the environment, achieving sustainable agricultural development and thus

poverty reduction are literacy, market forces and technology. Through extension services producers could also be taught the importance of using green manure and fertilizers to improve the quality of the soil, as field observations revealed that although there is a lot of green manure from livestock, it is rarely used by farmers.

Another important policy implication is that privatization of common property land would encourage land conservation practices and lead to an increase in productivity in semi-arid regions. This suggests the need to speed up privatization of the remaining schemes so that the community can enjoy the benefits of private property. However, privatization of common property resources could lead to a fall in the probability of migration. Such a policy may adversely affect herders with large herds and should therefore be considered in the light of its benefits and costs. As a policy option, we would recommend that if schemes cannot be privatized, then it would be important to strengthen the existing common rights system through promotion of the role of the group (collective action) and also by limiting the group sizes because very large groups result in the failure of collective action. However, Kebede (2002) argues that privatization not only creates the much-needed incentive to farmers to invest on their land but also to establish more stable social relationships that help to preserve common pool resources. This implies that privatization could create social institutions that regulate and govern the use of private resources as common pool, whereby certain households graze together but exclude others. This implication is supported by our field observations. Chopra and Gulati (1997) also find that once property rights are well defined with the help of appropriate institutional arrangements, labour moves towards the creation of common assets that result in the improvement of the environment.

In line with this, privatization would be expected to reduce the amount of common land, and therefore reduce the potential for “excluded” herders to migrate and eventually lead to environmental degradation. This would however be the case only if property rights possess the properties of enforceability and excludability (such as by fencing). However in the case of grazing land, enforcing property rights is either impossible or too costly for the individual to invest in. In the absence of such enforceability, the immediate

consequence would be pressure on trust land and conflict with wildlife and farmers. This argument is based on the fact that the community in question is very aggressive. For instance, in the recent past, the *Maasai* have been seen grazing in the city center and also invading private farms in search of pasture, due to severe drought. The implication here is that even in the light of privatization, migration may still be possible. This then raises the issue of livestock, human and wildlife conflicts resulting from privatization of common property resources. The possibility of such conflicts is highlighted by Kebede (2002), who notes that in some parts of Ethiopia, common grazing land is degraded most of the year and the peasant association managing the land is in conflict with neighbouring areas on the use of grazing land.

Another implication of this study is the need to conserve biomass and to adopt environmentally friendly conservation practices in order to improve productivity and reduce poverty. Our results show that all forms of environmental conservation and availability of biomass increase productivity and reduce the base poverty rate. The Ministry of Agriculture should therefore intensify extension efforts to teach farmers alternative environmental conservation practices especially in areas where land is more arable. On the same front, herders need to be educated on mitigating strategies that can be adopted when migrating so as to reduce incidence of livestock diseases. Producers should be sensitized on methods of preserving biomass, such as through keeping smaller herds, migration, leaving land fallow, and even protection of water catchment areas so as to enhance productivity and thus reduce poverty.

8.3 Areas for Further Research

This study unveils several areas for further research, which constitute part of our future research agenda. In the first place, our study explores the link between environmental conservation, productivity and poverty using new data and methods. The fieldwork was carried out at a period when the effects of *Elnino* and the drought that followed had a heavy toll on the study district. There is a need to extend such an analysis to other areas, especially where land is more arable in order to draw generalizable conclusions for the entire country. A comparative analysis of environmental conservation practices in

different agro-climatic zones would make it possible to capture important dynamics of the link between environmental conservation, productivity and poverty. This was beyond the scope of our thesis given time and budgetary limitations.

The direct impact of the non-farm sector on environmental conservation and poverty reduction also needs to be investigated. Our results imply that higher non-agricultural incomes discourage environmental conservation. However, one major source of non-agricultural income in the district is quarrying and construction which have adverse environmental implications. It would not be possible to tell the actual impact of such a sector on poverty reduction without further investigation.

Another potential area for further research is the relationship between nomadic pastoralism and environmental degradation as the causal relationship between migration and environmental degradation is not clear. Our study also hints at the need for further research into livestock, human and wildlife conflicts resulting from privatization of common property resources.

Finally, another important area of research is the impact of property rights and environmental conservation on the distribution of income and therefore on the welfare of households. In simulating the impact of policy on the base poverty rate, we do not take into account the distribution of households below the poverty line. On the other hand, adoption of environmental conservation could have ambiguous impacts on poverty through the impact on income distribution. If farmers adopting various practices become better off but the distribution of income worsens, then the non-adopting farmers will be relatively worse off and therefore environmental conservation will increase rather than reduce poverty.

REFERENCES

- Acevedo C., D. Barry and H. Rosa (1995), El Salvador's Agricultural Sector: Macroeconomic Policy, Agrarian Change and the Environment. *World Development*, Vol. 23,12: 2153-2172.
- Ahuja V. (1998), Land Degradation, Agricultural Productivity and Common Property: Evidence from Côte d'Ivoire: *Environment and Development Economics*, 3, 7-34.
- Alemu T. (1999), Insecure Land Tenure Regimes and Soil Conservation. *Studies in Environmental Economics and Development Working Paper Series* 1999:1, Göteborg University.
- Angrist J.D., and Krueger A.B., (2001), Instrumental Variables and the Search for Identification: From Supply and Demand to Natural Experiments. *Journal of Economic Perspectives*, Vol. 15,4: 69-85.
- Atwood D.A. (1990), Land Registration in Africa: The Impact of Agricultural Production. *World Development*, Vol. 18, 5:659-671.
- Baland J-M. and Platteau J-P. (1996), *Halting Degradation of Natural Resources: Is There A Role for Rural Communities*. FAO Rome.
- Baltagi B. H. (1995), *Econometrics Analysis of Panel Data*. John Wiley and Sons; Chichester.
- Barbier E. B. (1989), Cash Crops, Food Crops and Sustainability: The Case of Indonesia. *World Development*, 17(6): 879-95
- Barbier E. B. (1997), A Comment on "Environment, Poverty and Economic Growth by Mäler K-G. In *Proceedings of the Annual World Bank conference on Development Economics*: (Eds.) Pleskovic B and J.E. Stiglitz. The World Bank, Washington, D.C. pp.271-276
- Barbier E. B. (1998), Sustainable Agriculture and the Resource Poor: Policy issues and Options. *LEEC Paper* No 2.
- Barbier E.B. (1999), The Economics of Land Degradation and Rural Poverty linkages in Africa: UNU/INRA *Annual Lectures on Natural Resource Conservation and Management in Africa*. Nov. 1998, Accra Ghana (Edited by J.J. Baibu-Forson).
- Barbier E. B. and J .C. Burges (1992), Agricultural Pricing and Environmental Degradation *Policy Research Working Paper* No 960. The World Bank, Washington D.C

- Barbier E. B. and R. Lopez (1998), Debt, Poverty and Resource Management in a Rural Smallholder Economy. *Fondazione Eni Enrico Mattei. Nota Di Lavoro (Italy)*; No. 87.98:1-37
- Bardhan P., J-M. Baland, S. Das, D., Mookherjee and R., Sarkar (2002), The Environmental Impact of Poverty: Evidence from Firewood Collection in Rural Nepal. *Development Policy Paper* No. 126. The Institute for Economic Development, Boston University.
- Besley T. (1995), Property Rights and Investment Incentives: Theory and Evidence from Ghana. *Journal of Political Economy*, Vol. 103, no 5:903-937
- Bindlish V. and R. E. Evenson (1993), Evaluation of the Performance of T & V Extension in Kenya. *World Bank Technical paper*, Number 208: The World Bank, Washington D.C.
- Boserup E. (1965), *The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure*. New York Aldine.
- Braun J. V. (1992), Agricultural Growth, Environmental degradation, Poverty and Nutrition: Links and Policy Implications. *Quarterly Journal of International Agriculture*, 31:340-363.
- Brasselle, A.S., F. Gaspart, and J-P Platteau (2002), "Land Tenure Security and Investment Incentives: Puzzling Evidence from Burkina Faso", *Journal of Development Economics*, Vol. 67:373-418
- Broad R. (1994), The Poor and the Environment: Friends or Foes? *World Development*. Vol. 22, 6:811-822.
- Byiringiro F. and Reardon T. (1996), Farm Productivity in Rwanda: Effects of Farm Size, Erosion and Soil Conservation Investments. *Agricultural Economics*, 15:127-136
- Chopra K. and S. C. Gulati. (1997), Environmental Degradation and Population Movements: The Role of Property Rights: *Environment and Resource Economics*, 9: 383-408.
- Chopra K. and S. C. Gulati (1998), Environmental Degradation, Property Rights and Population Movements; Hypothesis and Evidence from Rajasthan (India): *Environment and Development Economics*, 3: 35-57.
- Chopra K. and S.C. Gulati (2001), *Migration, Common Property Resources and Environmental Degradation: Interlinkages in India's Arid and Semi-arid Regions*. Sage Publications; New Delhi.

- Cleaver M. K. and W.G. Donovan (1995), Agriculture, Poverty and Policy Reform in Sub Saharan Africa. *World Bank Discussion Papers* No 280. World Bank, Washington D.C.
- Darkoh M. K. (1994), The Deterioration of the Environment in Africa's Drylands and River Basins. *Desertification Control Bulletin*. 24, UNEP.
- Dasgupta P. and K.G. Mäler (1995), Poverty, Institutions, and the Environmental Resource Base: In *Handbook of Development Economics* Vol. III Elsevier science B.V. (Eds.) Behrman J. and T. N. Srinivasan.
- Deininger K.W. and B. Minten (1999), Poverty, Policies, and Deforestation: The Case of Mexico. *Economic Development and Cultural Change*, 47:313-344.
- Demsetz, H. (1967), "Toward a Theory of Property Rights". *American Economic Review*, Vol. 57,2: 347-359
- Dixon J. A. (1997), Comment on "Environment, Poverty, and Economic Growth", by Karl-Goran Mäler. In *Proceedings of the Annual World Bank Conference on Development Economics* (Eds.): Pleskovic B and J.T. Stiglitz. The World Bank, Washington, D.C.
- Duraiappah A. K. (1998), Poverty and Environmental Degradation: A Review and Analysis of the Nexus. *World Development*, Vol. 26, 12:2169-2179.
- Duraiappah et al. (1998), *The Poverty -Environmental Degradation Nexus: A Case Study of the Narok District in Kenya*: Mimeo - Nairobi.
- Ekbom, A., and J., Bojö (1999). Poverty and Environment: Evidence of Links and Integration into the Country Assistance Strategy Process, Discussion paper No. 4, *Environment Group and African Region*. The World Bank, Washington D.C.
- Ensminger J. (1996a), Culture and Property Rights. Beijer Discussion Paper Series No. 79, The Beijer International Institute of Ecological Economics, Stockholm.
- Ensminger J. (1996b), *Making a Market: The Institutional Transformation of an African Society*. Cambridge University Press.
- Evenson R. E. and G. Mwangi (2001), The Effects of Agricultural Extension on Farm Yields in Kenya. *African Development Review*, Vol. 13,1: 1-23
- Evenson R. E. and G. Mwangi (1995), *Household Composition and Expenditures on Human Capital Formation in Kenya*. Discussion paper No.731. Economic Growth Center. Yale University.

- Fafchamps M. (1998), The Tragedy of the Commons, Livestock Cycles and Sustainability. *Journal of African Economies*, Vol. 7, 3:384-423
- Feder G. (1987), Land Ownership Security and Farm Productivity: Evidence from Thailand. *Journal of Development Studies*, Vol. 24:1.
- Feder G. and D. Feeny (1991), Land Tenure and Property Rights: Theory and Implications for Development Policy. *The World Bank Economic Review*, Vol. 5,1: 135-153
- Feder G. and R. Noranha (1987), Land Right Systems and Agricultural Development in Sub-Saharan Africa: *The World Bank Research Observer*, Vol. 2:143-169
- Folke C. and F. Berkes (1995), Mechanisms That Link Property Rights To Ecological Systems. In *Property Rights and The Environment. Social And Ecological Issues*. (Eds.) Hanna S and Munasinghe J. The Beijer International Institute of Ecological Economics, Stockholm and The World Bank.
- García-Barrios, R. and L. García-Barrios (1990), Environmental and Technological Degradation in Peasant Agriculture: A Consequence of Development in Mexico. *World Development* Vol. 18, 11:1569-1585.
- Gavian S. and M. Fafchamps (1996), Land Tenure and Allocative Efficiency in Niger. *American Journal of Agricultural Economics*, 78:460-471.
- Greene W. H. (1997), *Econometrics Analysis*. 3rd Edition, Prentice-Hall International, Inc.
- Greer J. and E. Thorbecke (1986), Food Poverty Profile Applied to Kenyan Small Holders, *Economic Development and Cultural Change*, Vol. 35,1:115-141.
- Gujarati D. N. (1995), *Basic Econometrics*. United States Military Academy, West Point. McGraw-Hill, Inc.
- Haen H de. (1993), Livestock and the Environment: Interactions and Policy Implications. *Quarterly Journal of International Agriculture (Germany)*, 32:122-130.
- Hanmer L., G. Pyatt. and H. White (1996), *Poverty in Sub-Saharan Africa: What can we learn from the World Bank's Poverty Assessments?* Institute of Social Studies. The Hague.
- Hardin G. (1968), Tragedy of the Commons. *Science* 162:1243-8

- Heath J. and H. Binswanger (1996), "Natural Resource Degradation Effects of Poverty and Population Growth are Largely Policy - Induced: The Case of Colombia: *Environment and Development Economics*, 1: 65 - 84.
- Holden S. T., B. Shiferaw and M. Wik (1998), Poverty, Market Imperfections and Time Preferences: Of Relevance for Environmental Policy? *Environment and Development Economics* 3, 105 - 130.
- Jacobs A. H (1965), *The Traditional Political Organization of the Pastoral Maasai*. D.Phil Thesis. Nuffield College, University of Oxford.
- Jalal K. F. (1993), Sustainable Development, Environment and Poverty Nexus. *Occasional Paper* Number 7. Asian Development Bank, Manila.
- Jodha N. S. (1985), Population Growth and the Decline of Common Property Resources in Rajasthan, India: *Population and Development Review*, 11:247-264.
- Jodha N. S. (1993), Poverty Rights and Development. Beijer Discussion Paper Series No. 41, The Beijer International Institute of Ecological Economics, Stockholm.
- Jodha N. S. (1998), Poverty and Environmental Resource Degradation: An Alternative Explanation and Possible Solutions. *Economic and Political Weekly (India)*, 33:2384-2390.
- Kalabamu F. T. (2000), Land Tenure and Management Reforms in East and Southern Africa- The Case of Botswana. *Land Use Policy*, 17:305-319
- Kebede B. (2002), Land Tenure and Common Pool Resources in Rural Ethiopia: A Study Based on Fifteen Sites. *African Development Review*, Vol 14:1,113-149
- King'oriah G. K. (1995), *Land Use Planning and Coordination Study: An Economic Appraisal of Wildlife Conservation as A Land use Potential in Kenya*. Report Prepared for Kenya Wildlife Services: Nairobi February.
- Kituyi M. (1990), *Becoming Kenyans: Social-Economic Transformation of the Pastoral Maasai*. African Center for Technology Studies, Nairobi Kenya.
- Larson B. A. and D. W. Bromley (1990), Property Rights, Externalities and Resource degradation: Locating the Tragedy: *Journal of Development Economics*, Vol. 33: 235-262.
- Li G., S. Rozelle and L. Brandt, (1998), Tenure, Land Rights, and Farmer Investment Incentives in China. *Agricultural Economics*. 19:63-71

- Ligthelm A. A. and A. Wilsenach (1993), Development, Poverty and the Environment with Particular Reference to the Eastern Transvaal Region. *Development and Southern Africa*, Vol.10,1:45-65.
- Lopez R. (1997a), Environmental Externalities in Traditional Agriculture and the Impact of Trade Liberalisation: The Case of Ghana: *Journal of Development Economics*, 53:17-39.
- Lopez R. (1997b), Where Development Can or Cannot Go: The Role of Poverty-Environment Linkages: In *Proceedings of the Annual World Bank Conference on Development Economics*: (Eds.) Pleskovic B and J.E. Stiglitz the World Bank, Washington, D.C. Pp 285-306.
- Lopez R. (1998), The Tragedy of the Commons in Côte d'Ivoire Agriculture: Empirical Evidence and Implications for Evaluating Trade Policies: *World Bank Economic Review*, 12:101-131.
- Lopez R. and M. Niklitschek (1991), Dual Economic Growth in Poor Tropical Areas. *Journal of Development Economics*, 36:189-211.
- Lopez R., J. Nash and J. Stanton (1995), Adjustment and Poverty in Mexican Agriculture: How Farmers' Wealth Affects Supply Response. *Policy Research Working Paper* No 1494. The World Bank, Washington D.C.
- Maddala, G.S. (1983), *Limited Dependent and Qualitative Variables in Econometrics*, New York: Cambridge University Press.
- Mäler K-G (1997), Environment, Poverty and Economic Growth: In *Proceedings of the Annual World Bank conference on Development Economics*: (Eds.) Pleskovic B and J.E. Stiglitz. The World Bank, Washington, D.C. pp 251-270.
- Manda D. K. (1997), *Labour Supply, Returns to Education and the Effect of Firm Size on Wages: The Case for Kenya*. Ekonomiska Studier, Goteborgs Universitet, Sweden.
- McCay B. J. (1993), Management Regimes: Beijer Discussion Paper Series No. 38, The Beijer International Institute of Ecological Economics, Stockholm.
- McFadden D. (1987), Regression- Based Specification Tests for the Multinomial Logit Model. *Journal of Econometrics* 34. 63-82.
- Migot-Adholla S. E., P. Hazell, B. Blarel, and F. Place (1991), Indigenous Land Right Systems in Sub-Saharan Africa: A Constraint on Productivity? *The World Bank Economic Review*, Vol. 5, 1: 155-75.

- Migot-Adholla S. E., F. Place and Oluoch-Kosura (1994), Security of Tenure and Land Productivity in Kenya. In J.W. Bruce and S. Migot-Adholla (eds.), *Searching for Land Tenure Security in Africa*, Dubuque, Iowa: Kendall/Hunt Publishing Cy, pp 251-270.
- Mink S. (1993), Poverty, Population and the Environment. *World Bank Discussion Paper* No.189.
- Mwabu, G., W., Masai, G., Ndenge, J., Kirimi, R., Gesami, M., Chemingich, T., Kiriti, F., Munene and J., Kabubo-Mariara (2000), *Poverty in Kenya: Profiles and Determinants*, Paper Presented at the AERC Collaborative Research Project Workshop on Poverty, Income Distribution and Labour Market Issues in Sub-Saharan Africa; Nairobi; May.
- Mwabu G. and E. Thorbecke (2001), *Rural Development, Growth and Poverty in Africa*, *Journal of African Economies*, Forthcoming.
- North D. C. (1990), *Institutions, Institutional Changes and Economic Performance*. Cambridge University Press. Cambridge, U.K.
- Norton S. W. (1998), Poverty, Property Rights and Human Well-being: A Cross-National Study. *Cato Journal*, Vol. 18, 2: 233-245.
- O'Brien F. S. and T. C. I. Ryan (2001), "Kenya" In Devarajan S., D. Dollar and T. Holmgren, (eds.), *Aid and Reform in Africa: Lesson From Ten Case Studies*. The World Bank. Washington D.C.
- Ostrom E. (1990), *Governing the Commons: The Evolutions of Institutions for Collective Action*. Cambridge University Press.
- Ostrom E. (1993), The Evolution of Norms, Rules and Rights. Beijer Discussion Paper No.39, The Beijer International Institute of Ecological Economics, Stockholm.
- Otsuka K. (2001), Population Pressure, Land Tenure and Natural Resource Management. *ADB Institute Working Paper* 16. Asian Development Bank Institute, Tokyo.
- Otsuka K., A. R., Quisumbing, E., Payongayong and J.B. Aidoo (2003), Land Tenure and the Management of Land and Trees: The Case of Customary Land Tenure Areas of Ghana. *Environment and Development Economics*, 8:77-104
- Otsuki T., I.W. Hardie., and E. J. Reis, (2002), The Implication of Property Rights for Joint Agriculture-Timber Productivity in The Brazilian Amazon. *Environment and Development Economics*, 7:299-323

- Patel S. H., T.C. Pinckney and W.K. Jaeger (1995), Smallholder Wood Production and Population Pressure in East Africa: Evidence of Environmental Kuznets Curve? *Center for Development Economics: Economic Papers* No.137, Williams College.
- Pinckney T.C. and P. K. Kimuyu (1994), Land Tenure Reform in East Africa: Good, Bad or Unimportant? *Journal of African Economies*, Vol. 3,1: 1-28.
- Pinstrup-Andersen, P. and R. Pandya-Lorch, (1994), Poverty, Agricultural Intensification, and the Environment. *The Pakistan Development Review*, Vol. 33, 4:463-496.
- Place F., G. Kariuki, J. Wangila, P. Kristjanson, A. Makauki, and J. Ndubi (2002), Assessing the Factors Underlying Differences in Group Performance: Methodological issues and Empirical Findings From The Highlands of Central Kenya. *CAPRI Working Paper* No. 25. International Food Policy Research Institute, Washington D.C.
- Place F. and K. Otsuka (1997), Population, Land Tenure, and Natural Resource Management: The case of Customary Land Area in Malawi. *EPTD Discussion Paper* No. 27. International Food Policy Research Institute, Washington D.C.
- Place F. and K. Otsuka (2000), The Role of Tenure in the Management of trees at the Community Level: Theoretical and Empirical Analysis From Uganda and Malawi: *CAPRI Working Paper* No. 9. International Food Policy Research Institute, Washington D.C.
- Place F. and K. Otsuka (2002), Land Tenure Systems and their Impacts on Productivity in Uganda. *Journal of Development Studies*, Vol. 38, 6:105-128.
- Place F., M. Roth and P. Hazell (1994), Land Tenure Security and Agricultural Performance in Africa: Overview of Research Methodology. In J.W. Bruce and S. Migot-Adholla (eds.), *Searching for Land Tenure Security in Africa*, Dubuque, Iowa: Kendall/Hunt Publishing Cy, pp 15-40.
- Platteau J.P, (2000), *Institutions, Social Norms, and Economic Development*. Harwood Academic Publishers.
- Quiggin J. (1993), Common Property, Equality and Development, *World Development* Vol.21,7:1123-1138.
- Reardon T. and S.A. Vosti (1995), Links Between Rural Poverty and the Environment in Developing Countries: Asset Categories and Investment Poverty. *World Development*, Vol.23, 9:1495-1506.

- Reddy V. R. (1995), Environment and Sustainable Agricultural Development: Conflicts and Contradictions, *Economic and Political Weekly (India)*, 30:A21-A27.
- Republic of Kenya (1996), *Welfare Monitoring Survey II Basic Report*. Central Bureau of Statistics. Ministry of Planning and National Development, Nairobi.
- Republic of Kenya (1997), *Kajiado District Development Plan 1997-2001*: Office of the Vice -President and Ministry of Planning and National development. Government Printer, Nairobi.
- Republic of Kenya (1998), *Poverty in Kenya Vols. I & II*, Central Bureau of Statistics and the Human Resources and Social Services Department, Ministry of Planning and National development.
- Republic of Kenya (1999), *National Poverty Eradication Plan*. Ministry of Planning and National Development; Nairobi.
- Republic of Kenya (2000a), *Second Report on Poverty in Kenya: Incidence and Depth of Poverty*, Vol. I. Ministry of Finance and Planning.
- Republic of Kenya (2000b), *Second Report on Poverty in Kenya: Poverty and Social Indicators*, Vol. II. Ministry of Finance and Planning.
- Republic of Kenya: *Development Plan, Various Issues*: Government Printer Nairobi.
- Republic of Kenya: *Economic Survey, Various Issues*: Government Printer Nairobi.
- Republic of Kenya: *Sessional Paper, Various Issues*: Government Printer Nairobi.
- Roth, M., J. Cochrane, and W. Kisamba-Mugerwa, (1994), "Tenure Security, Credit Use, and Farm Investment in the Rujumbura Pilot Land Registration Scheme, Uganda", In J.W. Bruce and S. Migot-Adholla (eds.), *Searching for Land Tenure Security in Africa*, Dubuque, Iowa: Kendall/Hunt Publishing Cy, pp. 169-98.
- Rutten M. M. E. M. (1992), *Selling Wealth to Buy Poverty. The Process of the Individualization of Land Ownership among the Maasai Pastoralists of Kajiado District, Kenya 1890-1990*. Nicoles Verlag Breitenbach Publishers U.S.A.
- Sahn, D. E., S. D., Younger and G. Genicot (2003), The Demand for Health Care Services in Rural Tanzania, *Oxford Bulletin of Economics & Statistics*, 65(2): 241-259.
- Scherr S. J. and S. Yadah (1996), Land Degradation in the Developing World: Implications for Food, Agriculture and the Environment. *Food, Agriculture and The Environment Discussion Paper 14*. Washington D.C.

- Schultz, T. W. (1975), The Value of The Ability to Deal with Disequilibria, *Journal of Economic Literature*, Vol. 12, 3: 827-46.
- Shiferaw B., and S., Holden (1999), Soil Erosion and Smallholders' Conservation Decisions in the Highlands of Ethiopia. *World Development*, Vol. 27, No.4:739-752.
- Shiferaw B., and S., Holden (2001), Farm-level Benefits to Investment for Mitigating land Degradation: Empirical Evidence from Ethiopia. *Environment and Development Economics* 6:335-358
- Simonis U.E. (1992), Poverty, Environment and Development. *Intereconomics: Review of International Trade and Development (Germany)*, 27:75-85.
- Singh, I., L. Squire and J. Strauss, (1986), The Basic Model: Theory, Empirical Results, and Policy Conclusions. In Singh, I., L. Squire and J. Strauss (eds.). *Agricultural Household Models- Extensions, Applications and Policy*. John Hopkins University Press: Baltimore and London; pp.17-47.
- Southgate D. (1990), "The causes of Land Degradation Along Spontaneously Expanding Agricultural Frontiers in the Third World. *Land Economics*, Vol. 66, 3: 93-101
- StataCorp. (1999), *Stata Statistical Software: Release 7.0*. College Station, TX: Stata Corporation.
- Stevenson G. G. (1991), *Common Property Economics; A General Theory and Land Use Applications*. Cambridge University Press.
- Strasberg P.J. and S. Kloeck-Jenson (2002), Challenging Conventional Wisdom: Smallholder Perceptions and Experience of Land Access and Tenure Security in the Cotton Belt of Northern Mozambique. *Working Paper* No. 48. *Land Tenure Centre*, University of Wisconsin-Madison.
- Tiffen M., M. Mortimore and F.Gichuki (1994), *More People, Less Erosion: Environmental Recovery in Kenya*. John Wiley and Sons; ODI, Chichester.
- UNEP, G.O.K., RNG (1997), *National Land Degradation Assessment and Mapping in Kenya*. United Nations - office - Nairobi.
- Vainio M. (1998), The Effects of Unclear Property Rights on Environmental Degradation and Increased Poverty. *UNCTAD Discussion Papers* No. 130.

- Weir S. (1999), *The Effects of Education on Farmer Productivity in Rural Ethiopia. Centre for the Study of African Economies. Working Paper Series 99-7.* (Oxford: Centre for the Study of African Economies).
- Wooldridge, J. M. (2002), *Econometric Analysis of Cross Section and Panel Data*, MIT Press: Cambridge, MA.
- World Bank (1994), *Kenya: Poverty Assessment*. Washington D.C.
- World Bank (1997), *Taking Action to Reduce Poverty in Sub-Saharan Africa*. World Bank Washington D.C.
- World Commission on Environment and Development (WCED-1987), *Our Common Future*, Oxford University Press, Oxford.

APPENDICES

Table A1: Sample Statistics for Variables Included in the Regressions for Farmers (N= 1172)

Introduction

Our appendices are divided into two parts. Appendix one presents appendix tables while appendix two presents the field questionnaire. The first section of appendix one presents a summary of the sample statistics for variables included in the regression equations (Table A1-A3). Tables A4-A6 also presents regression results for productivity from various estimation procedures. Table A7 presents the impact of gender and environmental conservation practice interaction terms on productivity. Table A8 presents multinomial logit estimates for the choice of farm level environmental conservation practices, while Table A9 presents the corresponding FE-2SLS-Hausman regression estimates based on residuals derived from predicted values of conservation practices from the multinomial logit model. Table A10 presents the binary logit estimates for environmental conservation among herders. The questionnaire attached in appendix two was administered to households to collect the requisite data. The last section (Table 2.1b) was used to collect various product prices at the local markets for each cluster. The details of the data are discussed in chapter five.

Distance of water (km)	0.638	1.059
Log number of cattle owned	1.691	3.649
Log of biomass	7.580	0.336
Log of transfers received (Ksha)	1.986	1.587
Log of rent incomes (Ksha)	4.862	4.601
Log of value of farm equipment (Ksha)	3.781	9.878
Perceived effect on conservation on output (1=increases output, 0=decreases output)	0.295	0.456
Farmer engaged in blocking and erosion outlets (1=yes, 0=no)	0.103	0.304
Farmer engaged in land terracing (1=yes, 0=no)	0.104	0.306
Farmer engaged in planting land resistant vegetation (1=yes, 0=no)	0.235	0.424

APPENDIX ONE: APPENDIX TABLES

Table A1: Sample Statistics for Variables Included in the Regressions for Farmers (N= 1172)

Variable	Mean	Std. Dev.
Log of revenue per acre (kshs)	5.100	4.213
Property right regimes (1=private, 0=common)	0.793	0.406
Log of total land owned	2.888	2.015
Log of hired labour inputs	5.137	3.955
Log of household size	1.986	0.575
Log of age of household member	3.473	0.373
Sex (1=male, 0=female)	0.491	0.500
Marital status (1=married, 0=not married)	0.672	0.470
Primary school education (1=yes, 0=no)	0.367	0.482
Secondary school education (1=yes, 0=no)	0.201	0.401
Post secondary education (1=yes, 0=no)	0.038	0.192
Log of price of maize (Kshs/kg)	2.926	0.264
Log of price of beans (Kshs/kg)	3.630	0.312
Log of distance to market (kms)	1.974	0.948
Log of distance to source of water (kms)	0.686	1.050
Log number of cattle owned	1.691	1.649
Log of biomass	7.580	0.356
Log of transfers received (Kshs)	1.966	3.587
Log of rent incomes (Kshs)	4.668	4.601
Log of value of farm equipment (Kshs)	5.781	9.878
Perceived effect on conservation on output (1=increases output, 0=decreases output)	0.295	0.456
Farmer engaged in blocking soil erosion outlets (1=yes, 0=no)	0.103	0.304
Farmer engaged in land terracing (1=yes, 0=no)	0.104	0.306
Farmer engaged in planting land resistant vegetation (1=yes, 0=no)	0.235	0.424

Table A2: Sample Statistics for Variables Included in the Regressions for Herders (N=1518)

Variable	Mean	Std. Dev.
Log of revenue per acre (kshs)	7.968	2.362
Herder migrates with livestock (1=yes, 0=no)	0.586	0.493
Property right regimes (1=private, 0=common)	0.732	0.443
Log of total land owned	3.229	2.068
Log of hired labour inputs	4.190	4.104
Log of rent incomes (Kshs)	1.765	1.989
Log of transfers received (Kshs)	1.679	3.362
Log of value of farm equipment (Kshs)	7.754	1.639
Log of household size	2.000	0.550
Log of age of household member	3.488	0.372
Sex (1=male, 0=female)	0.493	0.500
Marital status (1=married, 0=not married)	0.708	0.455
Primary school education (1=yes, 0=no)	0.304	0.460
Secondary school education (1=yes, 0=no)	0.159	0.366
Post secondary education (1=yes, 0=no)	0.034	0.180
Perceived effect on conservation on output (1=increases output, 0=decreases output)	0.415	0.493
Log of price per cow (kshs)	8.792	0.536
Log of price of sheep/goat (kshs)	7.186	0.389
Log of distance to source of water (kms)	0.804	1.042
Log number of cattle owned	1.964	1.656
Log of distance to market (kms)	2.105	0.942
Log of biomass (kg per acre)	7.607	0.360

Table A3: Sample Statistics for Variables Included in the Regressions for the Full Sample (N=1600)

Variable	Mean	Std. Dev.
Log of revenue per acre	7.929	2.678
Property right regimes (1= private, 0= common)	0.733	0.443
Log of total land owned	3.097	2.126
Log of hired labour inputs	4.103	4.093
Log of household size	1.968	0.569
Log of age of household member	3.489	0.373
Sex (1=male, 0=female)	0.493	0.500
Marital status (1=married, 0=not married)	0.694	0.461
Primary school education (1=yes, 0=no)	0.310	0.463
Secondary school education (1=yes, 0=no)	0.169	0.375
Post secondary education (1=yes, 0=no)	0.034	0.181
Log of price of maize (Kshs/kg)	2.990	0.293
Log of price of beans (Kshs/kg)	3.700	0.329
Log of distance to market (kms)	2.076	0.943
Log of distance to source of water (kms)	0.765	1.041
Log number of cattle owned	1.863	1.670
Log of biomass (kg per acre)	7.617	0.361
Farmer engaged in blocking soil erosion outlets (1=yes, 0=no)	0.083	0.276
Farmer engaged in land terracing (1=yes, 0=no)	0.0766	0.265
Farmer engaged in planting land resistant vegetation (1=yes, 0=no)	0.187	0.390

Table A4: Estimation Results: Dependent Variable = Log Revenue per Acre; Farmers Sub-Sample (N= 1172)

Variable \ Estimation Method	FE-2SLS	OLS	FE	FE-2SLS- HAUSMAN	FE-IV
Property right regimes (1=private, 0=common)	3.391* (0.581)	0.973* (0.291)	3.406* (0.315)	3.391* (0.580)	3.391* (0.821)
Log of total land owned	-0.310* (0.122)	-0.070 (0.075)	-0.390* (0.103)	-0.310* (0.122)	-0.310 (0.172)
Log of hired labour inputs	0.175 (0.138)	0.126* (0.030)	0.184* (0.034)	0.175 (0.138)	0.175 (0.195)
Log of household size	-0.103 (2.016)	-0.036 (0.228)	0.240 (0.415)	-0.103 (2.011)	-0.103 (2.847)
Log of age of household member	0.191 (0.370)	-0.110 (0.361)	0.030 (0.332)	0.191 (0.369)	0.191 (0.522)
Sex (1=male, 0=female)	-0.218 (0.183)	-0.125 (0.224)	-0.140 (0.178)	-0.218 (0.182)	-0.218 (0.258)
Marital status (1=married, 0=not married)	-0.201 (0.309)	-0.128 (0.271)	-0.108 (0.291)	-0.201 (0.308)	-0.201 (0.436)
Primary school education (1=yes, 0=no)	0.236 (0.306)	0.441 (0.309)	0.081 (0.295)	0.236 (0.305)	0.236 (0.432)
Secondary school education (1=yes, 0=no)	0.040 (0.581)	0.447 (0.345)	0.075 (0.365)	0.040 (0.580)	0.040 (0.820)
Post secondary education (1=yes, 0=no)	1.204** (0.661)	0.152 (0.533)	0.848*** (0.546)	1.204** (0.659)	1.204 (0.933)
Log of price of maize (Kshs/kg)	-6.799*** (4.033)	-4.043* (0.852)	-3.983* (0.853)	-6.799*** (4.023)	-6.799 (5.694)
Log of price of beans (Kshs/kg)	5.371** (2.889)	-1.529* (0.622)	0.732 (0.609)	5.371** (2.882)	5.371 (4.079)
Log of distance to market (kms)	-2.420* (1.039)	-0.384* (0.145)	-1.466 (0.934)	-2.420* (1.037)	-2.420*** (1.468)

(Table A4 continued)

Log of distance to source of water (kms)	1.337 (2.710)	-0.180 (0.140)	-1.738 (2.312)	1.337 (2.703)	1.337 (3.826)
Log number of cattle owned	-0.319** (0.176)	0.468* (0.104)	-0.119 (0.156)	-0.319** (0.176)	-0.319 (0.249)
Log of biomass	-4.007 (3.453)	-2.026* (0.413)	-2.241 (0.602)	-4.007 (3.444)	-4.007 (4.875)
Predicted pr(blocking soil erosion outlets)	-6.718** (3.365)				
Predicted pr(land terracing)	-3.820 (14.69)				
Predicted pr(planting land resistant vegetation)	4.075 (7.135)				
Farmer engaged in blocking soil erosion outlets (1=yes, 0=no)		1.957* (0.383)	1.009* (0.352)	-6.718** (3.357)	-6.718 (4.751)
Farmer engaged in land terracing (1=yes, 0=no)		0.372 (0.427)	0.467 (0.419)	-3.820 (14.658)	-3.820 (20.745)
Farmer engaged in planting land resistant vegetation (1=yes, 0=no)		0.893* (0.259)	0.471*** (0.287)	4.075 (7.118)	4.075 (10.073)
Residual (blocking soil erosion outlets)				-7.759* (3.378)	
Residual (land terracing)				-4.183 (14.667)	
Residual (planting land resistant vegetation)				3.691 (7.127)	
Constant	37.355 (33.53)	36.607 (2.888)	32.069 (5.487)	37.355 (33.452)	37.355 (47.343)
F-statistics	(19,968)=11.9*	(19,1152)=37.1*	(19,968)= 11.9*	(22,965)= 10.7*	Wald $X^2(19)$ =2451.3*

*, **, *** Significant at 1%, 5% and 10% respectively.

Table A5: Estimation Results: Dependent Variable = Log Revenue per Acre; Herders Sub-Sample (N= 1518)

Variable \ Estimation Method	FE-2SLS	OLS	FE	FE-2SLS-HAUSMAN	FE-IV
Property right regimes (1= private, 0= common)	1.137* (0.213)	1.234* (0.157)	0.957* (0.152)	1.137* (0.211)	1.137* (0.219)
Log of total land owned	0.246* (0.046)	-0.261* (0.060)	0.274* (0.039)	0.246* (0.046)	0.246* (0.047)
Log of hired labour inputs	0.039* (0.017)	0.045* (0.014)	0.043* (0.016)	0.039* (0.017)	0.039* (0.017)
Log of household size	-0.408*** (0.235)	0.403* (0.105)	-0.288 (0.211)	-0.408*** (0.233)	-0.408*** (0.241)
Log of age of household member	-0.021 (0.168)	0.140 (0.172)	0.048 (0.157)	-0.021 (0.167)	-0.021 (0.173)
Sex (1=male, 0=female)	-0.036 (0.091)	-0.149 (0.109)	-0.064 (0.087)	-0.036 (0.090)	-0.036 (0.093)
Marital status (1=married, 0=not married)	-0.066 (0.158)	-0.121 (0.123)	-0.143 (0.143)	-0.066 (0.157)	-0.066 (0.162)
Primary school education (1=yes, 0=no)	0.066 (0.148)	0.344* (0.146)	0.056 (0.147)	0.066 (0.147)	0.066 (0.152)
Secondary school education (1=yes, 0=no)	0.117 (0.188)	0.943* (0.166)	0.113 (0.186)	0.117 (0.186)	0.117 (0.193)
Post- Secondary school education (1=yes, 0=no)	0.067 (0.287)	0.788* (0.265)	0.006 (0.280)	0.067 (0.284)	0.067 (0.294)
Log of price per cow (kshs)	0.337*** (0.201)	-0.564* (0.109)	0.152 (0.131)	0.337*** (0.200)	0.337*** (0.207)
Log of price of sheep/goat (kshs)	-0.865* (0.170)	-0.962* (0.213)	-0.781* (0.154)	-0.865* (0.169)	-0.865* (0.175)

(Table A5 continued)

	-0.796*** (0.458)	-0.270* (0.061)	-0.627 (0.433)	-0.796*** (0.455)	-0.796*** (0.470)
Log of distance to market (kms)					
	1.420* (0.569)	0.118** (0.062)	1.378* (0.563)	1.420* (0.564)	1.420* (0.584)
Log of distance to source of water (kms)					
	0.314* (0.095)	0.493* (0.051)	0.404* (0.059)	0.314* (0.094)	0.314* (0.098)
Log number of cattle owned					
	1.052* (0.309)	0.638* (0.188)	1.194* (0.284)	1.052* (0.306)	1.052* (0.317)
Log of biomass (kg per acre)					
	2.238*** (1.228)	0.008 (0.128)	0.762* (0.155)	2.238** (1.218)	2.238*** (1.260)
Predicted probability of migration					
				1.500 (1.228)	
Residual (migration)					
	0.945 (2.874)	12.816 (2.365)	0.868 (2.850)	0.945 (2.850)	0.945 (2.950)
Constant					
F-statistics	(17,1282) = 16.7*	(17,1500) = 59.2*	(17,1282) = 18.2*	(18,1281) = 17.3*	Wald $\chi^2(17)$ = 43864*

*, **, *** Significant at 1%, 5% and 10% respectively.

(Table A6 continued)

Table A6: Estimation Results: Dependent Variable = Log Revenue per Acre; Full Sample (N = 1600)

Variable \ Estimation Methods	FE-2SLS	OLS	FE	FE-2SLS-HAUSMAN	FE-IV
Property right regimes (1=private, 0=common)	1.003* (0.213)	0.922* (0.166)	0.741* (0.168)	1.003* (0.212)	1.003* (0.319)
Log of total land owned	0.288* (0.045)	-0.210* (0.059)	0.256* (0.042)	0.288* (0.045)	0.288* (0.068)
Log of hired labour inputs	0.023 (0.029)	0.038* (0.016)	0.051* (0.019)	0.023 (0.029)	0.023 (0.044)
Log of household size	0.701*** (0.403)	0.629* (0.131)	0.774* (0.218)	0.701*** (0.399)	0.701 (0.601)
Log of age of household member	-0.211 (0.183)	-0.254 (0.205)	-0.132 (0.176)	-0.211 (0.182)	-0.211 (0.274)
Sex (1=male, 0=female)	0.026 (0.107)	0.037 (0.128)	-0.027 (0.099)	0.026 (0.106)	0.026 (0.159)
Marital status (1=married, 0=not married)	0.088 (0.165)	0.122 (0.170)	0.006 (0.158)	0.088 (0.164)	0.088 (0.246)
Primary school education (1=yes, 0=no)	-0.101 (0.202)	0.507* (0.161)	0.027 (0.167)	-0.101 (0.200)	-0.101 (0.301)
Secondary school education (1=yes, 0=no)	0.114 (0.210)	0.598* (0.216)	0.142 (0.206)	0.114 (0.208)	0.114 (0.313)
Post secondary education (1=yes, 0=no)	0.076 (0.374)	1.188* (0.323)	0.277 (0.317)	0.076 (0.371)	0.076 (0.558)
Log of price of maize (Kshs/kg)	2.162*** (1.306)	0.855 (0.588)	0.261 (0.381)	2.162 (1.295)***	2.162 (1.950)
Log of price of beans (Kshs/kg)	-3.610 (1.807)	-1.715* (0.399)	-0.119 (0.343)	-3.610* (1.792)	-3.610 (2.699)
Log of distance to market (kms)	0.551 (0.702)	-0.051 (0.073)	-0.460 (0.499)	0.551 (0.697)	0.551 (1.049)

(Table A6 continued)

Log of distance to source of water (kms)	0.062 (0.880)	0.081 (0.068)	1.034 (0.651)	0.062 (0.873)	0.062 (1.314)
Log number of cattle owned	0.447* (0.103)	0.440* (0.055)	0.385* (0.066)	0.447* (0.102)	0.447* (0.153)
Log of biomass	1.366* (0.686)	0.519** (0.269)	1.042* (0.320)	1.366* (0.680)	1.366 (1.024)
Predicted pr(blocking soil erosion outlets)	7.842* (3.662)				
Predicted pr(land terracing)	-0.427* (3.259)				
Predicted pr(planting land resistant vegetation)	-1.670* (2.122)				
Farmer engaged in blocking soil erosion outlets (1=yes, 0=no)		0.719* (0.268)	0.434** (0.212)	7.842** (3.631)	7.842 (5.468)
Farmer engaged in land terracing (1=yes, 0=no)		0.272* (0.133)	0.502** (0.243)	-0.427 (3.231)	-0.427 (4.866)
Farmer engaged in planting land resistant vegetation (1=yes, 0=no)		0.661* (0.146)	0.386* (0.164)	-1.670 (2.104)	-1.670 (3.169)
Residual (blocking soil erosion outlets)				7.120** (3.638)	
Residual (land terracing)				-1.600 (3.244)	
Residual (planting land resistant vegetation)				-2.570 (2.114)	
Constant	-0.344 (6.008)	5.850 (1.800)	-3.689 (2.942)	-0.344 (5.957)	-0.344 (8.970)
F-statistics	(19,1354)= 10.2*	(19,1580)= 33.3*	(19,1354)= 10.4*	(22,1351)= 10.1*	Wald $X^2(19)$ =16425.9 *

*, **, *** Significant at 1%, 5% and 10% respectively.

Table A7 Fixed Effects Regression Estimates: Average Revenue for Farmers and Herders; Dependent Variable is Log of Revenue per Acre (Impact of Gender Interactions)

Variable	Coefficient	Std. Error	t-statistic
Property right regimes (1= private, 0= common)	0.738*	0.168	4.380
Log of total land owned	0.257*	0.042	6.040
Log of hired labour inputs	0.051*	0.019	2.760
Log of household size	0.770*	0.219	3.520
Log of age of household member	-0.139	0.176	-0.790
Sex (1=male, 0=female)	0.005	0.118	0.040
Marital status (1=married, 0=not married)	0.004	0.158	0.030
Primary school education (1=yes, 0=no)	0.012	0.167	0.070
Secondary school education (1=yes, 0=no)	0.122	0.207	0.590
Post secondary education (1=yes, 0=no)	0.260	0.317	0.820
Log of price of maize (Kshs/kg)	0.254	0.381	0.670
Log of price of beans (Kshs/kg)	-0.107	0.343	-0.310
Log of distance to market (kms)	-0.469	0.499	-0.940
Log of distance to source of water (kms)	1.050***	0.652	1.610
Log number of cattle owned	0.385*	0.066	5.840
Log of biomass (Kgs/acre)	1.043*	0.320	3.260
Farmer engaged in blocking soil erosion outlets (1=yes, 0=no)	0.298	0.273	1.09
Farmer engaged in land terracing (1=yes, 0=no)	0.536**	0.292	1.83
Farmer engaged in planting land resistant vegetation (1=yes, 0=no)	0.506*	0.202	2.5
Interaction terms			
Gender and blocking soil erosion outlets	0.235	0.319	0.74
Gender and land terracing	-0.074	0.336	-0.22
Gender and planting land resistant vegetation	-0.226	0.228	-0.99
Constant	-3.686	2.943	-1.25
Number of Observations			1600
F(12,1351)			9.08*
R-squared			0.1289

*, **, *** Significant at 1%, 5% and 10% respectively

Table A8: Multinomial Logit Results: Dependent Variable is Choice of Farm Conservation Practices (Asymptotic Standard Errors in Parenthesis)^v

Variable	Blocking soil erosion outlets	Land terracing	Planting drought resistant vegetation
	Parameter estimates	Parameter estimates	Parameter estimates
Property right regimes (1=private, 0=common)	0.543** (0.265)	2.213* (0.480)	1.747* (0.298)
Log of total land owned	-0.123** (0.064)	0.156*** (0.099)	-0.099 (0.067)
Log of hired labour inputs	0.076* (0.030)	0.072*** (0.040)	0.106* (0.028)
Log of household size	0.367*** (0.236)	1.280* (0.302)	0.624* (0.220)
Log of age of household member	0.912* (0.332)	0.125 (0.433)	0.346 (0.323)
Sex (1=male, 0=female)	-0.114 (0.218)	-0.024 (0.265)	-0.025 (0.198)
Marital status (1=married, 0=not married)	-0.438*** (0.244)	0.437 (0.377)	-0.051 (0.236)
Primary school education (1=yes, 0=no)	0.849* (0.310)	-0.112 (0.367)	0.289 (0.277)
Secondary school education (1=yes, 0=no)	0.379 (0.373)	0.313 (0.413)	0.591** (0.326)
Post secondary education (1=yes, 0=no)	1.102** (0.529)	2.345* (0.703)	0.977 (0.463)
Log of price of maize (Kshs/kg)	-0.661 (0.802)	2.856* (0.794)	4.374* (0.707)
Log of price of beans (Kshs/kg)	1.115** (0.555)	-0.754 (0.669)	-3.950* (0.524)
Log of distance to market (kms)	0.022 (0.130)	0.285*** (0.165)	0.347* (0.128)
Log of distance to source of water (kms)	0.096 (0.140)	0.316** (0.154)	0.081 (0.109)
Log number of cattle owned	-0.584* (0.114)	-0.559* (0.110)	-0.749* (0.093)
Log of biomass	0.658*** (0.395)	-0.725 (0.477)	-0.436 (0.353)
Log of transfers received (Kshs)	-0.044 (0.035)	0.102* (0.034)	0.030 (0.028)
Log of rents (Kshs)	0.028 (0.027)	0.031 (0.029)	-0.001 (0.023)
Log of value of farm equipment (Kshs)	0.217* (0.077)	0.156 (0.126)	0.343* (0.080)

(Table A8 continued)

Perceptions of practicing conservation practices on output (1=increases output, 0=decreases output)	4.505* (0.353)	6.541* (0.412)	5.636* (0.343)
Constant	-15.370 (3.161)	-12.026 (3.939)	-4.419 (2.685)
Number of Observations	1600		
Wald $X^2(60)$	632.23*		
Pseudo- R^2	0.4315		

∇ Dependent variable = practice adopted, which takes the values 1 to 3 for the above three practices, and a value of 0 for non-adoption, which is used as the comparison option.

*, **, *** Significant at 1%, 5% and 10% respectively.

Table A9 FE-2SLS-Hausman Regression Estimates: Average Revenue for Farmers and Herders Based on Residuals from Multinomial Logit for Practices; Dependent Variable is Log of Revenue per Acre

Variable	Coefficient	Std. Error	t-statistic
Property right regimes (1= private, 0= common)	0.698*	0.168	4.17
Log of total land owned	0.219*	0.044	4.96
Log of hired labour inputs	0.065*	0.019	3.45
Log of household size	0.877*	0.217	4.04
Log of age of household member	-0.042	0.176	-0.24
Sex (1=male, 0=female)	-0.033	0.098	-0.34
Marital status (1=married, 0=not married)	-0.013	0.158	-0.08
Primary school education (1=yes, 0=no)	0.088	0.168	0.52
Secondary school education (1=yes, 0=no)	0.064	0.206	0.31
Post secondary education (1=yes, 0=no)	0.425	0.318	1.34
Log of price of maize (Kshs/kg)	-0.143	0.408	-0.35
Log of price of beans (Kshs/kg)	0.432	0.400	1.08
Log of distance to market (kms)	-0.507	0.496	-1.02
Log of distance to source of water (kms)	1.042***	0.646	1.61
Log number of cattle owned	0.375*	0.066	5.69
Log of biomass (Kgs/acre)	1.243*	0.320	3.88
Farmer engaged in blocking soil erosion outlets (1=yes, 0=no)	-1.780*	0.671	-2.65
Farmer engaged in land terracing (1=yes, 0=no)	-0.625	0.477	-1.31
Farmer engaged in planting land resistant vegetation (1=yes, 0=no)	0.846*	.332	2.55
Residual(blocking soil erosion outlets)	-2.625*	0.684	-3.84
Residual (land terracing)	-2.067*	0.604	-3.42
Residual (planting land resistant vegetation)	0.152	0.389	0.39
Constant	-6.172	2.984	-2.07
Number of Observations	1600		
F(12,1351)	10.41*		
R-squared	0.1449		

*, **, *** Significant at 1%, 5% and 10% respectively.

Table A10 Binary Logit Regression Results for Herders: Dependent Variable is Choice of Conservation Practice[∇]

Variable	Coefficient	Std. Error	T-statistic
Property right regimes (1= private, 0= common)	-1.263*	0.184	-6.870
Log of total land owned	0.309*	0.044	6.990
Log of hired labour inputs	-0.031	0.021	-1.500
Log of household size	0.152	0.171	0.890
Log of age of household member	-0.463***	0.263	-1.760
Sex (1=male, 0=female)	0.209	0.157	1.330
Marital status (1=married, 0=not married)	0.477*	0.199	2.400
Primary school education (1=yes, 0=no)	-0.713*	0.197	-3.610
Secondary school education (1=yes, 0=no)	-0.946*	0.235	-4.030
Post secondary education (1=yes, 0=no)	-1.913*	0.380	-5.040
Log of price per cow (Kshs)	-0.495*	0.200	-2.470
Log of price per sheep/goat (Kshs)	-0.050	0.264	-0.190
Log of distance to market (kms)	0.457*	0.096	4.770
Log of distance to source of water (kms)	0.869*	0.071	12.300
Log number of cattle owned	-0.219**	0.096	-2.270
Log of biomass	0.944*	0.261	3.610
Log of transfers received (Kshs)	-0.082*	0.022	-3.800
Log of rent incomes (Kshs)	-0.124*	0.041	-3.040
Log of value of farm equipment (Kshs)	-0.206*	0.074	-2.760
Perception of conservation practices on output (1=increase output, 0=decrease output)	0.301***	0.161	1.870
Constant	-0.124	3.038	-0.040
Number of Observations			1518
Wald $X^2(20)$			446.77*
R squared			0.4479

[∇] Dependent variable, Y=1 if herder migrated, Y=0 otherwise

*, **, *** Significant at 1%, 5% and 10% respectively

APPENDIX TWO: FIELD QUESTIONNAIRE

1. Household Characteristics

Enumerator Name _____		Date _____		Time _____		Division _____	
Location _____		Sub location _____		Household No. _____		Cluster No. _____	
Cluster Name _____		Respondents Name _____					

List all members of households and provide the relevant information on each

No	Name of Household member	Relation to household head (see code)	Sex 1=Male 2=Female	Age (Years) 00 for less than 1 yr	Marital Status (see code)	Can read and write 1=Yes 2=No	Ever attended school 1=Yes 2=No	Number of years in school	Highest grade/level reached (see code)	Main occupation (see code)	Secondary occupation (see code)
A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											

Codes

Column A3

1=head
2=Spouse
3=Son
4=Daughter
5=Father
6=Mother
7=Other relatives
8=No relative

Column A6

1=Single
2=Married monogamous
3=Married polygamous
4=Divorced/Separated
5=Widowed

Column A11 and A12

1=Farming
2=Livestock production
3=Stock traders
4=General business
5=Employed
6=School
7=Other (specify)
8=None

Column A10

00 pre-school
01 Std. 1-8
02 Sat KCPE/CPE
03 Form 1-4
04 Sat KCSE/KCE/EACE
05 Completed Form 5-KACE

06 Post secondary education
07 University
08 Other specify
09 None

2. Economic Activities

2.1 Type of Crops Produced over the Last Season

Crop Name	Total area under crop (in acres)	Whether crop was planted in pure stand/ intercropped (see code)	How much did you harvest (indicate unit)	How much did you sell	Total value of crop sales (Kshs)	How much was used for seeds	How much was consumed	How much was given to labour and others	How much went into waste	How much is remaining in store now?	Selling Price Per Unit
B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12
Maize											
Beans											
Wheat											
Vegetables											
Fruits											
Coffee											
Cotton											
Other (Specify)											

Column B4-B12

0=None

1=Kilo

2=Bag

3=Basket

4=Debe

5=Number

6=Other (specify)

Column B3

1=Purestand

2=Intercropped

B10: damaged by insects, weevils, decaying etc

B8: Probe whether there is any domestic use of raw cotton

B5-B11: From last season's harvest

B7=Zero for crops which cannot be used for seeds

2.2 Provide Details on the Type of Livestock Raised by the Household in the Last 12 Months

Livestock Type	Method of grazing (see code)	For how much would you sell one today?	Number Slaughtered for consumption last 12 months	Number born last 12 months	Number sold over the last 12 months	Total value of sales	Number died last 12 months	Number bought over the last 12 months	Total value of purchases	Number kept by others	Number we keep for others
C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
Grade cow											
Grade bulls											
Mixed cow											
Mixed bulls											
Local cow											
Local bull											
Calves											
Ox											
Goats											
Sheep											
Donkey											
Camels											
Pigs											
Poultry											
Other (Specify)											

Codes

Column C2

1=Paddock grazing

2=Open grazing

3=Zero grazing

4= Paddock + open grazing

5= Other specify

Column C1

Ox=Castrated bull

Table 2.3a: Livestock Production. Approximately how much of each output did you receive from your livestock for the last one month.

Livestock D1	Milk		Hides & Skins		Manure		Other Specify			
	Quantity D2	Value D3	Quantity D4	Value D5	Quantity D6	Value D7	Quantity D8	Value D9	Quantity D10	Value D11
Cattle										
Goats										
Sheep										
Camel										
Other (specify)										

2.3 (b) If own chicken how many eggs have you sold in the last two weeks? Quantity _____ dozens Value _____ Kshs.

2.3 (c) If own oxen and donkeys, how much revenue have you earned from hiring them out over the last one month? (Probe for last 6 months)
Oxen _____ Kshs. Donkeys _____ Kshs.

2.4 How would livestock production in 2.2 and 2.3 (a) above change without open grazing? (remind respondents of the method they used in 2.2 above)

.....

.....

.....

3.1 Food Consumption and Expenditure (last 7 days) Probe whether this is the general trend for the last one month.

Food Item E1	Source (see code) E2	If own production		If purchased		If gift		If payment in kind		Transfer from relatives		Other (Specify)	
		Quantity E3	Value E4	Quantity E5	Value E6	Quantity E7	Value E8	Quantity E9	Value E10	Quantity E11	Value E12	Quantity E13	Value E14
Maize grain													
Maize flour													
Bread													
Other grains													
Other flours													
Beans													
Other pulses													
Roots & tubers													
Fruits													
Vegetables													
Meats													
Milk													
Eggs													
Sugar													
Oils & fats													
Tea & coffee													
Beer/alcohol													
Other (Specify)													

Codes E2 1=Own Production, 2=Purchased, 3=Gift, 4=Payments in kind, 5=Transfer, 6=Other (specify), For quantity use same units as in table 2.1.

Non-Food Expenditures

Health- Last Month				Education - Last term				
Consultation	Drugs	Transport	Other related health expenditures F4	Transportation	Books & Supplies	Tuition & Fees	Uniforms	Other
F1	F2	F3		F5	F6	F7	F8	F9

Bridal payments	Household durables e.g TVs, Radio	Salaries to Household Help	Harambee Contributions/ Donations	Clothing and Footwear	Fuels (Lighting & Cooking)	Soaps & Detergents	Gifts & Transfers to those outside the home	Other (specify)
F10	F11	F12	F13	F14	F15	F16	F17	F18

3.3

Non-Farm Income Last Month

Transfers in cash/kind	Gifts from others - cash/kind	Wages	Rent Income	Other (specify)
G1	G2	G3	G4	G5

4.1 Farm Equipment Owned:

Provide details of the farm equipment owned.

Farm Equipment H1	Number H2	When was this equipment procured H3	Estimated Value/ Purchase Price H4
Panga			
Jembes			
Animal Drawn Carts			
Wheelbarrows			
Ploughs/Motorized			
Spray Pumps			
Maize Cutters			
Tractors			
Milk Separators			
Axes			
Sickles			
Fork Jembes			
Buckets			
Shovels			
Water Tank			
Grass Cutters			
Other buildings (i.e. Milk shed/ store)			
Feeder for concentrates and forage			
Milk Equipment			
Others (Specify)			

4.2 Farming and Livestock Inputs

Indicate the type and value of inputs used over the last 6 months

Type of Inputs H5	Value (Kshs) H6	Method of Payment (see code) H7
Farming		
Seeds		
Fertilizer		
Chemicals		
Other		
Sub-total		
Livestock		
Purchased fodder		
Dipping & Spraying		
Vet. Services & Artificial Insemination		
Drugs and Medicines		
Salt Lick		
Other		
Sub-total		
Overall Total		

Codes H7;

1=Cash, 2=Credit, 3=Gift, 4=Kind, 5=Transfer, 6=Other (specify)

5. Credit and Labour Use (last 6 months)

5.1 a Did you need agricultural credit over the last 6 months
Yes ☐ No ☐

5.1 b Did you receive any credit over the last 6 months
Yes ☐ No ☐ (If No, go to 5.5)

5.2 If yes, what was the source? If no go to 5.5

- | | |
|---|--|
| 1. Family friend ☐ | 4. Bank ☐ |
| 2. Local trader ☐ | 5. Agricultural Finance Corporation ☐ |
| 3. Cooperatives ☐ | 6. Other specify ☐ |

5.3 How much money did you receive (last 6 months) Kshs.

5.4 Did you use the money for purchasing.

	Yes	No	If yes, indicate amount
Fertilizers			
Other chemicals			
Hiring labour			
Machinery			
Other agricultural uses (Specify)			
			

5.5 Were you unable to obtain any credit, or as much as you needed? (Tick only one)

Unable to obtain any credit

Obtained less than needed

Did not need/apply for credit

5.6 If you had more money available this season, would you have used more on (from any source)?

	Yes	No
Fertilizer		
Other chemicals		
Machinery		
Hired Labour		
Other agricultural inputs (specify)		

5.7 In future, which of the following inputs would you like to see more credit being made available for? (Could be more than one)

Fertilizer

Other chemicals

Machinery

Hired Labour

Other agricultural inputs (specify)

5.8 Indicate the amount of family labour employed over the last season.

	Full time (hrs)	Part time (hrs)
Yourself-head		
Spouse		
Children (over 10 years)		
Other relatives		

5.9 For which tasks did you hire labour the last season?

Land preparation

Planting/sowing

Weeding

Harvesting

Herding & Milking

Other tasks (specify)

None

5.10 How much labour did you hire (last season)

Land preparation
Planting/sowing
Weeding
Harvesting
Herding & Milking
Other tasks (specify)

6. Land Ownership

6.1 What is the approximate size of land that you use for:

Paddock grazing acres
Farming acres
Other (specify) acres

6.2 Is this land registered? Yes ☐ No ☐

6.3a If yes who is the registered owner of this land?

(a) Self ☐ (b) Spouse ☐ (c) Family -specify ☐ (d) Clan ☐
(e) Landlord ☐ (f) Scheme ☐ (g) Other specify ☐

6.3b If scheme, indicate the number of listed members.....

6.4 For how long has this ownership been like this years

6.5 Has the system of ownership changed over the last 10 years?
Yes ☐ No ☐

6.6 If yes what are the changes? (i.e type of system of ownership before the current one)

.....
.....

6.7 How have the changes in ownership affected output (tick one)

	Crops	Livestock
Increase		
Decrease		
No change		

6.8 What changes (if any) would you propose on the current system of land ownership?

.....
.....

6.9 How would these changes affect output (crops and livestock)

.....
.....

6.10 What in your opinion is the main constraint of the present system of ownership with respect to crop and livestock production?

.....
.....

7. Environmental conservation Practices

7.1 Do you engage in any of the following land use practices? Give details of each.

- | | | | |
|-------|---|------------------------------|-----------------------------|
| (i) | Blocking soil erosion outlets | Yes ☐ | No ☐ |
| (ii) | Terracing | Yes ☐ | No ☐ |
| (iii) | Cultivation of River valley/bends | Yes ☐ | No ☐ |
| (iv) | Leave land fallow | Yes ☐ | No ☐ |
| (v) | Planting resistant vegetation (indicate type) | Yes ☐ | No ☐ |
| (vi) | Other (specify) | Yes ☐ | No ☐ |
| (vii) | Number of trees planted | ----- | |

7.2 What are the effects of the land use practices mentioned in 7.1 on output (tick one)

- (i) Increased output ☐
- (ii) Decreased output ☐
- (iii) No change ☐

7.3 Do you plan to introduce any other land use practices in the future ? Yes ☐ No ☐
If yes, explain the nature and reasons

.....

.....

.....

7.4 How does the system of ownership (in 6.3) affect land use practices?

.....

.....

.....

8. Migration

8.1 Do you migrate/commute with livestock in search of water or pasture during any period or the year?

Yes ☐ No ☐

8.2 If yes, when do you normally migrate/Commute?

- i) Generally ☐ ii) Rainy season ☐ iii) Dry season ☐
- iv) Others (Specify)

8.3 How do you migrate with livestock?

- i) Commute with livestock and return daily ☐
- ii) Migrate with livestock but return only during the rainy season ☐
- iii) Others (Specify)

8.4 In each case in 8.3 above, how far do you go out to graze? km(s) Name of place

8.5 In each case, who takes the livestock out for grazing (indicate number) -----.

- i) self ☐ ii) spouse ☐ iii) children ☐ iv) Workers ☐
- v) Others (specify).....

8.6 Who controls the use of the following range resources outside the family farm?

Grass/pasture

Water

Other specify

8.7a) Does the household receive any transfers? Yes ☐ No ☐

If yes what is the source of transfers [name(s)]

b) What is the relationship of the person(s) in 8.8(b) to the household head?

.....

c) Where does this person(s) work.

d) How often does this member come home?.....

9. Infrastructural Facilities.

Facility I1	Distance from home (KMs) I2	Used by self I3	Used by family I4	Impact of facility on Economic activities I5
Schools -Primary				
-Secondary				
-Village Polytechnics				
Others (i)				
Church (specify)				
Mosque				
Health Facilities (specify)				
Shopping Center				
Market				
Roads -murram				
-tarmac				
-earth road				
-other specify				
Water points				
Livestock auction yards				
Slaughter Houses				
Salt Lick				

Codes I3 and I4 1=yes 2=no

Table 2.1b Local Market Prices

Prices of Crops, Livestock and Livestock Products

Crop Name B1	Farm Gate Price Kshs. Per Unit* B13	Local Market Price Kshs. Per Unit** B14
Maize		
Beans		
Wheat		
Vegetables		
Fruits		
Livestock products		
Milk		
Hides & Skins		
Manure		
Eggs		
Other (Specify)		
Livestock		
Grade cow		
Grade bull		
Mixed bull		
Mixed cow		
Local cow		
Local bull		
Calf (indicate type)		
Ox		
Goat		
Sheep		
Donkey		
Camel		

*Farm gate price is the price prevailing at home

**Price at local market center