Household Welfare, Investment in Soil and Water Conservation and Tenure Security: Evidence From Kenya

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Abstract

In Kenya, conservation and sustainable utilization of the environment and natural resources form an integral part of national planning and poverty reduction efforts. However, weak environmental management practices are a major impediment to agricultural productivity growth. This study was motivated by the paucity of literature on the poverty-environment nexus in Kenya, since poverty, agricultural stagnation and environmental degradation are issues of policy interest in the country's development strategy. The paper builds on the few existing studies from Kenya and explores the impact of household, farm and village characteristics as well as the development domain dimensions on household welfare and investment in soil and water conservation. The results show that strengthening the tenure security improves household welfare. Further, soil quality, topography and investments in soil and water conservation affect household welfare. Agro-ecological potential, which is related to environmental conservation, is also a key correlate of poverty. Results for investment in water and soil conservation confirm the importance of tenure security in determining adoption and also the intensity of SWC investments. We also find that household assets, farm characteristics, presence of village institutions and development domain dimensions are important determinants of adoption and intensity of soil and water conservation investments. The results for both poverty and investment in soil and water conservation suggest the existence of a strong poverty-environment link in our sample. The results also suggest that rural poverty can be alleviated by policies that improve environmental conservation and strengthen land tenure security. The study also underscores the importance of village institutions in both investment adoption of soil and water conservation and in improving household welfare.

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Poverty Reduction and Environmental Management (PREM)

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1. Introduction

Poverty in Kenya is most severe in rural areas (currently 56% of the rural population fall below the poverty line) where 85% of the population resides, deriving their livelihood from the natural resource base. Agriculture remains the main source of livelihood. One of the most important features of Kenyan agriculture is the large subsistence sector, which makes agriculture even more important for food security. However, over the last three decades, soil erosion and land degradation have become major environmental concerns and present a formidable threat to food security and sustainability of agricultural production. Access to land has become increasingly constrained in smallholder agricultural areas that were formerly land abundant, while declining agricultural productivity has greatly contributed to rural poverty, which further exacerbates soil degradation. The biggest challenge currently facing the Kenyan government is how to enhance agricultural productivity so that food output can keep pace with population growth without increasing the land devoted to food crops especially maize and milk. The poverty reduction strategy paper (Republic of Kenya, 2001) reinforces this position by emphasizing increasing farm productivity as a priority of public policy in agriculture. Weak environmental management practices and the consequent soil degradation, however, hamper this.

Land degradation is common in many parts of Africa and Kenya is no exception. The proximate causes of land degradation are numerous and go against the ongoing efforts at poverty alleviation. Efforts at poverty alleviation in the less-favoured areas, especially in Africa, have failed to bring progress and development despite decades of development assistance. Growing population in combination with poor initial resource endowments, military and political conflicts, and macro-economic policies biased against agriculture have not only failed to alleviate poverty but have also led to a deterioration of the natural resource base on which the livelihoods of the rural population depends critically. It is generally accepted that development hinges on the dimensions of ecological sustainability, economic feasibility and social acceptance. Trade-offs occur between the possibilities to attain acceptable levels of these dimensions and win-win-win situations. This is especially the case in what is commonly termed less-favoured areas. These are rural areas where a number of critical development domain dimensions are unfavourable. These development domain dimensions constitute the first main issue related to sustainable development. The development domain dimensions include agricultural potential, population density, market access and institutional setting. Less-favoured areas are typically characterized by a combination of low agricultural potential and/or poor market access, and often exist in an institutional setting that is not conducive to alternative viable development pathways (Pender *et al.*, 1999).

Agricultural potential is low due to agro-climatic conditions, the quantity and quality of the natural resource base or both. Poor market access is related to the relative isolation of an area and is often linked to poor physical infrastructure. High population density depends critically on the carrying capacity of the land since in many parts of Africa this is reached at low levels of population in absolute terms. The institutional setting refers to the set of rules governing natural resources and their use.

Soil and water conservation investments can therefore not be seen in isolation from development dimensions that frame the livelihood strategies of households in a specific area. Although Land tenure can be hypothesized to play an important role, it is not the only factor, and often not even an important factor in comparison to market access and relative resource endowments in general (Bruce *et al.*, 1994). One of the key issues at stake is that access to credit in order to make the investments is often seen as a crucial issue. Access to credit may or may not be directly linked to property rights. If collateral is needed to obtain credit, secure formal property rights are necessary.

There is a growing consensus in the research community that the complex situation of less-favoured areas does not have an easy solution. In order to improve the lot of these poorest people of the world, a combination is needed of appropriate technology, an institutional setup that helps households to cope with presently existing market and government failures, and a set of policy measures that induce behaviour that leads to both increased household welfare and improved management of the natural resource base (World Bank, 2003).

It is well documented that poverty, agricultural stagnation and resource degradation are interlinked (WCED, 1987; see also Pleskovic and Stiglitz, 1997). Overgrazing and certain modes of crop cultivation are the major causes of land degradation. In the past, many households in low potential areas responded to declining land productivity by abandoning degraded pasture and cropland, and moving onto new lands. However, due to privatization of land and population pressure, shifting cultivation is no longer possible. Furthermore, where households are neither able to generate a market surplus nor fall back on markets for both agricultural produce and factors of production, they continue to use traditional production techniques leading to a vicious circle of land degradation and low productivity. Pender *et al.*, (2004) support the existence of a downward spiral of resource degradation and poverty. In their view, natural resource degradation contributes to declining agricultural productivity and reduced livelihoods options, while poverty and food insecurity in turn contribute to worsening resource degradation by households.

Available evidence further indicates that there are two overall aspects of poverty-environment nexus at the rural household level both of which are critical to a better understanding of the land degradation process in developing countries (Barbier 1999). First, poverty is not a direct cause of land 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, a situation that further perpetuates poverty.

Livelihoods in many resource poor farming and pastoral systems have therefore been sustained by land use practices that have tended to perpetuate poverty, soil erosion and other land degradation phenomena. The exogenous and endogenous factors responsible for land degradation include lack of land policies, unavailability of technology for improving the productivity of traditional food crops, unfavourable weather conditions, low levels of physical and human capital, and migration. The feedback effects among these factors lead to a vicious circle of low productivity, poverty and land degradation (Shiferaw and Holden, 2001, Barbier, 1999, Reardon and Vosti, 1995; World Bank, 1997). Pender *et al.*, (2004) also suggest that households without access to extension, market in-

formation and other services are less likely to use modern non labour inputs, leading to low production. In addition, improving farmers' access to land, assets, education and extension among others can help break the downward cycle of poverty and land degradation. Pender *et al.*, (2004) further say that poverty has many dimensions, which have different impacts on land management, productivity, and incomes. The impacts of rural poverty on land management depend on the type of poverty. Households that are poorer in terms of the ownership of physical assets are less likely to adopt land management practices and non-labour inputs and are likely to obtain lower production and incomes. Households with less livestock obtain lower crop yields. This suggests a downward cycle of low assets, low investment in land management and low income leading to continued land degradation and low assets.

In Kenya, conservation and sustainable utilization of the environment and natural resources now form an integral part of national planning and poverty reduction efforts. The Poverty Reduction Strategy Paper (PRSP) recognizes that weak environmental management, unsustainable land use practices and depletion of the natural resource base have resulted in severe land degradation, thus seriously impeding increases in agricultural productivity and must be addressed in order to check its adverse impact on poverty. In order to ensure conservation, sustainable utilization and management of the environment and natural resources, the PRSP proposes strategies that develop and enforce environmental standards, develop environmentally sustainable development indicators, strengthen local environmental NGOs as well as develop natural resource inventory and intensify research on environment. To address the PRSP concern on poor environment conservation and management, and also to inform policy, studies on determinants of conservation technologies and household welfare are a priority in time and space. This study addresses these concerns and attempts to fill in research and policy gaps identified by the PRSP. In particular, the results of the proposed study will inform land use policy and provide guidelines for poverty reducing land conservation practices.

The present study is motivated by the paucity of literature on the poverty-environment nexus in Kenya, in spite of increased concern about land degradation in developing countries. Currently, there is hardly any empirical evidence on the actual impact of land degradation on household incomes (see Tiffen *et al.*, 1994; Duraiappah *et al.*, 2000; Kabubo-Mariara 2003a,b; 2004; 2005; Kabubo-Mariara *et al.*, 2006). The study builds on these earlier works and contributes to the literature by analyzing the impact of tenure security and development domain dimensions on household welfare and soil and water conservation investments in Kenya. The study focuses on both income and non-income measures of poverty, analyzing the direct and indirect impacts of all endogenous variables. For soil and water conservation, we focus on all the key investment strategies adopted by farmers in our sample, including permanent and seasonal technologies. The study addresses the following questions: which are the main land conservation strategies adopted by households in Kenya? Which factors determine investments in soil and water conservation? Which factors determine household poverty? What is the link between tenure security and soil and water conservation and household poverty? To what extent do poverty and investment in soil and water conservation depend on development domain dimensions? Is there any link between environment and poverty?

The rest of the paper is organized as follows: Section two presents the data collection and sampling procedures. Section three and four presents the literature review and con-

ceptual framework and methodology respectively. Section five and six present the descriptive statistics and factor analysis results respectively. Section seven and eight present and discusses the empirical results on poverty and investment in soil and water conservation respectively. Section nine concludes.

2. Data Collection, Sampling Procedures and Study Site

2.1 Data collection and sampling procedures

This study is based on data collected from a self-weighting probability sample of 457 households in November and December 2004. The National Sample Survey and Evaluation Programme (NASSEP) IV of the Central Bureau of Statistics, Ministry of Planning and National Development was used as the sampling frame for the field survey. The sample survey utilized a multi-stage sample design. A mixture of purposive, stratified and random sampling methods were employed to arrive at the final sample.

The first stage in the sampling procedure involved selecting study districts. Due to financial and time constraints, we limited our study to three districts in Kenya. The criteria for choosing three districts include: (*i*) High levels of poverty, currently estimated at an average of 30%, 37% and 52% in Murang'a, Maragua and Narok districts respectively. Even then there are pockets of very severe poverty in the three districts, confirming that the available poverty measures mask a lot of inequality in the distribution of assets and income within the district (Republic of Kenya, 2003). (*ii*) Murang'a and Maragua districts are relatively over populated with an estimated population density of about 400 persons per square kilometre (see Republic of Kenya, 2000). (*iii*) The terrain of Murang'a and Maragua districts is dissected, causing problems of slides and gulley erosion. Other areas of the districts are hilly and fragile, making the land prone to degradation and landslides. (*iv*) Narok district on the other hand constitutes a contrast to the two districts of Murang'a and Maragua because of a substantially lower population density (about 24 persons per square kilometre), differentiated farming systems, diversity in terrain, rainfall, agro-ecological zones and a wider variation in land tenure security. The terrain of the district consists of rolling hills, with the ground level rising gently from the South to the North. The large plains of Mara are dotted by small hills in Ngoringori area and high hills in Loita plateau reaching the peak of 3,100m in the Mau escarpment.

The second stage involved selecting administrative divisions within each of the three districts. The selection of divisions was based on agro-ecological diversity in the districts, and was purposely designed to capture all agro-ecological zones within a district. This was important since conservation practices change with zones. In the selection process, it was therefore necessary to transpose the agro-ecological on the administrative zones in order to come up with sample divisions. This was only varied for Narok where some divisions are largely utilized for livestock and wildlife. Using this criterion, we selected two out of the four divisions in Murang'a district (Kiharu and Mathioya divisions), three out of four divisions in Maragua district (Maragua, Makuyu and Kandara divisions) and five out of eight divisions in Narok district (Osupuko, Mau, Mulot, Ololunga and Olokurto).

The third stage involved selection of locations and sub-locations, which were also based on agro-ecological diversity. A total of 15 locations were selected, 5 in Murang'a, 4 in

Maragua, and 6 in Narok district. Out of the 15 locations, 26 sub locations were selected; 6 each from Murang'a and Maragua districts and 14 from Narok district. The reason for the large number of sub locations in Narok district is due to the large size of the district and the location of clusters. The poor state of road infrastructure also determined the selection of locations in the district.

The fourth stage involved selection of sample points (clusters) from the NASSEP frame, which was based on the total number of clusters within a sub location and the number of households in each cluster. In Murang'a and Maragua districts, one cluster was selected from each of the sub locations, making a total of 6 clusters per district. In Narok, some clusters traversed different sub locations and we selected a total of 6 clusters.

In the fifth and final stage, the desired number of households was selected from the 18 clusters. To arrive at the total number of households actually visited, we took a self-weighting probability sample from each cluster in a district making a total of 457 households from the three districts. This sample comprises of 188 households from Maragua district, 151 from Murang'a district and 118 from Narok district.

Table 2.1: Distribution of sampled households by district (number)

District	Divisions	Locations	Sub Locations	Clusters/villages	Households
Murang'a	2	5	6	6	151
Maragua	3	4	6	6	188
Narok	5	6	14	6	118

In addition to collecting information from the sampled households, a community questionnaire was administered to key informants (village elders) in each of the 18 villages. The village survey collected information on product and input prices, markets and village infrastructure and was meant to supplement information collected from households.

2.2 Study area

Murang'a District

Murang'a District is one of the seven districts in Central Province (see appendix Figure 2.1 for location). It borders Nyeri District to the North, Maragua District to the South-west, Nyandarua District to the West and Kirinyaga District to the East. It lies between latitudes 0034' South and 1007' South and longitudes 360 East and 37027' East. The district has a total area of 756 Km2 (excluding the Aberdare Forest, which is 174 Km2). It has four administrative divisions namely Kiharu, Kahuro, Kangema and Mathioya. The district is predominantly an agricultural region with farm holdings, which are generally small but varying from the highland areas, the middle zone and the low areas. The land rises gradually from an altitude of 914m in the East to 3,353m above sea level along the slopes of the Aberdares to the West. The highest areas to the West have a deeply dissected topography and are well drained by several rivers. The type of topography has a high potential for agriculture.

Temperatures vary with altitude. In the Eastern lower areas the maximum annual temperatures range between 260 and 300 Celsius while the minimum annual temperatures range between 140 and 180 Celsius. In the Western area, which has mostly higher alti-

tudes, the minimum temperatures can be as low as 60 Celsius. The temperatures are moderate in the medium potential areas. There are two rainfall seasons, that is, March-May (long rains) and October-November (short rains). The high potential areas receive an average annual rainfall of between 1,400mm and 1,600mm. Within the medium potential areas, annual rainfall averages between 900mm and 1,400mm. Low potential areas receive rainfall of less than 900mm per annum. Rainfall in the high and medium potential areas is reliable and well distributed throughout the year and is adequate for cultivation. In contrast, rainfall in the low potential areas is unevenly distributed and thus unsustainable for crop production.

Variations in altitude, rainfall and temperature between the highland and lowland areas coupled with differences in the underlying geology of both volcanic and basement system rocks give rise to a variety of soil types. The highland areas have rich red volcanic soils suitable especially for tea. Coffee, maize and dairy farming is also practiced in this region. Soils in the lower areas are predominantly black cotton soils with seasonal impended drainage.

The district has a combination of both natural and exotic forests all forming the expansive Aberdares Forest, which occupies a fifth (174 Km2) of the district's total area. The population density of the district ranges from the lowest population density of 354 persons per km^2 in Kiharu which falls under the lowland areas, to the highest population density of 552 persons per km^2 in Kahuro Division which falls under the transitional zone (that is, the middle zone).

The district is prone to disasters such as landslides, drought, and famine and disease outbreaks. Landslides are due to rugged topography and steep terrain and loose soil anchorage. Because of land shortage, people have settled in the landslide prone areas. Accidents are also common due to steep terrain and poor infrastructures. Drought and famine frequently occur in the lower part of Murang'a, which is semi-arid. Shortage of land and emphasis on cash crops has also contributed to famine. To satisfy their food requirements, the local people mainly rely on food purchases from the markets mainly from the neighbouring districts. In Kiharu division, the farms are relatively large in size ranging between 2 to 7 acres but the climate is unsuitable for cash crop production. Majority of the people in this division are living below the poverty line. Mathioya division has steep hilly topography and some parts enjoy a climate suitable for tea production. Some parts of the division suffer from unfavourable climatic conditions and live below the poverty line. Average farm holdings are very small with some households occupying less than one acre of land. Crop diversification is however limited because of unsuitable weather patterns.

The district has high poverty levels with about 30% of the population estimated to be living below the poverty line (Republic of Kenya, 2003). The vulnerable groups hardest hit by poverty in the district include the women, the unemployed youth, widows and orphans, neglected retired old people, the street children and those living in the marginal areas of the district. Gender inequality is a common phenomenon in the district and is deeply rooted in the cultural and traditional values. Women in the district are disadvantaged in terms of access and ownership to resources and decision-making. Women do not own household resources and they have limited decision-making power on the use of resources. Further, women lack exposure as they do not attend development meetings

and extension services hardly reach them despite the fact they perform most of the duties at the farm level.

Maragua District

Maragua is one of the seven districts of Central Province. It was carved from Murang'a district in September 1996, and borders Murang'a district to the North, Thika District to the South, Nyandarua district to the West, Machakos district to the East and Kirinyaga and Mbeere districts to the North-East. The district lies between latitudes 0045' South and 1007' South and Longitudes 360 East and 37^{0}27' East. It has four administrative divisions namely: Maragua, Kigumo, Makuyu and Kandara.

The district rises gradually from an altitude of 1,100 metres above sea level in the East to an altitude of 2,950 metres in the Western side. The highest area in the West has deeply dissected topography and is drained by several rivers. All rivers flow from the Aberdares towards the Tana River to the East. In the upper zones of the district where topography is dissected by steep ridges, slides and gully erosion are common. Further to the West, towards the boundary of the district, ridges are too steep for any agricultural activities. The low lands East of the Aberdare range are generally suitable for both coffee and dairy farming. The less steep areas, towards the border with Thika and Machakos districts are arid and semi-arid and reliable agriculture is only feasible with irrigation.

Temperatures vary with altitude. In the Eastern lower area, the mean annual temperature ranges between 260C and 300C while in the upper areas it is between 140C and 180C. In the high altitude area, minimum temperatures can be as low as 60C. Temperatures are moderate in the medium potential areas. The district receives annual rainfall ranging from 900mm in the lower zones to 2,700 mm in the upper zones. Rainfall increases with an increase in altitude and is highly affected by the South-Easterly trade winds. There are two main growing seasons, i.e. during the long rains (mid-March and June) and the short rains (mid-October to December).

The major part of the district consists of soils of volcanic origin, composed of red loams (nitosoils), which vary from high to moderately fertile. The rest of the district comprises of shallow poorly drained soils, with some areas consisting of stony soils that are mainly sandy and black cotton soils. The forest area in the district is composed of Gatare Forest Station situated in the Eastern side of Aberdare Ranges. There is also Karura Hills Forest and Kahumbu Hills Forest in Makuyu Division. The total gazetted forest area is 10,699 hectares.

It is estimated that about 37 percent of the population in the district live below the poverty line (Republic of Kenya, 2003). Basically, the women and youth are the most vulnerable. Like in Murang'a district, gender bias is deeply rooted in the cultural and traditional values and has discriminated against women by denying them land, credit, inputs, agricultural extension and training. Furthermore, traditional division of labour overburdens women who have to spend time and energy on domestic chores such as fetching water, fuel and marketing. Similarly, the distribution of resources within a family exhibits a pro-male bias. Women constitute 52 percent of the district's population and contribute 70 -80 percent of total agricultural work done yet their involvement in the development process at various levels is minimal.

The district is vulnerable to drought, which often leads to fluctuations in food supply, making parts of the district recipients of famine relief food. Landslides are also a common occurrence on the slopes of the hills. Due to scarcity of land, many people have settled in landslide-prone areas, which are dangerous, especially during the rainy seasons.

Narok District

Narok district in Kenya is situated in the South Western tip of the country in the Rift valley province. The district lies between latitudes 00 27' and 20 South and longitude 340 35' and 360 East. It is bordered by Tanzania to the South, Nakuru to the North, South Nyanza and Kisii to the West and Kajiado to the East. The district occupies an area of over 15,087.8km2 and is divided in to eight administrative divisions. These include: Central, Olokurto and Mau divisions in Narok North and Mulot, Ololunga, Osupuko, Mara and Loita in Narok South (Republic of Kenya, 2002c).

The district has altitude ranging from 3,098m above the sea level in the highlands to 1000m above the sea level in the lowlands. Although pastoralists predominantly occupy the district, there is crop farming in the area that consists of large commercial farmers, small and medium farmers and group ranching, where much of the topsoil has been eroded away due to over grazing by the large number of livestock (Republic of Kenya 2002c). The highlands, which consist of upper Mau, Olokurto and Mulot divisions, have a high potential for wheat, barley, maize, beans and potatoes. The high potential area includes the Mau escarpment and the Suswa crater, where large-scale farmers grow high value crops such as wheat and barley and zero grazing. The lowlands cover Ololunga, Mara, Loita and Osupuku divisions, which have high potential for livestock rearing. Altitude in this area ranges from 1400-1800m above sea level and the temperature range from 50 in July to 280. The area has poor quality soils and the rains are unreliable. These lower zones also experience flooding during the long rains.

Generally the landscape of the district is characterized by rolling hills, with ground level rising gently from the South to the North. The large plains of Mara are dotted by small hills in Ngoringori area and high hills in Loita plateau reaching the peak of 3100m in the Mau escarpment. Permanent and seasonal rivers originating from the Mau escarpment drain the district. Mara River, which is the longest, flows southwards into Tanzania and eastwards in to Lake Victoria.

The areas originally covered with thick forests have now been cleared for the cultivation of wheat and other commercial crops. The heavy presence of squatters in the district is a potential area of conflict and a cause of poverty. Due to the increased number of squatters, most of them have settled in areas with fragile ecological base and water catchment areas. This has resulted in massive destruction of the forest cover, environmental degradation and overcrowding in urban centres.

The lowland, which forms about 70% of the district, is mostly affected by the drought. Drought also exacerbates the wildlife human conflict as they both compete over scarce resources like water and grasslands. In Narok district, drought compels wild animals to move out of the Mara Game reserve to search for water and grass outside the park, thus causing massive destruction to properties and human life.

Poverty affects the lives of many people in the district. Approximately 52% people of the district's total population live below the poverty line (Republic of Kenya, 2003); and 70% of these are women without significant sources of income. High levels of poverty in the district are caused by lack of employment, moranism (young men graduating to Maasai warriors) and forced marriages. In the district, rural women provide 75% of agricultural labour force, yet they only control and have access to 40% of the accruing benefits. Women are at the forefront in water projects, where they contribute through laying of pipes, rock catchments and spring projection. They also do a lot of soil conservation works. Women in the district also attend Bazaas (meetings) more than men and yet they take few positions in leadership. This is due to culture, which prohibits women to rise to leadership positions.

3. Literature and theoretical background

3.1 Introduction

This chapter discusses literature on a number of concepts and issues that are particularly relevant for our study. We start by recognizing that sustainable development depends on the dimensions of ecological sustainability, economic feasibility and social acceptance. In any less-favoured rural areas at least one of the dimensions dominates. In practice, these dimensions are usually reflected in four development domain dimensions, agro-ecological potential, population density, market access, and institutional setting. The development dimensions have important implications for the poverty-environment nexus and also on adoption and levels of soil and water conservation. In the literature presented below, we first focus on development domain dimensions in Section 3.2. We then discuss the different concepts of property or land rights in Section 3.3. In Section 3.4, we summarize the findings in the literature on the impact of tenure security on soil and water conservation (SWC) investments. Section 3.5 discusses poverty-environment nexus in a broader perspective including the causality issue and the distinction between chronic and transitional poverty. Section 3.6 focuses attention on the resource dependency of households with a summary of the literature that deals with the question to what extent poor households depend on natural resources more so common pool resources to supplement their incomes. Section 3.7 concludes.

3.2 Development domain dimensions

It is generally accepted that sustainable development hinges on the dimensions of ecological sustainability, economic feasibility and social acceptance. Trade-offs occur between the possibilities to attain acceptable levels of these dimensions and win-win-win situations (scenarios where household welfare, agro-ecological sustainability and social acceptance go hand in hand) are more the exception than the rule. This is especially the case in what is commonly termed less-favoured areas. These are rural areas where a number of so-called critical development domain dimensions are unfavourable. These development domain dimensions constitute the first main issue related to sustainable development (Pender *et al.*, 1999). The development domain dimensions include agricultural potential, population density, market access and the institutional setting. Less-favoured areas are typically characterized by a combination of low agricultural potential or poor market access, and often exist in an institutional setting that is not conducive to

alternative viable development pathways. Agricultural potential is low due to agro-climatic conditions, low quantity and quality of the natural resource base, or both. Poor market access is related to the relative isolation of an area and is often linked to poor physical infrastructure. High population density depends critically on the carrying capacity of the land, since in many parts of Africa this is reached at low levels of population in absolute terms. The institutional setting including land tenure arrangements refers to the set of rules governing natural resources and their use.

A second issue that plays an important role in sustainable development is the time frame. Processes that affect ecological sustainability tend to have long-term dimensions and implications, while economic feasibility and social acceptance have a much shorter time horizon. This is especially true in poverty-stricken areas where the rate of real time preference (subjective discount rate) is (extremely) high.

Soil and water conservation (SWC) investments can therefore not be seen in isolation from development domain dimensions that frame the livelihood strategies of households in a specific area. Although land tenure can be hypothesised to play an important role, it is not the only factor, and often not even an important factor in comparison with market access and relative resource endowments in general (Bruce *et al.*, 1994). In addition, access to credit is often seen as the key issue at stake in order to make investments, although access to credit may or may not be directly linked to property rights. If collateral is needed to obtain credit, secure formal property rights are necessary.

3.3 Property rights

The notion of land tenure is closely linked to property rights. Property rights are commonly seen as bundles of rights instead of just a single right. Von Benda-Beckmann (2001) distinguishes between categorical and concretised rights. Categorical rights are "typified legal concepts that construct a general relationship of rights and options between categories of persons or groups with respect to categories of resources" (ibid, p. 299). Examples are constructs such as ownership and inheritance rights. Concretised rights deal with the rights relationship of actual persons or groups and a resource.

Besides this distinction, Schlager and Ostrom (1992) distinguish between different rights aspects. Property rights are a bundle of rights pertaining to some goods or income streams. They are the entitlements to undertake exploitative activities, management and to alienate the resource. The existence of effective property rights –requiring, prohibiting or permitting certain actions– implies their respect by other agents (e.g. the right of exclusive exploitation of a resource entails the acceptance by the other agents of their exclusion). The rules governing property rights can be divided into operational level and collective choice. The former relates to the possibility to access and withdraw from the resource; the latter relates to the possibility to change management rules, exclusion rights and alienation rights (Schlager and Ostrom, 1992).

At the lowest level, Schlager and Ostrom (1992) define access rights; which means that a person or group is allowed physical access to a resource, in our case land. The next right is the right of usufruct, implying the right to extract certain or all proceeds from the resource. In agriculture, this is a very important right since it justifies the allocation of other scarce resources to production oriented land use activities. We distinguish management rights from usufruct rights. Management rights relate to the long-term manage-

ment of the resource itself not to the extraction of the proceeds. Often it is impossible to distinguish between the two, since extraction technology and land management practices are interwoven (even in terms of semantics). However, there are cases in which a third party has a say in the way the land is managed. Exclusion rights refer to the possibility of determining who is and who is not allowed to access, extraction rights and management rights. Finally the highest level of rights refers to "ownership" or in other words the right to alienate the resource (sell the land, give it away, etc.).

Within this framework we can distinguish between sub-levels. For instance, alienation rights may be limited to inheritance (within a lineage) or may consist of full-fledged private property in the liberal capitalist sense. Management rights may be constrained by formal and informal rules.

Besides the content of the rights, there are two other important characteristics of the rights, namely duration and assurance of the rights. Duration of rights is the time horizon over which the rights are defined. The relationship between property rights and the utilisation of land resources is determined by the time horizon of the property holders. The time horizon depends on the subjective time preference of the rights holders and on the perception of the duration of the rights at stake. This can be a finite period or an indefinite time-span. The assurance refers to the perception of how certain it is that the rights holder can ascertain those rights during the period over which the rights are defined.

Duration and assurance are part and parcel of the institutional arrangement surrounding property rights. Institutional arrangements can be defined as the formal rules and informal constraints governing the interactions between individuals and/or groups and the means to enforce those rules (North, 1990). Note that institutional arrangements are often embedded in both statutory and customary law. These two legal frameworks may not be completely compatible which might lead to uncertainty about the applicability of rules. This is one source of uncertainty surrounding property rights. In the process of land reform, people are confronted with changing rules and a feeling of uncertainty even if the new rules will be stable.

The institutions themselves shape the process of updating the expectations with regard to the rules of the game according to actual experience. Hence, the natural dynamics of institutions is a process of gradual adaptation to changing circumstances. This process follows different speeds. Some institutional arrangements are deeply embedded in culture and tend to change only very slowly, while others evolve more quickly, (see Williamson, 2000 for a detailed discussion on this issue).

The common hypothesis is that institutions matter when talking about poverty reduction and resource conservation (Barrett *et al.*, 2004). If there is uncertainty or lack of information about property rights and the way they are enforced, this can give rise to conflicts over those resources that are detrimental for their conservation, (see for instance Haro *et al.* 2005; Amman and Duraiappah 2004; and Kabubo-Mariara 2004). The key issue is that it does not really matter which rules are adopted by a community or country, rather it does matters how well they are embedded and how well they are enforced (Barret *et al.*, 2004).

3.4 Empirical evidence

If property rights are both durable and assured, this could lead to increased investment due to two effects. The first is that the household perceives greater security of receiving the full benefits of long-term investments in land improvement; the second is that secure land rights may help in obtaining investment loans from potential lenders (Besley, 1995, see also Jacoby *et al.*, 2002). It is however difficult to separate out the two effects. A substantial part of the theoretical literature advocates for privatisation of land based on the premise that farmer's incentives to invest in technologies are inhibited by weak tenure security arising from indigenous property right institutions and by lack of land titles hindering their capacity to obtain credit to make investments (Shiferaw and Holden, 1999; Kabubo-Mariara, 2004). However, well-defined durable and assure property rights may be a necessary, but not a sufficient condition to have access to finance (Lopez, 1997; Carter and Olinto, 2003).

From the literature, we can derive three reasons why secure land tenure might lead to more willingness to invest in SWC measures. The first is the original idea that if farmers feel more secure in their right or ability to use their land in the long-run and they will be more willing to make investments that take a longer period to repay-high sunk costs (Demsetz, 1967; Ault and Rutman, 1979; Feder *et al.*, 1988; Binswanger *et al.*, 1995; Zimmerman and Carter, 1999; Shiferaw and Holden 1999; Place and Otsuka, 2000; Place and Swallow, 2000; Gebremedhin and Swinton, 2003; Deininger and Jin, 2002; Li *et al.*, 1998; Jacoby *et al.*, 2002). The second reason is that if land markets exist and farmers can easily sell their land, the added value of SWC investments can be made liquid, and hence the return to those investments can be realized without having to wait the full length of gestation period of the investment. This is an important consideration when time horizons are relatively short, as in the case of myopic time preferences (Besley, 1995; Platteau, 1996). The third reason is the collateral effect that states that if farmers have more secure land titles; it will be easier for them to use their land as collateral to get access to the necessary credit in order to do SWC investments. This is an important issue with formal credit when there is asymmetric information about borrowers and repayment.

In contrast, an alternative strand of literature claims that land tenure insecurity might also lead to more investment in land quality. Through land improvement, farmers expect to improve their rights on a plot of land. This is often linked to very specific types of investment, such as tree planting for instance (e.g. Bruce, 1988; Place and Hazell, 1993; Sjaastad and Bromley, 1997; Brasselle *et al.*, 2002; Otsuka *et al.*, 2003). Finally, there are also studies that have shown that tenure security is not important for land conservation (Migot-Adholla *et al.*, 1991, 1994; Place and Hazell, 1993; Pinckney and Kimuyu, 1994), or that highly individualized rights to land are more important for long-term rather than short-term investments (Place and Otsuka, 2000, Place and Swallow, 2000, Gebremedhin and Swinton, 2003).

The major reason for different findings is the definition of land rights and methodological approaches employed. In terms of definition, most studies focus on security of tenure rather than transferability. Many studies use binary dummies to capture security in terms of having a land title (see for instance Roth *et al.*, 1994a, 1994b; Pinckney and Kimuyu, 1994; Migot-Adholla *et al.*, 1994; Shiferaw and Holden, 1999; Place and Otsuka, 2002),

while Gebremedhin and Swinton (2003) take a continuum of expected rights. Brasselle *et al.* (2002), Otsuka *et al.* (2003) and Gavian and Fafchamps (1996) have focused on the mode of land acquisition, such as purchase, borrow, or gift. To overcome this arbitrariness in choice of indicators of tenure security, Kruseman *et al.* (2006) suggest the use factor analysis to derive measures of tenure arrangements from the existing information on various aspects of security.

In addition to the challenges in defining and measuring property rights and tenure security, there are a number of difficult theoretical and empirical issues involved in such studies, particularly in defining technology, identifying key dimensions of property rights and accounting for the endogenous determination of property rights. A number of studies (Besley, 1995; Brasselle *et al.*, 2002; Jacoby *et al.*, 2002) have treated property rights as endogenous following Boserup (1965), while other studies have argued that property rights could indeed be exogenous (Udry, 2003; Platteau, 1996, 2000; Goldstein and Udry 2002; Quisumbing *et al.*, 2001; Place and Otsuka, 2000; Kabubo-Mariara, 2005). A third issue is that researchers have different reasons for undertaking studies of the relationship between property rights and technology adoption and each reason may have different implications on methodology.

Following the seminal work of Feder *et al.* (1988), a large body of field studies have come to light on the impact of different land tenure arrangements on input use, labour allocation and investment decisions in Sub Saharan Africa, along with studies in other areas in the developing world. The empirical evidence for the economic logic that predicts productivity gains from increased tenure security is however, rather mixed. Many studies in Sub Saharan Africa show relationship between land-tenure security measured in terms of land titles and productivity gains (Migot-Adholla *et al.*, 1991; Roth *et al.*, 1994b). Other studies find positive effects that disappear when controlling for other factors of the development domain dimensions, especially farm size, and market access (Roth *et al.*, 1994b; Bruce *et al.*, 1994). Sometimes it is an inter-linked connection where tenure and wealth are jointly responsible for more investments in SWC (Smith, 2004).

Another important aspect of tenure security is with respect to gender. Women are the main managers of natural resources as they work on and, gather wood and collect water. They also act as repositories of indigenous knowledge (Juma and Ojwang 1996). Lack of secure access to, limited ownership and control over land has resulted in socially inferior and economically impoverished status of women in most African societies.

3.5 Poverty-environment nexus

Although different frameworks have been proposed and utilized to analyze the poverty environment nexus, there is no general consensus on the causal relationship between the two. Two schools of thought seem to dominate the literature. On one hand, environmental degradation is argued to lead to low productivity and poverty, which seems to be the most widely discussed paradigm in the literature (Ligthelm and Wilsenach, 1993; Pinstrup-Anderson and Pandya-Lorch, 1994; Deininger and Minten, 1999; Reardon and Vosti, 1995). On the other hand, Jalal (1993) and Barbier (1999) argue that poverty leads to environmental degradation, which then leads to low productivity and poverty.

However most studies concur that no matter the direction of causation, the link between poverty and environment is determined by a set of conditioning factors. These include

demographic, market and other institutional and social failures, poverty in assets, and property right structures (Duraiappah, 1998; Pinstrup-Anderson and Pandya-Lorch, 1994; Deininger and Minten, 1999; Reardon and Vosti, 1995; Barbier and Lopez, 1998; Gavian and Fafchamps 1996; Lopez *et al.*, 1995; Norton, 1998; Mink 1993; Pender and Kerr 1998; Pender *et al.*, 2004). Policy has also been shown to be important in influencing the nexus. Barbier, (1999) demonstrates how policy analysis can be effective in highlighting key dimensions of the poverty-environment linkages and how both good and bad policies can affect the economic incentives determining poor rural household's decisions to conserve or degrade their land.

Ekbom and Bojö (1999) summarize the above arguments in five major hypotheses linking poverty and the environment. The first hypothesis states that poor people are the main victims of environmental degradation. The authors argue that the poor live in ecologically vulnerable areas and lack the resources to relocate from such areas and to adopt defensive measures against negative exposure and are therefore more vulnerable to loss of biological resources. The second hypothesis states that the poor are agents of environmental degradation, through shorter time horizons and higher risk-aversion and discount rates. The third hypothesis states that higher income households reduce pressure on the environmental. Whereas poverty increases pressure on local natural resources, high-income earners tend to put relatively less stress on the national and global environment as evidenced by "Environmental Kuznets Curve". The fourth hypothesis states that population pressure exacerbates both poverty and environmental degradation. However, the authors note that though population growth plays a crucial role in determining the quality and stock of natural capital, it is not the root cause of environmental degradation in many instances. The last hypothesis states that incomplete property rights reinforce the vicious poverty-environment circle, but this aspect has not received much attention empirically (see Deininger and Minten, 1999).

Chronic versus transitional poverty

Though there are an increasing number of studies that focus on the poverty environment link, differences exist in the definition and measurement of both poverty and the environment. Some studies for instance proxy environmental degradation by declining productivity, while most studies measure degradation through quality of natural resources. In poverty measurements, it is important to distinguish between chronic and transitory poverty, but this is rarely the case in empirical. Most studies focus on transitory measures of poverty due to difficulties of measuring chronic poverty (Carter and Barrett, 2006).

Chronic poverty is poverty that persists for extended periods of time or through out a life-course and that may be transmitted across generations (Hulme and Shepherd, 2003; Aliber, 2003; Okidi and Mackay, 2003). This is the type of poverty that is most difficult to escape compared to transient poverty. Chronic poverty could be in terms of income/consumption, assets or capabilities such as health and education (Hulme and Shepherd, 2003). Chronic poverty could also be viewed as occurring when there is significant capability deprivations for periods of more than five years, because the longer the period one is deprived, the higher the probability of remaining poor and therefore vulnerable (Hulme, 2003; Harper *et al.*, 2003). Closely related to chronic poverty is vulnerability- the risk that a household will suddenly reach a position with which it is un-

able to cope i.e. poor people with a likelihood of experiencing highly stressful declines in income, consumption or capabilities. Households with assets are more likely to be able to cope with shocks and vulnerability than households without assets (Hulme and Shepherd, 2003).

In contrast, transitory poverty is more short term and is associated with low ability to insure households against fluctuations due to either external factors such as prices and other household level shocks. Transient poverty may also be associated with relatively low levels of asset holding (Mackay and Lawson, 2003). While income and consumption are better suited to study transient poverty (in the absence of panel income data to study poverty dynamics), chronic poverty requires multidimensional measures of poverty, such as nutrition and education. Alternatively adoption of capital or assets based analytical frameworks can help to deepen analysis beyond income and consumption, because assets and capital partly determine future income potential and also possibilities of bounce back from shocks. Repeated cross-sectional surveys may also be used to measure chronic poverty (Mackay and Lawson, 2003; Hulme, 2003; see also Barrett *et al.*, 2006; Carter and Barrett, 2006).

Though is it quite difficult to clearly distinguish between transient and chronic poverty, previous studies have used two key approaches: the spells and components approaches. In the spells approach, the chronic poor are identified based on the number or length of spells of poverty they experience. Households that experience relatively short spells may be seen as transitory poor while those experiencing long spells may be classified as chronic poor. In the components approach, a distinction is made between the permanent components of a household's income/consumption from the transitory variations. The chronic poor are then identified as those whose permanent component is below the poverty line, even if the household fluctuates in and out of poverty (Jalan and Ravallion, 1998; Bird and Shepherd, 2003)

The literature identifies several socio economic groups that are most likely to be chronic poor: the aged, children and widows, female headed households, marginalized groups (nomads and pastoralists), persons with health problems or disabilities, persons living in conflict zones, the uneducated and large households. Others include households with low asset holdings, rural and agricultural households, migrant workers, households affected by HIV/AIDS and chronic illness of main income earner. Occupation of the household head, retrenchment, homelessness and prevalence of shocks are also correlated with chronic poverty (Bird and Shephard, 2003; Jalan and Ravallion; 1998, 2000; Mckay and Lawson, 2003; Aliber, 2003). However, the literature concurs that the determinants of chronic and transient poverty are the same, only that some factors are more important for one type than for the other. For instance, ownership of physical assets including livestock increase the likelihood of a household exiting from poverty and so households with low asset holdings are likely to be chronic poor. It is therefore important to distinguish between chronic and transient poverty for the purpose of policy focus and targeting.

3.6 Resource dependency

Within the poverty-environment nexus, one important aspect is the question how and to what extent a rural household depends on common pool natural resources (CPNRs) in their daily livelihoods. CPNRs are often freely available or managed at the community

level, and the exploration (or degradation) of these CPNRs depends largely on the frequency/intensity of use by households. The use of CPNRs depends on many factors, and in the literature there are two perspectives on categorizing of these factors.

From a micro-economic point of view, Cavendish (2000) summarizes the different uses of goods extracted from CPNRs: consumption goods (fuel wood), consumer durables (furniture), production inputs (grass form pastures for livestock, organic manure, or marketable products), inputs into productive capital (wood for farm equipment) and assets (construction of a house). The utilization of these extracted goods depend on various factors, such as the household's spatial location, the opportunity cost of labour (i.e. loss of agricultural production due to collecting forest products or water, for instance), relative price of environmental goods (resource scarcity), other sources of household income, and agricultural productivity (Cavendish 2000).

In a broader perspective, Angelsen and Wunder (2003) distinguish five dimensions in which poor people benefit from forests and forest products: the type of beneficiaries, types of forest products and services provided, the role of forest benefits within the households strategy (subsistence versus commercial use), type of natural resource management (ranging from pure natural forest extraction to (re)planted forests, and high or low return products. These dimensions might be different for other CPNRs, such as pastures or grasslands, and water resources (drinking water, irrigation water or water for livestock). In addition to the studies by Cavendish (2000) and Angelsen and Wunder (2003), Heltberg (2001) mentions the presence of local institutions. He argues that local institutions managing CPNRs contribute positively to the conservation of CPNRs, but their impacts are often insufficient to safeguard CPNRs from further environmental degradation. But as Duraiappah (1998) mentions in his review of the poverty-environment nexus, targeting policy for poverty alleviation and environmental policy simultaneously is very case specific. In addition, Kuik (2004) argues that the case-specific character of the question on how and to what extent rural households rely on common pool natural resources is an empirical question.

In some empirical studies, the relationship between resource dependency and household income is considered (see for instance Cavendish. 2000; Adhikari, 2005; and Narian *et al.*, 2005). Cavendish (2000) argues that actual household income is usually underestimated, because household income measurements usually omit benefits generated from freely extracted goods and services from common pool natural resources. In a study for Zimbabwe, for instance, Cavendish shows that the incorporation of environmental income in household accounts results in significant reductions in measured poverty of 50% compared to conventionally measured income. Moreover, the inclusion of environmental income also reduces measured inequality with roughly 30%. Since environmental income sources are entry free, rural households disproportionately undertake the extraction of products from CPNRs, which has low returns. Hence, Cavendish concludes that the extraction of products from CPNRs plays a little role in helping households overcome accumulation constraints that impede the household from raising its income significantly.

Until recently, many studies in the literature on resource dependency suggested that poor household depended more on natural resources than rich households, although the total amount of resources used by rich households was found to be larger than for poor house-

holds, (Cavendish, 2000). This suggests that comparative affluence rather than comparative poverty could be the main issue of concern. Based on evidence from Nepal, however, Adhikari (2005) suggests that the contribution of forests to net household income follows an inverted U shaped curve, i.e. resource dependency declines after a threshold value of income. Furthermore, based on a study of forest dependency in rural India, Narian *et al.* (2005) argue that the relationship between resource use and the wealth of households is more complicated. In particular, for households that extract positive amounts of the CPNRs, the dependency follows a U-shaped relationship with income. Furthermore, the probability of being a CPR user follows an inverted U-shaped relationship with income. As a consequence, rich household show either high or low resource dependency.

In resource scarce areas, resource dependency is often not directly linked to income sources. However, the lack of CPNRs can induce the search for substitutes and the reallocation of labour inputs by farm households. In a study of four different villages in central Malawi, Brouwer *et al.* (1997) showed that with increasing distance to woodlots, household members initially collected at greater distances. But when distance to woodlots increased beyond a certain point, they collected alternative resources (such as twigs) from nearby places, often switching over to lower quality wood. Moreover, the study showed that the time spent on collecting fuel wood depends upon household's labour allocation: larger households and households with more adult females tended to collect fuel wood more frequently and at greater distances.

3.7 Overview of literature

In this Chapter, we have discussed some of the relevant concepts and issues relating to poverty, the environment and land tenure systems. Given the notion that history matters, we can assume the existence of co-evolutionary processes of key state variables. These state variables are the environment, institutions (constellation of property rights arrangements) and technology, which are subject to pressures related to the development domain dimensions. Population growth is a fairly autonomous process that increases pressure on natural resources. On-going globalisation with macro-economic effects in terms of liberalisation and structural adjustment and with its local impacts in terms of market access, changes in service provision, and development of rural infrastructure affects, the relative profitability of SWC investments. Every day new technological innovations are introduced and appropriate ones adapted to local circumstances are adopted. Technology development and the process of technology adaptation cannot be seen in isolation from the other pressures. The institution of property rights arrangements related to agricultural lands is also subject to evolution, partly as a result of changing formal rules regarding land tenure and sustainable land management, partly as a result of endogenous processes of co-evolution.

The literature reviewed above shows that development dimensions have important implications for the poverty-environment nexus and also on adoption and levels of soil and water conservation. This paper contributes to the existing literature by analyzing the impact of four development domain dimensions (agro-ecological potential, population density, market access and institutional setting) as well as household characteristics on household welfare and investment in soil and water conservation. The most important dimension of institutional setting in this context is land tenure. The literature review

shows that there is often arbitrariness in choice of indicators of tenure security due to challenges of defining and measuring property rights and tenure security and also in identifying key dimensions of property rights. In this study, we collected data on all aspects of land rights - ranging from access to duration of ownership - on both actual and expected land rights, and on modes of acquisition. We then used factor analysis to generate indicators of tenure security variables in order to overcome arbitrariness in choice of indicators.

The literature further indicates that many studies do not distinguish between chronic and transitory definitions of poverty. Most studies on poverty have concentrated on transitory measures because of lack of appropriate data to study chronic dimensions. Previous studies distinguish between the spells and components approaches to the study of chronic versus transient poverty. In this study, the data available does not allow us to clearly distinguish between chronic and transitory poverty. However, based on the components approach, the paper analyses asset poverty (livestock wealth) as an additional measure of poverty. The argument is that assets are a better measure of long-term household welfare than either current expenditures or incomes. Linking asset welfare with tenure security and investment in SWC is an important contribution of this study to the literature.

The final aspect of the literature review focuses on resource dependence of poor households. Although the issue of resource dependence is an important aspect of the poverty-environment nexus, the present study focuses attention on environmental concerns and poverty alleviation with respect to privately owned farmland where households barely depend on CPNRs. The data collected on resource dependency in this study was too scanty to do any meaningful analysis. Since resource dependence is particularly important for forest dependent communities, we propose to address this issue in future research.

4. Conceptual framework and methodology

4.1 Conceptual framework

Over the last two decades a consensus has been reached on the way economists analyze agricultural household behaviour. The basic concept is the agricultural household model, where an agricultural household is assumed to engage in activities using their scarce resources in order to attain their goals and aspirations taking into account that they are constrained by external environmental and socio-economic circumstances.

The model can be summarized in a number of basic equations that are a slight expansion of the original model (Singh *et al.*, 1986). The first equation is the utility function where u denotes utility and c a vector of consumption goods and l denotes leisure, ξ denotes household characteristics, F_n denotes the cumulative distribution function of states of nature that captures the inherent risk and uncertainty of rural livelihood systems in terms of prices, weather and in some cases tenure (see for instance Kruseman, 2000; 2001). The inclusion of SWC technology implies a longer time horizon, which requires the inclusion of a subjective time preference as discount rate r comparable to the general formulation of optimal control models (Bulte and van Soest, 1999). Suppressing time and nature subscripts (as in all following equations), the utility function is:

$$u = \int\int u(c,l,\xi)e^{-rt}\,dt\,dF \tag{1}$$

Utility is maximized subject to a cash income constraint where c^m and c^a are vectors of market purchased and household produced consumption commodities, q is a vector of commodities produced by the household, p^m and p^a are vectors of market and farm-gate commodity prices respectively, p^b is a vector of input prices related to material inputs x, w^i and w^o are vectors of factor prices (including wage rates and land rents) for hiring in or renting out production factors (f^i and f^o respectively), and y^* is exogenous income:

$$p^m c^m = p^a\left(q - c^a\right) - p^b x - w^i f^i + w^o f^o + y^* \tag{2}$$

The household faces a set of resource constraints that specify that the household cannot allocate more resources to activities than is available in terms of total stock f^T:

$$f^o + f^a \le f^T \quad \text{for all factors} \tag{3}$$

Note that for labour there is an additional component of leisure

$$f_L^o + f_L^a + l = f_L^T \tag{3a}$$

The household faces a production constraint reflected by a technology function that depicts the relationship between inputs (x, f^i, f^a) and outputs (q) conditional on farm characteristics ζ, soil quality s and technology level τ:

$$q = q(x, f^i + f^a, \zeta, \tau, s) \tag{4}$$

Solving the agricultural household model can be done in a number of ways: the first is to estimate the full structure of the model, by estimating each equation separately and then using the quantified model to simulate responses as commonly done in bio-economic modelling (see Kruseman and Ruben, 1996; Kruseman and Bade, 1998; Kruseman, 2000).

The alternative is to estimate reduced form equations of the household model. Using reduced form equations is traditionally considered the most appropriate way of dealing with these types of complexities. The coefficients in the reduced form equations capture the sum of both direct and indirect effects. Because of this characteristic it is imperative to include all relevant explanatory variables in the analysis, even if their coefficients are insignificant for the analysis being undertaken. This approach however deserves some attention. If we derive the first-order conditions for the agricultural household model and meticulously combine and collapse the resulting equations the end result is a system of equations where the dependent variables consist of the choice variables of the household (production structure, investment, consumption, resource allocation) and on the right-hand side all the exogenous factors (household characteristics, farm characteristics, institutional characteristics). However, we have to be very careful about causality and attribution in the inter-temporal context.

The equations that capture these decision processes include quasi-fixed inputs and determinants of wealth. The problem is however, that past decisions that lead to current wealth and already available SWC structures are based, in principle, on the same set of

independent variables. Total cumulative investment and wealth are part of a set of inter-temporal dependent variables. This inter-temporal aspect is something that is often not taken fully into account.

4.2 Modelling household welfare

One principal goal of this paper is to analyze the impact of tenure security and land conservation investments on household welfare. According to economic theory, households faced with uncertain outcomes with respect to income streams will diversify their portfolio of activities in order to ameliorate the threat to its welfare by the failure of individual activities. The overriding objective of the household will therefore be to maximize its welfare. Closely related to welfare is vulnerability, which is related to the activities and investment decisions that a household will take. Insecurity of land tenure for example, adds to vulnerability and will determine how much investment a household can undertake on the farm (Ellis 2000).

In addition to the farm household model (Singh *et al.*, 1986; Sadoulet and de Janvry, 1995), household welfare analysis is founded on the standard economic theory of consumer behaviour (Deaton and Muellbauer, 1980; Glewwe, 1991). Because household welfare is unobservable, consumption expenditure can be used as a proxy for welfare. The expenditure variable can however be scaled down as desired to take into consideration differences such as household size, so that the dependent variable collapses into per capita rather than absolute expenditure. This allows for comparison of welfare levels across households with different composition and across regions with different prices.

Standard farm household theory, however, postulates that farm households in developing countries often show behaviour that indicates that consumption and production decisions are non-separable. The difficulty of estimating the underlying structural relationships and the complexity of the interacting components of the farm household, and the problem of unobservable or non-measurable key variables, imply that there are serious consequences for econometric estimation of empirical models (Kruseman, 2001).

To explain household welfare, we can therefore estimate a reduced form model of per capita expenditure or income combining all the various structural relationships, which affect welfare. For policy analysis it is important to include variables influenced by government actions. We therefore include a vector of standard explanatory variables (see for instance, Glewwe, 1991). These include household characteristics, farm characteristics and institutional variables. Using the survey data we examine the correlation that exists between welfare, resource conservation, land tenure security and land quality. To find out if there is a relationship between the endogenous variable related to welfare and resource conservation beyond the relationship between the exogenous variables that determine both issues, we use analysis of the regression model residuals. The residuals enter into the final model as error correction terms (ECM) and there eliminates any bias that could arise from inter-relationship between these endogenous variables and welfare.

The basic model that we want to estimate is a generalized reduced form equation, which is expressed as:

$$Y = f(\zeta, \xi, \upsilon) + \varepsilon \tag{5}$$

Where Y is per capita expenditure or any other measure of welfare; ζ is a vector of farm characteristics, including land tenure arrangements surrounding the arable land and the asset base of the household; ξ is a vector of household characteristics and υ is a vector of village characteristics, including development domain dimensions and quantifiable institutional arrangements at village level. The regression coefficients capture the sum of direct and indirect effects of the truly independent variables on household choice variables. Our deviation from standard poverty analysis is to introduce institutional factors and SWC investment variables into the welfare model (see Figure 4.1). The institutional factors such as the presence of special interest groups and extension agencies, and the choice of SWC investments are (partly) endogenous determinants and they have to be explained themselves. In particular, the presence of interest groups and the willingness to listen to extension agents affect the willingness to invest. In order to disentangle partly endogenous effects we use a step-wise estimation approach.

Institutional factors are indicators of how well households/villages organize themselves to enhance household welfare. To capture the impact of the membership of the household in special interest groups/village institutions (p_{m_grpi}), we use the following probability model.

$$p^*_{m\_grp(i)} = f(\zeta, \xi, v) + \varepsilon_{m\_grp(i)} \tag{6}$$

$$\text{with } p^*_{m\_grp(i)} > 0 \text{ if } p_{m\_grp(i)}=1 \text{ and } p^*_{m\_grp(i)} \leq 0 \text{ if } p_{m\_grp(i)}=0.$$

We specify equation (6) for three (i=3) different interest groups: membership in income generating groups, loans groups and benevolent groups. By definition, the expected probability for membership if there is no organization present is zero. We therefore estimate a series of probit models on membership based on equation (6).

In addition, we are interested in analyzing the impact of extension services on household welfare. However, we do not have direct information on the presence of natural resource management (NRM) extension possibilities at village level. What we do have is information on whether households use extension for a variety of purposes. Even though we have information on specific NRM extension, information may have been supplied through other extension sources without the household realizing this. Therefore, we distinguish between the willingness to listen to extension services in general (*ex_yn*) and the willingness to listen to extension in NRM (*ex_NRM*). Both are explained by similar probability models including the exact same explanatory variables as in equation (6), i.e.:

$$p_{ex\_yn} = f(\zeta, \xi, v) + \varepsilon_{ex\_yn} \tag{7}$$

$$\text{with } p^*_{ex\_yn} > 0 \text{ if } p_{ex\_yn}=1 \text{ and } p^*_{ex\_yn} \leq 0 \text{ if } p_{ex\_yn}=0.$$

and

$$p_{ex\_NRM} = f(\zeta, \xi, v) + \varepsilon_{ex\_NRM} \tag{8}$$

$$\text{with } p^*_{ex\_NRM} > 0 \text{ if } p_{ex\_NRM}=1 \text{ and } p^*_{ex\_NRM} \leq 0 \text{ if } p_{ex\_NRM}=0.$$

The willingness to invest in NRM at household level (p_{I_hh}) depends on household, farm and village characteristics. The willingness to invest is taken for investments made up to five years ago. If the household made no investments in the past 5 years the investment

is set to zero. Past investments ($\delta_{\xi EvNRM}$) are SWC investments made more than 5 years ago. Next to the common determinant, the willingness to invest depends on the willingness to listen to NRM extension, and the willingness to listen to extension in general as well as the awareness of the presence and membership of NRM and other special interest groups. However, since these variables are endogenous, we need to apply a nested methodology for capturing these variables. We can then use the residual terms of each of the equations (membership in each of the three interest groups, probability of listening to extension services and probability of listening to extension in NRM) as explanatory variables in the willingness to invest equation. The reason for using these residual terms for estimating the endogenous variables is that the terms are orthogonal to the other independent variables in the equation at hand[1]. The truly independent variables still capture the sum of the direct and indirect effects, while the residual terms capture the effect of the endogenous variable.

The willingness to invest at household level then becomes:

$$p_{I\_hh} = f(\zeta, \xi, v, p^{\varepsilon}_{m\_grpi}, p^{\varepsilon}_{ex\_yn}, p^{\varepsilon}_{ex\_NRM}, \delta_{\xi EvNRM}) + \varepsilon_{I\_hh} \quad (9)$$

$$\text{with } p^{*}_{I\_hh} > 0 \text{ if } p_{I\_hh}=1 \text{ and } p^{*}_{I\_hh} \leq 0 \text{ if } p_{I\_hh}=0,$$

where the superscript ε over a variable denotes that the variable is a residual. However, we note that the equations deriving the residuals are a set of identical equations. In principal membership in special interest groups and willingness to listen to extension services (including extension in NRM) are related and therefore we should correct for correlation of variances. However application of methods such as seemingly unrelated regression (SUR) cannot be applied with probit models. We can however find a common variance factor by applying a factor analysis on the residuals of each of the probit results for each equation. Since all observations are present in all equations and the set of exogenous explanatory variables of each model is identical, the residuals are uncorrelated with the set of explanatory variables. The un-rotated factors with eigenvalues greater than 1.0 provide us with a measure of common variance. This can be included in the final estimation model of the willingness to invest in SWC. In the empirical analysis, the factor analysis loads on two factors, willingness to listen to extension in general and membership in special interest groups in general. These two factors are then used in the final estimating model of the willingness to invest at the household level. Equation (9) therefore becomes

$$p_{I\_hh} = f(\zeta, \xi, v, \varphi_{ext}, \varphi_{m\_grp}) + \varepsilon_{\varphi\_hh} \quad (10)$$

$$\text{with } p^{*}_{I\_hh} > 0 \text{ if } p_{I\_hh}=1 \text{ and } p^{*}_{I\_hh} \leq 0 \text{ if } p_{I\_hh}=0.$$

To capture the effect of membership in interest groups, willingness to listen to extension and the willingness to invest in SWC on household welfare, we enter the residual terms

[1] Note that the predicted residuals are not necessarily independent form the error term of the equation in which the endogenous variable appears as explanatory variable. Particularly, if they are dependent this estimation approach will yield biased estimators, although the bias will be small.

of equations (6), (7) and (10) into the welfare equation (5). This way we are able to capture the sum of direct and indirect effects of both the exogenous and potentially endogenous variables. The final estimating welfare equation[2] becomes:

$$Y = f(\zeta, \xi, v, p^{\varepsilon}_{m\_grpi}, p^{\varepsilon}_{ex\_yn}, p^{\varepsilon}_{I\_hh}) + \varepsilon_y, \quad (11)$$

where $p^{\varepsilon}_{I\_hh}$ is the residual of the willingness to invest in soil and water conservation derived from equation (10). Equation (11) is estimated for usual income measures of household welfare (expenditure and incomes) and asset measures (livestock wealth) using ordinary least squares. We extend the analysis to diversified sources of incomes (livelihood diversification strategies) namely incomes from livestock flows, transfers, non-farm enterprises, crops, casual labour and permanent employment. Seemingly unrelated regression method is used to explain incomes from diversified activities.

4.3 Modelling investment in soil and water conservation

Investment in soil and water conservation is based on the same conceptual framework as household welfare analysis. However, in studies on land tenure security and tree planting, there is the feedback mechanism between tenure security and investment and investment and tenure security. Otsuka *et al.*, (2003) develop a model with the two equations that are substituted in one another to get a reduced form equation that could be estimated econometrically. However the inter-temporal aspect is missing and hence tree-planting now to improve security and trees planted in the past that have increased security are mixed. In their case the types of investment are the same (cacao tree planting so the overall result is only somewhat biased). However such an approach using different types of investments would be seriously flawed, especially when taking into account that tenure security has influence not only on willingness to invest but also on the type of investments undertaken (Gebremedhin and Swinton, 2003).

The basic model we want to estimate is the probability of investment in SWC on a plot, (P_{inv_j}) which is defined as:

$$p^{*}_{inv\_j} = f(\varsigma, \xi, v) + \varepsilon_{inv\_j} \quad (12)$$

$$\text{with } p^{*}_{inv\_j} > 0 \text{ if } p_{inv\_j}=1 \text{ and } p^{*}_{inv\_j} \leq 0 \text{ if } p_{inv\_j}=0.$$

Where j refers to the plot, and ζ, ξ and υ are as defined in equation (5). We use a similar approach as in equations (6) to (10) to derive the residuals and factors for willingness to listen to extension in general, membership in special interest groups (institutional presence) and the willingness to invest at the household level. We then apply this informa-

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[2] p^{ε}_{i} is measured at plot level. To transform data from multiple plots into household level variables, factor analysis was applied to determine the final variables of interest at the plot level, then weighted household averages were calculated using plot areas as weights. Note also that in the final estimating equation, previous SWC structures on plot are included because this variable is exogenous. Inclusion of the ECM of the willingness to invest (and also for other variables) however helps us to capture both the direct and indirect effects.

tion to the plot level data to explain investment in soil and water conservation. Equation 12 can therefore be re-written as

$$p^{*}_{inv\_j} = f(\zeta, \xi, v, p^{\varepsilon}_{m\_grpi}, p^{\varepsilon}_{ex\_yn}, p^{\varepsilon}_{I\_hh}) + \varepsilon_{inv\_j} \quad (13)$$

$$\text{with } p^{*}_{inv\_j} > 0 \text{ if } p_{inv\_j}=1 \text{ and } p^{*}_{inv\_j} \leq 0 \text{ if } p_{inv\_j}=0.$$

Where $p^{\varepsilon}_{m\_grpi}$, $p^{\varepsilon}_{ex\_yn}$ and $p^{\varepsilon}_{I\_hh}$ refer to the residuals of the willingness to listen to extension in general, membership in special interest groups and the willingness to invest at the household level respectively.

Equation (13) is based on actual investments made by a household. We limit the analysis to plots that have had investments in the last two seasons. We specify the investment model for both dichotomous choice investments and continuous variable investments. We base the analysis on for the dichotomous choice investments on 7 main types of investments: grass strips, mulching, tree planting, general terraces, soil terraces, grass stripped terraces and all other investments (fallowing, ridging and crop rotation). We further categorize these investments into permanent and seasonal investments, depending on how they were adopted. Probit regression method is used to explain adoption of each of these investments. For continuous variable investments, we apply the Tobit regression method to explain how much (intensity) investments have been made at the plot level because some plots have no investment. The dependent variable is obtained by a count of all SWC investments per plot.

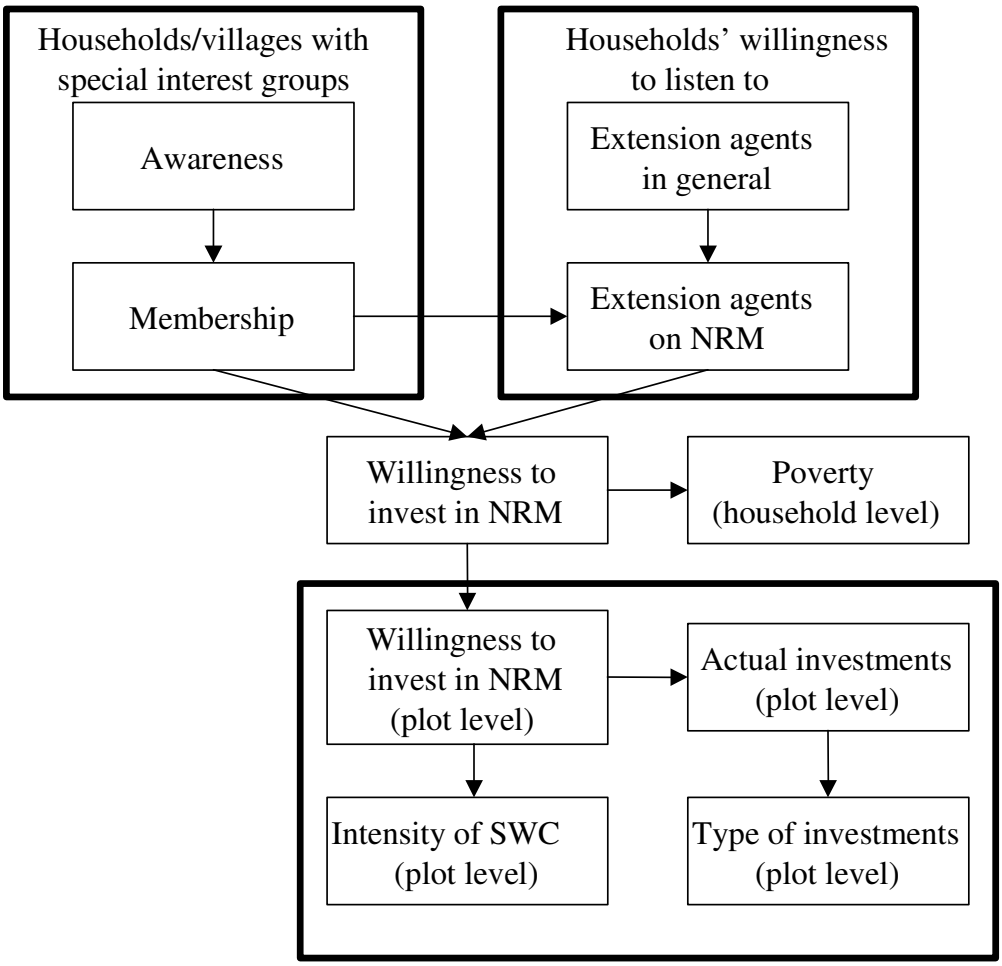
In this paper, we use the ECM approach because use of instrumental variables to take into account endogeneity is only possible in the case of longer time series relationships, which is highly uncommon in household level analyses based on survey data. However the principles that underpin the use of instrumentation in time series analysis don't just disappear in cross-sectional analysis. In order to capture the effects of endogenous variables we can make use of time related variables from the survey data. In this paper, recall data on for instance past investments as opposed to investments made in the past season lets us distinguish between the two. The investments made in the past two seasons (the time horizon of all the choice variables in the model) are assumed to be related to strictly exogenous variables and can also be related to the somewhat exogenous variable of past investments. The past investments themselves have been determined by the values of strictly exogenous variables at the time of the decision making process concerning those investments.

By using an error correction formulation where we take the deviations from the expected value, we can capture the effects of partially endogenous variables. We cannot relate the effects of strictly endogenous variables directly, such as current incomes and current investments, because both jointly depend on the same set of exogenous variables. If all the exogenous variables are included on the RHS of all equations related to household choice, then the error terms of the equations are unbiased, and the results are comparable to those of seemingly unrelated regressions (Davidson and McKinnon, 1993). Correlations between current choice variables can, therefore, be explored by comparing the correlation matrix of the error terms. The effect of income on investments in SWC measures can be explored using this last procedure, but not by using an error correction formula-

tion. The error correction formulation would only be valid if information was used over past income streams and their effect on current SWC investments.

Figure 4.1 illustrates the relationships modelled above.

Figure 4.1: Link between village institutions, investment in SWC and poverty



5. Data Description

5.1 Sample characteristics

Sample characteristics are presented in appendix Table A1. The table details and compares characteristics of the household heads namely gender, age and education among other factors across the three districts. The table also decomposes family size into household composition categories. Generally, the data shows that the household characteristics for Murang'a and Maragua are robust/closely comparable, except for percentage of heads that attended school and years of schooling. The two districts also show some variation with respect to primary and secondary occupations of household heads. The average family size in the two districts is 5 persons per household.

The characteristics for Narok suggest that 90% of respondents were male compared to 80% in Murang'a and Maragua. Other notable differences between Narok and the other

two districts include the percentage of heads who had attended school (81%, 91% and 70% in Murang'a, Maragua and Narok districts respectively), maximum years of schooling per household, with Narok reporting the highest (about 10 years of schooling, compared to about 9 in each of the other districts) and the main occupation of household head (only 59%) is farming compared to about 70% in the other districts. Professional skills, proxied by head being employed or running a business shows little variation across the three districts. There are also differences in religion categories as well as in the prevalence of widowed female heads across the three districts.

Family size and composition is also notably different with an average of 7 persons per household in Narok, compared to 5 in the other districts. Narok district also shows high dependency ratios compared to the other districts with an average of 1 child under 5 years and 3 children between 6 and 16 years per household, compared to 0 and 1 kids respectively in the two districts. For the whole sample, 83% of households were male headed while the average years of schooling for all household members is 7.4 years implying that on average, the respondents have primary education as their highest level of education.

5.2 Welfare indicators

Incomes and inequality among sampled households

In this study, we use a number of variables as measures of household welfare. In particular, both income and asset measures are used. These measures include (*i*) income from crop production, defined as gross revenue from major crops produced by households valued at local market prices less hired labour costs; (*ii*) income from livestock and livestock products; (*iii*) Income from farm equipment owned by households, valued at local market prices; (*iv*) Income from labour which is defined as income from casual labour activities, self-employment and permanent employment; (*v*) Incomes from village institutions, defined as net earnings per year from membership in village institutions; (*vi*) Transfer incomes defined as the sum of total incomes from both monetary and non-monetary transfers received by households from various sources; (*vii*) Income from household enterprises, defined as total profit from any non-agricultural enterprise operated by a household.

To compare the welfare of households using the above indicators, we divide the sample into 5 groups (quintiles) based on the total income from these sources. The argument here is that households at the bottom of the distribution represent the poorest while the households at the top represent the richest households holding all other factors constant. This categorization enables us to compare welfare, and conservation activities among other aspects of the households.

Table 5.1 presents estimates of household per capita monthly expenditure and monthly household expenditure as well as earnings from crop production, equipment and livestock. The table suggests that comparing households on the basis of monthly expenditures, the top 20% consume more than twice as much as the poor (Kshs 6,028 per month for the top 20% compared to 2,351 Kshs per month for the lowest 20%). However, when we control for household size, the difference across quintile is not as marked, though the top quintile still consumes more than the bottom quintile. For the income sources, there

are clear disparities across quintiles. For instances, crop income ranges from Kshs. 5040 per year for the lowest quintile to Kshs. 67,148per year for the upper 20%, implying that the upper quintile earns more than 13 times as much as the bottom quintile. The highest inequality is however in incomes from livestock where the top quintile earns about 83% times as much as the lowest quintile.

Table 5.1: Expenditures and incomes by total income quintiles

	Quintile 1	**Quintile 2**	**Quintile 3**	**Quintile 4**	**Quintile 5**
Per capita monthly expenditure	722	805	883	839	891
Total monthly expenditure	2,351	3,172	3,741	4,761	6,028
Total monthly income	3,636	8,880	15,078	25,062	122,425
Crop income	5,040	9,697	13,784	21,254	67,148
Value of capital equipment	1,999	5,161	8,979	9,434	14,416
Total value of livestock (current)	6,408	20,081	36,746	66,568	565,791
Total value of livestock products	642	1,786	6,265	12,827	22,373
Total labour income	5,979	11,815	14,907	21,748	21,016
Earnings from village institutions	478	2,915	2,720	6,809	15,254
Household enterprise profits	283	-436	3,902	10,016	27,305
Transfer incomes	987	2,261	3,167	1,716	1,247

In Table 5.1, we also present a tabulation of labour incomes, incomes from village institutions, incomes from household enterprises and transfer incomes by quintile groups. The table shows that casual off farm activities are much more important sources of incomes for households at the lower end of the distribution, than for those at the upper end. However, self and permanent employment are much more important source for the upper quintile than for the lower quintiles. The top quintile earns 4 times more labour income than the lowest quintile. Income from village institutions and household enterprises is highest from the top 20%, but very low for the bottom quintiles, implying that the poor may not be participating much in village institutions, probably due to financial constraints. Net earnings from the second quintile are actually negative, implying that they give more than they receive. Transfer incomes are highest for the second and third quintiles.

Comparing the income measures across districts, the data indicates that Narok district is better off than the other district in terms crop revenue, value of equipment and total value of livestock production. The high value of crop revenue is due to the influence of some wheat farmers in the sample. However, the district is clearly worse of in terms of all other sources of income; namely labour incomes, transfer incomes, incomes from village institutions and income from household enterprises (Table 5.2). The very high standard deviations in most categories of incomes indicate that there is a lot of inequality in the distribution of income in the three districts, with the highest inequality being observed in livestock, crop, labour, institutional and household enterprise profits.

Table 5.2: Expenditures and incomes by district (Kshs)

Variable	Murang'a		Maragua		Narok	
	Mean	**Std. dev**	**Mean**	**Std. dev.**	**Mean**	**Std. dev.**
Per capita monthly expenditure	721	645	886	648	870	462
Total monthly expenditure	2,861	1,884	3,696	2,192	5,966	3,077
Total monthly income	3,368	5,380	4,536	5,042	5,916	13,526
Crop income	7,805	8,352	17,661	24,323	43,171	142,606
Value of capital equipment	6,564	9,008	7,570	14,752	10,473	17,455
Total value of livestock (current)	21,785	24,972	34,116	31,714	454,566	971,013
Total value of livestock products	4,599	11,031	8,304	35,495	14,792	23,105
Total labour income	15,268	24,910	18,141	25,943	9,935	14,965
Earnings from village institutions	4,373	13,898	7,886	29,964	3,596	18,204
Household enterprise profits	11,017	51,250	5,351	18,438	9,085	27,347
Transfer incomes	1,087	3,532	3,431	12,808	410	2,395

Indicators of Household Vulnerability

Our study further investigates the probability of a household being vulnerable by analyzing the type and magnitude of shocks that may have afflicted the household in the last 5 years. Table 5.3 tabulates the experience with 5 main shocks: (*i*) Loss of harvest, due to adverse weather conditions or other causes. (*ii*) Loss of livestock to theft, disease or other causes (*iii*) Loss of land due to redistribution or eviction (*iv*) Loss of labour due to illness (*v*) Loss of house to fire or other causes (*vi*) Producer price shocks (unexpected price falls). From the table, there is no clear pattern of the impact of shock on different quintiles. Both the poor and the rich experienced various types of shocks. The results show that harvest shocks seem to have affected a large majority of households in the last 5 years. Also significant was price and loss of livestock shocks. Though a slightly larger proportion of households in the lower end of the distribution than in the upper end were affected by harvest shocks, almost twice as much of the top 40% than the rest of households reported to have been affected by price shocks. This could be explained by the fact that the poor may be less engaged in market exchange and therefore experience less impact of price variations.

Table 5.3: Percentage of households affected by shocks by quintile

Type of shock	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Loss of Harvest	58	58	52	66	52
Loss of livestock	23	15	18	23	37
Loss of land	2	1	0	4	3
Loss of labour	16	24	23	18	14
Loss of house	2	1	1	1	5
Price shocks	20	25	25	42	43

At the district level, the data shows that 59% of all households in Narok reported to have experienced harvest shock, compared to 56% in the other two districts. The district also had a relatively higher proportion reporting livestock (46%) and price (49%) shocks than the other districts (Table 5.4)

Table 5.4: Percentage of households affected by shocks by district

Type of shock	Murang'a	Maragua	Narok
Loss of Harvest	56	56	59
Loss of livestock	17	14	46
Loss of land	1	2	5
Loss of labour	21	22	13
Loss of house	1	2	5
Price shocks	21	27	49

Table 5.5 tabulates the percentage of households per quintile by their perceptions of the magnitude of shocks. Households reporting to have experienced a particular type of shock were asked to indicate whether the shock was moderate or severe. The table shows that in general, most households (about 70% and above) perceived the shocks as severe. Except for labour and price shocks, the lowest quintile perceived the shocks to be more severe than the upper quintile. Comparing perception of magnitude of shocks across households, there is no significant difference for harvest, livestock and price shocks (Table 5.6). Though differences for house and land shocks seem major, we note that the percentage of households involved is quite minor. However, taking into account the percentage of households involved, the difference in perceived magnitude of labour shock is much more significant.

Table 5.5: Percentage of households perceiving shocks as severe by quintile

Type of shock	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Loss of Harvest	72	81	85	72	70
Loss of livestock	71	93	88	70	70
Loss of land	100	100		75	67
Loss of labour	60	77	95	75	92
Loss of house	100	100	100	0	60
Price shocks	67	78	91	82	67

Table 5.6: Percentage of households perceiving shocks as severe by district

Type of shock	Murang'a	Maragua	Narok
Loss of Harvest	76	75	75
Loss of livestock	73	78	77
Loss of land	100	67	83
Loss of labour	77	78	93
Loss of house	100	67	67
Price shocks	75	78	76

5.3 Social capital: Village institutions

Social capital is an important determinant of household welfare, and in this study, it is proxied by membership in village institutions. We investigated the nature and membership in village institutions, as well as earnings from these institutions. We found that there are three main types of institutions: village based committees (either clan or church based, drawing membership from both men and women), women (only) groups and men

(only) groups. We however analyze these institutions in terms of purpose rather than membership. We found that the committees can be grouped into twelve different purposes: buying livestock, benevolent groups (safety nets), income generation, merry go rounds/loans, paying school fees for children, conflict resolution, growing trees, education on natural resource management, purchase of household goods including tanks and building materials, HIV/AIDs education, communal farming and payment of dowry. However, in most of these groups are organized by and are run by women. In particular, merry go round groups and groups purchasing household goods are most common and are dominated by women.

Table 5.7: Membership in village institutions (%) by purpose and quintile

Purpose	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Benevolent (safety nets)	11	16	23	15	16
Loans/ Roscas	64	56	57	68	60
Income generation	18	23	15	15	12
Other purposes	8	5	5	2	13
Women only committees	72	65	75	69	58
Men only committees	6	9	4	7	10

Table 5.7 presents a tabulation of membership in village institutions by households in the sample by quintile. We narrow down on the key types and purposes of institutions in the sample. Analyzing institutions by purpose, the table shows that the most common is Loans/'merry go rounds' (ranging from 57% in the third quintile to 44% in the first quintile). This is followed by benevolent groups (ranging from 11% in the bottom quintile to 23% in the third quintile). A combination of all other purposes shows that they are less popular with membership ranging from 2% in the 4th quintile to 13% in the top quintile. Considering institutions by type, we found that membership in women groups range from 58% in the top quintile to 75% in the third quintile compared to men only groups which range from 4% in the third quintile to 10% in the top quintile. Looking at the membership in village institutions across districts, it is clear that women only institutions are more popular in Murang'a and Maragua districts than in Narok, but the reverse holds for men only institutions. Safety nets also seem to be much more popular in Narok than Maragua. Overall, there seem to be no clear pattern in the difference in membership in the institutions across the three districts by purpose of institution (Table 5.8).

Table 5.8: Membership in village institutions (%) by district

Purpose	Murang'a	Maragua	Narok	Full Sample
Benevolent (safety nets)	18	13	19	16
Loans/ Roscas	55.	66	63	61
Income generation	20	16	9	16
Other purposes	7	4	9	6
Women only committees	65	76	55	67
Men only committees	**8**	**5**	**11**	**7**

In Table 5.9, we analyze earnings from various institutions by quintile. The analysis is only based on the sample of households that are actually members of the respective insti-

tutions. The results show that for the few households in the bottom quintile who are members, the highest earnings are from a combination of other purposes (income generation, paying school fees for children, conflict resolution, growing trees, education on natural resource management, communal farming and payment of dowry), while the lowest earning is from institutions for purchase of livestock. Earnings from men committees are negative implying that they contribute more than they receive. Earnings from women committees are very low for the lowest and fourth quintiles compared to other income groups. Quintiles 2 and 5 also report negative net earnings from the second category of village committees. Except for the fourth quintile, the data indicates that net earnings from institutions are higher for the rich than for the poor. Though the net earning for the fourth quintile is hard to interpret, the results seems to suggest that ability to pay may determine membership and the consequent earning from institutions.

Table 5.9: Net annual earnings from village institutions (Kshs) by quintile

Purpose	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Benevolent (Safety nets)	2,651	5,213	3,991	6,036	6,110
Loans/ Roscas	4,496	9,232	12,414	7,912	11,389
Income generation	8,740	2,550			9,460
Other purposes	10,658	11,600	7,907		15,615
Women only committees	7,704	9,332	13,816	8,162	13,157
Men only committees	-27,200	3,429	-333	275	16,371

Net earnings from village institutions by district are presented in Table 5.10. The results show that taking into account the proportion of households that are actually members of these institutions, net earnings from loans/roscas and a combination of other purposes are most important for Murang'a and Maragua districts. In Narok households earn most from income generation and other purpose institutions. Net earnings from men committees in Murang'a are negative, but quite high in other districts. Overall, there are a lot of disparities in net earnings from institutions, more so for Narok district as shown by the very high standard deviations.

Table 5.10: Net annual earnings from village institutions (Kshs) by district

	Murang'a		Maragua		Narok	
Purpose	Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
Benevolent (Safety nets)	5,262	5,209	3,955	7,045	5,358	5,908
Loans/ Roscas	8,587	33,099	10,542	31,374	6,948	29,339
Income generation	2,251	8,416	12,413	21,616	9,049	15,550
Other purposes	10,623	20,587	8,160	8,534	15,196	41,401
Women only committees	9,411	28,581	11,715	30,530	8,991	31,945
Men only committees	-9,225	29,285	2,014	7,378	12,978	39,259
Any committee	7,039	25,301	9,689	26,925	7,600	27,149

5.4 Plot characteristics: Tenure security, soil quality and SWC investments

Tenure security

To capture all aspects of tenure security, this study collected data on both the mode of acquisition and expected land rights on all plots owned, used or rented/lent out by the household. The mode of acquisition probed on how, when and for how long the plot has been in the household. The expected land rights probed on the perception on land rights in terms of tenure security (whether land is shared, whether it can be taken away from household and by whom etc). In addition, we probed nature of rental arrangements and land rights on rented out and lent out land. A summary of the tenure security factors is presented in Table 5.11. The data shows that households owned (and often used) 71% of the plots, rented in 22% of the plots, and rented out 7% of the plots. More than half of the plots are inherited, and the duration of ownership is more than 18 years on average. In addition, 5% of the plots are owned for more than 50 years. In 46% of the cases the plots are registered to the household management team (head or spouse) while 31% of the plots are registered to relatives (like father or mother of head of the household).

Table 5.11: Summary statistics of tenure security variables

Description	**Mean**	**Std. dev.**	**Min.**	**Max**
Acreage	4.75	11.52	0	100
Distance from homestead	2.34	21.24	0	500
Own plot	0.71	0.46	0	1
Rented plot	0.22	0.42	0	1
Plot rented out	0.07	0.26	0	1
Purchased plot	0.10	0.30	0	1
Gifted plot	0.05	0.22	0	1
Inherited plot	0.62	0.49	0	1
Ownership duration in years up to 50 years	18.1	14.7	0.5	50
Ownership duration 50 years or more (dummy)	0.05	0.21	0	1
Plot registered to head or spouse	0.46	0.50	0	1
Plot registered to another relative	0.31	0.46	0	1
Sell without permission	0.36	0.48	0	1
Sell or bequeath with permission	0.09	0.28	0	1
Bequeath without permission	0.21	0.41	0	1
Rent or lent with(out) permission	0.12	0.33	0	1
Permission of a relative	0.10	0.30	0	1
Rental arrangement	0.14	0.34	0	1
Indefinite arrangement	0.26	0.44	0	1
Payment per acre for land rented in or out	525.0	1221.4	0	10,000

Soil quality and topography

The households in our survey have 684 plots. Table 5.12 shows the summary statistics on soil characteristics of plots. The soil characteristics are amongst others the type of soil, the soil depth, the slope, the workability and the soil texture of a plot.

Table 5.12: Summary statistics on the soil characteristics (plot level)

Characteristics	Number of plots	Share of plots
Soil type		
Red	287	0.42
Mixed	174	0.25
Black	157	0.23
Rocky	51	0.07
White	15	0.02
Position		
Flat	150	0.22
Weak undulation	78	0.11
Slightly sloped	256	0.37
Moderately sloped	101	0.15
Steeply sloped	99	0.14
Workability		
Easy	409	0.60
Moderate	186	0.27
Difficult	89	0.13
Soil texture of the plot		
Coarse	98	0.14
Intermediate	257	0.38
Fine	327	0.48
Perceived soil quality		
Very fertile	76	0.11
Fertile	266	0.39
Average	255	0.37
Not fertile	66	0.10
Very poor	16	0.02
	Mean	*St.dev.*
Soil depth in centimetres	22.5	28.1

In the survey, 42% of the plots have red soils, while 23% have black soils and 25% have a mixture of red and black soils. More than half of the plots are slightly to steeply sloped, while 22% of the plots is flat. The workability is in 60% of the plots easy, and the soil texture is fine in almost half of the plots. Only for 14% of the plots, the soil textures are coarse. The average soil depth of plots is 22.5 cm. For only 12% of the plots, household judge the fertility as poor or very poor. For 37% of the plots, the fertility is average, while for a similar share of plots, the fertility is judged as good. In 11% of the cases, the soil of plot is very fertile.

Soil and Water Conservation (SWC) Investments

There were 1,016 SWC investments reported in the 684 plots in our survey. Table 5.13 shows two indicators on investments. The first and second column shows the different aspects of the number of investments, while the third and fourth column present the different aspects of investments at the plot level. The table shows that the three most frequently observed SWC investments in the survey are tree planting (28%), terracing with

grass strips (26%), and grass strips (23%). Most investments (namely 72%) are permanent investments. Of all investments 317 (31%) investments have been made last year. One-third of the investments were already made more than five years ago. In 47 cases (i.e. 5%), the investments were already abandoned. The average period of abandonment was more than 3 years.

Table 5.13: Summary statistics on soil and water conservations (SWC) investments

	Number of investments	**Share of investments**	**Number of plots**	**Share of plots**
Total number	1,016		684	
Type of investment[a]				
Grass strips	233	0.23	230	0.34
Mulching	63	0.06	62	0.09
Ridging	12	0.01	12	0.02
Fallowing	31	0.03	31	0.05
Stone terraces	1	0.001	1	0.001
Soil terraces	60	0.06	59	0.09
Terracing with hedges	59	0.06	59	0.09
Terracing with grass strips	264	0.26	254	0.37
Tree planting	286	0.28	273	0.40
Other investments	7	0.01	6	0.01
Seasonality of investment				
Permanent	729	0.72	409	0.60
Long rains	185	0.18	143	0.21
Short rains	102	0.10	89	0.13
Period of investment				
Last year	317	0.31	229	0.33
Last five years	262	0.26	189	0.28
More than five years ago	333	0.33	203	0.30
Already on land upon acquisition	98	0.10	64	0.09
	Mean	*St.dev.*	*Minimum*	*Maximum*
Abandonment of investment				
Investment has been abandoned	0.05	0.21	0	1
Period of abandonment[b]	3.34	3.09	1	20

[a] Note that there can be more than one investment on one plot.

[b] The period of abandonment only applies to investments that have actually abandoned.

From the third and fourth column, there are 273 plots on which trees were planted, i.e. on 40% of all plots trees were planted. Since we reported 286 tree-planting investments, this means that there are 13 plots on which were trees planted more than once. In addition, there were 254 plots with terracing with grass strips (37%) and 230 with grass strips investments (34%). Furthermore, on 229 plots (one-third of all plots) there have been investments in the last year.

Note that the total number of investments is 1,016 and there are 684 plots, which means that on average there was more than one investment per plot. Table 5.14 shows the number of investments per plot. On 159 plots (23%), there were no investments reported at all, while 30% of the plots have had one investment. There are 3 plots with 4 invest-

ments, and there is one plot with 5 investments. In addition, there are 229 plots (33%) on which there have been investments in the last year. On 160 plots there has been one investment last years, and on 69 plots there were two or more investments made.

Table 5.14: Number of SWC investments per plot

Number of investments per plot	Number of plots		Period of implementation			
	Total Number	Share (%)	Last year	Last five years	More than five years ago	Already on land upon acquisition
No investment	159	0.23	455	495	481	620
One investment	206	0.30	160	132	114	39
Two investments	172	0.25	51	43	51	16
Three investments	123	0.18	17	13	35	9
Four investments	3	0.03	1		3	
Five investments	1	0.001		1		
Total	684	100	684	684	684	684

5.5 Extension services

The provision of extension services was considered in terms of services on crop production, livestock production and soil conservation. Table 5.15 presents the percentage of households receiving extension services from the three sources. The government is the main source of extension services, while NGOs and other agents play a minimal role in agricultural extension. About 35% of all the households received any extension service from any source but only 27% of all households received any extension services on natural resource management.

Table 5.15: Source of extension services (% of households)

Source	Crop	Livestock	Soil conservation
Government	19.9	14.9	10.3
Agricultural Research station	10.3	10.1	8.3
NGO	2.0	1.1	0.7
Other	1.5	2.8	0.0

5.6 Resource Dependency

Extraction of natural resources is considered in terms of three products namely, wood for fuel, fodder and wood for construction. The data show that wood fuel was the most common resource extracted by the households (99% in Murang'a, 96% in Maragua and 91% in Narok), followed by fodder (only 1.5% of all households) and wood for construction (only 0.4% of all households). Most of the households (58%), sourced resources from own land, followed by purchasing (14%) and open access (10%) (see Table 5.16). The data suggest that extraction from nature is not an important source of income for the sampled households and therefore does not have any major implications on household welfare.

Table 5.16: Sources of extracted resources (% of households)

Source of Product	Total Sample	Murang'a	Maragua	Narok
Own Land	58.2	69.5	66	31.4
Open access	10.3	1.3	3.2	33.1
Endorsed extraction from other people	7.2	4	8	10.2
Illegal extraction from private land	2.8	2.6	4.8	0
Community forest	3.1	0.7	1.1	9.3
Buying	14.2	20.5	17	1.7
None	4.1	1.3		8.5
Total	100	100	100	100

6. Factor Analysis

6.1 Introduction

Traditionally, factor analysis is a methodology to reduce the number of variables in the case of large sets of variables with possible interactions[3]. Factor analysis is especially used in empirical studies that are based on large datasets with many (possible) interactions between variables. In micro-economic studies on households, however, this method is rarely used (see Kruseman *et al.*, 2006). In the case of empirical studies on agricultural household models, data reduction is particularly important because the inclusion of all relevant explanatory variables into reduced form regression equations derived from the agricultural household models might easily lead to multi-collinearity in the explanatory variables. Using factor analysis to determine explanatory variables to be used in the final estimating equation solves this problem. In addition, the advantage of using factor analysis is that the resulting factors are orthogonal, which is particularly convenient for factors to be used in econometric estimation.

When using factor analysis as a data reduction method[4], we need a guideline for selecting factors. The main results of the factor analysis consist of the eigenvalue of each factor and the marginal proportion of the variance explained by each factor. From the latter, we derive the cumulative proportion of the variance explained. There are multiple criteria for selecting the number of factors, namely (*i*) the eigenvalue of the factor exceeds 1; (*ii*) the cumulative proportion of the variance explained exceeds 75%; and (*iii*) the marginal proportion of the variance explained is significant (at least 5-10% depending on the number of variables included (the more variables the lower the marginal proportion of the last factor will be). At least one, but preferably more than one of the criteria has to be satisfied in order to select the factor for further analysis.

[3] Factor analysis is also used to derive structures between variables, but in this paper we use it as a variable reduction method.

[4] For all analysis presented in this chapter, we apply the Iterated Principle Factor method to calculate the eigenvalues, the Varimax method to calculate the factor loadings and Bartlett's method to calculate the score factors. Although many different calculation methods are available for the different stages of Factor Analyses, the discussion on the methods used is beyond the scope of this study.

After selecting the number of factors, factor loadings are determined for which we used the Varimax method in all cases. Factor loadings reflect to what extent the factor is determined by the original variables, and only variables with factor loadings larger than 0.5 are considered. Note that the factor loadings can be either positive or negative. Based on the set of variables with significant factor loadings, the resulting factor is given an interpretation, although this interpretation is not always straightforward. Ultimately, score factors are used in further analysis, and score factors are the sum of products of variables and factor loadings.

In this study, we apply factor analyses on four different sets of exogenous variables (tenure security, soil quality, village institutions, and market access). In all cases, it is our objective to reduce the number of variables, although the reasons to reduce the number of variables differ. For instance, in the case of tenure security we apply a factor analysis at plot level to obtain the key elements of tenure security (see Section 6.2). For soil quality, we included a number of mainly qualitative questions in order to obtain the farmer's perception of the quality of the soil of their plots. From this set of questions, we derive a number of key aspects of soil quality (see Section 6.3). At the community or village level, we have information on presence of village institutions and one of the development domain dimensions, namely market access. In this case, we have a limited number of observations, namely 18 villages, while there are number of corresponding variables. Since the data was collected at village level, households from a village will score the same value on these variables. Thus, village institutions and market access show variation for households from different villages, but not for households from the same villages. In order to include aspects of presence of village institutions or market access in further analysis at the household level, we have to determine the key elements of these village institutions (see Section 6.4) and market access (see Section 6.5). Actual membership in village institutions varies across households and villages and does not enter into the factor analysis but is used directly in the empirical analysis.

6.2 Tenure security

In the literature on land tenure systems in developing countries, there is consensus on the fact that they have many different aspects, such as ownership, right to use, right to access, right to sell, rental arrangement and so forth. However, empirical studies present a large variety of indicators to measure tenure security. These indicators for tenure security usually cover only a selection of these aspects, because the inclusion of all aspects of tenure security would require the incorporation of many interrelated variables in empirical analyses. In practice, this is cumbersome, and the choice of a specific indicator is more or less arbitrary. To capture all aspects of tenure security, this study collected data on both the mode of acquisition and expected land rights. However, in order to take into account most relevant aspects of tenure security, we used factor analysis (FA) to filter the key elements of tenure security out of a wide range of tenure security variables[5]. Consequently, we can limit the number of tenure security variables in our analysis, while we maintain the key elements. The FA was applied to the plot level data.

[5] As far as we know, the use of Factor Analysis is a novelty in the research on tenure security.

We exclude variables such as plot acreage and distance to homestead from the FA because these variables will enter empirical analysis directly. Since we are trying to capture the general aspects of tenure security, we ignore possible differences between the three study areas Murang'a, Maragua and Narok. In the case of ownership duration, the extreme values might influence the outcomes of the FA significantly. Therefore, we truncate the ownership duration at 50 years, and we add a dummy variable indicating whether the ownership duration exceeds 50 years or not. We used the iterated principal factors method to carry out factor Analysis of tenure security factors. To select the factors we apply the guidelines described earlier. Table 6.1 shows the results of the FA on tenure security, and we select five factors that all have eigenvalues larger than one and that explain almost 80% of the variance in the data. The fifth factor has a marginal proportion of 8.4% in the explanation of the variance.

*Table 6.1: Factor analysis results for tenure security at plot level**

Factor	Eigenvalues	Difference between eigenvalues	Proportions of variance explained		Description of the factor
			Marginal	Cumulative	
1	5.123	2.139	0.319	0.319	Farmland
2	2.983	1.215	0.186	0.505	Family land
3	1.768	0.208	0.110	0.616	Land for sale
4	1.561	0.208	0.097	0.713	Rented out land
5	1.353	0.392	0.084	0.797	Rental land
6	0.960	0.183	0.060	0.857	n.a.
7	0.778	0.081	0.049	0.906	n.a.
8	0.697	0.169	0.044	0.949	n.a.
9	0.528	0.333	0.033	0.982	n.a.
10	0.195	0.147	0.012	0.994	n.a.
11	0.048	0.031	0.003	0.997	n.a.
12	0.017	0.005	0.001	0.998	n.a.
13	0.012	0.007	0.001	0.999	n.a.
14	0.005	0.001	0.000	0.999	n.a.
15	0.005	0.001	0.000	1.000	n.a.
16	0.003	0.001	0.000	1.000	n.a.
17	0.002	0.003	0.000	1.000	n.a.
	0.000	.	0.000	1.000	n.a.

*Calculated using iterated principal factor method

Table 6.2 presents the rotated factor loadings leading to the selection of the five factors. Variables appear in particular factors if the absolute value of the factor loadings are larger than 0.5. The first factor is referred to as farmland ranging from full ownership to indefinite rental arrangements. Farmland is the land owned or rented that is used for agricultural purposes. On the one hand, the positive factor loadings are characterized by owned plots which are often inherited, which are in the family for a long period of time and which can be sold without permission. Moreover, these plots are often registered to what we refer to as the household management unit (either head or spouse). On the other hand, the negative coefficients are related to rented plots with indefinite rental arrangements involving payments.

The second factor reflects plots owned (own use or rented out) by the family, or family land. Positive coefficients reflect the plots owned by the household management unit (head or spouse) while the negative coefficient reflects land owned by other relatives. The third factor presents plots (land for sale) for which other relatives have to give permission for selling or bequeath, and the fourth factor covers the possibly specific aspects of plots rented out (land rented out). Households in the survey own those plots although they do not use them for agricultural activities themselves. The final factor reflects rental conditions of plots that are either rented or lent with or without permission.

Table 6.2: Factor loadings for the tenure security factors

	Varimax Rotated factors				
Variable	Farmland	Family land	Land for sale	Rented out land	Rental land
Own plot	0.928	-0.017	0.078	-0.340	-0.006
Rented plot	-0.951	-0.036	-0.083	-0.231	0.075
Plot rented out	-0.105	0.088	-0.003	0.981	-0.110
Purchased plot	0.139	0.158	-0.013	-0.004	0.011
Gifted plot	0.028	0.068	-0.038	0.087	-0.147
Inherited plot	0.710	-0.102	0.100	0.162	0.045
Ownership more than 50 years	0.054	0.041	-0.036	0.043	0.043
Ownership duration (<50 yrs)	0.422	0.189	-0.077	0.108	0.036
Plot registered to head/spouse	0.427	0.823	-0.135	0.174	-0.051
Plot registered to relative	0.386	-0.846	0.226	0.010	0.001
Sell without permission	0.431	0.266	-0.289	0.116	0.390
Sell/bequeath with permission	0.103	-0.096	0.986	-0.011	0.085
Bequeath without permission	0.309	-0.239	-0.219	0.013	0.193
Rent/lent with(out) permission	0.099	0.039	-0.035	0.117	-0.978
Permission of a relative	0.120	-0.193	0.866	0.007	-0.093
Rental arrangement	-0.708	-0.027	-0.062	-0.170	0.056
Indefinite arrangement	-0.926	0.005	-0.067	0.213	0.021
Payment for rented land	-0.669	0.019	-0.048	0.164	0.032

6.3 Soil quality

Soil quality and topographical factors are also constructed using factor analysis. The collected data on soil quality on all plots included type, workability, texture, depth of soil, as well as the perceptions regarding fertility of the soil. A good number of the initial variables relating to soil quality and topography (see Table 6.3) are selected from the factor analysis (a total of eleven factors). The first two factors reflect the dimensions of texture (from fine to intermediate) and fertility (modest to average fertility). The third and fourth factors are dominated by one single variable. The fifth factor reflects the steepness of the slope of the plot (from flat to slightly sloped). The rest of the factors are dominated by one single variable, which makes the interpretation straightforward (Table 6.3a).

*Table 6.3: Factor analysis results for soil quality at plot level**

Factor	Eigenvalues	Difference between eigenvalues	Proportions of variance explained		Description of the factor
			Marginal	Cumulative	
1	3.617	1.422	0.151	0.151	Texture
2	2.195	0.135	0.092	0.242	Fertility
3	2.060	0.237	0.086	0.328	Unknown fertility
4	1.823	0.328	0.076	0.404	Difficult workability
5	1.495	0.074	0.062	0.466	Flat vs. slight slope
6	1.421	0.070	0.059	0.525	Very fertile
7	1.351	0.078	0.056	0.582	Coarse soil
8	1.274	0.115	0.053	0.635	Moderate slope
9	1.158	0.044	0.048	0.683	Red vs. black soil
10	1.115	0.103	0.046	0.730	Undulated
11	1.011	0.033	0.042	0.772	Poor soil
12	0.979	0.040	0.041	0.812	n.a.
13	0.939	0.045	0.039	0.852	n.a.
14	0.894	0.097	0.037	0.889	n.a.
15	0.798	0.039	0.033	0.922	n.a.
16	0.759	0.150	0.032	0.954	n.a.
17	0.609	0.107	0.025	0.979	n.a.
18	0.503	0.503	0.021	1.000	n.a.
19	0.000	0.000	0.000	1.000	n.a.
20	0.000	0.000	0.000	1.000	n.a.
21	0.000	0.000	0.000	1.000	n.a.
22	0.000	0.000	0.000	1.000	n.a.
23	0.000	0.000	0.000	1.000	n.a.
24	0.000		0.000	1.000	n.a.

*Calculated using iterated principal factor method.

Table 6.3a: Factor loadings for the soil quality and topographical factors

	Varimax rotated factors										
Variable	**Texture**	**Fertility**	**Unknown fertility**	**Difficult workability**	**Flat vs slight slope**	**Very fertile**	**Coarse**	**Moderate slope**	**Red versus black soil**	**Undulated**	**Poor soil**
Red soil	-0.233	-0.072	-0.040	-0.094	0.032	-0.084	-0.081	0.049	0.570	-0.009	-0.012
Mixed soil	0.139	-0.106	0.012	0.038	-0.032	-0.085	-0.064	-0.049	0.213	-0.025	-0.021
Black soil	0.093	0.155	0.049	0.003	0.005	0.103	0.097	0.012	-0.951	0.002	0.042
Rocky soil	0.049	0.059	-0.018	0.070	-0.019	0.110	0.025	-0.033	0.073	0.060	0.011
Other soil	0.017	0.010	-0.010	0.069	0.005	0.043	0.141	0.003	0.039	-0.008	-0.038
Flat plot	-0.052	0.036	0.081	-0.022	0.942	0.003	0.014	0.185	0.002	-0.168	0.020
Undulated plot	0.005	0.008	0.015	0.002	-0.053	0.005	-0.034	0.076	-0.003	0.989	0.041
Slightly sloped plot	-0.016	0.011	-0.041	-0.057	-0.674	0.025	-0.018	0.450	0.002	-0.378	-0.017
Moderate sloped plot	0.042	-0.012	-0.024	-0.026	-0.067	-0.005	0.004	-0.985	0.002	-0.088	0.020
Steeply sloped plot	0.037	-0.053	-0.029	0.129	-0.065	-0.039	0.035	0.094	-0.004	-0.085	-0.057
Workability easy	-0.321	-0.002	-0.061	-0.410	0.004	0.007	-0.016	-0.002	0.035	0.009	0.068
Workability moderate	0.234	-0.028	-0.020	-0.265	-0.005	0.012	-0.052	-0.015	-0.024	-0.014	0.006
Workability difficult	0.158	0.039	0.116	0.949	0.000	-0.025	0.092	0.023	-0.020	0.006	-0.108
Texture unknown	0.010	-0.001	-0.004	-0.009	0.048	-0.009	-0.008	0.009	0.018	-0.009	0.008
Texture coarse	0.001	0.036	-0.027	0.083	0.018	0.008	0.975	-0.005	-0.101	-0.033	-0.028
Texture intermediate	0.871	0.017	0.064	0.094	-0.040	0.007	-0.316	-0.034	-0.064	0.017	0.000
Texture fine	-0.846	-0.042	-0.043	-0.148	0.021	-0.011	-0.375	0.036	0.131	0.008	0.019
Unknown fertility	0.037	-0.003	0.996	0.056	0.043	-0.009	-0.013	0.011	-0.027	0.009	0.009
Very fertile	0.011	-0.015	-0.023	-0.025	-0.005	0.983	0.007	0.007	-0.108	0.004	0.056
Fertile	0.016	0.890	-0.075	-0.008	0.025	-0.308	0.010	0.004	-0.085	0.010	0.277
Moderate fertility	-0.035	-0.885	-0.067	-0.061	-0.013	-0.284	-0.044	-0.015	0.131	0.000	0.279
Poor fertility	0.012	-0.002	-0.023	0.098	-0.022	-0.054	0.027	0.021	0.040	-0.042	-0.987
Very poor fertility	-0.006	-0.003	-0.009	0.050	-0.011	-0.026	0.048	-0.026	0.015	0.035	0.027
Unknown soil depth or quality	0.037	-0.003	0.996	0.056	0.043	-0.009	-0.013	0.011	-0.027	0.009	0.009

6.4 Village institutions

To capture the influence of institutional presence we constructed village level organizational presence. We used 27 dummy variables for type of organization (village, men's groups, women groups and other) combined with purpose (investments in livestock and agriculture, burial and illness, income generation, household investments, non-economic purposes, NRM management). In addition, we counted the number of institutions in each of the eighteen clusters. We used a factor analysis with iterative procedure to shed light on the issue. Eight factors were retained from the 27 variables (Table 6.4).

*Table 6.4: Factor analysis for village characteristics**

Factor	Eigenvalue	Difference	Proportions of variance explained		Description
			Proportion	Cumulative	
1	15.539	10.991	0.555	0.555	Scale
2	4.549	1.527	0.162	0.717	Men's groups
3	3.022	0.692	0.108	0.825	Household investment/income generation
4	2.330	0.849	0.083	0.909	Village groups
5	1.481	0.823	0.053	0.961	Safety nets and NRM investment
6	0.658	0.310	0.024	0.985	n.a.
7	0.347	0.272	0.012	0.997	n.a.
8	0.075	0.075	0.004	1	n.a.

*Calculated using iterated principal factor method

Of the 8 factors, five are useful for further analysis, using the 1.0 cut-off point for eigenvalues and the 5% proportion of variance explained. These five factors explain 96% of variance (Table 6.4). We then obtained the factor scores that summarize the whole data set (Table 6.5). From the results, we deduce that the first factor reflects scale or in other words the presence of groups for the social cohesion regardless of the group's objective. The second factor represents the presence of men's group. The third factor is the presence of groups for household specific investment or income generation. Village institution presence is reflected by the fourth factor. The final factor combines the presence of safety nets groups and groups for natural resource management (NRM) investments.

Table 6.5: Factor loadings for the village institutions

	Varimax Rotated factors				
Variables	Scale	Men's group	Groups on investments	Village groups	NRM investments
Village group for agriculture	0.775	0.097	-0.052	0.523	-0.089
Men's group for agriculture	0.426	0.884	-0.100	0.037	0.060
Women's group for agriculture	0.946	0.223	0.012	0.172	-0.156
Other group for agriculture	0.946	0.223	0.012	0.172	-0.156
Village group for safety net	0.645	0.017	-0.156	0.393	-0.478
Men's group for safety net	0.337	0.807	-0.200	-0.062	-0.311
Women's group for safety net	0.783	0.127	-0.102	0.050	-0.559
Other group for safety net	0.783	0.127	-0.102	0.050	-0.559
Village group for income generation	0.643	0.076	0.413	0.556	-0.175
Men's group for income generation	0.335	0.863	0.337	0.092	-0.025
Women's group for income generation	0.780	0.190	0.498	0.221	-0.240
Other group for income generation	0.780	0.190	0.498	0.221	-0.240
Village group for credit	0.315	0.023	-0.199	0.914	-0.136
Men's group for credit	-0.009	0.936	-0.143	-0.041	0.000
Other's group for credit	0.731	0.111	0.163	-0.338	0.034
Village group for investments	0.176	0.002	0.346	0.886	-0.224
Men's group for investments	-0.100	0.889	0.309	0.017	-0.087
Women's group for investments	-0.193	-0.033	0.951	0.121	-0.186
Other group for investments	0.498	0.073	0.722	-0.211	-0.085
Village group for social reasons	0.775	0.097	-0.052	0.523	-0.089
Men's group for social reasons	0.426	0.884	-0.100	0.037	0.060
Women's group for social reasons	0.946	0.223	0.012	0.172	-0.156
Other group for social reasons	0.946	0.223	0.012	0.172	-0.156
Village group for NRM practices	0.268	0.019	0.219	0.557	-0.724
Men's group for NRM practices	-0.018	0.810	0.154	0.093	-0.543
Women's group for NRM practices	0.386	0.130	0.293	0.222	-0.817
Other group for NRM practices	0.650	0.105	0.366	0.106	-0.622
Number of institutions	0.608	0.416	0.257	0.309	-0.527

6.5 Market access

One of the development domain dimensions in the farm household models is market access. Market access reflects the potential of selling products at local or regional markets, such as agricultural products or products extracted for common pool natural resources, such as fuel wood for instance, at local markets or village markets. Despite the fact that communities in rural areas are often a widespread cluster of households (in terms of distance to neighbouring households), market access is a typical community feature with respect to market access of larger town and their markets.

In this study market access is based on information on distance, mode, travel time and expenses from the village to particular destinations like markets and roads amongst others collected using the community questionnaire. Some indicators of market access (for instance distance and travel time) are interrelated, but there is no unique relationship, be-

cause other aspects such as presence of infrastructure and morphological environment play a role as well.

Summary statistics of different measures of market access from the community survey are presented in Table 6.6. The FA for market access is limited to four facilities, namely distance to local market, all-weather roads, public transport (*matatu*) and main town (market). Since the number of observations is limited, we construct a database of facility per village (4x18 =) 72 observations. In 69% of the trips from the village to particular facilities, the main mode is by foot, while the *matutu* as the local type of public transport is called is the main mode in 28% of the trips.

*Table 6.6: Summary statistics for distances to facilities**

Variable	Mean	Standard deviation	Minimum	Maximum
Distance (km)	10.9	16.5	0	66
Main mode to facility				
By foot (%)	0.69	0.46	0	1
By *matutu* (%)	0.28	0.45	0	1
By bicycle (%)	0.03	0.17	0	1
Travel time (minutes)	45.8	63.2	0	480
Travel expenses (Kshs)	32.2	60.5	0	250
No travel expenses or no estimate	0.64	0.48	0	1
Travel expense per km (Kshs)	1.65	2.66	0	10

* Although the community surveys includes facilities such as schools and health centres, we focus on markets and limit the analysis to the facilities local market, all-weather roads, public transport, and main town market.

Table 6.7 shows the results of the FA on market access. In this FA, there is only one factor selected that covers almost 75% of the variation in the distance to facility data set under consideration.

*Table 6.7: Factor analysis results for market access**

Factor	Eigenvalue	Difference between eigenvalues	Proportion of variance explained		Factor description
			Marginal	Cumulative	
1	2.325	1.741	0.749	0.749	Market access
2	0.585	0.392	0.188	0.938	n.a.
3	0.193	0.193	0.062	1.000	n.a.
4	–0.0002		–0.0001	1.000	n.a.

*Calculated using iterated principal factor method

The factor loadings (Table 6.8) show that four variables enter the factor analysis. The travelling mode is excluded, because it was highly correlated with the travel expenses per kilometre. The interpretation of the factor is that the spectrum of travel expenses per kilometre is the best proxy for market access. On the one hand there are no expenses for relatively short trips (in travel time and distances) by foot and on the other hand there are trips by *matatu* with high travel costs (mostly main town markets). So, the FA yields a

market access variable at cluster level that is included in the empirical analysis on poverty and land conservation investments.

Table 6.8: Factor loadings for market access

Variable	**Varimax Rotated factors**
Distance in km	0.257
Travel time	0.193
Travel expenses per km	0.942
No travel costs or unknown	–0.855

7. Household welfare, tenure security and investment in SWC

7.1 Preliminaries

In this section we present the regression results linking household welfare, tenure security and investment in water and soil conservation. To explain household welfare empirically, we use both the expenditure and income approaches to poverty on one hand and asset approach (livestock) on the other. We specify per capita values of these measures as a function of household, farm and village level characteristics including development domain dimensions and quantifiable institutional arrangements at village level as specified in equation (11) in the conceptual framework and methodology section. Household characteristics include gender and age of the household head, household composition and years of schooling of the household head. Farm characteristics are primarily related to the production factors: land, labour, capital and knowledge. Land is defined as the interplay of plot area, soil, topography, and the institutional arrangements in terms of quantity and quality. In addition, investment in environmental conservation has an important bearing on land quality. Village characteristics consist of socio-economic conditions, institutional aspects and ecological potential proxied by district dummies. District dummies also capture the impact of unaccounted for other factors such as agro-ecological zones and climate that differ across districts. This controls for the community fixed effects, eliminating any bias from unobserved community level heterogeneity, provided such heterogeneity enters the welfare function linearly. Market access, population density and village institutions are the key village variables utilized in the empirical analysis.

Before estimating the welfare model, we first explain the process generating the institutional variables (membership in special interest groups), the willingness to listen to extension services (general and natural resource management) and willingness to invest in SWC as specified in equations (6) to (10). Membership in special interest groups is defined as membership in four main village groups: income generation activities, loans generating groups, benevolent groups and general membership. To save on space, the results for individual Probit models are not presented. Because the process explaining membership in special interest groups and willingness to listen to extension is the same, the residuals from the Probit model equations (6) to (8) enter into factor analysis in order derive a common variance factor(s) for explaining the willingness to invest at the household level. The factor analysis of these residuals suggests two factors that have eigenvalues larger than 1 (Table 7.1a). After the Varimax rotation, the factor analysis loads on

two factors, willingness to listen to extension in general and membership in special interest groups in general (Table 7.1a). These two factors are then used in the final estimating model of the willingness to invest at the household level (equation 10), from which we derive residuals for the willingness to invest at the household level. The residuals derived for membership in special interest groups (from equation (6)) and for the willingness to invest enter the welfare model as exogenous explanatory variables.

Table 7.1a: Factor analysis for institutional membership and willingness to listen to extension

Factor	Eigenvalue	Difference	Proportion	Cumulative
1	1.713	0.128	0.474	0.474
2	1.585	0.842	0.438	0.912
3	0.744	0.814	0.206	1.117
4	-0.070	0.047	-0.020	1.098
5	-0.118	0.119	-0.033	1.065
6	-0.236	.	-0.065	1.000

Table 7.1b: Factor loadings for institutional membership and willingness to listen to extension

	Rotated Factor Loadings			
Variable (residual)	**1**	**2**	**3**	**Uniqueness**
Membership in income generating groups	-0.051	0.037	0.642	0.584
Membership in loans generating groups	0.062	0.897	-0.046	0.190
Membership in any group	-0.013	0.894	0.086	0.193
Membership in benevolent groups	-0.141	0.034	0.617	0.598
Listened to extension services	0.889	0.002	-0.064	0.205
Listened to extension in NRM	0.899	0.043	-0.041	0.188

7.2 Determinants of per capita expenditures and incomes

The results for per capita expenditure and incomes are presented in Table 7.2. A quick overall picture shows that vector of determinants used to explain welfare have significant impact on per capita expenditure and incomes. In particular, the models fit the data better than the intercept only model at all levels of significance as shown by the F statistic. In addition, the variables explain 33% of the total variation in per capita expenditure but only 25% of the total variation in per capita income. Since expenditure is argued to be a better measure of welfare than incomes, we base the discussion on the per capita expenditure function. However, a quick overview indicates that some variables differ in their impact on the two measures of welfare, in terms of the magnitude, signs and significance of the coefficients. These include the number of children less than 5 years old, coarse soils, workability of soils, red vs. black soils, plot area and the ECM for willingness to listen to extension and membership in benevolent groups.

For tenure security, we use five variables constructed using factor analysis to capture tenure security. The first variable captures owned plots (which are often inherited), which have been owned by the family for a long period of time and which can be sold

without permission. The second variable captures family land that can be sold or bequeathed without permission or with permission. The other variables include land registered in family name, rented out and the right to rent out land without permission. Farmland and plots whose ownership is vested in relatives are negatively and significantly correlated with welfare.

Table 7.2: Reduced form estimates of household welfare: per capita expenditure and income

Variable	Per capita expenditure	Per capita income
Household characteristics and assets		
Female head	-0.0563	0.1573
	[0.52]	[0.49]
Age of household head	-0.0363	-0.048
	[1.93]*	[1.19]
Age of household head squared	0.0002	0.0003
	[1.48]	[1.08]
Child less than 5 years old in a household	-0.1133	0.2207
	[2.52]**	[1.90]*
Children 6 to 16 years old in a household	-0.0771	-0.0628
	[2.17]**	[0.67]
Number of adult women in a household	-0.1654	-0.1085
	[3.40]***	[0.78]
Number of adult men in a household	0.0637	0.2581
	[0.75]	[0.96]
Household head years of schooling	-0.0008	-0.0034
	[0.06]	[0.09]
Masaai tribe dummy	2.1198	2.3465
	[2.09]**	[0.81]
Lagged value of livestock (log)	0.1461	0.1761
	[2.68]***	[1.05]
Lagged value of farm equipment (log)	0.1534	0.6226
	[3.26]***	[4.23]***
Investment in SWC		
Number of SWC structures already on farm	0.1951	0.1818
	[4.16]***	[1.38]
Soil quality and topography		
Fine texture	0.0189	0.0144
	[0.71]	[0.16]
Coarse soils	-0.1082	0.1706
	[2.91]***	[1.90]*
Workability	0.0706	-0.0088
	[2.91]***	[0.13]
Red vs. black soils	0.058	-0.2041
	[1.79]*	[2.02]**
Fertility	-0.0007	0.1128
	[0.02]	[1.50]
Very fertile soils	-0.035	0.0161
	[1.25]	[0.18]

Table 7.2 continued

Variable	Per capita expenditure	Per capita income
Poor soils	0.09	0.3971
	[1.42]	[1.86]*
Unknown quality	-0.0263	-0.0307
	[1.14]	[0.54]
Moderate slope	-0.0076	0.0458
	[0.34]	[0.63]
Flatness of slope	-0.002	-0.1641
	[0.09]	[1.81]*
Undulating terrain	-0.0776	-0.0578
	[3.14]***	[0.96]
Tenure security and related factors		
Land registered in household head or spouse	-0.0704	-0.281
	[1.68]*	[2.20]**
Family land (registered in extended family)	0.0456	0.114
	[1.34]	[1.17]
Right to sell family land with permission	-0.1368	-0.122
	[3.44]***	[0.99]
Rented out land	-0.0455	-0.2714
	[0.63]	[1.11]
Lent out land	0.0043	0.0293
	[0.21]	[0.44]
Plot area (farm size)	-0.0587	0.0647
	[2.29]**	[0.76]
Distance to plot	-0.0044	-0.0022
	[2.82]***	[0.45]
Village Characteristics		
Number of institutions present	-0.2077	0.3957
	[0.86]	[0.50]
Presence of men's groups	0.095	-0.1454
	[1.47]	[0.83]
Presence of income generating groups	-0.557	-0.5268
	[2.27]**	[0.73]
Presence of village committees/groups	0.4025	1.2383
	[1.45]	[1.37]
Presence of safety net and NRM groups	0.3363	0.2107
	[1.44]	[0.28]
Population density	-0.0016	-0.0022
	[3.54]***	[1.42]
Market access	-1.0539	-2.1673
	[2.02]**	[1.46]
Murang'a district dummy	-0.2965	-0.9338
	[1.85]*	[2.16]**
Narok district dummy	-4.4717	-4.3405
	[2.46]**	[0.82]

Table 7.2 continued

Variable	Per capita expenditure	Per capita income
Error correction terms (residuals)		
Listened to extension services	0.1316	-0.0531
	[1.85]*	[0.23]
Membership in income generating groups	0.1933	0.52
	[1.57]	[1.35]
Membership in loans generating groups	0.0222	0.382
	[0.32]	[2.03]**
Membership in benevolent groups	0.1988	-0.1932
	[2.20]**	[0.64]
Willingness to invest in SWC	-0.1411	-0.3127
	[1.77]*	[1.67]*
Constant	5.7948	8.0008
	[6.83]***	[3.50]***
Observations	454	454
R-squared	0.33	0.25
F(44, 409)	4.62***	3.38

Robust t statistics in brackets and * significant at 10%; ** significant at 5%; *** significant at 1%

The first impact is counter-intuitive because when interpreted from the factor loadings, the negative coefficient suggests that land perceived to belong to the family is inversely related to welfare, while indefinite rental arrangements would positively impact of welfare. Taking together the impact of farmland and plots owned by relatives, the results imply that land rights based on inherited land are inversely related with income. Though these results imply that tenure security may not matter for household welfare, we note that this may be due to the sum of direct and indirect effects of all endogenous variables.

The impact of investment in soil and water conservation is captured by two variables: the number of SWC investment structures present per plot[6] and a residual for the willingness to invest in SWC. The results show that the total number of SWC investments on land used by a household has a large positive and significant impact on household welfare, implying a poverty environment link. However, we do not uncover any important impact of the willingness to invest in SWC on household welfare. The interpretation is that it is the actual investments made rather than the willingness to invest that matters for welfare. The SWC variables are jointly significant determinants of welfare at all conventional levels of testing {F(2, 409)= 9.87}, further confirming the poverty-environment link.

A vector of variables, which are indicators of institutional presence, captures village characteristics. The variables include the number of village institutions present, presence of men's groups, income generation, village committees and safety net and natural resource management institutions. Presence of village-based institutions alone does not seem to matter for poverty reduction. For instance, presence of income generating

[6] The number of SWC investment structures includes all SWC investments that have been present since one year and which have not been abandoned. Thus, actual SWC investments made in the current year are excluded.

groups is inversely related to expenditures, while all other institutional factors have insignificant coefficients. However, membership in village institutions is positively correlated to income as shown by the error correction terms (ECM). Membership in benevolent and income generation groups is positively and significantly related to expenditure, confirming the importance of institutional factors in poverty reduction. Furthermore, the ECM variables are jointly significant at the 5% level of significance {F(3,409)=2.45}. Households that listened to land conservation extension services are also less poor than their counterparts who never listened.

We also investigate the impact of population density and market access. Population density is inversely related to expenditure, implying that poverty is concentrated in regions of high population density. Market access has the unexpected negative and significant sign, making it difficult to explain. Though the analysis disentangles their impacts, the expected correlation between population density and market access and also the inclusion of both direct and indirect effects probably explain this result. The significance of population density confirms the importance of development domain dimensions in poverty alleviation.

The two district dummies included in the model (Murang'a and Narok), in reference to Maragua district exhibit negative and significant coefficients implying that households located in Murang'a and Narok are likely to be poorer than households located in Maragua district. This result is not unexpected given the distribution of per capita expenditure across the three districts.

We investigate the impact of two different categories of farm characteristics: soil quality and topography, both indicators of development domain dimensions. In addition, we include acreage and distance to plot. For soil quality, we investigate the impact of the workability of soil, colour of the soil (red vs. black), and texture. For topography, we investigate the impact of the nature of terrain and slope. The results indicate that soils with easy workability are positively correlated with household welfare, but coarse soils exhibit an inverse relationship with welfare. Relative to black soils, red soils have a significant positive impact on welfare. The implication of these results is that households with better quality soils will increase availability of food/income through higher crop productivity. We find that undulating land is inversely and significantly correlated with household welfare. This is because such land is more prone to soil erosion than flat land. Acreage has a negative and significant coefficient, implying that controlling for other factors; more land may not be an important determinant of welfare. Though this result may be surprising, a further look at the data shows that high acreage of land is among households located in less favourable agro-ecological zones and therefore the productivity of their land is likely to be much lower than for households with low acreage. Distance to plot exhibits a negative and significant impact on welfare. This can be explained by the fact that time wasted in moving to distant plots results to lower farm productivity and incomes, which translate into poverty. All different groups of farm characteristics pass the joint significance test, confirming the importance of farm characteristics and therefore development domain dimensions in household welfare.

The household characteristics are important correlates of welfare. The dummy for female heads of households shows that female-headed households are poorer than male-headed household. Though this is consistent with studies on poverty in Kenya, the impact is in-

significant. Age of the household head exhibits a U shape relationship with expenditure per capita implying that household welfare declines with the age of the household but after some age starts to increase. This points at family life cycle effects on welfare. Young households may not accumulate wealth in the formative years due to increased expenditure to cater for a growing family. After some threshold, the households are able to diversify their income base and even to save and thus increase per capita expenditure. The coefficient for age squared is not statistically different from zero.

Family composition variables are included to capture differential impact of different gender-age groups on household consumption. The gender-age categories of interest are number of children up to 5 years, number of children 6 to 16 years and number of adult males and females. Except for number of adult males, all the household composition variables are negative and statistically significant implying that larger households are worse off than smaller households. The presence of children aged 0-5 years has a negative impact on per capita expenditure, while the presence has a positive impact on income per capita. This latter result is rather counterintuitive, because female members of households with young children usually have a larger nursery task and less time to work of the land. We uncover no impact of education of household head on welfare. Household characteristics are jointly significant at all conventional levels of testing $\{F(9,409) = 8.26\}$.

Other characteristics of interest are household assets (livestock and equipment ownership). Because these two variables are potentially endogenous, we use previous (lagged) endowments of livestock and equipment as determinants of welfare. Both variables are positive and significant correlates of welfare. The results show that household assets are welfare improving.

7.3 Determinants of livestock wealth (asset poverty)

Assets are a measure of the structural income of the household and vary in importance among households Barrett *et al.,* (2006)[7]. Assets (and changes in assets) can therefore be good indicators of whether households suffer the risk of remaining poor or whether they are likely to move out of poverty. In addition, asset measures of poverty overcome the limitations of standard poverty measurement (such as being defined over the wrong space to measure economic policies directly and the difficulties of distinguishing between transitory and chronic poverty even where panel data is available). An asset based approach therefore makes it easier to address the key questions surrounding household's longer-term prospects of being non-poor (Carter and Barrett, 2006)[8].

In this paper, we use livestock wealth as a proxy for asset poverty. This is based on the fact that one of the districts of study (Narok) has livestock production as a major economic activity. Income measures may therefore not be good indicators of the levels and

[7] Structural approach to poverty alleviation is based on enhancing the returns that poor households earn on their household endowments (assets) and facilitating accumulation of productive assets (Carter and Barrett, 2006).

[8] See Carter and Barrett (2006) for detailed discussion on the value of asset-based approach to poverty measurement over other approaches.

characteristics of poverty in that district[9]. We explain livestock wealth using the same determinants as the other measures of welfare. However, we use a two stage process to explain livestock wealth; first explaining livestock wealth a year prior to the survey. Previous livestock wealth is determined by the same characteristics that determine wealth today. This therefore means that there is a correlation between livestock now and livestock owned a year ago. To solve for this endogeneity, we need to use two stage least squares. In the first stage, we explain lagged livestock and predict residuals, which we use to correct for the correlation between current wealth and previous wealth. Though the coefficients of variables do not change dramatically by including the residual of past wealth, this residual act as an error correction variable and the results are therefore more efficient than without this correction. The results for the second stage are presented in Table 7.3. The livestock wealth model fits the data better than the per capita expenditure and income models, with the model explaining 60% of the total variation in livestock wealth.

The results suggest that some aspects of land tenure are important determinants of livestock wealth. In particular, land in the family rather than land titles has a positive impact on livestock wealth. However, rented land is inversely correlated with livestock wealth. Taken together, these two variables imply that tenure security is associated with more livestock wealth. The importance of tenure is confirmed by a test of joint significance, which shows that tenure security variables are jointly significant at the 5% level. We uncover no important impact of the existing soil and water conservation assets on livestock wealth, but we find that the willingness to invest in soil and water conservation investments is a positive and significant determinant of livestock wealth. Other assets, namely education of the household head, equipment and the initial level of livestock wealth are positive and significant correlates of livestock wealth.

Topography and soil quality factors also affect livestock wealth. Flat terrain is associated with higher livestock wealth. On the other hand, moderately sloped land, poor soils and general fertility of soil are inversely related to livestock wealth. Farm size and distance to plot do not seem to matter. Market access is a positive correlate of livestock wealth. Households in Narok are better off in livestock wealth terms than households in the other districts.

Both presence and membership in village institutions are important correlates of livestock wealth. However, presence of men's groups and village committees are inversely related to livestock wealth. The same result is found for membership in income generation groups. This could mean that these different groups provide members with other opportunities outside livestock production. However presence of income generation groups and membership in loans groups are positive and significant determinants of livestock wealth.

Household characteristics also affect livestock wealth. Age exhibits an inverted U-shaped relationship with livestock wealth implying life cycle effects of age on wealth. Consistent with the results for per capita expenditure and incomes, larger households are

[9] Barrett *et al.* (2006) use a similar approach for herders in Northern Kenya, but use total livestock units rather than total value of livestock as in this paper.

poorer than smaller households. We uncover no impact of female headship and number of adult females on livestock wealth.

The regression results for the three welfare models imply that farm, household and village characteristics (including development domain dimensions) are important determinants of household welfare and that the impact is more pronounced on livestock wealth than on incomes poverty. The results however suggest that targeting interventions for alleviating incomes poverty would also have an important on a livestock wealth.

Table 7.3: Reduced form estimates of household welfare: livestock wealth

Variable	Coefficient	Robust Std. Err.	T-value
Household characteristics and assets			
Female head	-0.185	0.376	-0.49
Age of household head	0.144	0.041	3.55***
Age of household head squared	-0.001	0.000	-3.04***
Child less than 5 years old in a household	-0.178	0.102	-1.74*
Children 6 to 16 years old in a household	-0.277	0.089	-3.13***
Number of adult women in a household	0.144	0.130	1.11
Number of adult men in a household	-0.729	0.235	-3.10***
Household head years of schooling	0.108	0.027	4.01***
Masaai tribe dummy	-5.685	2.577	-2.21**
Lagged value of farm equipment (log)	0.272	0.155	1.76*
Investment in SWC			
Number of SWC structures already on farm	-0.020	0.116	-0.18
Soil quality & Topography			
Fine texture	0.068	0.070	0.97
Coarse soils	-0.035	0.105	-0.34
Workability	0.048	0.075	0.64
Red vs. black soils	0.111	0.096	1.16
Fertility	-0.128	0.075	-1.72*
Very fertile soils	0.062	0.090	0.69
Poor soils	-0.307	0.156	-1.97**
Unknown quality	0.106	0.051	2.08**
Moderate slope	-0.110	0.064	-1.73*
Flatness of slope	0.127	0.066	1.92*
Undulating terrain	-0.089	0.060	-1.48
Tenure security and related factors			
Land registered in household head or spouse	0.049	0.105	0.46
Land registered in extended family	-0.124	0.094	-1.31
Right to sell family land with permission	0.228	0.117	1.94**
Rented out land	0.254	0.196	1.30
Lent out land	-0.163	0.059	-2.75***
Plot area (farm size)	0.113	0.092	1.23
Distance to plot	0.005	0.005	1.16

Table 7.3 continued

Variable	Coefficient	Robust Std. Err.	T-value
Village Characteristics			
Number of institutions present	-0.503	0.668	-0.75
Presence of men's groups	-0.338	0.156	-2.17**
Presence of income generating groups	1.706	0.714	2.39***
Presence of village committees/groups	-1.721	0.672	-2.56***
Presence of safety net and NRM groups	-0.274	0.701	-0.39
Population density	0.001	0.001	0.74
Market access	3.914	1.183	3.31***
Murang'a district dummy	-0.436	0.372	-1.17
Narok district dummy	11.019	5.391	2.04**
Error correction terms (residuals)			
Listened to extension services	0.168	0.194	0.87
Membership in income generating groups	-0.725	0.292	-2.48***
Membership in loans generating groups	0.355	0.188	1.89**
Membership in benevolent groups	-0.384	0.325	-1.18
Willingness to invest in SWC	0.438	0.194	2.26**
Lagged value of livestock	1.081	0.147	7.33***
Constant	6.243	2.092	2.98***
Observations		454	
R-squared		0.6054	
F (44, 409)		13.54	

Robust t statistics in brackets and * Significant at 10%; ** significant at 5%; *** significant at 1%

7.4 Livelihood diversification strategies

One of the main hypotheses of development domains concept is the existence of differences in comparative advantages for adopting alternative livelihood strategies. The differences in comparative advantage can be attributed to household, farm and village level characteristics. Like assets, most livelihood diversification strategies are better measures of poverty than incomes and expenditures as they are indicators of the structural poverty of households. In rural Kenya, assets vary in importance among households. The poorest households rely heavily on unskilled agricultural labour markets (casual employment) and therefore labour comprises their most productive asset. Wealthier households however rely more on earnings from crops, livestock and skilled employment (including salaried labour and non-farm enterprises). Other households may rely on remittances from relatives, friends and institutions. In this paper, we focus on six livelihood diversification strategies as alternative poverty measurement approaches: casual off farm labour incomes, permanent off farm labour incomes, household enterprises, transfer incomes, crop incomes, and incomes from livestock products.

First we note that diversified sources of income within households may not be fully independent and so the error terms of their equations may be correlated. We test for their independence and correct for any possible bias by using two stage least squares and

seemingly unrelated regression methods[10]. The results (Table 7.4) suggest that household, farm and village characteristics correlate differentially with different livelihood strategies. However, few variables have significant coefficients, which is due to the inclusion of both direct and indirect effects of different vectors of characteristics of livelihood strategies. Female-headed households have lower crop income than male-headed households. Age of the household head exhibits a U-shaped relationship with incomes from casual labour but an inverted U-shaped relationship with permanent labour income implying lifecycle effects of age on labour incomes. Children aged less than 5 years are positively correlated with household enterprise incomes, implying the relationship between a family's lifecycle and enterprise formation. Total number of females is inversely correlated with livestock and transfer incomes, but positively related to casual labour income. These results suggest that livestock production is a male affair and that adult women may be more engaged in casual labour than their male counterparts. That all household composition variables are inversely correlated with transfer incomes suggests that large households are less likely to receive transfers than smaller households.

Household assets seem to matter more for incomes from livestock products and crops than other sources. Soil and water conservation methods are also important correlates of livestock products. This suggests complementarity between livestock production and SWC investments. The impact of SWC investments on crop incomes is insignificant. We however find that SWC does not automatically imply higher crop income at the household level.

[10] The use of SURE with identical X matrices takes into account that the analysis does not consider that the activities are done in isolation but part of broader livelihood strategies.

Table 7.4 Seemingly Unrelated Regression Equations: diversified sources of incomes

Variables	Livestock	Transfers	Enterprise	Crops	Casual labour	Permanent employment
Household characteristics and assets						
Female head	-0.8303	-0.0552	0.0337	-0.6689	-0.6216	0.3532
	[1.44]	[0.13]	[0.07]	[2.21]**	[1.09]	[0.68]
Age of household head	0.0611	0.0463	0.0112	0.0157	-0.164	0.1614
	[0.71]	[0.71]	[0.15]	[0.34]	[1.91]*	[2.08]**
Age of household head squared	-0.0005	0.0003	-0.0004	-0.0002	0.001	-0.0011
	[0.84]	[0.60]	[0.74]	[0.66]	[1.80]*	[2.24]**
Child less than 5 years old in a household	-0.2007	-0.16	0.4907	0.117	-0.1868	-0.0971
	[0.90]	[0.96]	[2.49]**	[1.00]	[0.85]	[0.49]
Children 6 to 16 years old in a household	-0.2014	-0.2359	-0.1511	0.1914	0.3694	-0.0847
	[1.01]	[1.58]	[0.85]	[1.83]*	[1.87]*	[0.47]
Number of adult women in a household	-0.7159	-0.3325	0.2867	0.1425	0.7263	-0.147
	[3.11]***	[1.93]*	[1.40]	[1.18]	[3.19]***	[0.71]
Number of adult men in a household	-0.7801	-0.8195	-0.6503	0.0942	0.8386	-0.511
	[1.33]	[1.87]*	[1.25]	[0.31]	[1.44]	[0.97]
Household head years of schooling	0.0557	0.0574	0.0559	0.002	-0.1673	0.2946
	[0.76]	[1.05]	[0.86]	[0.05]	[2.31]**	[4.49]***
Masaai tribe dummy	-1.3592	-2.9977	-2.324	1.2016	-1.2603	-4.0971
	[0.21]	[0.63]	[0.41]	[0.36]	[0.20]	[0.72]
Lagged value of livestock (log)	0.6989	-0.3009	0.0264	0.1255	-0.4487	-0.1627
	[1.97]**	[1.13]	[0.08]	[0.67]	[1.28]	[0.51]
Lagged value of farm equipment (log)	0.7184	-0.0276	0.1326	0.2875	-0.2948	-0.1138
	[2.35]**	[0.12]	[0.49]	[1.79]*	[0.97]	[0.42]

Table 7.4 continued

Variables	Livestock	Transfers	Enterprise	Crops	Casual labour	Permanent employment
Investment in SWC						
Number of SWC structures already on farm	0.4099	0.1443	0.1248	0.0575	0.2014	0.407
	[2.56]**	[1.21]	[0.88]	[0.68]	[1.27]	[2.84]***
Soil quality and topography						
Fine texture	-0.1488	0.0562	0.0917	-0.1258	-0.0709	-0.0162
	[1.19]	[0.60]	[0.82]	[1.91]*	[0.57]	[0.14]
Coarse soils	-0.0142	-0.287	0.2658	-0.0868	-0.0635	-0.3476
	[0.08]	[2.21]**	[1.72]*	[0.95]	[0.37]	[2.23]**
Workability	0.0222	0.2681	0.1387	-0.0283	0.0437	-0.1101
	[0.16]	[2.60]***	[1.13]	[0.39]	[0.32]	[0.89]
Red vs. black soils	-0.0738	0.3061	0.0692	-0.0236	0.1803	0.0214
	[0.42]	[2.33]**	[0.44]	[0.26]	[1.04]	[0.14]
Fertility	-0.2562	-0.0981	0.0643	0.0442	-0.2164	-0.1495
	[1.66]*	[0.85]	[0.47]	[0.55]	[1.42]	[1.08]
Very fertile soils	-0.0653	-0.1619	0.025	0.0579	-0.1652	0.0483
	[0.43]	[1.43]	[0.19]	[0.73]	[1.10]	[0.36]
Poor soils	-0.1846	-0.4269	0.1079	0.1287	-0.4271	-0.3924
	[0.43]	[1.34]	[0.28]	[0.57]	[1.01]	[1.03]
Unknown quality	0.0925	0.1452	-0.1431	0.067	0.3289	0.0201
	[0.56]	[1.18]	[0.98]	[0.78]	[2.02]**	[0.14]
Moderate slope	0.056	-0.1361	0.1356	0.0668	-0.0284	0.0348
	[0.47]	[1.53]	[1.29]	[1.07]	[0.24]	[0.33]
Flatness of slope	0.0442	0.1437	-0.1201	-0.0079	0.2216	0.1089
	[0.33]	[1.41]	[1.00]	[0.11]	[1.65]*	[0.89]

Table 7.4 continued

Variables	Livestock	Transfers	Enterprise	Crops	Casual labour	Permanent employment
Undulating terrain	-0.0173	-0.1394	-0.1513	-0.0442	-0.1507	0.0048
	[0.16]	[1.77]*	[1.62]	[0.80]	[1.44]	[0.05]
Tenure security and related factors						
Land registered in house hold head or spouse	0.301	0.2635	-0.4086	-0.2059	0.1241	0.1817
	[1.21]	[1.41]	[1.85]*	[1.57]	[0.50]	[0.81]
Family land registered in extended family	-0.1173	-0.1386	0.1285	0.1398	-0.2836	-0.0668
	[0.54]	[0.85]	[0.67]	[1.23]	[1.32]	[0.34]
Right to sell family land with permission	0.0455	0.3194	0.1361	-0.1026	0.0437	0.336
	[0.18]	[1.66]*	[0.60]	[0.76]	[0.17]	[1.46]
Rented out land	0.3268	0.8407	-0.1951	-0.1388	0.433	0.2775
	[0.67]	[2.30]**	[0.45]	[0.54]	[0.90]	[0.63]
Lent out land	0.1124	-0.1375	0.2984	-0.0476	0.06	-0.1566
	[0.80]	[1.30]	[2.38]**	[0.64]	[0.43]	[1.24]
Plot area (farm size)	-0.167	-0.2339	0.1791	-0.0588	-0.1647	0.0152
	[1.12]	[2.10]**	[1.36]	[0.75]	[1.12]	[0.11]
Distance to plot	0.0111	0.0166	0.0063	-0.0056	0.0036	0.0063
	[1.04]	[2.07]**	[0.67]	[1.00]	[0.34]	[0.66]
Village Characteristics						
Number of institutions present	-3.0214	-2.5808	3.2512	-1.1918	-0.3326	-1.0466
	[2.07]**	[2.36]**	[2.51]**	[1.55]	[0.23]	[0.80]
Presence of men's groups	-0.3291	-0.1728	0.2105	-0.2392	-0.1574	-0.1565
	[0.85]	[0.60]	[0.61]	[1.18]	[0.41]	[0.45]
Presence of income generating groups	-0.987	-1.0922	2.4141	-1.6088	-0.6618	0.1389
	[0.69]	[1.02]	[1.90]*	[2.14]**	[0.47]	[0.11]
Presence of village committees/groups	-1.5728	-2.0188	0.205	-0.2388	-0.2965	-1.6493
	[0.84]	[1.44]	[0.12]	[0.24]	[0.16]	[0.98]

Table 7.4 continued

Variables	Livestock	Transfers	Enterprise	Crops	Casual labour	Permanent employment
Presence of village committees/groups	-1.5728	-2.0188	0.205	-0.2388	-0.2965	-1.6493
	[0.84]	[1.44]	[0.12]	[0.24]	[0.16]	[0.98]
Presence of safety net and NRM groups	2.3854	1.964	-3.1953	1.6905	0.2107	0.3975
	[1.72]*	[1.89]*	[2.59]***	[2.32]**	[0.15]	[0.32]
Population density	-0.0026	-0.008	0.0029	-0.0007	-0.0046	-0.0034
	[0.96]	[3.94]***	[1.23]	[0.51]	[1.73]*	[1.39]
Market access	1.2931	2.766	1.7326	-1.4383	1.0715	2.3623
	[0.39]	[1.11]	[0.59]	[0.82]	[0.32]	[0.79]
Murang'a district dummy	-0.9382	-1.7073	0.8478	-0.4181	-0.848	-0.5198
	[1.05]	[2.56]**	[1.07]	[0.90]	[0.96]	[0.65]
Narok district dummy	-7.7228	-10.6001	16.7924	-9.9428	-7.5775	2.2281
	[0.72]	[1.33]	[1.77]*	[1.77]*	[0.72]	[0.23]
Error correction terms						
Listened to extension services	0.0169	0.1015	-0.3662	0.2954	0.312	0.2607
	[0.05]	[0.37]	[1.13]	[1.55]	[0.87]	[0.80]
Membership in income generating groups	-0.6954	-0.98	0.0126	0.1065	-0.4651	-0.7144
	[0.85]	[1.60]	[0.02]	[0.25]	[0.58]	[0.98]
Membership in loans generating groups	-0.1945	0.3619	1.2434	0.2978	-0.3385	0.2581
	[0.61]	[1.52]	[4.40]***	[1.78]*	[1.07]	[0.91]
Membership in benevolent groups	0.5671	0.8624	-0.6641	0.1869	0.6374	0.0282
	[1.08]	[2.19]**	[1.43]	[0.68]	[1.23]	[0.06]
Constant	6.7057	10.9698	-3.4644	7.9668	14.4209	1.1359
	[1.38]	[3.01]***	[0.80]	[3.12]***	[2.99]***	[0.26]
Observations	454	454	454	454	454	454
R-squared	0.3156	0.281	0.1822	0.3679	0.3553	0.1857
Chi^2	209.38***	177.46***	101.13***	264.21***	250.16***	103.51***

Absolute value of z statistics in brackets and * Significant at 10%; ** significant at 5%; *** significant at 1%.

Tenure security matters for enterprise development. Households with weak rights are more likely to seek alternative earning opportunities in enterprises, while lack of safety nets also drive households into alternative enterprises. Labour earnings seem to be driven by experience and education. Other factors such as land tenure, though significant do not necessarily imply a causal relationship.

Presence of village institutions has a mixed impact on livelihood strategies. Income generation groups are positively correlated with welfare, but inversely related with crop income. Presence of safety net and natural resource management institutions is positively correlated with most strategies. Membership in village institutions, also affect livelihood diversification strategies differentially. Membership in loans groups is positively and significantly correlated with enterprise and crop incomes, implying the importance of access to credit in poverty alleviation. Membership in benevolent groups is particularly important as a source of transfer incomes. This reflects the roles of safety nets in improving household welfare.

District dummies capture community heterogeneity not captured directly in the model including the interrelationship between various factors such as population density and agro-ecological zones. The results therefore show the relative importance of different development domains leading to various livelihood diversification strategies in the three districts. Population density affects labour utilization decisions and hence agricultural management practices as well as returns to different types of investments. Except for enterprise incomes, population density is inversely related to all other strategies. The negative significant impact of population density on casual labour incomes suggest that low population densities imply more land available and therefore more opportunities for casual employment. Relative scarcity of land faced by large households corrects for general abundance of land in a village. Market access would be expected to determine the comparative advantage of a specific locality in terms of resource endowment and would therefore influence farm household decisions related to consumption and production (Kruseman *et al.*, 2006). However, we do not uncover any important impact on market access on livelihood diversification strategies. This may be because we are interested in the sum of direct and indirect effects of farm, household and village characteristics on livelihood diversification strategies. We may therefore not necessarily capture the individual impact of each of the variables. For instance, market access and population density are very often correlated at local levels. Increasing population density may lead to better market access, while improved market access tends to attract immigration hence increasing population density. In addition, farm characteristics, such as soil quality and elevation may be related to population and market access.

Like for the welfare models, the results suggest that development domain dimensions have important implications on livelihood diversification strategies. However, the overall impact of household, farm and village characteristics on these strategies is quite modest. The R-squared range from 0.18 for enterprise incomes to 0.36 for crop income. Nevertheless, the results capture the sum of direct and indirect impacts of the three vectors of characteristics and shed important light on targeting interventions for improving household welfare.

8. Soil and water conservation investments: role of tenure security

8.1 Preliminaries

In this section, we empirically test the role of household, farm and community characteristics as well as development domain dimensions in determination of soil and water conservation investment decisions at the plot level. We observe the degree to which the decisions are explained by the above factors as a combined result of direct and indirect effects. We seek to explain the factors influencing adoption of six main soil and water conservation practices namely: grass strips, mulching, tree planting, terracing in general, soil terraces and grass stripped terraces. In addition, we explain factors influencing adoption of "other" SWC investments (fallowing, crop rotation and ridging) and also analyze the determinants of adoption of permanent and seasonal SWC investments.

8.2 Determinants of adoption of SWC investments

We note that the types of investments that we consider are determined by the same set of factors. Furthermore, we expect that all important variables will influence them in the same direction. It is therefore important to investigate for any possible correlation between the adoption decisions. This is done in several steps. First, we run the individual Probit type models for each of the adoption decisions mentioned above. Second, we derive individual residuals from each investment regression equation and examine the relationship between investment decisions further by carrying out a factor analysis on the residuals from each of the regression equations. The results of the factor analysis, (Table 8.1a) shows that there is only one factor in which residuals for more long-term SWC investments, such as permanent investments in soil fertility and tree planting, are significantly present. Since the residual of seasonal or short-term investments in SWC are not present, we refer to this unique factor as the "speed of regenerating chemical fertility" because higher levels of regenerating soil fertility characterize these long-term investments. This is further confirmed by factor loadings based on Varimax rotation (Table 8.1b). The results of the factor analysis confirm our intuition and findings of the regression equations on investment decisions (Tables 8.2a and 8.2b): different types of SWC investments are explained by similar sets of explanatory variables.

The Probit regression results are presented in Tables 8.2a and 8.2b. Since we are interested in both the direct and indirect effects on the probability of adopting SWC, we retain all variables in the regression models, irrespective of whether they are significant or not. Inclusion of all variables however has implications on the overall explanatory power of the model. In particular, our results show that only between 25% and 56% of the diversity in various practices is explained by household, farm and village characteristics including development domain dimensions. The lowest percentage (25%) is explained for adoption of grass strips, while the highest (56%) is for soil terraces. Comparing permanent and seasonal SWC technologies, only 27% and 20% (respectively) of the diversity is explained by the independent variables.

Table 8.1a: Factor analysis of SWC residuals

Factor	Eigenvalue	Difference	Proportion	Cumulative
1	3.196	2.529	0.899	0.899
2	0.667	0.514	0.188	1.087
3	0.153	0.112	0.043	1.130
4	0.040	0.165	0.011	1.141
5	-0.125	0.022	-0.035	1.106
6	-0.147	0.085	-0.041	1.065
7	-0.231	.	-0.065	1

Table 8.1b: Factor loadings for SWC residuals

	Rotated Factor Loadings				
Variable (residual)	**1**	**2**	**3**	**4**	**Uniqueness**
Grass strips	0.551	-0.379	0.304	-0.114	0.447
Mulching	0.490	-0.463	0.180	0.094	0.505
Other investments	0.180	0.602	0.034	0.012	0.603
Terraces	0.467	-0.203	0.448	0.101	0.529
Tree planting	0.840	-0.070	0.200	-0.031	0.249
Permanent investments	0.816	0.006	0.143	0.085	0.307
Seasonal investments	0.660	0.047	0.507	-0.039	0.303

The results suggest that most household characteristics do not matter much in influencing the adoption decision. While this result is not uncommon in the literature (see for instance, Gebremedhin and Swinton, 2003), it could also be due to the fact that our models capture both direct and indirect effects of the explanatory factors. However, age seems to matter for mulching and all seasonal improvements. Specifically, age exhibits an inverted U-shaped relationship with the decision to adopt these types of investments. This suggests life cycle impacts on the investment decision. Younger farmers may have more energy to engage in labour intensive conservation practices but after some threshold, the likelihood of adoption declines. Presence of children aged less than 5 years is negatively correlated with adoption of all types of terraces. Given that terracing is labour intensive, the result implies that presence of young children diverts labour from conservation activities to childcare. However, presence of older children (aged 6 to 16 years) is positively correlated with investment decisions (more so terracing), suggesting that they provide additional labour inputs for soil and water conservation. Another important finding is that number of adult females in a household is positively correlated with adoption of all SWC investments except grass strip. The significant impact on adoption of terracing (and grass stripped terracing) suggests the importance of female labour in adoption of SWC investments. This is further confirmed by the coefficient for total males, which is negative (though insignificant) for most types of SWC investments. The number of years of schooling of the household head is positively and significantly correlated with all other investments (fallowing, crop rotation and ridging) as well as with permanent investments. This reflects the importance of human capital in SWC decisions.

Like in the poverty analysis, we do not uncover much impact of the presence of village institutions on adoption of SWC investments. The presence and type of institutions only

matter for adoption of terracing with grass strips. In particular, the number of institutions present, presence of men's groups, household income generation and other village committees are positively and significantly correlated with the decision to invest in SWC.

Similarly, market access and population density are positively correlated with terracing, which suggests the importance of development domain dimensions in adoption of SWC investments. We do not uncover any important impact of population density and market access on the other methods of conservation. The two district dummies (Murang'a and Narok) suggest that location is an important determinant of the decision to adopt SWC. Specifically, there is a higher probability of adoption if a household is located in Murang'a relative to Maragua district, more so for all permanent investments. The likelihood of adoption is lower in Narok district but the coefficients are insignificant. Given the diversity of agro-ecology in the three districts, we conclude that the impact of regional dummies reflect the unobserved relative importance of different development domains. For instance, Murang'a is more hilly and undulated than Maragua district, while Narok is relatively flat in terms of terrain.

The impact of tenure security factors is captured by five variables discussed in the previous section: owned plots (which are often inherited); family land that can be sold or bequeathed with or without permission; land registered in family name; rented out and the right to rent out land without permission. In this case, the first three rights represent the strongest rights to land. The coefficients of those variables exhibit positive and significant coefficients for most adoption models, confirming the importance of tenure security in adoption of SWC investments. The differences in coefficients for permanent and seasonal investments support the finding that tenure security favours long term conservation investments more than short term investments (Gebremedhin and Swinton, 2003). The negative and mostly significant coefficients of the last two variables show that weak security of tenure will discourage investment in SWC, more so long term investments such as grass strips, terracing and tree planting.

Table 8.2a: Probit regression results for adoption of SWC Investments

Variable	Grass strips	Mulching	Other investments	Tree planting
Household characteristics and assets				
Female head	0.1313	0.1988	-0.6138	-0.0129
	[0.47]	[0.63]	[1.10]	[0.04]
Age of household head	0.0002	0.1249	0.085	0.0151
	[0.01]	[1.87]*	[1.01]	[0.28]
Age of household head squared	-0.0001	-0.0014	-0.0007	-0.0003
	[0.18]	[2.02]**	[0.84]	[0.57]
Child less than 5 years old in a household	0.0244	-0.0328	0.075	-0.0434
	[0.20]	[0.25]	[0.47]	[0.31]
Children 6 to 16 years old in a household	0.0419	0.0947	0.0272	0.0819
	[0.63]	[1.31]	[0.31]	[1.06]
Number of adult women in a household	-0.2397	0.0936	0.0926	0.0484
	[1.47]	[0.65]	[0.57]	[0.31]

Table 8.2a continued

Variable	Grass strips	Mulching	Other investments	Tree planting
Number of adult men in a household	0.0157	0.1999	-0.0343	-0.0548
	[0.13]	[1.50]	[0.21]	[0.40]
Household head years of schooling	-0.0184	0.0266	0.0625	0.028
	[0.67]	[0.84]	[1.93]*	[0.96]
Masaai tribe dummy	-1.5154	0.1605	0.6064	-1.2382
	[1.16]	[0.16]	[0.43]	[1.63]
Lagged value of livestock (log)	0.1109	0.297	-0.1841	0.2413
	[1.11]	[2.68]***	[1.37]	[2.15]**
Lagged value of farm equipment (log)	0.0702	-0.186	0.0362	0.0237
	[0.98]	[2.41]**	[0.33]	[0.29]
Previous soil conservation structures	-0.666	-0.2775	-0.1848	-1.262
	[4.86]***	[2.26]**	[1.03]	[6.69]***
Village Characteristics				
Number of institutions present	0.6782	-1.2791	0.2578	0.4315
	[0.67]	[1.03]	[0.20]	[0.54]
Presence of men's groups	0.0773	-0.1347	-0.5284	-0.0076
	[0.33]	[0.47]	[1.04]	[0.04]
Presence of income generating groups	0.0992	-0.9347	-0.0793	0.7082
	[0.20]	[1.34]	[0.12]	[1.21]
Presence of village committees/groups	0.2118	-0.4156	0.692	0.1176
	[0.82]	[1.40]	[1.18]	[0.57]
Presence of safety net and NRM groups	-0.3393	1.2951	-0.0871	-0.5924
	[0.38]	[1.20]	[0.08]	[0.77]
Population density	-0.0011	0.0001	-0.0046	0.0009
	[1.10]	[0.10]	[1.02]	[0.86]
Market access	0.0278	-0.3316	0.6452	-0.0987
	[0.07]	[0.81]	[0.96]	[0.25]
Murang'a district dummy	0.0718	0.1481	0.402	1.0466
	[0.26]	[0.49]	[0.61]	[3.39]***
Narok district dummy	-0.2149	-6.1594	-1.3859	1.371
	[0.06]	[1.46]	[0.32]	[0.48]
Tenure security and related factors				
Land registered in household head or spouse	0.1734	0.4124	-0.2187	0.9611
	[1.89]*	[2.52]**	[1.49]	[4.90]***
Family land registered in extended family	0.0001	-0.1496	0.405	0.293
	[0.00]	[1.17]	[2.04]**	[2.68]***
Right to sell family land with permission	-0.0985	0.2101	0.1778	0.148
	[1.08]	[2.68]***	[1.27]	[1.72]*
Rented out land	-0.1493	-0.8005	-0.1039	-0.3502
	[1.05]	[1.27]	[0.89]	[1.14]
Lent out land	-0.2389	-0.1881	-0.062	-0.2397
	[2.05]**	[1.18]	[0.55]	[1.92]*
Plot area (farm size)	0.0091	0.0064	0.0162	0.0132
	[0.43]	[0.31]	[1.90]*	[0.99]

Table 8.2a continued

Variable	Grass strips	Mulching	Other investments	Tree planting
Distance to plot	-0.0111	-0.0062	-0.0161	-0.0205
	[1.48]	[0.99]	[1.15]	[2.64]***
Soil quality & Topography				
Moderate vs. fine texture	-0.0193	-0.2174	-0.3681	-0.4148
	[0.20]	[1.99]**	[2.41]**	[3.61]***
Coarse soils	-0.0712	0.2031	-0.033	-0.1727
	[0.57]	[1.85]*	[0.27]	[1.33]
Soil depth	-0.0011	0.0461	0.0512	0.0272
	[0.07]	[3.18]***	[2.22]**	[1.56]
Red vs. black soils	-0.1674	-0.2054	0.1858	-0.1438
	[1.59]	[1.62]	[1.07]	[1.26]
Very fertile soils	-0.207	-0.1783	-0.0328	-0.0664
	[1.21]	[0.92]	[0.27]	[0.55]
Fertile to average fertile	0.0578	-0.0567	0.1121	-0.0464
	[0.64]	[0.54]	[0.71]	[0.41]
Poor soils	-0.0672	0.0279	0.1175	0.0328
	[0.75]	[0.31]	[1.00]	[0.33]
Steep slope	0.0538	-0.2114	0.1352	-0.079
	[0.66]	[1.82]*	[0.97]	[0.82]
Moderate slope	0.3228	0.186	-0.0633	0.1576
	[3.63]***	[2.00]**	[0.44]	[1.47]
Flatness of slope	-0.0191	-0.1047	0.0187	-0.1199
	[0.21]	[0.88]	[0.14]	[1.08]
Undulating terrain	-0.1304	0.1647	0.1598	-0.0333
	[1.26]	[1.86]*	[1.52]	[0.37]
Error correction terms (residuals)				
Listened to extension services	0.1787	0.0243	0.0066	-0.1448
	[1.19]	[0.15]	[0.03]	[0.86]
Membership in village institutions	-0.0667	-0.0565	-0.0491	-0.121
	[0.58]	[0.45]	[0.30]	[0.90]
Willingness to invest in SWC	0.3312	0.6273	0.0238	1.0622
	[1.94]*	[3.15]***	[0.10]	[4.50]***
Constant	-0.6659	-4.3352	-4.595	-3.68
	[0.42]	[2.02]**	[1.59]	[1.99]**
Observations	684	684	684	684
LR $chi^2(42)$	99.66	118.16	70.75	167.88
Pseudo R^2	0.254	0.3302	0.311	0.4082
Log likelihood	-146.37	-119.843	-78.354	-121.698

Absolute value of z statistics in brackets and * significant at 10%; ** significant at 5%; *** significant at 1%

Table 8.2b: Probit regression results for adoption of SWC investments

Variable	Terracing	Soil terraces	Grass strip terraces	Permanent investments	Seasonal investments
Household characteristics and assets					
Female head	0.261	0.5989	0.1843	0.0516	0.0042
	[1.04]	[0.86]	[0.66]	[0.22]	[0.02]
Age of household head	-0.0096	0.1179	-0.0194	-0.0389	0.0576
	[0.24]	[0.71]	[0.47]	[1.54]	[1.70]*
Age of household head	0	-0.0013	0.0001	0.0003	-0.0005
squared	[0.05]	[0.81]	[0.28]	[1.18]	[1.69]*
Child less than 5 years old in a	-0.2496	-0.1999	-0.1441	0.0215	-0.0401
household	[2.24]**	[0.66]	[1.20]	[0.23]	[0.47]
Children 6 to 16 years old in a	0.0826	0.4599	0.0717	0.1809	-0.0126
household	[1.36]	[2.22]**	[1.05]	[3.51]***	[0.26]
Number of adult women in a	0.2336	0.0079	0.3189	0.0637	0.0517
household	[1.96]**	[0.02]	[2.24]**	[0.59]	[0.54]
Number of adult men in a	-0.021	0.559	-0.0927	0.0175	-0.0151
household	[0.19]	[1.63]	[0.74]	[0.18]	[0.18]
Household head years of	0.0039	0.1043	-0.004	0.0432	-0.0061
schooling	[0.17]	[1.31]	[0.15]	[2.07]**	[0.33]
Masaai tribe dummy	-0.5148	1.5899	-0.5014	-0.1434	-0.4022
	[0.86]	[1.22]	[0.59]	[0.30]	[0.79]
Lagged value of livestock	0.0485	-0.0542	0.0214	0.2697	0.0348
(log)	[0.54]	[0.21]	[0.21]	[3.45]***	[0.49]
Lagged value of farm equip-	0.1318	0.3673	0.0728	0.1063	0.0414
ment (log)	[1.96]*	[1.71]*	[1.01]	[1.79]*	[0.77]
Previous soil conservation	-1.1669	-1.0437	-1.1123	-0.7971	-0.6483
structures	[7.72]***	[2.61]***	[6.37]***	[7.71]***	[7.01]***
Village Characteristics					
Number of institutions present	-1.3349	-1.3395	6.3515	-0.0072	0.1363
	[0.36]	[0.70]	[18.09]***	[0.01]	[0.26]
Presence of men's groups	-0.3395	0.0351	1.3617	-0.1052	0.1092
	[0.38]	[0.06]	[9.64]***	[0.86]	[0.90]
Presence of income generating	-1.0019	-0.988	1.8476	-0.0597	0.0123
groups	[0.43]	[0.87]	[6.96]***	[0.22]	[0.04]
Presence of village commit-	-0.4101	-1.2143	1.3213	0.0364	0.0855
tees/groups	[0.41]	[2.23]**	[5.81]***	[0.30]	[0.69]
Presence of safety net and	-0.3811	1.085	-6.9579	-0.2211	-0.0478
NRM groups	[0.26]	[0.75]	[.]	[0.49]	[0.10]
Population density	0.0021	0.0085	0.0029	-0.0001	0.0002
	[2.25]**	[2.06]**	[2.64]***	[0.17]	[0.24]
Market access	0.5765	-0.8427	0.9418	0.0071	0.0689
	[1.87]*	[1.26]	[2.02]**	[0.03]	[0.32]
Murang'a district dummy	0.4492	0.8803	0.257	0.6544	0.1561
	[1.86]*	[1.15]	[0.94]	[2.86]***	[0.78]
Narok district dummy	-3.6614	-0.9163	13.6314	-1.1159	-0.4541
	[0.34]	[0.14]	[0.00]	[0.62]	[0.24]

Table 8.2b continued

Variable	Terracing	Soil terraces	Grass strip terraces	Permanent investments	Seasonal investments
Tenure security and related factors					
Land registered in house hold head or spouse	0.3582 [4.18]***	0.4595 [1.56]	0.2841 [2.97]***	0.4048 [4.88]***	0.1902 [2.81]***
Family land registered in extended family	0.1161 [1.43]	0.2228 [0.78]	0.0986 [1.08]	0.0556 [0.77]	-0.0138 [0.21]
Right to sell family land with permission	0.2411 [3.45]***	0.1652 [0.91]	0.2053 [2.74]***	0.0214 [0.32]	0.1267 [2.10]**
Rented out land	-0.3088 [2.66]***	-0.3529 [0.92]	-0.264 [2.08]**	-0.2892 [2.53]**	-0.2268 [2.55]**
Lent out land	-0.16 [1.71]*	-0.0114 [0.04]	-0.1521 [1.20]	-0.1977 [2.43]**	-0.1443 [1.97]**
Plot area (farm size)	0.0039 [0.36]	-0.106 [1.67]*	0.0364 [1.81]*	0.0103 [1.35]	0.0061 [0.85]
Distance to plot	-0.0251 [2.59]***	-0.009 [0.53]	-0.0146 [1.81]*	-0.0174 [2.97]***	-0.0229 [2.62]***
Soil quality & Topography					
Moderate vs. fine texture	0.023 [0.27]	0.2729 [1.18]	0.0378 [0.41]	-0.3143 [3.89]***	-0.1473 [2.10]**
Coarse soils	0.0984 [1.10]	0.6518 [2.82]***	0.1458 [1.30]	-0.0365 [0.46]	0.0566 [0.78]
Soil depth	0.0194 [1.34]	0.0638 [1.62]	-0.0092 [0.58]	0.0436 [3.70]***	0.0068 [0.60]
Red vs. black soils	-0.0949 [1.05]	-0.3747 [1.49]	-0.2115 [2.07]**	-0.0719 [0.78]	-0.1752 [2.29]**
Very fertile soils	0.1239 [1.35]	0.5332 [2.20]**	0.0812 [0.69]	0.0104 [0.12]	0.0284 [0.38]
Fertile to average fertile	-0.1002 [1.15]	-1.1101 [2.21]**	0.0115 [0.12]	-0.1639 [2.07]**	-0.0132 [0.19]
Poor soils	-0.0099 [0.13]	0.8363 [2.57]**	-0.0725 [0.87]	0.051 [0.73]	-0.0124 [0.19]
Steep slope	-0.0072 [0.09]	0.3671 [1.42]	-0.0313 [0.35]	-0.1357 [1.67]*	-0.0618 [0.96]
Moderate slope	0.3032 [3.60]***	0.732 [2.46]**	0.3037 [3.31]***	0.3745 [5.27]***	0.1415 [2.11]**
Flatness of slope	-0.2229 [2.58]***	-0.7784 [1.87]*	-0.2502 [2.58]***	-0.1646 [2.16]**	-0.1193 [1.77]*
Undulating terrain	0.1458 [2.02]**	0.3906 [1.63]	0.1854 [2.36]**	-0.0345 [0.48]	0.1553 [2.60]***
Error correction terms (residuals)					
Listened to extension services	0.1053 [0.81]	0.4921 [1.47]	-0.0291 [0.20]	0.1619 [1.39]	0.0035 [0.03]
Membership in village institutions	-0.1287 [1.22]	0.0233 [0.08]	-0.2304 [1.92]*	-0.1009 [1.09]	-0.1052 [1.25]
Willingness to invest in SWC	0.5795 [3.70]***	1.1151 [2.00]**	0.5581 [3.20]***	1.0285 [6.94]***	0.2304 [1.89]*

Table 8.2b continued

Variable	Terracing	Soil terraces	Grass strip terraces	Permanent investments	Seasonal investments
Constant	-1.3638	-14.6171	-8.2651	-1.6391	-2.1832
	[0.43]	[2.13]**	[6.58]***	[1.53]	[1.96]*
Observations	684	684	684	684	684
LR chi^2(42)	211.95	85.46	191.77	169.07	137.11
Pseudo R^2	0.3656	0.563	0.3854	0.2715	0.2001
Log likelihood	-183.853	-33.169	-152.932	-226.847	-273.999

Absolute value of z statistics in brackets and * significant at 10%; ** significant at 5%; *** significant at 1%

Soil texture does not seem to matter much for conservation. For instance, moderate versus fine soils are inversely and significantly correlated with the probability of adopting all practices except all forms of terracing. Course and very fertile soils encourage adoption of terracing, while there is less likelihood of investment in SWC on fertile soils compared to average fertile soils. Red versus black soils is also inversely related with adoption of SWC investments. Soil depth is however positively correlated with most investments: mulching, others (fallowing, crop rotation and ridging), terracing and all permanent investments. Turning to slope/topography, moderate slopes and undulating terrain favour adoption of grass strips, mulching, terracing and all permanent investments. Undulating terrain is also positively correlated with the probability of adopting seasonal investments. Conversely, steep slopes lower probability of adoption of all SWC investments. There is also less likelihood of adoption of most SWC investments on flat land.

Household assets are captured by a vector of variables namely: lagged values of farm equipment and livestock wealth, plot size and existing conservation assets (permanent SWC investments not made in the past year but still in function). Farm equipment is positively correlated to all permanent improvements, including mulching and tree planting. Livestock wealth is also positively correlated with permanent improvements but is only significant for terraces and soil terraces. Livestock wealth is inversely correlated with mulching. This is probably due to the fact that most material used for mulching is crop residuals, which is also used as feed for cattle. Mulching and livestock feeding are therefore competing alternatives rather than complements.

Plot size increases the likelihood of adoption of other investments (fallowing, crop rotation and ridging) as well as terracing with grass strips. The results for other investment is because fallowing and crop rotation are land intensive and households may not leave land fallow or rotate crops if there is land scarcity. The impact of plot size on other technologies, including all permanent and seasonal SWC investments is insignificant. Plot size is however inversely correlated with adoption of soil terraces, probably due to the labour intensity of this technology, which would reduce the likelihood of adoption for labour constrained households. This could also imply that factor markets are not efficient to allow large farmers to hire labour in sufficient quantities. Related to plot size is distance to the plot. Distance is inversely and significantly correlated with adoption of all

SWC technologies, implying that all technologies are more likely to be adopted on home plots rather than distant plots.

Existing soil and water conservation assets on a plot are inversely related to the probability of making new investments. This implies that additional investments are more likely to be made on plots without any prior land improvements than plots with existing investments.

Finally we turn to the error correction variables. We include three error correction residuals in the determination of the investment decision. We test the impact of listening to agricultural extension services in general, membership in village institutions and the willingness to invest in SWC. We uncover no important impact of the residuals of extension services and membership in village institutions. This result suggests that there is no need to put a lot of effort into extension and helping local organizations for SWC because they have very little impact. However, the residual of the willingness to invest is positively correlated with all investment decisions, both permanent and seasonal, implying the need to provide incentives for SWC.

8.3 Determinants of the intensity of SWC investments

In addition to the determinants of the probability of adoption of various SWC investments, we also measure the extent or intensity of adoption, measured through the number of SWC investment structures on a plot. Since some plots have no SWC structures, we use the Tobit model to explain how much households participate in SWC investments. The results are presented in Table 8.3. Comparing the intensity of adoption with the adoption of seasonal and permanent investments, the results suggest that save for some variables, intensity of adoption is determined by the same set of factors that influence the decision to invest in SWC. Presence of children aged 6 to 16 years is the only household characteristics that seem to matter for intensity of adoption, which implies the importance of family labour in SWC. We uncover no impact of presence of village institutions, population density and market access on intensity of adoption, which is consistent with findings for adoption of general permanent and seasonal technologies. This result implies that though development domain dimensions may matter for some individual investment decisions, they may not matter much for intensity of conservation. There is a higher intensity of adoption in Murang'a relative to Maragua district but the reverse is observed for Narok (though not significant). This is consistent with the results for the adoption of individual conservation investments.

The results further show that tenure security variables not only influence the probability of adopting various SWC technologies but also determine how much to invest in SWC. Soil quality and topography also matter, and the results are comparable to those of adoption. Plot size is positively correlated to the number of actual investment structures, but the reverse is observed for distance to plot. Previously owned farm equipment and livestock wealth are positively correlated with number of investments but only the former has a significant coefficient. The permanent SWC investments not made in the past year but still in function are inversely related with the intensity of conservation, implying that most investment structures are seasonal rather than permanent. Like in the adoption model, we uncover no impact of extension services and membership in village institutions on the intensity of conservation. The residual for willingness to invest in SWC is

however positively correlated with the intensity of conservation, confirming earlier results that willingness to invest raises participation in SWC.

Table 8.3: Tobit regression results for intensity of SWC investments

Variable	Coefficient	Std. Error	t-value
Household characteristics and assets			
Female head	0.0966	0.2267	0.43
Age of household head	-0.0030	0.0317	-0.09
Age of household head squared	-0.0001	0.0003	-0.23
Child less than 5 years old in a household	0.0174	0.0883	0.20
Children 6 to 16 years old in a household	0.1208***	0.0509	2.37
Number of adult women in a household	0.0581	0.1008	0.58
Number of adult men in a household	0.0313	0.0922	0.34
Household head years of schooling	0.0129	0.0197	0.66
Masaai tribe dummy	-0.3417	0.4825	-0.71
Lagged value of livestock (log)	0.2229***	0.0756	2.95
Lagged value of farm equipment (log)	0.0619	0.0563	1.10
Previous soil conservation structures	-1.0887***	0.1048	-10.39
Village Characteristics			
Number of institutions present	-0.0625	0.5000	-0.13
Presence of men's groups	-0.0309	0.1195	-0.26
Presence of income generating groups	-0.1441	0.2748	-0.52
Presence of village committees/groups	0.0125	0.1219	0.10
Presence of safety net and NRM groups	-0.1235	0.4521	-0.27
Population density	0.0001	0.0007	0.16
Market access	-0.0908	0.2184	-0.42
Murang'a district dummy	0.8461***	0.2135	3.96
Narok district dummy	-1.4038	1.7920	-0.78
Tenure security and related factors			
Land registered in house hold head or spouse	0.4392***	0.0753	5.83
Family land registered in extended family	0.0151	0.0695	0.22
Right to sell family land with permission	0.1392**	0.0637	2.18
Rented out land	-0.3656***	0.0981	-3.73
Lent out land	-0.2053***	0.0769	-2.67
Plot area (farm size)	0.0150**	0.0074	2.03
Distance to plot	-0.0099**	0.0049	-2.01
Soil quality & Topography			
Moderate vs. fine texture	-0.3570**	0.0776	-4.60
Coarse soils	-0.0268	0.0759	-0.35
Soil depth	0.0413***	0.0117	3.53
Red vs. black soils	-0.2244***	0.0820	-2.74
Very fertile soils	0.0791	0.0789	1.00
Fertile to average fertile	-0.1481**	0.0752	-1.97
Poor soils	0.0487	0.0677	0.72
Steep slope	0.0264	0.0683	0.39
Moderate slope	0.3982***	0.0709	5.62
Flatness of slope	-0.1391**	0.0729	-1.91
Undulating terrain	0.0973	0.0660	1.47

Table 8.3 continued

Variable	Coefficient	Std. Error	t-value
Error correction terms (residuals)			
Listened to extension services	0.0918	0.1147	0.80
Membership in village institutions	-0.0571	0.0895	-0.64
Willingness to invest in SWC	0.9692***	0.1385	7.00
Constant	-1.2329	1.0961	-1.12
Observations		684	
LR $chi^2(42)$		236.58	
Pseudo R^2		0.1802	
Log likelihood		-538.12	

* significant at 10%; ** significant at 5%; *** significant at 1%

9. Discussion and conclusions

9.1 Discussion of results

In this paper, we investigate the impact of household, farm and village characteristics including development domain dimensions on household welfare/poverty and adoption of soil and water conservation investments. We consider both direct and indirect effects of variables that determine poverty and SWC investments. In household welfare, we focus on both income and non-income measures of poverty, and then extend the analysis to livelihood diversification activities. Understanding how the variables of interest affect various measures of welfare is a good indicator of the relevance of targeting that can be based on policies drawn from the findings of this study. This also applies to investment in SWC. By explaining all possible types of SWC and intensity of adoption, we can derive broad policy options for improving SWC in the reference districts and also for Kenya.

A number of issues can be derived from the results. First, we find that tenure security may have no direct impact on household incomes and expenditures but is important for livestock wealth and non-farm incomes (enterprises). For expenditures and incomes, the negative coefficient of family land can be viewed in the context of people's ability to invest in productivity increasing activities. Those with family land, which is mostly inherited, may be poor relative to those who are able to rent the land. Hence if you consider a situation where land purchase and renting are options of access to land then use of land registered in household name may have a negative relationship with household welfare.

From the results presented in this paper, membership rather than presence in village institutions matter for poverty alleviation. Specifically, membership in benevolent and income generating groups is positively and significantly related to welfare, while households that listened to extension are also less poor. Mobilization of resources and availability of safety nets, as well as access to information on agricultural extension should therefore be important policy concerns for poverty alleviation among rural households.

Market access and population density along with other development domain dimensions would be expected to positively influence household welfare. Market access is found to be more important for livestock wealth than other measures of welfare. The results for

population density show that poverty is highest in areas of high population density. Higher population density may imply low use of external inputs, leading to low farm productivity and hence low levels of welfare. The impact of market access and population density confirms the importance of development domain dimensions in household welfare. In addition, agro-ecological diversity, suggested by location further confirms the role of development domain dimensions.

Plot size is inversely related to household welfare (measured through income and expenditures, as well as some of the diversified sources of incomes). The negative coefficient of acreage seems to conform to other results in Kenya that have shown that the poor have relatively higher acreages of land than the less poor (UNDP 2002). A plausible explanation however may also be found in the fact that larger farm sizes seems to be associated with lower welfare due to the fact that larger farms are likely to be of poor quality compared to smaller sizes. Addressing the problem of poverty may therefore require more than increasing the amount of land that people own. Rather, emphasis should be put on the quality of the land that they own rather than acreage. Distance to plots has cost implications for the farmers, which can have an impact on household welfare. The transaction costs and time lost in travelling to plots have adverse impacts on productivity and hence household incomes from such plots.

Soil quality and topography impact on household welfare differentially depending on the measure of welfare. Topography and soil quality are particularly important in determining livestock wealth. Our results seem to concur with other studies that have found that more livestock per household are likely to be found in settings with better quality soils and lower population density (Kruseman *et al.*, 2006).

Turning to investment in soil and water conservation, results from this study show that tenure security is positively correlated with adoption of investments in SWC as well as intensity of adoption. Moreover, the results support the literature, which argues that tenure security favours long-term conservation investments more than short-term investments. Previous literature has shown that farmers with long-term tenure security are argued to be more likely to invest in costly and durable conservation measures (Gebremedhin and Swinton 2003). The literature further argues that investments in SWC entail costs that may affect farmers' decisions depending on the security of tenure. Farmers' attitudes towards adoption of new technology have also been shown to depend on the profitability and uncertainty of the new technology. Our findings also concur with previous studies on soil and conservation in Kenya (see Kabubo-Mariara, 2006).

The results on farm characteristics represented by soil quality and topography means that the use of appropriate productivity increasing technologies must consider the type of soil quality and topography and their effect on land degradation. Very steep slopes lower the likelihood of investment in SWC. This conforms to results from literature. The results on plot size can be seen in terms of the opportunity cost of labour and also the expected return of that investment. Technologies that are labour intensive will have implications for other uses of labour. The availability of off farm employment opportunities may also reduce the use of intensive conservation practices due to competing uses for labour. Drawing from the negative relationship between plot size and household welfare, the results may suggest that those with smaller plot sizes are likely to practice SWC that eventually increases their productivity and hence welfare. However, results from previous literature

also suggests that the size of holdings is a substitute for many potentially important factors like credit, risk bearing capacity, access to inputs and access to information (Feder *et al.*, 1985). Related to plot size is distance to plot. The transaction costs of travelling to plots will determine the type of conservation measures on such plots (Gebremedhin and Swinton, 2003). Hence plots distant from the homestead or highly fragmented plots are more likely to be developed with less expensive SWC investments.

Market access and population density confirm the importance of development domains in adoption of SWC investments. The results on village institutions highlight the importance of institutional presence in adoption of technology, though these variables seem to matter most only for adoption of grass strips.

Another important issue in adoption is that it should not be viewed in dichotomous terms; but what is most important is the intensity of use of the technology. The complementarity of certain technologies may also imply that in certain cases adoption decisions are interrelated. This explains the results in this paper, which suggest that different types of SWC investments are explained by similar sets of factors. Furthermore, these results are confirmed by factor analysis of residuals of different conservation technologies. The results on the intensity of adoption suggest that, intensity of adoption is determined by the same set of factors that influence the decision to invest. This is consistent with most empirical literature though a few studies have shown that factors explaining adoption of SWC investments may differ from those determining the intensity of adoption (see for instance Gebremedhin and Swinton, 2003).

9.2 Conclusions and policy issues

This paper investigates the impact of tenure security on household poverty on one hand and on investment in soil and water conservation on the other using survey data from Kenya. The key hypothesis tested in this paper is that tenure security affects both investments in soil and water conservation and household welfare, but that investment in soil and water conservation also affects household welfare. In analyzing these relationships, we also test the impact of household, farm and village characteristics including development domain dimensions that condition this link between poverty and the environment. A novel aspect of this paper is use of factor analysis to choose variables for tenure security that go into the empirical analysis. Factor analysis is further applied to create variables for soil quality and topography, institutional presence and market access. In addition, we are not aware of any study that directly links household welfare, investment in SWC and tenure security as done in this paper. We estimate simple reduced form models of household welfare (per capita expenditure and incomes) as in the literature but introduce tenure security and soil and water conservation variables into the welfare function. In addition, we estimate a reduced form model for livestock wealth as a proxy for asset based poverty. We also use seemingly unrelated regressions to explain diversified sources of incomes as measures of household welfare. For investment in soil and water conservation, we estimate Probit models for adoption of various SWC technologies, including seasonal and permanent technologies, then explain the intensity of adoption using the Tobit regression method.

The results show that tenure security is positively correlated to household welfare when welfare is measured through livestock wealth but not through expenditures and incomes.

The total number of conservation structures in place is also important determinants of household welfare, implying a poverty-environment link. This link is also confirmed by the positive significant coefficient of willingness to invest in SWC for livestock wealth. Our results further show that presence and membership in village institutions are important determinants of household welfare. However presence matters more for livestock wealth, while membership is more important for income measures of poverty. Farm characteristics are also important determinants of household welfare. In particular, our results show that variables related to soil quality and topography are important determinants of household welfare. Since these variables are directly linked to the environmental status and agro ecological potential of land, their impact on welfare also confirms existence of the poverty-environment link. Results for district dummies suggest existence of district specific direct and indirect effects on household welfare and therefore suggest unobserved heterogeneity in determinants of welfare. These results also confirm that among other factors, the poverty-environment link is also conditioned by the agro-ecological potential. Household characteristics point at the importance of family composition and size as well as family cycle effects on welfare. We conclude that development domain dimensions together with other farm, household and village characteristics are important correlates of household welfare and that their impact is more pronounced on livestock wealth than on incomes poverty. Though not consistent across broad, the above results are confirmed by the SURE results for diversified sources of incomes.

Consistent with the literature, our analysis for SWC investments affirms the importance of tenure security in determining adoption and also the intensity of SWC investments. In addition the results confirm the importance of household assets, farm characteristics (soils and topography), presence of village institutions and development domain dimensions (market access and population density) in adoption of soil and water conservation investments. Soil quality and topography, as well as location (agro ecological diversity) are particularly important determinants of investment in SWC. The impact of household assets (livestock and farm equipment) on investment in soil and water conservation implies a poverty environment link because households poor in assets are less likely to invest in soil and water conservation. The intensity of adoption is also lower for households poorer in assets than their richer counterparts. The results further suggest that the factors affecting the level of investment are the same as the factors determining the decision whether or not to invest in SWC.

The results suggest a number of policy interventions for alleviating poverty and providing incentives for soil and water conservation. The importance of development domain dimensions suggest the need for geographical targeting, with incentives oriented towards specific development domains, taking into account diversity on market access, population density and agro ecology. In addition policies that provide incentives for boosting household assets and village institutions would positively impact on both investment in SWC and household welfare.

The results point to the need for a comprehensive land use policy that will facilitate land use management and tenure security for environmental protection as a way of increasing agricultural productivity and hence enhancing rural livelihoods. The results show that contrary to expectations, the poor have relatively higher land acreages than those enjoying higher levels of welfare. Other studies in the country have shown that in regions with higher levels of poverty and low agricultural potential, the poor have more land than the

well off. Policy aimed at addressing poverty through land therefore needs to be region or area specific. While in some areas improving access to more land may be the solution, in certain cases, improvement in the delivery of services like extension and inputs that increase land productivity may be more relevant. From these results, access to extension and information on land conservation measures may need more policy emphasis than simply increasing acreage. In addition, incentives that encourage investments on SWC are also important in a policy aimed at improving land productivity.

The importance of village institutions suggest the need for a policy that facilitates the development and strengthening of community based organisations and institutions. This is important especially for access to information and participation in income generating activities. A policy that guarantees market access especially for livestock wealth is important for reducing vulnerability and increasing welfare. There is therefore need to strengthen environmental management programmes, which have integrated the development of livestock markets as their components. This may indirectly lead to improved environmental quality, as households are able to sell their stock, thus reducing environmental degradation that results from overstocking.

The results on investments on SWC, implies the need for a policy that improves security of tenure as a way of encouraging investments on long term conservation measures. It is recognized in Kenya that land conservation policy and laws have not been effective in generating environmentally sound land use practices. This policy needs to be strengthened. It is also apparent from the results that policies aimed at environmental degradation, just like for poverty need to be region and area specific. In addition, given the strong support for the existence of an environment-poverty link in this study, there is need for broad policies that provide incentives for environmental conservation and poverty reduction.

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Annex

Figure 2.1: Location of Study Area

Table A1: Household characteristics per district

Variable	**Murang'a**		Maragua		Narok		Full Sample	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Male head dummy (1= male)	0.79	0.41	0.81	0.39	0.91	0.29	0.83	0.37
Age of household head	52.44	14.93	52.13	16.65	44.39	12.28	50.23	15.41
Marital status dummy (1= married)	0.72	0.45	0.77	0.42	0.88	0.32	0.78	0.41
Widowed female head	0.18	0.38	0.19	0.39	0.08	0.28	0.16	0.36
Head's religion is catholic	0.34	0.47	0.39	0.49	0.24	0.43	0.33	0.47
Head's religion is protestant	0.45	0.50	0.34	0.47	0.43	0.50	0.40	0.49
Head's religion is Pentecostal	0.20	0.40	0.27	0.44	0.14	0.35	0.21	0.41
Head's religion is other	0.01	0.11	0.01	0.07	0.19	0.39	0.05	0.23
Minority tribe dummy (*Maasai*=1)	0.00	0.00	0.00	0.00	0.74	0.44	0.19	0.39
Household head attended school	0.81	0.40	0.91	0.29	0.69	0.46	0.82	0.38
Household head's years of schooling	6.05	4.00	7.12	3.71	6.08	4.90	6.50	4.16
Household's maximum years of schooling	8.78	3.70	9.19	3.36	10.28	3.02	9.33	3.44
Head is employed/business	0.23	0.42	0.24	0.43	0.21	0.41	0.23	0.42
Number of children 0 to 5 years	0.48	0.74	0.54	0.83	1.08	1.05	0.66	0.90
Number of children 6 to 16 years	1.12	1.24	1.50	1.46	2.67	1.68	1.68	1.57
Number of females 16 to 64 years	1.11	0.80	1.10	0.68	1.44	0.67	1.19	0.73
Number of females above 64 years	0.15	0.35	0.13	0.33	0.09	0.32	0.12	0.34
Number of males 16 to 64 years	0.92	0.79	0.95	0.87	1.53	1.00	1.14	0.92
Number of males above 64 years	0.16	0.37	0.15	0.38	0.11	0.32	0.14	0.36
Household size	4.64	2.13	4.85	2.30	7.41	2.56	5.44	2.59
Number of observations	151		188		118		457	