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INSTITUTIONAL ISOLATION, SOIL CONSERVATION AND CROP PRODUCTIVITY: EVIDENCE FROM MACHAKOS AND MBEERE DISTRICTS IN KENYA

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ABSTRACT

Some rural areas in Kenya are characterized by a combination of low agricultural potential, high population density, poor market access, and un-conducive institutional setting. Such areas have been classified as suffering from institutional isolation. This paper analyses the role of institutional isolation on the adoption of soil conservation technologies and crop productivity in Machakos and Mbeere districts of Kenya, using survey data. Multinomial *logit* and *probit* models of adoption of soil conservation and ordinary least squares model for crop productivity are estimated. The results show that institutional isolation hinders conservation and also adversely affects productivity. The effect is more pronounced in Machakos than in Mbeere district. To encourage adoption of soil conservation practices and boost crop productivity, there is the need for policies that improve tenure security, facilitate market access and access to information and extension services, as well as promote social capital formation.

Keywords: Land Tenure Security, Soil Conservation, Crop Productivity, Kenya
JEL Classification: O13 O17 Q15 Q16 Q24 Q56

1. INTRODUCTION

Agriculture is an important source of livelihood in Kenya, with more than 65% of the population residing in rural areas, deriving their livelihood from the natural resource base. The agriculture sector has a large subsistence sector, which makes agriculture even more important for food security. However, over time, 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. Like many other less-favoured areas, rural areas in Kenya are characterized by unfavourable development domain dimensions: a combination of low agricultural potential, high population density, poor market access, and an institutional setting that is not conducive to alternative viable development pathways. Agricultural potential is low due to agro-climatic conditions, the quantity and quality of the natural resource base. Poor market access relates 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, while the institutional setting depends on rules governing natural resources and their use (Kabubo-Mariara et al. 2006; Pender *et al*., 1999).

Less-favoured areas in Africa have been classified as suffering from institutional isolation and decay. That is, the structured set of order and relations that define individual expectations and behaviour are incoherent (Bromley, 2008). With institutional isolation, purchase of inputs and sale of outputs must "run a gauntlet" of high information costs, high contracting costs, and high enforcement costs. High transaction costs prevent remote farmers from using purchased inputs in ideal quantities, and thus hinder adoption of soil conservation technologies. Necessary investments are postponed, cropping intensity suffers, production declines, net economic returns are diminished, and a gradual degradation of the natural resource base results (Bromley, 2008). Stifel and Minten, (2008) concur that productivity is much lower in geographically isolated relative to non-isolated areas, while Barrett and Swallow (2007) suggest that economically dysfunctional institutions can undermine incentives to invest in land improvements and thereby perversely reinforce the economic dysfunctionality of the system. Adoption of soil conservation practices can therefore not be seen in isolation from development domain dimensions that frame the livelihood strategies of households in a specific area, or the larger economy.

There is growing research on the role of tenure security and other factors on adoption of land conservation technologies, with a few extending the analysis of the impact on agricultural productivity and household welfare (see Kabubo-Mariara et al. 2006 for a review of relevant studies). There is also growing literature on the role of development domains on sustainable land management especially in Africa (see Pender, Ehui and Place, 2006a). There is however a dearth of literature on the role of institutional isolation (impact of integrating market access and tenure security) on adoption of soil conservation or on agricultural productivity.

This study empirically disentangles the complex relationships between institutional isolation, adoption of land management technologies and crop productivity and adds to the growing literature on institutional economics. The study is based on the premise that institutional isolation leads to disinvestment and land deterioration and thus immiserization of agriculture (Bromley, 2008). The study hypothesizes that although tenure security has been shown to be important for sustainable agriculture and welfare improvements, integration of market access and tenure security is particularly crucial in Kenya. By either directly affecting or conditioning the relationship between soil conservation and crop production, interaction of market access and tenure security, together with other developmental domains and household assets play a crucial role in the poverty-environment nexus. The study tests this hypothesis through case studies from two districts: Machakos district, historically referred to as a success story (Tiffen et al., 1994) and Mbeere district (neighbouring Machakos), for which there is no evidence of this success. Though the key developmental domains in the two districts would be characterized as poor, the two districts have closely comparable agricultural potential. Machakos is however relatively less isolated institutionally due to integration of tenure security and market access, compared to Mbeere district which is relatively more isolated.

2. METHODS AND MATERIALS

2.1 CONCEPTUAL FRAMEWORK AND HYPOTHESES

To analyse the role of institutional isolation in soil conservation and agricultural productivity, this study focuses on various sets of institutional factors: market access; tenure security; agro-ecological diversity; technology improvement; and, development domains. The analytical framework draws from the theory of agricultural household models (Singh, Squire and

Strauss, 1986). The study also anchors on the sustainable land management framework[1]. This framework draws on the theories of induced technical and institutional innovation in agriculture that explains changing management systems in terms of changing microeconomic incentives facing farmers as a result of changing relative factor endowments (Pender, Ehui and Place, 2006a; Boserup 1965; Kabubo-Mariara, 2005). The study also draws from the literature on land tenure security and investment incentives (Kabubo-Mariara, 2007; Kabubo-Mariara et al., 2006; Pender, Ehui and Place, 2006b; Besley, 1995).

The farm household model assumes that a household engages 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 social-economic circumstances. In such a model, the main equation relates to the utility function, which is a function of a vector of consumption goods, leisure, and household characteristics. Utility is maximized subject to a cash income constraint. In addition, the household faces a set of resource and technology constraints that limit the amount of goods and services that can be produced (Kabubo-Mariara et al., 2006). Based on this framework and the literature (see for instance Kabubo-Mariara, 2010; Benin, 2006; Pender, Ehui and Place, 2006b; Pender and Gebremedhin, 2006; Kabubo-Mariara, Mwabu and Kimuyu, 2006; Nkonya et al., 2004; Pender et al., 1999), it can be hypothesized that agricultural productivity is influenced by factors such as the biophysical factors determining agricultural potential, population density, and access to markets and infrastructure, which determine the comparative advantage of a location by affecting the costs and risks of producing different commodities, the costs and constraints to marketing, local commodity and factor prices (Pender, Ehui and Place, 2006b; Nkonya et al. 2004). Other important factors include access to programs and services, such as government or nongovernmental organizations (NGOs), technical assistance and micro-finance institutions. These influence soil conservation investments (SCI) and crop productivity through increasing access to technologies and information, and therefore expanding households' available production and marketing possibilities. In addition: households' endowment of physical assets (e.g. Livestock and equipment); human capital (assets embodied in people's knowledge and abilities, such as education, experience, and training); social capital (assets embodied in social relationships, such as through participation in organizations or informal networks); financial capital (access to liquid assets, including credit and savings); and natural capital (quantity and quality of land). The crop productivity and SCI models can therefore be specified as:

$$Y = f(SCI, Kc, Nc, T, Z, Hc, Fc, Sc, Vc, Uy) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$SCI = f(Nc, T, Z, Hc, Fc, Sc, Vc, U_{sci}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where Y is the total value of net crop production per hectare; SCI is a vector of current soil conservation investments; KC is value of inputs; NC is a vector of plot characteristics (soil quality, topography, distance to plot etc.); T is a vector of tenure security characteristics of the plot; Z is a vector of households' endowments of physical capital such as land, equipment and livestock; Hc is a vector of household human capital (education, family composition and age of household head); Fc is a vector of financial capital variables (access to credit and other forms of financing); Sc is social capital (participation in village level institutions); Vc is a vector of village level characteristics (market access, source of market information and population density); U*y* and U_{sci} are random error terms. We briefly explore the expected relation between these factors and, SCI and crop productivity below.

[1] Adoption of soil conservation investments (SCI) is a form of land management system and long term SCI measures can be seen as sustainable land management practices.

2.1.1 MARKET ACCESS

Access to markets and roads is expected have both direct and indirect effects on SCI and crop production through various mechanisms. Better access to markets and roads is expected to encourage SCI through increasing farmers' access to credit and facilitating the use of purchased inputs and capital intensity of agriculture. Market-driven intensification may however reduce fallowing, which will contribute to declining soil fertility and increased erosion unless sufficiently offset by adoption of more intensive soil fertility management and soil conservation practices. Market-driven intensification may also lead to reduced erosion and improved soil fertility management as a result of the increased incentive to invest in SCI, given the rising value of land relative to labour (Pender and Gebremedhin 2006; Tiffen et al. 1994, see also Pender, Ehui and Place, 2006a; Kabubo-Mariara et al. 2006). Access to markets and roads is also critical for determining the comparative advantage of a particular location, given its agricultural potential because of the substantial transaction costs of storing, transporting, and marketing commodities (Stifel and Minten, 2007; Barrett 2007; Place, Kristjanson, Staal, et al. 2006; Holden et al., 2006; Pender and Gebremedhin 2006; Benin, 2006; Jagger and Pender, 2006; Pender, Place and Ehui, 2006; Bromley, 2006). The literature postulates that land will be allocated to its highest rent use, which in areas close to urban markets is more likely to be in the production of intensive high-value commodities that involve substantial transport costs or used for industrial purposes than in production of lower-value and more transportable food grains or livestock using extensive methods.

2.1.2 LAND TENURE AND PROPERTY RIGHT INSTITUTIONS:

Land rights can have substantial effects on the adoption of SCI and productivity by regulating land use and land management decisions, by facilitating or inhibiting collective action, and by affecting households' incentive and ability to invest in soil conservation (see Kabubo-Mariara, 2007; Pender, Nkonya, Jagger et al. 2004; Nkonya et al. 2004; Besley 1995). Compared to security of tenure, the set of rights associated with the different tenure systems may have different impacts on land management. For instance, freehold lands have complete rights to use, lease, sell, bequeath, and mortgage, but the owners or occupants of lands under other tenure systems may have more restricted rights. Even in the presence of private land rights, customary land tenure institutions determine what land use rights and land management obligations farmers have, how secure those rights are, whether those rights may be transferred or used as collateral and how conflicts are resolved among other issues. Acquisition of land may also influence farmers' tenure security and incentives to invest in soil conservation (Pender, Ehui and Place, 2006b; Nkonya et al. 2004).

The key issue of interest in land rights in this study is the impact of tenure security on soil conservation and on crop productivity. Literature however suggests that there is no universally accepted definition of tenure security. While most authors do not define precisely what they mean by security of tenure, others offer a wide range of definitions, often relating to both content and assurance aspects of tenure (Arnot et al., 2010). Though Arnot et al. (2010) suggest the need to distinguish between content and assurance aspects, they acknowledge that measures of the two may be correlated. For instance, households with strong land rights such as title deeds, may also have stronger assurance that they are unlikely to lose their land. In this study, tenure security is defined as the interaction between content and assurance aspects of tenure.

2.1.3 ACCESS TO PROGRAMS AND SERVICES

Institutional endowment affects the adoption of SCI and crop productivity by affecting farmers' access to information about technologies, their capacities to effectively use technologies or to organize collective action, and their financial constraints (Bromley, 2006; Pender and Gebremedhin 2006; Jagger and Pender, 2006). Three types of programs and organizations may be expected to have significant influence on SCI: technical assistance programs and organizations (such as agricultural and natural resource management extension groups); credit programs, which may enable farmers to purchase inputs, hire labourers acquire physical capital, increased capital, input and labour intensity; and human capital services, such as education. Education is likely to increase households' alternative income earning opportunities for salary employment of the farmer and may increase their ability to start up various non-farm activities (Pender, Ehui and Place, 2006b; Holden et al., 2006).

2.1.4 POPULATION PRESSURE

Population pressure may cause households to expand agricultural production into areas less suited to agriculture, contributing to lower agricultural productivity and natural resource degradation. But population pressure may also cause households intensify their use of labour and other inputs on the land and may also induce innovations in technology, markets, and institutions or investments in infrastructure, thus possibly mitigating or outweighing such negative Malthusian effects (Stifel and Minten, 2007; Kabubo-Mariara 2007; Pender, Ehui and Place, 2006b; Tiffen et al., 1994; Boserup, 1965). Population-induced intensification is likely to lead to higher yields and higher value of crop production per hectare unless the greater intensity is offset by land degradation (Pender, Nkonya, Jagger et al., 2004; Pender and Gebremedhin 2006; Jagger and Pender, 2006; Benin, 2006). However, labour intensification may lead to lower labour productivity and per capita income unless offset by technical change, improvement in infrastructure and market access, or other improvements in opportunities.

2.1.5 AGRICULTURAL POTENTIAL

Agricultural potential is an abstraction of various biophysical and agro-climatic factors including rainfall, altitude, soil type and depth, topography, access to irrigation, presence of pests and diseases, among others, that influence the absolute advantage of producing agricultural commodities in a particular place. Higher potential is expected to promote more intensive and productive use of inputs and production of higher-value, leading to higher value of crop production and income. Agro-ecological conditions also influence labour intensity and SCI, though increasing the marginal return and/or reducing the risks of inputs necessary for intensification (Jagger and Pender, 2006; Pender, Nkonya, Jagger et al., 2004; Place, Njuki, Murithi, et al., 2006; Benin, 2006). The overall impact of agricultural potential for adoption of the SCI and on the productivity outcomes is mixed (Pender, Ehui and Place, 2006b).

2.1.6 DEVELOPMENT DOMAINS

The interaction of agricultural potential, market access, and population pressure define the developmental domains of a locality. The interactions may contribute to self-reinforcing patterns of development, while some of the relationships may cause offsetting tendencies leading to declining productivity and land degradation. Consequently, the potentials for adoption of SCI, and the effects of policies influencing these decisions are likely to vary across developmental domains. The profitability of agriculture and the feasibility of crops to be produced will vary across different domains. Areas with good market access, favourable agricultural potential and high population promoted adoption of the SCI and production of high value crops. Adoption of intensive crop production is more risky and less profitable in areas of low agricultural potential and poor market access (Pender, Ehui and Place, 2006b; Pender et al. 1999). A Boserupian development path also tends to occur when there is sufficient market access that enables specialization, leading to a more efficient use of scarce resources (Tiffen et al. (1994). Some literature however shows that the areas with high population density, low agricultural potential and low market access can be expected to follow a Malthusian development path, where land resources typically suffer from soil mining and resource degradation (Kruseman et al. 2006).

2.17 HOUSEHOLD ASSETS

Household assets including farm size, labour endowment, and livestock among other endowments have important implications for adoption of SCI. Farm size and labour endowments impact through opportunities for intensification, especially for labour intensive practices. The impact of livestock on soil conservation strategies and land degradation may be mixed and depends on the type of degradation as well as on interactions between crops and livestock. Farm equipment may also have mixed effects on land degradation. Ploughs and other machinery may contribute to soil erosion through tillage, especially if used on sloping lands. On the other hand, equipment may be used to help construct soil conservation structures or to apply fertilizer or other inputs that help to prevent soil erosion, nutrient depletion, or other forms of degradation (Pender, Ehui and Place, 2006b; Kabubo-Mariara, 2007). The overall impact of SCI and land degradation determines the impact on crop productivity.

2.2 EMPIRICAL IMPLEMENTATION

To achieve the objectives of the study, descriptive statistics and econometric methods are used. First we carry out bivariate comparisons of the two samples in terms of the land tenure contents, tenure security, and other aspects of the institutional setting and the socioeconomic characteristics of the households. We further carry out econometric analysis of investments in soil conservation and also crop productivity.

Estimation of equations (1) and (2) above is not straight forward because a number of the explanatory variables in the equation (1) are potentially endogenous. For instance, in addition to the adoption of soil conservation investments, social capital and use of credit are influenced by the household's endowments of physical, human, social, and financial capital; market access and population density among other factors. Estimation of the system of equations including several endogenous right hand side variables would however be quite challenging due to difficulties of identification. We simplify the system of equations by including only exogenous forms of inputs, social capital and financial capital in the crop productivity model, but take into account the potential endogeneity of the conservation decision. Only exogenous measures of all right hand side variables are included in the specification of the SCI model.

The best solution to the endogeneity of soil conservation would be to use instrumental variable (IV) methods in estimation of the system of equations presented above. This however requires that there are valid instruments to facilitate identification of the system of equations. An alternative is to estimate the full model and test for endogeneity bias using a Hausman (1978) test, (Wooldridge, 2002). If exogeneity is not rejected, the results would suggest that the discrete model regression gives consistent and efficient estimates. If exogeneity is rejected, then it will be necessary to use the IV method. A reduced-form specification is also estimated because it allows estimation of both the direct and indirect effects of the exogenous explanatory variables on the dependent variable and also eliminates the potential for endogeneity bias (Benin, 2006). A comparison of the results from various estimation procedures sheds light on the true impact of the direct and indirect determinants of crop productivity.

To instrument for adoption of soil conservation investments, the ratio of productive to non-productive household members (household dependency ratio) is used. The dependency ratio is expected to have a direct effect on adoption of soil conservation investments, but an indirect effect on crop productivity, through the effect on conservation. In empirical implementation, the system of equations in (1) and (2) become:

$$SCI^* = \alpha_0 + \alpha_1 Nc + \alpha_2 T + \alpha_3 Z + \alpha_4 Hc + \alpha_5 Fc + \alpha_6 Sc + \alpha_7 Vc + \alpha_8 \psi + \varepsilon_{sci}) \text{ .... (3)}$$

$$Y^* = \beta_0 + \beta_1 SCI^* + \beta_2 Nc + \beta_3 T + \beta_4 Z + \beta_5 Hc + \beta_6 Fc + \beta_7 Sc + \beta_8 Vc + \varepsilon_Y) \text{ .... (4)}$$

Where α and β are vectors of parameters to be estimated, ψ is the dependency ratio (the instrumental variable), an asterix indicates the variable belongs to a system of equations, ε_{sci} and ε_Y are uncorrelated error terms. All other variables are as defined earlier. IV methods are used to estimate the system of equations (3) and (4). Multinomial logit methods are employed to estimate the equation (3) for adoption of various soil conservation investments.

3. STUDY SETTING AND DATA

The study is based on Machakos and Mbeere districts of the Eastern Province of Kenya. Machakos is historically referred to as a success story (Tiffen et al. 1994) and is thus assumed to be relatively less isolated institutionally compared to Mbeere in terms of tenure security and market access. Though the districts are fairly comparable in terms of welfare, demographic characteristics, topography and climate and agricultural potential, they seem to differ in that inequality is much higher in Machakos than in Mbeere. Further, Machakos is relatively accessible due to the proximity to Nairobi and also the Nairobi Mombasa highway, but Mbeere district is less accessible, located over 200 kilometres from Nairobi with most feeder roads virtually impassable during the heavy rains.

This study is based on primary data. Household and community questionnaires were used to collect the requisite data. The data were supplemented by secondary data on rainfall and village level population density. To ensure adequate representation of the selected zones, the National Sample Survey and Evaluation Program (NASSEP IV) frame of the Kenya National Bureau of Statistics, Ministry of Planning, National Development and Vision 2030 was used as the sampling frame for the field survey. The NASSEP frame has a two-stage stratified cluster design for the whole country. First, enumeration areas are selected using the national census records, with the probability proportional to size of expected clusters. The number of expected clusters is obtained by dividing each primary sampling unit into 100 households. The clusters are then selected randomly and all the households enumerated. From each cluster, 10 households were drawn at random. The national sampling strategy is deemed appropriate for the study because it is representative of any local situation. Relative to any other sampling frame that a researcher may opt to use, a sample chosen using this frame will report the lowest possible sampling error.

Multistage random sampling methods were used to arrive at the final sample of households for each district. The first stage involved selecting administrative divisions within each district. A total of 7 divisions were selected, 3 from Mbeere district and 4 from Machakos district. This choice was informed by diverse of the districts in terms of geography, agro-ecology, economic activities, physical size and population density. The choice of the divisions was expected to yield adequate variability in market access, tenure content and security among other variables. The second stage involved selection of locations and sub-locations, which were also based on agro-ecological diversity. Five (5) locations from each district, 4 and 5 sub-locations were selected from Mbeere and Machakos respectively. The fourth stage involved selection of sample points (clusters) from the NASSEP frame, which was based on the total number of clusters (each corresponding to a village) within a sub location and the number of households in each cluster. To arrive at the total number of households actually visited, we took a probability sample from each cluster making a total of 251 and 277 households from Mbeere and Machakos districts respectively. In addition to the household survey, a community questionnaire was administered to selected key informants in each village. The community survey collected data on sources of market information and access, village infrastructure and prices of farm inputs and livestock. The data were collected in late October to early November 2008.

4. RESEARCH FINDINGS

4.1 DESCRIPTIVE STATISTICS

The sample characteristics of all households are presented in Appendix 1. Generally, the data show that differences between most of the household characteristics for the two districts are statistically significant. Notable differences are observed for education, and the main occupation of the household head. It is interesting to note that the proportion of heads with post primary education in Mbeereis less than half of the proportion with primary education, while in Machakos, the proportions are almost equal. This perhaps explains the observed differences in the occupation of the household head, where only 7% are in wage employment in Mbeere compared to 13 % in Machakos and also between the proportions of farmers in the two districts.

4.1.1 ASSETS AND INCOMES

The economic characteristics of households are defined in terms of physical household assets (access to electricity, ownership of radio, television set and other assets, housing type) and values of assets (farm capital and livestock). The data suggest that 90% of all households in the sample owned radios, but only 40% had television sets. In addition, 61% had telephone facilities. The data further show that 48% of households had mud (natural), while 51% had cemented floor. Only 1% had tiled floor. The percentage with cemented floor is relatively high for a rural setting and perhaps reflects the economic status of the households. The results of mean comparisons tests are presented in Appendix 2. The results suggest that there were significant inter district differences in the ownership of telephones and also in floor materials, with households in Machakos better endowed with telephones and better material of the floor. Differences in other physical assets (not presented), and values of equipment and livestock were statistically insignificant. The total crop value is higher in Mbeere than in Machakos. Crop productivity (total crop value per hectare) is also higher but the difference is insignificant.

4.1.2 CREDIT, REMITTANCES AND EXTENSION SERVICES

This study hypothesized that access to credit, remittances and extension services influence adoption of soil conservation investments and also crop productivity. Appendix 3 presents the sample statistics for these variables by district. The data show that relatively few households (about 23%) received any credit. Informal rotating credit and savings schemes (*Roscas*) formed the main source of credit in the two districts. The inter district differences in the amount of credit received was found to be statistically significant, with households in Mbeere district reporting more credit than their counterparts in Machakos. This perhaps suggests that households in Machakos rely more on own sources of finance than on credit. Remittances are higher in Machakos than in Mbeere, perhaps suggesting higher levels of social capital. A higher proportion of households in Machakos (23%) received extension services than their counterparts in Mbeere (17%), but more households in Mbeere had paid for extension service (sourcing from private providers).

4.1.3 SOCIAL CAPITAL

Social capital is an important determinant of adoption of soil conservation investments. The study investigated membership, contributions and proceeds from these groups. In the whole sample, 85% of the households were found to be members of at least one village group. Three main types of village groups were found to be most common: merry go round[2], benevolent, income generation and church groups. A significantly higher proportion of households in Machakos (88%) were members of social capital groups compared to households in Mbeere (82%) district. Most households in Machakos were members of *merry go round* groups, while those in Mbeere were members of benevolent groups. The study further found that on average a higher proportion of households in Machakos received both emergency (61%) and social (52%) support, compared to their counterparts in Mbeere (Appendix 4). Compared to Machakos (2%), significantly more households in Mbeere (5%) also join groups for other purposes, such as planting trees.

On social cohesion, respondents were also asked to indicate the proportion of villagers who are likely to provide assistance in case of emergency. The results indicate that on average, households expect that about 67% and 56% of the villagers in Machakos and Mbeere respectively would assist (Appendix 5).Other measures with notable differences included whether the respondent would provide the same assistance to others, the number of confidants and participation in community projects. The results of the two-sample 't' test for differences in district means for all measures of community cohesion suggest that households in Machakos are relatively richer in social capital than their counterparts in Mbeere district. This finding and the differences in endowment of all other forms of social capital in the two districts support Nyangena and Sterner (2009), who found significant differences in social capital formation between Machakos and two other regions in Kenya.

4.1.4 LAND OWNERSHIP AND RIGHTS

Land tenure security is an abstraction of many factors. This paper collected data on the tenure content, and assurance aspects, the mode of acquisition, expected land rights, perceptions on transferability and expropriation and also for how long the land had been with the household.
The results (Appendix 6) show that that the average farm holdings are almost equal in the two districts, though a higher variability is observed in Machakos. Households in Machakos have marginally more plots than their counterparts in Mbeere, and the difference is statistically significant at the 1% confidence level. A total of 793 plots,were observed in the sample, 356 in Mbeereand 437 in Machakos. The average distance to the plot in Machakos is about 4 kms compared to only 2 kms in Mbeere district.

On land acquisition, for the whole sample, 62% of the plots were inherited, while 26% were purchased. Only 9% were rented. Patterns of land acquisition suggest more secure modes in Machakos than in Mbeere district. Specifically, 96% of the households occupy either inherited or purchased land in Machakos compared to only 78% in Mbeere. Twenty three percent (23%) of the households in Mbeere district have rented and gifted land compared to only 4% Machakos.

[2]Merry go round is a type of arrangement where members contribute some agreed upon amount of money every month and the money is given to one member on a rotating basis. Sometimes, these groups graduate into Rotating Savings and Credit Associations (ROSCAs).

Other than for purchased land, the differences are statistically significant at all levels of significance. Land in the two districts is mostly registered under parents (extended family), followed by nuclear family. A significantly higher proportion of land is registered outside the family (landlords and other relatives) in Mbeere than in Machakos. An analysis of land rights indicate stronger rights to sell land in Machakos (41%), but stronger rights (24%) to bequeath land in Mbeere. Ninety one percent (91%) of the households in Machakos further indicated that they are unlikely to lose their land to someone else compared to 78% in Mbeere. Comparing all measures of land acquisition and expected rights, the data suggest that in general, households in Machakos have stronger land rights than their counterparts in Mbeere district.

4.1.5 SOIL CONSERVATION INVESTMENTS

The study sought information on all forms of soil conservation efforts and whether the investments were current (seasonal), long term or permanent investments. Eighty percent (80%) of all plots had some form of soil conservation investment. The most common form of investment was grass strips and agro forestry (on about 58% of all plots for each), followed by terracing (44% of all plots) and ridging (23% of all plots). Thirty eight percent (38%) of all investments were current, 32% were long term and the rest 26% were permanent investments. On average, the adoption of soil conservation investments was higher in Machakos than in Mbeere (Appendix 7). A significantly higher percentage of plots had current and permanent investments in Machakos than in Mbeere, but the latter had longer term investments. The most common types of investments in Machakos were terraces (59% of plots) and ridging (29%), while the most common types in Mbeere were agro forestry (70%) and grass strips (0.66).

4.1.6 AGRICULTURAL POTENTIAL - SOIL QUALITY AND TOPOGRAPHY

This study also sought detailed information on soil characteristics; including the type, texture and depth of the soil, as well as the perceived quality of soil in terms of fertility and level of erosion. The two-sample mean test results for differences in district soil quality are presented in Appendix 8. The results show that soils in Machakos were significantly deeper than those in Mbeere, suggesting richer and probably more fertile soils. This is also probably due to the type of soils, which was largely red (51%) in Machakos, but mixed (52%) in Mbeere. The workability of most of the soil (57%) in the two districts was easy, but significant differences were observed in the occurrence of moderate and difficult soils in the district, with more difficult soils in Mbeere. Significant differences were also observed in the distribution of coarse and intermediate soils in the two districts. The data further suggest that land was significantly flatter in Mbeere (37% of all plots) compared to Machakos (23% of all plots). In Machakos, there is twice as much steep slope (22%) than in Mbeere district (11%).

The results further show that only a small proportion of plots in the two districts were described as having fertile soils, 23% and 34% in Mbeere and Machakos district respectively. A higher proportion of plots are perceived to have low erosion in Mbeere (44%) than in Machakos (32%), where more plots (23% in Machakos and 16% in Mbeere) were reported to have high erosion.

4.1.7 MARKET ACCESS

The study also investigated market access factors in the district, probing the distance and travel time to the nearest facility. The data suggests that on average, households have to travel for at least 4.5 kms to get to the nearest market, though this distance varies from 0.5 to 12 kilometres.

Results for mean comparison tests for differences in distance to facilities between the two districts suggests that facilities are more accessible in Machakos than in Mbeere district, but only distance to markets, primary and secondary schools differ significantly. Travel time to key facilities is significantly higher in Mbeere than in Machakos district (Appendix 9). Market information is however more accessible in Machakos than in Mbeere districts. The most important sources of such information are community leaders and village groups.

The results of the bi-variatecomparisons show that compared to Mbeere district, households in Machakos are better endowed in assets, have stronger land rights and participate more in social capital formation. Further, the results suggest higher agricultural potential and better market access in Machakos. There is also higher adoption of soil conservation investments in Machakos, district. These results support the initial hypothesis of better integrated market and tenure security in Machakos relative to Mbeere. We use multivariate regression analysis to test whether these differences translate into differences in adoption of soil conservation investments and crop productivity outcomes.

4.2 ECONOMETRIC RESULTS

4.2.1 PRELIMINARIES

In this section, the researcher presents the econometric results relating investment in soil conservation to the hypothesized determinants, namely household and plot characteristics, tenure content and security, financial capital, social capital and village level characteristics. First we examine the correlation between different measures of two categories of variables (market access, soil quality and characteristics) and pick the variables that best explain the composition of each category. Factor analysis is used to derive the final factors for inclusion in the regression models.

For soil quality and characteristics, we apply factor analysis to responses on soil types, workability and texture of the soil and topography. The factor analysis loaded into three variables: red soils, moderate slope and easily workable (easy and fine) soils. After a series of regressions, only the latervariable was retained in the final model. Four market access variables were derived from factor analysis. These included travel time, cost and distance to facility, as well as access to market information. In the final analysis, only travel time and access to market information are retained because travel time, cost and distance to facilityare all spatial measures.

4.2.2 ADOPTION OF SOIL CONSERVATION INVESTMENTS

To assess the impact of the hypothesized determinants on soil conservation, a multinomial logit model for adoption of various soil conservation investments is estimated. This model is based on adoptionof terracing, tree planting (agroforestry), ridging and grass strips relative to non-adoption of any conservation measure. The study considered alternative estimation procedures for analyzing the conservation decision: multinomial logit models for adoption of various soil and water conservation measures; Probit/logitmodels for the probability of investing in individual conservation measures; and, OLS models for indices of soil conservation investments. The Multinomial logit regression is more appropriate than probit or logit models because the adoption decision, though nominal consists of more than two categories and the responses are not ordinal in nature as in ordered probit/logit. The OLS model results are difficult to interpret because of the nature of the dependent variable. For these reasons, we retain the multinomial logit model results. In order to run a multinomial logit model, the choicewas made of the main type of investment on each plot to ensure that the investments are mutually exclusive. The study further made the assumption of Independence from Irrelevant Alternatives (IIA) property.

The average marginal effects from the multinomial logit for adoption of soil conservation investments are presented in Appendix 10 and Appendix 11. The LR Chi2 value suggests that the data fits the data better than an intercept only model. All the results should be interpreted relative to the base category of non-adoption of any conservation measure. The marginal effects imply that on average, an increase in dependency ratio by1 reduces the likelihood of adopting conservation practices, relative to non-adoption by between 0.02 and 0.12 points, other factors held constant. Better tenure security is associated with 0.09 points higher likelihood that a household will adopt ridging, relative to non-adoption of any measure. Other marginal effects can be interpreted similarly.

The household characteristics did not seem to matter much for the adoption of conservation practices in Machakos, but seem to matter for adoption of terraces in Mbeere district. The impact of household wealth on investment in soil conservation is captured by farm equipment and value of livestock. More wealth reduces the probability of adoption of terracing and ridging in Machakos district, but has no significant effect in Mbeere district.

Relative to plots with difficult soils, presence fine soils increases the likelihood of adoption of terracing and tree planting in Machakos district by 0.02 points, but reduces the probability of adoption of tree planting by 0.035 points in Machakos and 0.037 points in Mbeere. There is a lower likelihood of adoption of tree planting and grass strips on plots perceived to have low levels of soil erosion, but a higher likelihood of adaption of ridging in Machakos. There is a 0.054 higher likelihood to adopt grass strips on plots with non-erodible soils in Mbeere district. Longer distance to plot increases the probability of adoption of terraces by 0.06 in Machakos district, but reduces the probability of adoption of grass strips by 0.163 in Mbeere. The effect on adoption of other practices in the two districts is insignificant.

The analysis suggests that remittances increased the likelihood of planting trees in Mbeere, but does not seem to matter for other practices and in Machakos. Access to agricultural extension services increases the likelihood of adoption of terraces in Machakos district by 0.05 and the likelihood of tree planting in Mbeereby 0.10.

Social capital is captured by the proportion of households in a village that are likely to assist one another in cases of emergency, and the proportion of persons participating in collective action. These two measures of social capital are exogenous as the household has no control over the proportion of households participating in social capital activities[3]. The results show that an increase in the proportion willing to assist in emergencies raises the probability of adoption of grass strips by 0.29 and 0.431 in Machakos and Mbeere districts respectively. It also increases the likelihood of planting trees by 0.166 points.

The results show that higher population density increases the likelihood of adoption of all soil conservation measures relative to non-adoption of any practice in Machakos district, but the effect is only significant for terracing. The effect is mostly negative but insignificant in Mbeere district. Rainfall increases has large significant impacts on adoption of grass strips in Machakos and terracing and tree planting in Mbeere district.

The results suggest that the impact of tenure security and market access depend on the type of conservation investments adopted. Specifically, tenure security is important for ridging in Machakos, and ridging and grass strip in Mbeere. Market access is important for adoption of ridging and grass strip in Machakos district, but does not seem to matter for individual investments in Mbeere district. The main hypothesis of this study was that integration of tenure security and market access is important for adoption of soil conservation investments. Though individual impacts of some of the indicators of these two factors suggest that both tenure security

[3]Initial regressions included membership in village groups, trust and also an aggregate social capital index. The results suggested that both measures are positively correlated with conservation. These variables are however potentially endogenous. Attempts at instrumentation of these variables became problematic and no meaningful results were obtained. For this reason, they were dropped from the soil conservation model.

and market access are important and significant determinants of conservation, we test for their joint impact by including interaction terms of tenure security and travel time, and also tenure security and access to market information. The results suggest that an interaction of tenure security and travel time to facility (remoteness) is inversely correlated with adoption of tree planting and grass strips in Mbeere district, but does not seem to matter for other practices. Institutional isolation does not seem to matter for Machakos district.

4.2.3 IMPACT OF INSTITUTIONAL ISOLATION ON CROP PRODUCTIVITY

The OLS crop productivity model results are presented in Appendix 12. The results show that education is associated with higher productivity in the two districts. Employment is also associated with higher productivity in Mbeere district, but is inversely correlated with productivity in Machakos district. Non–erodible soil boost crop productivity in Mbeere, but the impact for Machakos is insignificant. Productivity is more responsive to remittance in Mbeere than in Machakos district, but the reverse is the case for access to extension services.

Social capital has large significant positive effects on productivity. The results suggest that an increase in the proportion of households likely to assist in emergency by 1% would increase productivity by 0.3% in Machakos and by 1.04% in Mbeere district. An increase in the proportion participating in collective action by 1% would increase productivity by between 0.34% and 0.37% in the two districts. Population density has a significant positive effect in Machakos district, but the effect in Mbeereis insignificant. Rainfall has a large negative effect, but is only significant for Mbeere district.

Travel time significantly influences crop productivity in the two districts. An increase in travel time by 1 more unit reduces crop productivity by 0.28 points in the two districts, all other factors held constant. An increase in access to market information by one more unit would increase crop productivity by 0.80 and 0.29 points in Machakos and Mbeere districts respectively. The study uncovers no significant impact of adoption of soil conservation practices on productivity in the two districts[4].

We further re-examine the key hypothesis of the study by evaluating the significance of the joint marginal impacts of tenure security, market access variables, and their interaction terms (institutional isolation) on adoption of soil conservation on one hand and on crop productivity on the other. The results (Appendix 13) suggest that the variables are jointly significant in influencing crop productivity in both districts, and also the adoption of soil conservation in Machakos district. The joint marginal impact of market access on conservation in Machakos district is 0.036. Thus an improvement in market access by 1 % would boost adoption of soil conservation by about 4%, other factors held constant. A reduction in the extent of institutional isolation (through integration of tenure security and market access) by 1 % would boost adoption of soil conservation by about 6%, *ceterius paribus,*while development domains have a relatively small impact. The results further show that a reduction in the extent of institutional isolation by 1 % would increase crop productivity by 0.12 and 0.657 points in Mbeere and Machakos districts respectively. Development domains have a large significant impact on crop productivity in the two districts. These results support our earlier hypotheses and suggest that adoption of soil conservation and crop productivity in Machakos are more responsive to institutional isolation and favourable development domains than in Mbeere district.

[4]Adoption of soil conservation is however a household choice variable and is potentially endogenous. An attempt was made at instrumenting the adoption of conservation using the household dependency ratio. The effect of conservation on productivity turned out to be insignificant in both districts. Test for endogeneity however failed to support the expectation that conservation is endogenous. The IV results are therefore not presented.

5. DISCUSSION

The results presented above suggest that farmers with a higher school grade attainment are less likely to adopt soil conservation practices. This suggests that better educated farmers may have alternative economic opportunities outside farming (Kabubo-Mariara, 2007). High dependency ratio is also associated with lower likelihood of investment in soil conservation (Benin, 2006). The results for the adoption of ridging and terracing, as well as probits for conservation support literature that has found tenure security to provide incentives for soil conservation (Kabubo-Mariara, 2007).

The negative significant marginal effect of distance to plot suggests that increased production costs (time wise) will hinder adoption of sustainable land management practices (Kabubo-Mariara, Linderhof and Kruseman 2010;Pender and Gebremedhin, 2006; Gebremedhin and Swinton, 2003). The positive effect of remittances in Mbeere district suggests that farmers use transfer incomes as a source of capital for investment in soil conservation practices (Kabubo-Mariara, 2007). The positive impact of access to some form of extension services points at the importance of disseminating information on conservation and other extension advice to farmers (Kabubo-Mariara, 2007).

The positive significant impact of population density on adoption of terracing in Machakos district supports Boserup's hypothesis of increased agricultural intensification as population density increases (Kabubo-Mariara, 2007; Pender, Ehui and Place 2006b; Boserup 1965). The positive impact of rainfall in the same district suggests that areas with higher rainfall are associated with greater adoption of soil conservation practices because of higher biomass productivity in such areas (Pender, Ehui and Place, 2006b).

The impact of market access suggests that institutional isolation will hinder adoption of soil conservation investments. The results further suggest that an interaction of tenure security and travel time to facility (remoteness) encourage conservation practices in Mbeere, but discouraged conservation in Machakos. This implies that the advantage of tenure security is outweighed by the disadvantage of travel time. The interaction of tenure security and access to information encourages conservation. Evaluation of the joint significance of tenure security and market access suggests that integration of tenure security and good market access boosts adoption of soil conservation in Machakos district, but not Mbeere district. This supports the key hypothesis of this study.

The results further suggest that market access boosts crop productivity (Pender, Place and Ehui, 2006b). This could be through promotion of the production of high-value crops, more intensive use of inputs and increased local prices. This result supports the hypothesis that institutional isolation adversely affects productivity (Stifel and Minten, 2008). The positive significant impact of population density on crop productivity in Machakos supports the expected positive impact of higher population on crop productivity through land intensification (Boserup 1965). The negative effect of rainfall supports finding in the literature that suggest that higher rainfall in some areas may be more erosive and soil nutrient depletion may be higher especially in steeply sloping areas as a result of greater off take of biomass from fields, especially if use of fertilizer or other means of soil fertility restoration is limited (Pender, Ehui and Place, 2006b).

Some other factors also have significant effects on crop productivity. Age of the household is inversely correlated with agricultural productivity, suggesting life cycle effects. The positive impact of education attainment on crop productivity probably captures experiences and managerial ability of more educated farmers (Pender and Gebremedhin, 2006). The household asset endowment has a positive impact on crop productivity. Households with more assets are better placed to make decisions leading to sustainable land management, while the impact of livestock assets suggests complementarity between crop farming and livestock production. The effect of social capital could be through the provision of group labour, social learning and also building self-help institutions such as farmer cooperative societies.

6. CONCLUSION AND POLICY IMPLICATIONS

This paper investigates the role of institutional isolation on adoption of soil conservation and crop productivity in Kenya. The study is based on the expectation that integration of market access and tenure security is crucial for adoption of soil conservation investments. The analytical framework of the study draws from the theory of agricultural household models and the theory of induced technical and institutional innovations in agriculture. The study is based on 793 plots from a sample of 528 households drawn from Mbeere and Machakos districts of the Eastern Province of Kenya. A community survey is used to augment the household survey.

Descriptive and econometric methods are used to test the study hypothesis. For descriptive analysis, bivariate comparison of the key variables in the two samples is carried out. Multinomial logit model is estimated for adoption of various soil conservation investments, while probit models are used to explain the adoption decision. An OLS crop productivity model is estimated. To test the hypothesis that integration of tenure security and market access is important for adoption of soil conservation investments and crop productivity, three alternative ways are utilized. First we evaluate the impacts of tenure security and market access. Second, we evaluate the impact of interaction terms of tenure and market access variables. Third, we evaluate the significance of the joint impact of the two groups of variables and their interaction terms.

Descriptive results suggest that there are significant differences in the two districts with respect to land tenure arrangements, soil type and topography, adoption of soil conservation investments, social capital and market access. Compared to households in Mbeere, households in Machakos district seem to face more favourable socio-economic circumstances. Households in Machakos are also more likely to adopt soil conservation investments than their counterparts in Mbeere. The data also suggest better market access in Machakos than in Mbeere district. We do not observe any significant difference in the crop productivity in the two districts.

The regression results suggest that tenure security is an incentive for soil conservation. Population density encourages adoption of terracing in Machakos district, supporting Boserup's hypothesis of increased agricultural intensification as population density increases. Institutional isolation will hinder adoption of soil conservation investments, but the impact will depend on the relative effects of tenure security and market access factors. Institutional isolation is more important for adoption of soil conservation in Machakos than in Mbeere district. The results further show that market access boosts crop productivity, supporting the hypothesis that institutional isolation adversely affects productivity (Stifel and Minten, 2008). The significant impact of population density on crop productivity in Machakos supports Boserup's hypothesis. Other factors that have significant effects on crop productivity include age of the household, education attainment, household assets and social capital.

The findings of this study suggest that institutional isolation is important for adoption of soil conservation technologies and also for crop productivity. The results call for policies that facilitate market access, access to information and general opening up remote areas in order to encourage adoption of soil conservation practices and boost crop productivity. Other important policy options include improved tenure security, increased access to remittances and extension services. The social capital formation would also play an important role in adoption of soil conservation practices and crop productivity.

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APPENDICES

APPENDIX 1: CHARACTERISTICS OF HOUSEHOLD HEADS

Variable	*Mbeere*		*Machakos*		*Full sample*	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Head is male	0.79	0.41	0.84	0.37	0.82	0.39
Age of head***	45.72	14.89	49.31	15.12	47.60	15.10
Number of years in school***	7.78	4.20	8.64	3.87	8.23	4.05
Household size***	4.33	1.75	4.72	2.02	4.53	1.90
Head is married*	0.78	0.41	0.84	0.36	0.81	0.39
Head is widowed	0.12	0.33	0.12	0.32	0.12	0.33
Religion of head						
Pentecost***	0.35	0.48	0.47	0.50	0.41	0.49
Protest***	0.31	0.46	0.15	0.36	0.23	0.42
Catholic	0.35	0.48	0.38	0.49	0.36	0.48
Highest level of education						
No education	0.08	0.27	0.08	0.27	0.08	0.26
Primary***	0.65	0.48	0.47	0.50	0.55	0.50
Post primary***	0.28	0.45	0.46	0.50	0.37	0.48
Main occupation						
Farming***	0.80	0.40	0.69	0.46	0.74	0.44
Business	0.06	0.24	0.08	0.27	0.07	0.26
Employed**	0.07	0.25	0.13	0.33	0.10	0.30
Casual labour	0.07	0.26	0.11	0.31	0.09	0.29
Sample size	251		271		528	

***, **, * *Significant at 1%, 5% and 10% respectively- Differences in district means for two-sample t- test with equal variances.*

APPENDIX 2: HOUSEHOLD ASSETS AND INCOMES

Variable	*Mbeere*	*Machakos*	*Mean Difference*	*t-value*
Value of equipment	8782.35	8735.25	47.10	0.04
	(-651.87)	(-815.76)		
Value of livestock	23604.71	27594.22	-3989.51	-0.95
	(2391.81)	(3346.43)		
Value of livestock products	188735.5	248691.3	-59955.8	-0.67
	(54001.91)	(70477.86)		
Total crop value	64057.28	53533.71	58258.03	1.86**
	(86745.74)	(72920.46)		
Total crop value per hectare	16652.56	15314.28	1338.282	1.09
	(18969.24)	(15661.83)		
Credit by (Kshs)	3043.347	1382.671	1660.675	2.52***
	(567.54)	(358.46)		
Remittances (Kshs)	489.54	2186.53	-1696.81	-1.41
	(130.27)	(1137.52)		
Received any extensionservices	0.17	0.38	0.23	-1.80*
	(0.40)	(0.43)		

***, **, * *Significant at 1%, 5% and 10% respectively. Standard deviations in parenthesis*

APPENDIX 3: ACCESS TO CREDIT AND REMITTANCES

Variable	*Mbeere*		*Machakos*	
	Mean	Std. Dev.	Mean	Std. Dev.
Credit by source (Kshs)				
Roscas	2566.45	8287.70	1151.99	5722.08
	(15%)		(15%)	
Relatives	307.37	3239.31	137.55	1272.29
	(5%)		(3%)	
Friends	169.52	1961.09	93.14	870.07
	(3%)		(4%)	
Total credit*	3043.35	8991.55	1382.67	5966.04
Remittances (Kshs)	489.54	2063.83	2186.35	18932.05
	(19%)		(18%)	
Received any extension services*	0.17	0.38	0.23	0.42
Paid for extension services *	0.03	0.18	0.01	0.10

**Difference significant at 1%. Figures in parenthesis are proportion of households accessing.*

APPENDIX 4: BENEFITS FROM SOCIAL CAPITAL GROUPS (%)

	Mbeere	*Machakos*	*Mean Difference*	*t-value*
Social support	0.41	0.52	-0.11	-2.54***
	(0.49)	(0.50)		
Emergency support	0.57	0.61	-0.04	-0.94
	(0.50)	(0.49)		
Other forms of support	0.05	0.02	0.03	1.94*
	(0.21)	(0.13)		

***, * *Significant at 1% and 10% respectively. Standard deviations in parenthesis*

APPENDIX 5: DISTRICT DIFFERENCES IN MEASURES OF COMMUNITY COHESION

	Mbeere	*Machakos*	*Mean Differenc e*	*t-value*
Proportion likely to provide	55.50	67.17	-11.67	-
emergency assistance	(24.23)	(24.52)		5.49***
Ever received emergency	0.23	0.22	0.00	0.09
assistance	(0.42)	(0.42)		
Ever given emergency assistance	0.79	0.86	-0.07	-2.02**
	(0.41)	(0.35)		
Number of close confidants	1.58	2.56	-0.98	-
	(1.70)	(3.61)		3.92***
Participated in community	0.35	0.47	-0.12	-
projects last 12 months (1=yes)	(0.48)	(0.50)		2.88***
Percentage of villagers	59.28	60.37	-1.08	-0.33
participating in community	(21.32)	(22.33)		
projects last 12 months				

***, **, * *Significant at 1%, 5% and 10% respectively. Standard deviations in parenthesis*

APPENDIX 6: LAND OWNERSHIP AND TENURE

Variable	*Mbeere*	*Machakos*	*Mean Difference*	*t-value*
Plot acreage	2.03	2.10	-0.07	-0.29
	(2.08)	(4.26)		
Distance to plot	1.91	4.20	-2.29	-1.20
	(9.84)	(34.89)		
Number of plots per household	1.36	1.50	-0.14	-2.82***
	(0.62)	(0.76)		
Acquisition of land				
Purchased	0.24	0.28	-0.05	-1.45
	(0.43)	(0.45)		
Inherited	0.54	0.68	-0.14	-4.15***
	(0.50)	(0.47)		
	0.17	0.03	0.14	7.08***
Rented	(0.37)	(0.16)		
Gift land	0.06	0.01	0.05	3.886***
	(0.23)	(0.10)		
Registration of land				
Family land	0.36	0.53	-0.17	-4.74***
	(0.48)	(0.50)		
Other	0.20	0.04		
	(0.40)	(0.20)	0.16	7.14***
Land rights				
Sell	0.34	0.41	-0.07	-2.099**
	(0.47)	(0.49)		
Bequeath	0.24	0.17	0.07	2.35***
	(0.43)	(0.38)		
Rent right	0.04	0.09	-0.05	-2.73***
	(0.20)	(0.29)		
Unlikely to lose land to anyone	0.78	0.91	-0.13	-5.08***
	(0.42)	(0.29)		
Number of plots	356	437		

***, **, * *Significant at 1%, 5% and 10% respectively. Standard deviations in parenthesis*

APPENDIX 7: SOIL CONSERVATION INVESTMENTS

Variable	*Mbeere*	*Machakos*	*Mean Difference*	*t-value*
Any conservation on plot	0.76	0.84	-0.08	-2.97**
	(0.25)	(0.18)		
Terraces	0.27	0.59	-0.32	-9.48***
	(0.44)	(0.49)		
Tree planting	0.70	0.48	0.22	6.38***
	(0.46)	(0.50)		
Ridging	0.15	0.29	-0.14	-4.91***
	(0.35)	(0.45)		
Grass strips	0.66	0.52	0.14	3.97***
	(0.47)	(0.50)		
Other investments	0.18	0.13	0.05	2.01**
	(0.38)	(0.33)		

**, **, * *Significant at 1%, 5% and 10% respectively. Standard deviations in parenthesis*

APPENDIX 8: SOIL QUALITY AND TOPOGRAPHY

Variable		*Mbeere*	*Machakos*	*Mean Difference*	*t-value*
Soil depth		0.99	1.17	-0.18	-3.5850***
		(0.65)	(0.71)		
Soil type					
Red soil		0.28	0.51	-0.23	-6.8728***
		(0.45)	(0.50)		
Mixed soil		0.52	0.35	0.16	4.6476***
		(0.50)	(0.48)		
Black soil		0.11	0.09	0.02	0.73
		(0.31)	(0.29)		
Rocky soil		0.10	0.04	0.06	3.4144***
		(0.29)	(0.19)		
Slope					
Flat slope		0.37	0.23	0.14	4.4184***
		(0.48)	(0.42)		
Moderate slope		0.52	0.55	-0.03	-0.81
		(0.50)	(0.50)		
Steep slope		0.11	0.22	-0.11	-4.5381***
		(0.31)	(0.41)		
Workability	Easy soil	0.57	0.57	-0.01	-0.20
		(0.50)	(0.50)		
	Moderate soil	0.22	0.29	-0.07	-2.3627***
		(0.41)	(0.46)		
	Difficult soil	0.21	0.13	0.08	3.1287***
		(0.41)	(0.34)		
Texture	Coarse soil	0.10	0.14	-0.04	-1.8254**
		(0.30)	(0.35)		
	Intermediate soil	0.40	0.32	0.08	2.2903***
		(0.49)	(0.47)		
	Fine soil	0.50	0.54	-0.03	-0.92
		(0.50)	(0.50)		
Perceptions	Fertile soil	0.23	0.34	-0.11	-3.3635***
		(0.42)	(0.47)		
	No erosion	0.44	0.32	0.12	3.5843***
		(0.50)	(0.47)		
	Low erosion	0.40	0.45	-0.05	-1.41
		(0.49)	(0.50)		
	High erosion	0.16	0.23	-0.07	-2.5716***
		(0.37)	(0.42)		

***, **, * *Significant at 1%, 5% and 10% respectively. Standard deviations in parenthesis*

APPENDIX 9: DISTANCE TO NEAREST FACILITY (KILOMETRES)

Variable	*Machakos*	*Mbeere*	*Mean Difference*	*t-value*
Market	1.21	6.60	-5.38	-3.29***
	(0.39)	(4.21)		
Primary school	1.21	1.90	-0.69	-2.02**
	(0.39)	(0.80)		
Secondary school	1.54	3.20	-1.66	-2.20**
	(0.42)	(1.96)		
Travel time to market (minutes)	21.71 (8.10)	45.00 (40.29)	-23.29	-1.70*

***, ** *Significant at 1% and 5% respectively. Standard deviations in parenthesis*

APPENDIX 10: ADOPTION OF SOIL CONSERVATION INVESTMENTS IN MACHAKOS - AVERAGE MARGINAL EFFECTS

	Multinomial Logit Model				Probit model
Variables	Terracing	Tree planting	Ridging	Grass strips	
Household characteristics					
Dependency ratio	-0.024	-0.070	-0.068	-0.122	-0.018*
	(0.023)	(0.124)	(0.127)	0.180	[0.011]
Age of head	0.001	-0.001	0.001	-0.005*	0.0001
	(0.001)	(0.001)	(0.001)	0.002	[0.0001]
Education grade	-0.024	0.030	-0.023	-0.033	-0.004***
attained	(0.023)	(0.025)	(0.024)	0.036	[0.003]
Head is employed	-0.026	0.024	-0.030	0.019	-0.001
/business person	(0.034)	(0.040)	(0.039)	0.059	[0.003]
Tenure & other plot characteristics					
Tenure security	0.002	0.020	0.090**	0.067	0.007***
	(0.029)	(0.031)	(0.050)	0.052	[0.005]
Easy & fine soils	0.044***	0.038**	0.012	0.008	-0.001
	(0.018)	(0.019)	(0.019)	0.028	[0.002]
Non-erodible soils	0.015	-0.034**	0.053***	-0.067*	-0.007*
	(0.014)	(0.018)	(0.017)	0.025	[0.004]
Log distance to	0.055*	0.033	-0.022	-0.093	-0.005***
plot	(0.031)	(0.040)	(0.044)	0.068	[0.004]
Household assets					
Log farm	0.023	0.034	-0.047**	0.054	0.001
equipment	(0.027)	(0.030)	(0.025)	0.041	[0.002]
Log value of	-0.030***	-0.007	0.009	0.006	-0.001
livestock	(0.010)	(0.014)	(0.016)	0.022	[0.001]
Financial capital					
Log amount of	-0.006	0.002	0.002	0.015	0.002
remittance	(0.011)	(0.013)	(0.013)	0.019	[0.002]
Household received	0.050*	0.016	0.031	0.066	0.001
extension services	(0.032)	(0.039)	(0.040)	0.057	[0.004]
Social capital					
Proportion likely to assist in	-0.092	0.001	0.015	0.290*	0.009
emergency	(0.062)	(0.070)	(0.070)	0.106	[0.010]
Proportion participating in	0.067	-0.032	-0.045	-0.038	-0.004
collective action	(0.046)	(0.050)	(0.050)	0.074	[0.004]
Village level & market access variables					
Log population	0.309*	0.046	0.210	0.246	-0.023
density	(0.189)	(0.184)	(0.191)	0.279	[0.023]
Log annual	-2.297	1.460	-3.242	6.417*	-0.369
rainfall (mm)	(2.038)	(1.420)	(2.504)	2.692	[0.385]
Travel time	-0.010	-0.001	-0.067***	-0.015	0.638**
	(0.026)	(0.030)	(0.042)	0.046	[0.462]
Access to market	0.071	0.141	0.340*	0.296***	0.004
information	(0.101)	(0.120)	(0.146)	0.183	[0.008]

Tenure security & travel time	0.014 (0.022)	0.017 (0.027)	-0.044 (0.039)	-0.035 0.040	0.003 [0.004]
Tenure security & access to information	0.001 (0.001)	-0.023 (0.102)	0.176 (0.132)	0.131 0.154	0.003* [0.005]
Observations	437				437
LR chi2(80)	240.55*				51.19***
Log likelihood	-547.912				-43.98

***, **,* *Significant at 1%, 5% and 10% respectively. Robust standard errors in parenthesis*

APPENDIX 11: ADOPTION OF SOIL CONSERVATION INVESTMENTS IN MBEERE-AVERAGE MARGINAL EFFECTS

	Multinomial Logit Model				Probit model
Variables	Terracing	Tree planting	Ridging	Grass strips	
Household characteristics					
Dependency ratio	-0.038	-0.102	0.002	0.122	-0.12
	(0.069)	(0.122)	(0.062)	(0.173)	[0.051]
Age of head	-0.002***	-0.002	-0.001	-0.001	-0.002*
	(0.001)	(0.002)	(0.001)	(0.002)	[0.001]
Education grade attained	-0.059*	0.009	0.012	-0.006	-0.02***
	(0.026)	(0.027)	(0.012)	(0.037)	[0.009]
Head is employed /business	-0.016	0.124*	-0.009	0.120	0.036
person	(0.025)	(0.071)	(0.024)	(0.080)	[0.032]
Tenure & other plot characteristics					
Tenure security	0.086	0.002	0.025***	0.101**	0.008
	(0.080)	(0.035)	(0.016)	(0.054)	[0.008]
Easy & fine soils	0.001	-0.037*	0.010	0.037	0.004
	(0.014)	(0.023)	(0.011)	(0.030)	[0.009]
Non-erodible soils	0.009	-0.014	0.009	0.054**	-0.004
	(0.012)	(0.018)	(0.010)	(0.027)	[0.010]
Log distance to plot	-0.009	-0.020	-0.022	-0.163**	-0.034***
	(0.033)	(0.054)	(0.019)	(0.075)	[0.018]
Household assets					
Log farm equipment	0.029	0.000	0.009	-0.019	0.004
	(0.019)	(0.036)	(0.020)	(0.054)	[0.014]
Log value of livestock	-0.007	-0.007	-0.005	0.020	-0.004
	(0.007)	(0.013)	(0.007)	(0.021)	[0.007]
Financial capital					
Log amount of remittance	0.001	0.025**	0.014	-0.027	0.011**
	(0.009)	(0.014)	(0.008)	(0.022)	[0.006]
Household received	0.019	0.102*	-0.029	0.108	0.024**
extension services	(0.027)	(0.042)	(0.025)	(0.073)	[0.013]
Social capital					
Proportion likely to assist in	-0.056	0.166*	-0.011	0.431*	0.011
emergency	(0.046)	(0.069)	(0.041)	(0.099)	[0.028]
Proportion participating in	-0.078	-0.121	-0.025	0.190**	0.066*
collective action	(0.068)	(0.078)	(0.037)	(0.096)	[0.031]
Village level & market access variables					
Log population density	-0.215	-0.019	-0.172	0.064	0.095
	(0.150)	(0.201)	(0.141)	(0.288)	[0.070]
Log annual rainfall (mm)	1.448*	1.721***	0.255	-0.096	-0.369
	(0.880)	(1.113)	(0.548)	(1.436)	[0.385]

Travel time	-0.045	-0.093	-0.014	-0.021	-0.001
	(0.035)	(0.039)	(0.018)	(0.049)	[0.013]
Access to market	0.234	-0.059	0.069	-0.100	0.004
information	(0.220)	(0.062)	(0.072)	(0.133)	[0.008]
Tenure security & travel	0.000	-0.067*	0.001	-0.085*	0.010***
time	(0.016)	(0.024)	(0.008)	(0.025)	[0.006]
Tenure security & access to	0.255	-0.064	-0.063	-0.099	0.003*
information	(0.238)	(0.065)	(0.059)	(0.138)	[0.005]
Observations	356				356
LR chi2(80)	213.11*				51.7***
Log likelihood	-300.703				-62.813

***, **,**Significant at 1%, 5% and 10% respectively. Robust standard errors in parenthesis.*

APPENDIX 12: DISTRICT LEVEL CROP PRODUCTIVITY OLS REGRESSION MODEL RESULTS

Variables	Machakos	Mbeere
Household characteristics		
Dependency ratio		
Age of head	-0.0061*	-0.0047
	[0.003]	[0.006]
Education grade attained	0.1461**	0.1586**
	[0.059]	[0.077]
Head is employed /business person	0.1824*	-0.3758**
	[0.114]	[0.169]
Tenure & plot other plot characteristics		
Tenure security	0.1489	0.1144
	[0.091]	[0.101]
Easy & fine soils	0.0427	-0.0141
	[0.052]	[0.073]
Non-erodible soils	0.0414	0.1586**
	[0.046]	[0.070]
Log distance to plot	0.055	0.0943
	[0.120]	[0.122]
Household assets		
Log farm equipment	0.0541	0.4272***
	[0.076]	[0.136]
Log value of livestock	0.2047***	0.1108*
	[0.043]	[0.069]
Financial capital		
Log amount of remittance	0.0443	0.0671*
	[0.031]	[0.034]
Household received extension services	0.2222**	0.1539
	[0.097]	[0.143]
Social capital variables		
Proportion likely to assist in emergency	0.3138*	1.0380***
	[0.179]	[0.366]
Proportion participating in collective action	0.3706***	0.3423*
	[0.140]	[0.200]

Village level and market access variables			
Log population density	1.0239**	0.876	***,
	[0.495]	[0.711]	
Log annual rainfall (mm)	-4.5924	-9.4589**	
	[3.196]	[3.792]	
Travel time	-0.2761***	-0.2863***	
	[0.081]	[0.110]	
Access to market information	0.7992**	0.2855***	
	[0.335]	[0.080]	
Tenure security & travel time	0.1477*	0.0375	
	[0.077]	[0.066]	
Tenure security & access to information	0.2818	0.0458	
	[0.278]	[0.048]	
Conservation	0.1882	0.2377	
	[0.239]	[0.232]	
Constant	18.0721*	32.3563***	
	[9.233]	[9.882]	
Observations	437	356	
R-squared	0.193	0.205	
Wald chi2(20)			
Log pseudo likelihood			

,,****Significant at 1%, 5% and 10% respectively. Robust standard errors in parenthesis.*

APPENDIX 13: JOINT IMPACT OF MARKET ACCESS, INSTITUTIONAL ISOLATION AND DEVELOPMENT DOMAINS BY DISTRICT

	Mbeere			***Machakos***		
Model	***Joint impact***	***Statistic***	***Value***	***Joint impact***	***Statistic***	***Value***
Conservation model						
Market access	0.003	Chi2(2)	0.76	0.036	Chi2(2)	5.54**
Institutional Isolation	0.024	Chi2(5)	4.54	0.059	Chi2 (5)	13.56***
Development domains	0.097	Chi2(5)	4.90	0.006	Chi2(5)	18.91***
Crop productivity model						
Market access	0.572	F(2,335)	6.40***	1.075	F(2,416)	5.79***
Institutional Isolation	0.122	F(5,335)	3.96***	0.657	F(5,416)	3.96***
Development domains	1.592	F(5, 335)	3.98***	2.18	F(5,416)	2.97***

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

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