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Exploring The Nexus Between Crop Diversification and Household Welfare, in Borabu Sub-County, Kenya

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Abstract

Following the effects of climate change, there has been a resurgence of interest in promoting crop diversification as a climate-smart agricultural practice in Sub-Saharan Africa to improve food security, increase income, and reduce vulnerability to external shocks. This practice is considered an effective risk management strategy and consumption smoothing strategy in a context characterized by repeated exposure to shocks. Agricultural production in Kenya is mainly dependent on rain-fed cultivation, with maize as the principal staple food crop. However, staple crops face major challenges and therefore, a diversification from over-reliance on staples will be important as part of progress toward achieving food security. The Kenyan government has, for a long time, been promoting crop diversification to improve household welfare and minimize risks associated with heavy dependence on maize. A decline in maize yields associated with the emergence of new pests and diseases, such as maize lethal necrosis disease (MLND) in Borabu sub-county, emphasized the need for maize farmers to diversify away from maize production. Although this strategy is in use, there is no clear evidence of the impact it has on the livelihoods of vulnerable households. Thus, the study sought to find out the nexus between crop diversification and household welfare among small-scale farming households in Borabu sub-county. Multi-stage sampling procedure was used to select a representative sample size of 385 small-scale farmers. Primary data was collected using observations and interviews with the help of a semi-structured questionnaire. The data were analyzed using the STATA computer program. This paper adopted the Endogenous Switching Regression Model to determine the nexus between crop diversification and household welfare, with household welfare being proxied by household financial savings. The findings indicate that smallholder maize farmers who practiced crop diversification experienced an enhanced ability to save than a random individual would have experienced.

Keywords: Crop diversification, household welfare, Maize Lethal Necrosis Disease, Endogenous Switching Regression Model.

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1. Introduction

Farmers' dependence on specific environmental conditions for crop production has made managing climatic risks as well as risks associated with pests and diseases an intrinsic and critical part of agriculture. According to Eichsteller *et al*. (2022), farmers' frequent exposure to climatic shocks is one of the major causes of low agricultural productivity, slow economic growth, and persistent poverty.

In most parts of Kenya, maize is a major staple food crop for the majority and a source of income. About 90% of the Kenyan population depends on maize for food, labor, and income (Leitich *et al*., 2021). In Nyamira County, maize is mainly grown on small-scale farms in four Sub Counties: (Manga, Nyamira North, Nyamira South & Masaba North). Most of the time, it is produced on 0.25 to 0.75 acres in majority of these sub-counties. However, in Borabu Sub-County, the production is mainly concentrated on relatively bigger farms with a capacity of 4 to 20 Ha (Motanya, 2019).

Like other food crops, maize is grown twice a year in the entire region. The primary season is typically from February to August and the short rainy season is from September to December. In 2013, the total acreage under maize in the entire county was 31,546 ha giving a cumulative production of 44,780 MT of maize. By the end of the 2017 season, the total land under maize had marginally risen to 31,950 Ha, giving production of 45,504 MT of maize. As of 2017, the total land area under maize remained relatively constant (Muthini *et al*., 2020).

Despite the favourable weather conditions for farming in Nyamira County, the average production level of maize has remained low, with farmers recording as low as four bags per acre (Gikemi, 2022). The significant challenges that face maize production in the region are declining soil fertility and soil acidity, as well as impacts of climate change, including delayed onset and untimely cessations of rains, skewed rainfall distribution & intensity, occasional hailstorms, and the emergence of new pests and diseases such as Maize Lethal Necrotic Disease (MLND) and Fall Army Worm (FAW).

In September 2011, the first Maize Lethal Necrosis Disease (MLND) case was reported in Kenya in Bomet county (Leitich *et al*., 2020). This disease was said to be caused by a combination of maize chlorotic mottle virus (MCMV) and sugarcane mosaic virus (SMV). The disease further spread to other counties, including but not limited to Nyamira, Narok, Naivasha, Sotik, Embu, Meru, and Trans-Nzoia, with Trans-Nzoia and Narok counties considered the country's major food baskets and the others, self-sufficient, concerning maize production.

MLND seriously impacted maize production and grain yields in Eastern Africa (De Groote *et al.*, 2016; Marenya *et al.*,2018). For instance, in 2012-2013, the estimated maize yield losses in Kenya due to MLND were reported as 23–100% in the affected counties in the country. In 2012, losses by MLND were estimated at US$ 52 million, which increased to US$180 million in 2013, equivalent to about a 0.5million tonnes (De Groote *et al*., 2021). MLND had a devastating effect on the maize crop and the livelihoods of the affected counties' resource-poor farmers and other key actors in the maize seed/grain value chain, especially small- and medium-enterprise (SME) seed companies and processors. Demand for the seed of commercial maize varieties decreased when MLND was a major epidemic in the affected counties, with consequent sales losses for maize-based seed companies and carry-over of significant quantities of seed. Thus, besides resource-poor farmers, SME seed companies were affected by the intensity and spread of MLND in Eastern Africa (Islam, 2021). This affected maize prices, spiking from Ksh.1500 per 90 kg bag in 2011 to Ksh.2500 per 90 kg bag in 2013.

Effective countermeasures to combat the incidence, spread, and adverse impacts of MLND required strong, coordinated, and synergistic efforts from multiple institutions due to the multifaceted and complex nature of the disease. Farmers were encouraged to integrate cultural practices with insecticides and host resistance to combat the MLND (Bin-hui *et al*., 2022).

The International Maize and Wheat Improvement Centre (CIMMYT) implemented a multi-institutional strategy to reduce the impact of the disease and protect the environment (Prasanna *et al.,* 2021). This included conducting intensive germplasm screening and fast-tracked development and deployment of MLN-tolerant/resistant maize hybrids in Africa-adapted genetic background, optimizing the diagnostic protocols for MLND-causing viruses (especially maize chlorotic mosaic virus), and capacity building of relevant public and private sector institutions on MLND diagnostics and management. Additionally, the strategy involved MLND monitoring and surveillance across Sub-Saharan Africa(SSA) in collaboration with National Plant Protection Organizations (NPPOs), partnership with the private seed sector for the production and exchange of MLN pathogen-free commercial maize seed, and raising awareness among relevant stakeholders about MLND management, including engagement with policymakers (Boddupalli *et al*., 2020).

Certified seeds, sanitation, quarantine, crop rotation with a non-maize crop, and resistant and tolerant maize varieties were the most effective ways of managing MLND (Shango *et al*., 2019). However, implementing some of these strategies was not possible in Borabu Sub-County, citing their cost implication and high incidences of poverty. For instance, due to the dense population in the region, most households own small parcels of land, necessitating them to practice intercropping. This, therefore, makes crop rotation as a way of dealing with MLND not ideal.

Despite all the efforts put in place to combat the disease, most farmers in some parts of Borabu Sub-County are still dealing with the impacts of MLND and are, therefore, unable to produce maize. This necessitated the government to encourage farmers to diversify away from maize production so as to improve the household food and nutrition status of farming households. It was envisaged that this strategy would help improve the living standards of farming households while offering various cropping alternatives to farmers instead of relying on a single crop, maize. Among the crops farmers consider are orange sweet potatoes, beans, finger millet, cabbages, carrots, black nightshade, spider plant, passion fruits, pineapples, and eucalyptus trees. One of the advantages of growing more than one crop is that it allows farm households to mitigate the risks associated with crop-specific failure due to shocks such as MLND. The disease is still a significant threat to the maize crops in Eastern Africa, and the threat of its emergence in other regions in Sub-Saharan Africa (SSA) still looms (Johnmark *et al*., 2022).

Exogenous trends and shocks are essential in pushing rural people towards a diversified livelihood strategy. However, diversification choices are firmly rooted in the microeconomic logic of farming households. The majority of people in Kenya depend on maize production for food, labor, and income. With unpredictable weather patterns and the emergence of new pests and diseases such as MLND that attack maize, farmers have long been advised to diversify away from the production of maize. Farmers in Borabu sub-county have been planting maize for a long time, but ten years ago, the occurrence of MLND brought some changes to its production in the region. The disease saw up to 100% crop loss, which jeopardized the economic and food security of most maize farming households. The disease's persistence over the years necessitated the government to encourage farmers to plant crops other than maize. However, a few of the farmers in the region were able to diversify away from maize while others were not. This study, therefore, sought to find out why this was the case and thereby determine the effect of crop diversification on household welfare in the Borabu sub-county.

1.1 Objective of the Study

To determine the effect of crop diversification on household welfare in Borabu sub-county.

1.2 Research Question

i. What is the effect of crop diversification on household welfare in Borabu Sub-County?

2. Theoretical Framework

2.1 Theory of crop diversification

The fundamental assumption is that a farmer's decision on whether to diversify is based on utility maximization (Rahm and Huffman 1984). The expression U (Wij, Lji) is a non-observable underlying utility function that ranks the preference of the ith farmer for the jth diversification process (j=0,1; where 0=no diversification and 1=diversification). Thus, the utility derived from crop diversification depends on W, a vector of farm and farmer-specific attributes of the diversifier, and L, a vector of attributes associated with crop diversification.

Although the utility function is unobserved, the relation between the utility derivable from the jth diversification process is postulated to be a function of the vector of observed farm, farmer, and crop diversification-specific characteristics and a disturbance term that has a mean of zero, as shown in equation 1:

$$U_{ji} = \propto_j F_i(W_i L_i) + \varepsilon_{ji} \quad (1)$$

Where: j=0,1; i=1,2, 3.... n. Since the utilities Uij are random, the ith farmer will select the alternative j=1 if Uij>Uoi or the non-observable (latent) random variable Y*=Uij-Uoi>0. The probability that Yi equals one. That is, the probability that the farmer practices crop diversification is a function of the explanatory variables as shown in equations 2 to 6 below:

$$P_i = P_r(Y_i = 1) = P_r(U_{1i} > U_{0i}) \quad (2)$$
$$= P_r[\propto_i F_i(W_i, L_i) + \varepsilon_{1i} > \propto_0 F_i(W_i, L_i) + \varepsilon_{0i} \quad (3)$$
$$= P_r[\varepsilon_{1i} - \varepsilon_{0i} > F_i(W_i, L_i)(\propto_1 - \propto_0)] \quad (4)$$
$$= P_r(\mu_i > -F_i(W_i, L_i)\beta \quad (5)$$
$$= F_i(X_i\beta) \quad (6)$$

X is the n*k matrix of the explanatory variables, β is a k*1 vector of parameters to be estimated, the probability function μi is the random error term, and Fi*X_iβ is the cumulative distribution function for U_i evaluated at X_iβ. The probability that a farmer will diversify in crop production is a function of the vector of explanatory variables, unknown parameters, and the error term.

2.2 Overview of crop diversification

Crop diversification refers to the process of increasing the diversity of crops through the use of multiple crops (Sharma *et al*., 2021). It is regarded as one sub-set of a large matrix of production options in the cropping sector. This can be achieved through various means, such as crop rotation, multiple cropping, or intercropping, compared to specialized farming to improve the productivity, stability, and delivery of ecosystem services (Hufnagel et al., 2020). A more sustainable production system can be established by diversifying crops and increasing the variety of crops available (Revoyron *et al.*, 2022), contributing to socio-economic benefits (Feliciano, 2019).

From an economic point of view, diversification can be examined from two analytical viewpoints: First, as a problem of determining, given a set of prices, the optimal crop mixes on a production possibility frontier, and second, as a mechanism for incorporating risk aversion into a farmer's decision-making process in which crop specialization may lead to precarious income due to variance in output, production or price for a particular crop (van Zonneveld et al., 2020). Diversification has two main properties; first, it expands the production possibility set or area allocation frontier for a farmer, thereby increasing income generation and employment creation. Second, crop diversification reduces the risk of having all of one's eggs in a basket with one crop only or a few crops with potentially high covariance risk (Pyman, 2021).

In agriculture, diversification is regarded as reallocating some of a farm's productive resources, such as land, capital, labor, and equipment, into new farm activities (Mutea *et al*., 2020). Crop diversification is usually viewed as a shift from traditionally grown, less profitable crops to newer, more profitable crops (Mwololo *et al*., 2019). It is also a strategy used to maximize the use of land, water, and other resources for the overall agricultural development in a country. It provides farmers with feasible options to grow different crops on their land. Therefore, a farmer's decision to diversify is considered a significant economic decision that strongly affects the farmers' income level and food security.

The economic theory asserts that households diversify their economic activities to improve risk management capacity, smooth income streams ex-ante, and smooth consumption ex-post shocks. Consumption smoothing expresses a household's desire to have a stable and predictable consumption path in their lifetime. Although diversification is a common practice across different sectors (e.g., finance), the peculiarities of agricultural production, such as dependence on weather patterns, seasonality in demand for inputs, and heterogeneity in land quality, distinguishes diversification in agricultural production from other sectors (Issahaku *et al*., 2021). Incomplete credit and insurance markets or market failures, quasi-universal circumstances in developing countries, are among the primary conditions that lead to diversification in rural economies

Although diversity is often seen as equal to diversification, from an agronomic point of view, that is not the case. While the former deals with biological principles such as genetic diversity, the latter deals with agronomic principles such as crop rotation or mixed cropping that might lead to higher biodiversity and associated ecosystem services. Diversification is a process that involves diversifying a crop's diversity. Although it is claimed that it is the solution to many problems of today's intercropping, the process can also lead to the development of new ecosystems (Beillouin *et al.*, 2021).

Crop diversification is a process that makes a simplified cropping system more diverse in time and space by adding additional crops (Garland et al., 2021). Diversification by agronomic measures, such as tillage, shall not be considered unless tested in combination with crop diversification. This analysis was restricted to crop diversification at the field level. In contrast to many studies, an agronomic perspective was taken on crop diversification as a basis for this review.

Crop diversification has several potential benefits for the household welfare of smallholder farmers, including enhanced food security, increased income and reduced vulnerability to external shocks such as droughts or market fluctuations (Vernooy, 2022). The determinants of crop diversification on household welfare include farm size, market access, land quality, access to credit and household income, among other factors. They are, however complex, and may vary depending on social, economic and environmental factors (Kiani *et al*., 2021). Understanding these determinants can help policymakers and practitioners design interventions that support more sustainable and diversified agricultural systems and promote improved household welfare.

2.3 Empirical Literature on crop diversification

In their paper on the role of crop diversification in improving household food security in central Malawi, Mango et al. (2018) found that crop diversification, cattle ownership, access to credit, and attaining education have a positive and significant effect on household Food Consumption scores. Precisely, crop diversification, cattle ownership, and access to credit are all significant at 5%, while education is 10%. In addition, crop diversification and attaining formal education by household heads were found to have a negative and significant effect on Household Food Insecurity Access scores and were all significant at a 1% level. The study is based on 271 randomly selected smallholder farming households from central Malawi. It investigates the influence of crop diversification and other household socio-economic characteristics on the household Food Consumption Score and Household Food Insecurity Access Score. The analysis relied heavily on a combination of ordinary least squares techniques and some descriptive statistics.

In their paper on crop diversification and food security, Ijaz *et al.* (2019) found that risk avoidance, land suitability, social norms, income level, and contact with extension officers are vital challenges that hinder the wide adaptation of crop diversification. Acceptance of new crops in the market is also a challenge. In this scenario, including oilseed crops and legume crops and promoting an agroforestry system may be a viable option to adjust as new crops in already adopted cropping systems. But before the adaptation of new crops, long-term experiments on the impact of crop diversification on soil properties, farmer income, food security, and global warming should be carried out to exclude the farmers' risk.

Another study carried out in Elgeyo Marakwet by Kemboi *et al*. (2020) found that age, education of household head, type of crops, cropping system, amount of credit, and irrigation facilities influenced crop diversification. Their study examined the determinants of crop diversification and their gross margins. The study used a multi-stage sampling technique to draw a sample of 72 smallholder farmers. Primary data was collected using semi-structured questionnaires and analyzed using descriptive, gross margin, and logistic regression. Gross margin results revealed a significantly higher value of revenues for diversified cropping systems of farming (KES.54, 583.33) compared to non-diversified (KES.37, 250).

Crop diversification is essential in dealing with risk and uncertainty related to climate change. It helps to increase the resilience of farmers, significantly improving their income stability, but at the same time, it can lower the economic efficiency of small farms. This article aimed to identify the determinants of crop diversification and the impact of crop diversification on the economic efficiency of small farms in Poland. This article first provides a critical review of the literature on crop diversification, its role in stabilizing agricultural income, and its impact on economic efficiency in small farms. Secondly, the level of crop diversification was determined and empirical research was conducted considering farms' economic, social, and agronomic characteristics. Thirdly, the economic efficiency of farms diversifying crops was compared with farms focused on one type of production (Kurdyś-Kujawska *et al*., 2021).

The research material consisted of small farms participating in the Polish system of collecting and using farm accountancy data (FADN) in 2018. The level of diversification was determined using the Herfindahl-Hirschman Index. The factors influencing crop diversification were identified using the logit regression model. The Mann–Whitney *U* rank-sum test was used to assess the significance of the differences in distributions. The research results indicate an average level of crop diversification in small farms in Poland and its regional differentiation (Kurdyś-Kujawska *et al*., 2021).

In addition, a statistically significant positive impact on the probability of crop diversification in small farms in Poland was found in variables such as the level of exposure of agricultural production to atmospheric and agricultural drought and the location of the farm in the frost hardiness zone and a statistically significant negative impact of the variable: the value of fixed assets. Significant differences in the level of economic efficiency of farms diversifying crops and farms focused on one profile of agricultural production were proved. The study is an important voice in the discussion on increasing measures to strengthen support for small farms that diversify crops to ensure their more excellent stability and economic efficiency (Kurdyś-Kujawska *et al.,* 2021).

2.4 Concept of household welfare

A welfare measure is a set of measures that allows the evaluation of living patterns within a population over time. Consumption expenditure, household savings, asset accumulation, and income are proxies for household welfare. Researchers have debated income and consumption intensely, with a clear consensus on favouring consumption over income (Blesch *et al*., 2022). First, consumption seems to capture the standard of living better since individuals derive material well-being from the actual consumption of goods and services rather than income. Consumption better reflects long-term income as it is not closely tied to short-term fluctuations. It smoothens over seasons and is less variable than income.

Income is more likely to be affected by seasonal patterns resulting in either an underestimation or overestimation of real income (Beckman & Countryman, 2021). Although collecting data on consumption is usually very time-consuming, the concept of consumption is usually more apparent than the concept of income. Furthermore, it is challenging to accurately measure household income, especially for self-employed households and those working in informal sectors. Finally, income is likely a more sensitive issue for respondents than consumption. Those well-off are less likely to participate in the survey or respond, leading to an underestimation of income inequality among the population (Deaton & Deaton, 2020).

Assets indices are also an alternative measure of welfare. Using asset-based wealth indices as an alternative metric has become increasingly prominent in recent years. It has been considered superior to consumption and income as wealth better reflects long-term welfare and is less volatile than income and consumption (Onemolease & Akioya, 2020). It is suitable for analyzing multidimensional poverty and is less data-intensive hence easier to calculate. These features, however, make the wealth index a specific indicator such that it cannot be comparable to conventional measures of economic status.

Different studies report that the asset index is a poor proxy for current household income or expenditure, even though it may reflect permanent income (Howland *et al.*, 2021). Some reasons limiting the use of asset bases indices are; first, this index measures household wealth relative to other households in the sample but does not quantify the households' current levels of welfare or poverty. Secondly, it has been found to have an urban bias and limited discriminatory power at the lower end of the wealth distribution. Thirdly, differences in price levels and asset quality across regions are not considered in the asset-based approach (Campbella *et al*., 2023). Therefore, the wealth index cannot be used as a perfect substitute for income or consumption, which among other considerations, remain the most common and accepted welfare measures.

Household savings can be one measure of household welfare for smallholder maize farmers in Kenya (Gikonyo, 2022). Smallholder maize farmers in Kenya face many challenges, including low productivity, inadequate infrastructure, and limited access to finance and markets (Rutsaert & Donovan, 2020). These challenges can affect their ability to save and accumulate assets.

Benami and Carter (2021) argued that household savings could reflect the ability of smallholder maize farmers to set aside money for future needs or unexpected expenses, which may suggest that they have a degree of financial stability and security. By saving money, smallholder farmers can have a cushion against financial shocks, such as crop failure, illness, or other emergencies. They can also invest in their farms or businesses, increasing productivity and income. However, smallholder maize farmers in Kenya face several barriers to saving. One of the main barriers is low and unstable income, which can make it difficult to set aside money for savings (Gikonyo, 2022). Despite these challenges, some smallholder maize farmers in Kenya have found innovative ways to save and invest. For example, some farmers have formed savings and credit cooperatives (SACCOs) or self-help groups to pool their resources and provide each other with loans and other financial services. Others have used mobile money platforms like M-PESA to save and transfer money.

Household savings reflect the household's ability to set aside money for future and daily needs or unexpected expenses for household consumption (Sunardi *et al*., 2020). Therefore, efforts to promote household savings among smallholder farmers should be enhanced by addressing the factors that affect household savings to promote household welfare.

3. Methodology

3.1 The Study Area

The study covered the Borabu sub-county in Nyamira county. The county borders Homabay county to the North, Kisii county to the west, Bomet county to the southeast, and Kericho County to the east. The sub-county occupies about 246.9 square kilometers with a total population of about 73,167 people and a population density of 296 persons per square kilometer. The number of households in the region is 19,468, with an average household size of 4 (KNBS, 2019). The sub-county is between the longitudes 340 45' and 350 00' east and latitude 00 30' and 00 45' south(Nyamira County, 2018). It is divided into four wards: Nyansiongo, Esise, Mekenene, and Kiabonyoru.

The area has a bimodal rainfall pattern that is well-distributed, reliable, and adequate for various crops. The long rains are experienced between December and June and the short rains occur from July to November, with no distinct dry spell separating them. The annual rainfall ranges between 1200 to 2100 mm per annum, with the altitude ranging between 1250 meters and 2100 meters above sea level (ASL). The minimum night and maximum day temperatures are generally between 10.1 degrees Celsius and 28.7 degrees Celsius, respectively, resulting in an average normal temperature of 19.4 degrees Celsius which is favorable for agricultural and livestock production (Kimathi, 2022).

The sub-county is endowed with red volcanic soils (Nitisols), which are deep, fertile, and well-drained, accounting for 75% of soils in the region, while the remaining 25% are those found in the valley bottoms and swampy areas, which are suitable for brick making (Motanya, 2019) Small scale crop and livestock production is an essential component of agricultural activity in the area with the majority of farmers engaging in the production of maize, beans, local vegetables, bananas, potatoes among others. Livestock production includes dairy cattle, goats, sheep, and chicken.

There is a total labor force of about 38,047 people, which accounts for 52% of the total population, with the majority being engaged in the agricultural sector. Borabu sub-county was selected because it is one of the areas in Kenya affected by MLND. Secondly, despite the efforts put by the government to combat the disease being effective in other regions that were affected by the disease, there are still signs of the disease in the area hence impeding the farmers' ability to produce maize. Figure 3.1 below shows the study area map, that is, the Borabu sub-county.

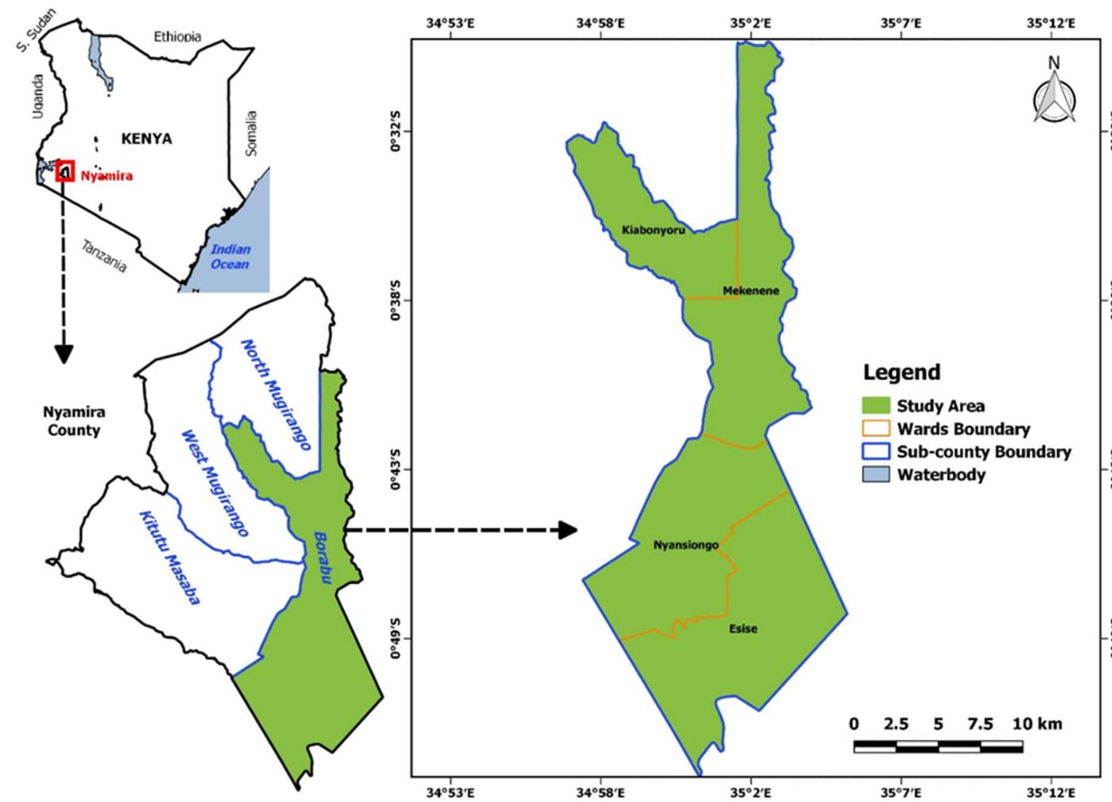

Figure 3.1: Map of Borabu Sub-County

Source: Egerton University School of Geography

3.2 Sample Size Determination

Cochran's (1977) formula was used to determine the number of respondents needed for the study from each ward, as shown in equation 7:

$$n = \frac{pqZ^2}{e^2} \quad (7)$$

Where n is the sample size to be determined, p is the sample proportion, q=1-p, Z=confidence level(α=0.05), and e is the acceptable or allowable error since the population proportion is unknown, p=0.5, q=1-0.5=0.5, Z=1.96 and e=0.05.

$$n = \frac{(0.5)(0.5)(1.96)^2}{(0.05)^2} = 384.16 \approx 385$$

This resulted in a sample population of 385 respondents.

3.3 Sampling Procedure

This study used a multi-stage sampling procedure to select the appropriate sample size. In the first stage, Borabu Sub-County was purposively selected as it is one of the areas that was affected by MLND. In the second stage, the four wards of the Borabu sub-county (Nyansiongo, Esise, Kiabonyoru, and Mekenene) were purposively selected based on the severity of MLND in the wards. The farmers in the area were then stratified into four groups based on the ward where they were located. A source list of maize farmers in the four wards was acquired from MoALF, Borabu sub-county. From each of these four groups, the number of farmers was selected proportionate to the group size using a stratified random sampling procedure to select a total sample of 385 farmers. Table one shows the sample size.

Table 1: Sample Size

Strata	Maize farming households	Sample proportion	Sample
Nyansiongo	3000	0.20	79
Esise	2700	0.18	70
Mekenene	5000	0.34	131
Kiabonyoru	4000	0.27	105
Total	**14700**		**385**

3.4 Data Collection Method

The study used full-on primary data using a semi-structured questionnaire administered to Borabu Sub-County households by a team of well-trained enumerators. Methods used included observations and face-to-face interviews.

3.5 Model Specification and Analysis

3.51 To Determine the Effect of Crop Diversification on Household Welfare

This paper sought to determine the effect of crop diversification on household welfare. Observable and non-observable factors determine farmers' decision to diversify or not diversify. A methodological challenge in this estimation is the sample selection problem since smallholder maize farmers may self-select themselves into diversification or have innate characteristics that correlate with household welfare. To control for the possible bias resulting from non-observable characteristics, the study adopted the endogenous switching regression model(ESRM). This model corrects for both observable and non-observable biases that may result from the non-random assignment of small-scale farmers into diversification, hence providing unbiased estimates of the impact of diversification on household welfare. Household financial savings was used as a proxy for household welfare.

The endogenous switching regression model estimated the average treatment effect (ATE) of crop diversification on the outcome variable, which is household welfare. The endogenous switching model was further used to examine the average treatment effect by comparing the expected outcomes of each alternative package of diversification. This model computed the average treatment effects of the treated (ATT), whereby the expected outcomes of diversification were compared. To estimate the effect of crop diversification, a counterfactual effect is an outcome a farmer could have achieved had they picked a different diversification strategy from the one they did. According to Khosla and Jena (2023), the ATT is computed in the actual and counterfactual scenarios as follows:

For actual diversifiers in the sample, the outcome estimation model is given as follows:

$$\begin{cases} E(Q_{h2}|H=2) = J_h\alpha_2 + \sigma_2\lambda_2 & (8a) \\ E(Q_{hg}|H=2) = J_h\alpha_g + \sigma_G\lambda_G & (8b) \end{cases}$$

$$\begin{cases} E(Q_{h1}|H=1) = J_h\alpha_1 + \sigma_1\lambda_1 & (9a) \\ E(Q_{h3}|H=3) = J_h\alpha_3 + \sigma_3\lambda_3 & (9b) \end{cases}$$

If users of a given diversification strategy had not chosen that specific strategy, the counterfactual was modeled as follows:

$$\begin{cases} E(Q_{h1}|H=2) = J_h\alpha_1 + \sigma_1\lambda_2 & (10a) \\ E(Q_{h3}|H=G) = J_h\alpha_1 + \sigma_1\lambda_G & (10b) \end{cases}$$

$$\begin{cases} E(Q_{h2}|H=1) = J_2\alpha_2 + \sigma_2\lambda_1 & (11a) \\ E(Q_{hg}|H=3) = J_2\alpha_3 + \sigma_3\lambda_3 & (11b) \end{cases}$$

The above-estimated values are helpful in the derivation of unbiased estimates of the average treatment effects on treated (ATT) and untreated(ATU). ATT is the difference between 8a and 10a or equation 8b and 10b, which is given as:

$$ATT = E(Q_{h2}|H=2) - E(Q_{h1}|H=2) = J_h(\alpha_2 - \alpha_1) + \lambda_h(\alpha_2 - \alpha_1) \quad (12)$$

The expected change in the mean outcome for a farmer who uses h diversification strategy is equal to the returns of a farmer who has not diversified their crop mix given by

$J_h(\alpha_2 - \alpha_1) + \lambda_h(\alpha_2 - \alpha_1)\Lambda_h$ is the choice term capturing all potential effects of the differences in unobserved variables. On the other hand, ATU is given as the difference between equations 9a and 11a or equations 9b and 11b, resulting in equation 13 below:

$$ATU = E(Q_{h1}|H = 1) - E(Q_{h2}|H = 1) = J_h(\alpha_2 - \alpha_2) + \lambda_2(\alpha_2 - \alpha_2) \quad (13)$$

Table 2: Definition of Variables Included in the Estimation of ESRM

Variable	Type	Description	Apriori Assumption
Dependent Variable			
Household welfare		Household saving as a proxy of welfare	+/-
Independent Variables			
Gender of household head	Dummy	1=Male, 0=Female	+/-
Age	Continuous	Age of household head in years	+/-
Household size	Continuous	Number of household members	+/-
Education	Categorical	Highest level of education of household head	+/-
Marital status of head	Categorical	1=Married,2=Single,3=Widow/widower,4=Separated, 5=Divorced,6=Other	+/-
Household income	Continuous	The average amount of monthly income in KSH	+/-
Herd size	Continuous	Number of livestock owned by the farmer	+/-
Land tenure	Categorical	1= Land owned with title deed,2= Land owned without title deed,3=Family/Communal,4= Rented land,5= Leased land	+/-
Size of land	Continuous	Size of landholding in acres	+/-
Access to credit	Dummy	1=Access, 0=No access	+/-
Farmland	Continuous	The proportion of land under agriculture in acres	+/-
Occupation of household head	Continuous	1=farmer, 2=government sector, 3= private sector, 4= self-employed, 5= unemployed, 6=other(specify)	+/-
Belonging to a social group	Dummy	1=yes, 0=No	+/-

4. Results and Discussion

4.1 Preliminary Diagnostics Assumptions of Variables Included in the ESRM

Before conducting the ESRM model analysis, preliminary diagnostics were performed to address the multicollinearity and heteroskedasticity statistical issues for the intended variables.

4.1.1 Multicollinearity Test

Multicollinearity, a state of very high inter-correlations or inter-association among the proposed independent variables, was tested using the variance inflation factor (VIF) for all continuous and discrete variables. The results are presented in Table 3.

Table 3: Variance Inflation Factor Test Results for Continuous, categorical and Discrete Socio-economic and Institutional Factors Variables

Variable	VIF	1/VIF
Acres of land under crop farming	4.09	0.2447
Farmland	3.46	0.2887
Sources of income	2.02	0.4954
The household head's main source of income	1.94	0.5164
Gender of household head	1.70	0.5874
Education of household head	1.53	0.6519
occupation of household head	1.48	0.6734
Marital status of household head	1.48	0.6776
Number of household members	1.44	0.6960
Type of Labour	1.43	0.6985
Land tenure	1.23	0.8099
Welfare	1.17	0.8577
Group membership	1.14	0.8756
Age of household head	1.10	0.9132
Herd size	1.07	0.9318
Locational dummy	1.07	0.9323
Size of land owned in acres	1.06	0.9398
Credit access	1.06	0.9440
Mean VIF	**1.64**	

There was no multicollinearity as indicated by **1/VIF** > 0.2 and Variance Inflation Factor (VIF<10), agreeing with the finding of the study done by García *et al*. (2019).

4.1.2 Heteroscedasticity Test

The White test was used to detect heteroscedasticity for all hypothesized explanatory variables, and the results are presented in Table four. The White test was preferred over the Breusch-Pagan test since the latter only identifies linear forms of heteroscedasticity. In contrast, the former considers both the magnitude and direction of change for non-linear forms of heteroscedasticity (Bongole *et al*., 2020). White's general test is a case of the Breusch-Pagan test, where the assumption of normally distributed errors has been relaxed.

Table 4: Test for Heteroscedasticity

Source	chi^2	df	p
Heteroskedasticity	156.81	184	0.9277
Skewness	12.83	18	0.8018
Kurtosis	1.32	1	0.2503
Total	170.96	203	0.9504

chi^2(184) = 156.81

Prob > chi^2 = 0.9277

No heteroscedasticity was detected since the chi^2 of 156.81 was not significant.

4.2 Determinants of Crop Diversification on Household Welfare

An endogenous switching regression model was employed in the econometric analysis of the effect of crop diversification on household welfare in the Borabu sub-county. This model divided the sample into savers and non-savers sub-samples, accomplished through counterfactual questions.

To test for endogeneity, Durbin's (1954) and Wu-Hausman's (1974) statistics were utilized, as recommended by Patrick (2020). It is essential to distinguish between these two tests because Durbin's statistic employs an estimate of the error term's variance based on models that assume the variables under consideration are exogenous. In contrast, Wu-Hausman's statistic estimates the error term's variance based on models assuming endogenous variables. Both error variance estimates are consistent under the null hypothesis, which posits that the variables are exogenous. The results of the endogeneity tests are presented in Table 5.

Table 5: Tests of Endogeneity

H0: Variables are exogenous	
Durbin (score) chi2(1)	= 2.9950 (p = 0.0835)
Wu-Hausman F(1,374)	= 2.9322 (p = 0.0877)

The test of endogeneity results indicates that the null hypothesis of the Durbin and Wu–Hausman tests is that the variable under consideration can be treated as exogenous (Table 5). Both test statistics results are highly significant. Hence the null hypothesis of exogeneity was rejected.

The over-identifying restrictions tests were used to establish if the instruments were uncorrelated with the error term, if the equation was incorrectly defined, and if one or more of the exogenous variables left out of the equation should have been included. Table 6 displays the results of the over-identifying restrictions tests.

Table 6: Tests of Over-Identifying Restrictions

Sargan (score) chi2(4)	= 7.82067	(p = 0.1000)
Basmann chi2(5)	= 7.69254	(p = 0.1035)

Tests of overidentifying restrictions were insignificant, indicating that the instruments were valid and correctly specified for the endogenous switching regression equation (Table 6). Table seven shows the results of the endogenous switching regression model.

Table 7: Results of Endogenous Switching Regression Model for the Effect of Crop Diversification on Household Welfare

Savers (Smallholder farmers who make a conscious effort to save money)			**Non-savers.** (Farmers who do not make a conscious effort to save money)		
Variables	Coefficient	Std. Err.	Variables	Coefficient	Std. Err.
Occupation	-0.01671	0.04344	Occupation	0.08785***	0.03020
Group member	0.18582*	0.10673	Group member	0.13519**	0.05533
Gender (SEX)	-0.15934	0.11788	gender	-0.11161*	0.05896
Marital status	-0.04900	0.07706	Marital status	-0.04979*	0.02633
Age	0.06781	0.07488	Age	-0.04880*	0.02887
Education	0.19810**	0.09949	Education	0.06290*	0.03766
Herd size	0.01806**	0.00898	Herd size	-0.00001	0.00004
Farmland	-0.00239	0.11193	Farmland	0.06559***	0.02226
cons	-0.18991	0.29153	cons	0.13984	0.14375
lns1	-1.0155***	0.0963			
lns2	-0.8869***	0.0429			
r1	0.0246	0.2502			
r2	0.5544**	0.2260			
Number of obs = 385					
Log likelihood = -277.89119					
Wald chi2(8) = 14.50					
Prob > chi2 = 0.0695*					
LR test of indep. eqns. : chi2(1) = 19.20 Prob > chi2 = 0.0000					

Legend: * p<.1; ** p<.05; *** p<.01

Notes: Savers (smallholder farmers who consciously try to save money) and non-savers. (Smallholder farmers who do not make a conscious effort to save money)

The correlation coefficients rho1 specified by r1 and rho2 specified by r2 are positive but significant only for the correlation between the diversification and non-savers equations. Since rho_2 is positive and significantly different from zero, the model suggests that smallholder maize farmers who practiced crop diversification experienced an enhanced ability to save than a random individual from the sample would have experienced. This implies enhanced welfare since saving is a welfare dimension (Fowowe, 2020). The likelihood-ratio test for joint independence of the three equations reported in the last line indicated as 'L.R. test of indep' shows that the equations were dependent, signifying their suitability.

The occupation of the household head, which makes a conscious effort to save, had a negative but insignificant association with non-crop diversification (Table 7). Contrastingly, the occupation of household heads who make no conscious effort to save their money was significantly and positively associated with non-crop diversification at a one percent significance level. This implies that non-savers, smallholder maize farmers were more likely not to practice crop diversification than savers. These results echo the study by Shan and Ahmed (2020) on "Determinants of Livelihood Diversification of Rural Households in Sylhet," where he established a significant association between occupation and diversification in Rural Households in Sylhet.

The group membership of the household head who made a conscious effort to save positively was positively and significantly associated with crop diversification at a 10% significance level (Table 7). Consequently, the group membership of household heads was significantly and positively related to post-crop diversification of non-savers at a five percent significance level. This implies that group membership influences the adoption of crop diversification by smallholder maize farmers in Nyansiongo, Esise, Mekenene, and Kiabonyoru wards in the Borabu sub-county. This could be attributed to the influence brought about by group members on crop diversification. These results are consistent with Myers's (2022) study on "Growing Gardens, Building Power: Food Justice and Urban Agriculture in Brooklyn." Their study established a significant association between group membership and crop diversification.

The gender of the household head of savers had an insignificant negative value on crop diversification. This implies an insignificant negative association between the gender of the household head and crop diversification. At a ten percent significance level, the coefficient of the male-headed households who were non-savers had a significant negative value on crop diversification. This implies that female-headed households had a lower likelihood of making the final decision on crop diversification. These findings conform with the results of Nguyen et al. (2019), who established that the gender of the household head insignificantly influenced non-farm labor diversification in rural Vietnam.

The marital status of the household head for savers had a negative, insignificant value on crop diversification. This implies that married smallholder maize farmers are less likely to experience non-crop diversification than non-savers. On the contrary, the marital status of non-savers significantly affected crop diversification at 10 percent. This implies that married household heads who are non-savers were more likely not to adopt crop diversification. These results echo the study done by Abegunde et al. (2019) on "Determinants of the adoption of climate-smart agricultural practices by small-scale farming households in King Cetshwayo District Municipality, South Africa," where they established that the marital status of the household head was statistically associated with crop diversification in the adoption of climate-smart agricultural practices in King Cetshwayo District Municipality, South Africa.

The age of the household head for savers had an insignificant positive influence on crop diversification. Analogously, the age of non-savers was significantly and negatively associated with the probability of practicing crop diversification at a ten percent significant level. This implies that the age of the household head was negatively associated with crop diversification among smallholder maize farmers who are non-savers compared to farmers who made conscious efforts to save. These results agree with Tesfaye and Tirivayi (2020), who observed that older farmers were negatively associated with crop diversification in rural Uganda.

The education of the household head of savers was positively and significantly associated with crop diversification at a five percent level of significance (Table 7). Consequently, the education of household heads was significantly and positively associated with crop diversification of non-savers at a 10% significance level. This implies that household heads' highest level of education significantly influences the decision on crop diversification adoption. This could be attributed to the crop diversification meditation knowledge associated with education. These results conform with the findings of the study done by Adjimoti and Kwadzo (2018) on "Crop diversification and household food security status in rural Benin," where they established that the education of the household head was statistically associated with crop diversification in rural Benin.

The number of livestock owned by smallholder farmers (Herd size) for savers had a positive, significant effect on crop diversification at a five percent considerable level. This implies that smallholder maize farmers who owned livestock were more likely to adopt crop diversification than non-savers. Contrastingly, the distance to the herd size for non-savers had a negative but insignificant effect on crop diversification.

Land available for farming (farmland) in acres for savers had a negative, insignificant influence on crop diversification. In contrast, the farmland for non-savers significantly and positively affected crop diversification at a one percent significance level. This implies that non-savers with small land available for farming were less likely to practice crop diversification. These results agree with the study done by Feliciano (2019), "A review on the contribution of crop diversification to Sustainable Development Goals in different world regions," where they established a significant association between land size and crop diversification.

4.2.1 Endogenous treatment-effects estimation

The average treatment effect of saving as a proxy of welfare among farmers, controlling occupation, group membership, gender (sex), marital status, age, education, herd size, and farmland were estimated under the Endogenous treatment-effects estimation. Table 8 shows the results of the average treatment effect of saving as a dimension of welfare.

Table 8: Results of Average Treatment Effect of Saving as a Dimension of Welfare

	Crop diversification	**Coefficient**	**Robust Std. Err.**	**z**	**P>z**	**95% conf. interval**	
ATE	Welfare						
	(Yes vs. No)	-0.07002	0.08338	-0.84	0.401	-0.23344	0.0934
POmean	Welfare						
	No	0.128538	0.022124	5.81	0.000	0.085177	0.1719

If all farmers were to practice saving as a critical dimension of welfare, the average crop diversification would be -0.07002 units less than the average of 0.128538 units if none had practiced financial saving as a proxy of welfare.

ATET was used to establish the average amount by which crop diversification for savers was increased as a result of financial saving. Table 9 shows the results of the average treatment effect of saving as a dimension of welfare.

Table 9: Results of Average Treatment Effect of Saving as a Dimension of Welfare

	Crop diversification	**Coefficient**	**Robust std. Err.**	**z**	**P>z**	**95% conf. interval**	
ATET	Welfare saving						
	(Yes vs. No)	0.1109	0.05969	1.86	0.063	-0.0061	0.2279
POmean	Welfare						
	No	0.0173	0.05015	0.34	0.731	-0.081	0.11555

Number of obs = 385

The average crop diversification increased by 0.1109 units when all the farmers made a conscious effort to save more than the average of 0.0173 units that would have occurred if none of the smallholder farmers had made a conscious effort to save their money.

5. Conclusion and recommendations

Based on the research findings, socio-economic and institutional factors affecting smallholder maize farmers' household welfare differ between households that save and those that do not. For savers, group membership, education and herd size are the key factors that positively and significantly influence household welfare. In contrast, for non-savers, occupation, group membership, being female, marital status, age, education and farmland have a significant positive effect.

Therefore, promoting group membership, education, and increasing access to land can significantly impact smallholder farmers' household welfare. These findings have important policy implications for governments and development organizations that seek to improve the welfare of smallholder farmers. For instance, policies should focus on promoting group formation among smallholder farmers, investing in education, and increasing access to land for smallholder farmers to enhance crop diversification that improves their welfare.

Conflict of Interest

The authors have not declared any conflict of interest.

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