INFLUENCE OF SOCIAL CAPITAL ON ADOPTION OF CLIMATE SMART AGRICULTURE: EVIDENCE FROM NYANDO BASIN, SOUTHWESTERN KENYA

BY

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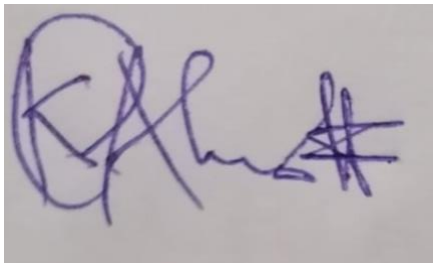
DECLARATION

I declare that this is my original work and it has not been presented in this or any other university for the award of a degree.

Sign:  Date: 25/07/2021

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APPROVAL

This thesis has been submitted for examination with our approval as university supervisors.

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ABBREVIATIONS AND ACRONYMS

CBO's	Community Based Organizations
CSA	Climate Smart Agriculture
CCAFS	Climate Change, Agriculture and Food Security
ILRI	International Livestock and Research Institute
NBR	Negative Binomial Regression
NGO's	Non-Governmental Organizations
SSA	Sub-Saharan Africa
TPR	Truncated Poisson Regression
ZINB	Zero Inflated Negative Binomial

ABSTRACT

Climate change is threatening smallholder farmers' livelihoods, specifically in the sub-Saharan region. In Kenya, floods, droughts and temperature rise have had an adverse impact on livestock and crop production resulting in acute food crises. Climate Smart Agricultural (CSA) practices are aimed at improving food security. Although CSAs have, in recent times, received widespread goodwill through social groupings and CBOs in the Nyando region, not all farmers have adopted them. Thus, this study looks into the effect of social capital on uptake of CSAs. The Poisson regression was used to analyze data collected from 122 farmers in Nyakach and Soin-Sigowet sub-counties through face-to-face interviews using the ODK tool kit. The study point out that membership to farmer groups has been on a steady rise as classified in the statistics. It concludes that membership to farmer groups has a positive influence on the adoption of CSA practices. Further, the results points out a significant relationship between awareness and education, and further with adoption. It is found that increased investment in education tend to boost the adoption of CSA practices. Education should thereby be extended to organized Community Based Organizations and diverse farmers groups to increase their uptake of the new farming techniques. The governments should come up with prudent policy mechanisms and structures that support Farmer groups in order to ensure their sustainability and efficiency in the society.

CHAPTER ONE: INTRODUCTION

1.1 Background

Agriculture plays a significant role in economic development, growth, fostering food security, job creation and poverty eradication. It is primary income provision sector to approximately 2.5 billion people in third world countries (World Bank, 2008). According to Muzari et al., (2012) smallholder agriculture is critical developmental aspect to meet Standard Development Goals one that is to alleviate poverty. However, the majority of smallholder farmers have not fully adopted new agricultural techniques. Muzari et al., (2012) argues that over 70% of farmers in developing countries lack information on appropriate farming practices. They obtain low crop yields because of cultivation of low yielding varieties and over-reliance on rain-fed agriculture with dominant crops being maize, sorghum, millet and beans.

Intergovernmental Panel on Climate Change, (2014) points out that agricultural production systems worldwide are anticipated to change in reaction to climate change, endangering livelihoods and exacerbating the already existing food insecurity among millions of people. In most Sub-Saharan countries, food production has dropped due to change in rainfall patterns, increased temperatures and intense floods. Climate change is evident in Kenya and according to Macoloo et al. (2013), there is rise in floods, droughts, and unexpected rainfall that adversely affect agriculture, communities living styles and food security. In Nyando villages, farmers practice farming in two seasons; short and long season. Dry spell associated with the changing weather pattern has impacted negatively on the families. According to Kinyangi et al. (2015), 17 % of families in Nyando are faced with three to four months of hunger while 81% of families experience at least two months of hunger where persons lack enough food for consumption. The main source of food and income is definitely mixed farming, most farmers have not diversified to new agricultural practices (Mango et al., 2011). In household baseline survey carried out in 2011, 47% of households engage in new crop farming. However, with the introduction of CSA practices in Western Kenya, it has improved the livelihoods of people as it counters adverse climate change effects. CSAs provide a variety of products ranging from fruits grown in greenhouses, trees, and meat products (Macias, 2008). It is in this system whereby farmers partner with other community members in groups to create a sustainable food system as well as improve productivity. In Nyando region, farmers have diversified production from traditional mixed-crop and livestock farming to improved seed varieties and farm inputs. It is noted that CSA practice has multiple ecological and community benefits, including

increased collaboration at local levels in society and preservation of farmland through sustainable production practices (Macias, 2008).

Challa, (2013) points out that 67% of the households that are actively involved in new agricultural practices are majorly engaged in Community-Based Organizations (CBOs) and various Self Help Groups (SGHs). Social engagements within the community influence climate-smart agriculture practices adoption and foster diffusion of new agricultural approaches. Rogers (2010) suggest that social structures affect adoption among farmers. He further pointed out qualitative and quantitative evidence from early researchers that support his argument. Munasib and Jordan (2011) defines social capital is evidenced in society as 'a dense network of institutional and social connection that fosters economic and political efficiency'. Solow (1995), while supporting the social capital influence in decision making, called for a thorough measurement and sought additional empirical evidence.

In Nyando majority of small scale farmers are majorly instrumental members of over 16 CBOs. It is noted that three CBOs namely, KAPSOKALE, Agoro North East Community Development Project (NECODEP) and Friends of KatukOdeyo (FOKO) that encourage farmers work towards adoption of climate-smart agricultural practices among vital rural households interest this enquiry. They work closely with Climate Change, Agriculture and Food Security (CCAFS) that has been instrumental in their formation and awareness on essence of keeping improved breeds of Gala goats, introduction of planting fodder trees, water harvesting, enhancing greenhouse farming, and other activities for instance, beekeeping and grass cultivation. The CBO farmers have benefitted immensely from their interventions. They have, however, heightened their farm production and vital resilience towards alleviating extreme hunger. For example, among farmers in big CBO of FOKO, the pure animal breeds and crossbreeds have doubled to 60 and further to 150 respectively from initial less than 30 in both the cases. The paradigm shift in productivity by farmers who are members of CBOs is a clear manifestation on the importance of CBOs in enhancing technology adoption aimed at achieving food security. Rodgers (2010) argues that the adoption of new agricultural practices involves various factors such as social capital and social interactions. Social interactions occur when households ask questions, observe, and imitate adoption patterns of relatives, friends, community-based organization group members, and their neighbours (Rodgers, 2010). This study analyzed why the CSA gains achieved by small scale farmers from being members of CBOs and social groups have not encouraged some farmers to adopt the CSAs.

1.2 Problem Statement

The capacity of people's social ties, solidarity and self-organization are at the core of social capital. Social capital offers the means of accessing a variety of resources, obtaining skills and support at vulnerable life cycles (Macias, 2008). Thereby, a key channel that provides information on the adoption of CSA practices in community-based organizations and groups. Despite the existence of numerous CBOs and self-help groups advocating innovative agriculture in Nyando through CSA projects funded by donor communities, there has been a slow adoption rate of CSA practices. This study thereby seeks answers to the following questions: Given all the benefits of CSAs in food security and the work of over sixteen CBOs and their various affiliate groups in advancing innovative agriculture in Nyando, why have some farmers not adopted climate-smart agriculture? Three CBOs of interest, NECODEP, FOKO and KAPSOKALE have nearly60 self-help groups (SHGs) and membership of close to Seven hundred suggests strong social capital among farmers in Nyando. From this fact, several questions could be asked: To what extent does group membership influence a farmer's adoption of CSAs? Does the number of groups that a household belongs to say anything about its CSA adoption? Does it matter what groups the household belongs to in this regard? With different groups having varying interests and focus, does joining many groups amongst household members influence the intensity of adoption? Do the regulations and penalties in a group influence or deter adoption? Is the adoption of CSA practices greater amongst group members or non-members?

1.3 Research Questions

1. What are the attributes of small scalefarmers adopting climate-smart agriculture practice in Nyando region?
2. What are the different social capital forms among farmers in Nyando basin?
3. What is the effect of social capital on the adoption of CSA practices in Nyando?

1.4 Main Objective

The main objective of the study is to analyze the effect of social capital on farmers' adoption of climate-smart agricultural practices in Nyando region, Kenya.

1.5 Specific Objectives

1. To characterize small scale farmers adopting climate-smart agricultural practices in Nyando region, Kenya.
2. To determine the different forms of social groupings that farmers in Nyando basin ascribe to.
3. To assess the effect of social capital on the adoption of CSA practices.

1.6 Justification

The study focused on social capital on uptake of CSA practices. It highlights the effect of group participation on the adoption of CSA practices on a household level. This is beneficial to local, national and county governments' policymakers as well as donors fostering initiatives on poverty eradication, environment conservation and improvement of farmers' welfare through social groupings. Subsequently, understanding the group participation and number of groups a household member is engaged in is also important in itself for policy formulation. The study contributes to literature by assessing the influence of social groups on the uptake of CSA practices.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter offers in-depth theoretical and empirical reviews. The sections are divided as follows: theories, empirical studies and overview.

2.2 Theoretical Literature review

2.2.1 Social Capital Theory: Rational Choice Approach

James Coleman's (2008) views on social capital were focused on economists' rational action principle. He was primarily interested in the study of social systems without isolating social organizations in the process. As such, Coleman connected social actions of individuals within the community and their rational ideas. Like Bourdieu (2008), Coleman described social capital as a critical component residing in the social structure of relationships amongst diverse groups of people. However, Coleman saw social capital as a prudent public good that individuals' action benefits the whole community. He conceptualized aspect of social capital as a key inclusive asset of social community groups. For Coleman, individuals actively engage in social relationships, interactions and networks for as long as there are benefits. This logic thereby brings out the rational behaviours of human beings. They seek to adopt practices that in turn offer them direct or indirect benefits. In this sense, social capital is both a public and private good benefitting persons in the group or community organizations. Moreover, Coleman saw social capital as universally productive and as amechanism that influences individual decisions.

2.2.2 Induced Action Theory

This study is based on Hicks (1932) theory of induced innovation. He argued that change in factor of production prices spurs an innovation meant to economize the use of the factor that becomes relatively expensive. Scholars such as Hayami and Ruttan (1985) have made a significant contribution to this theory. Hayami and Ruttan (1985) hypothesized that the development of new technologies and innovations are spurred by a change in resource endowments so that the technology enhances the substitution of an abundant factor with a scarce factor of production. The fundamental insight of this theory is thereby agriculture innovation investment that is a function of change that enters into the specific farm's production function.

The progress in agriculture is a crucial aspect of global economic growth. Ability to meet the high demand of a rapidly increasing population can be a problematic task, more so if we put into consideration the fact that one of the essential substantive factors, land, persists as fixed.

According to the recent World Bank Survey data, acute percentage of the world surface area can be seen usable for permanent pastures or useful cultivation. The challenges encountered emerge as a result of climate changes and poor agricultural techniques.

In this theory, Hick's puts into perspective a case in which the extent and demand for agriculturally derived products rises as an outcome of increased household income or population growth. The theory stipulates that in such a case, prices of materials needed for which supply is inelastic will tend to increase relative to specific prices of the quite elastic inputs. Also, if the input supplies increases at a faster rate than the other input supplies, the input price of such will reduce relative to the market price of the other factors of production used. Basically, farmers would be looking to replace the more inelastic and un-responsive factors of production since they are quite expensive to use. Thus, innovations that takes over place of such inputs would lead to reduced cost and thus higher profits. Suffice to say, when demand for their products rises, farmers positively fall prey to changes in relative prices to look into technological alternatives that replace the increasingly scarce factors of production. Hence, an increase in social capital improves the chances of adopting new innovations in agriculture. It enhances the substitution of traditional practices with technological alternatives that may increases yields.

2.3 Empirical Literature

2.3.1 Effects of Social Capital on Adoption of New Agricultural Technologies

Tesfamicheal et al. (2014) in the study of social capital, cases of risk preference and entire process on adoption of improved farmland management practices in Ethiopia. The study seeks evidence on effects of diverse dimensions of social capital on the adoption of new agricultural techniques across households in Ethiopia. Using panel data and cross-section from Ethiopia, they found out that social capital plays a substantive role in facilitating the adoption of improved farmland management techniques. Also, in accordance to their estimation, the higher the number of early adopters in the village, then subsequently is higher the probability of adopting new land management practices. This implies that farmers learn new farming mechanisms from their peers.

Using socio-economic data of 398 farming households in Ethiopia, Nizam et al. (2017) assessed social capital as a key determinant for water and soil conservation practices such as agroforestry, bunds, and terraces as well as adopting agricultural technologies such as improved high yield seed varieties and fertilizers applying a probit model. The results showed that *Iddir*(informal funeral group) members were less likely to adopt new agricultural practices by 12.8% and 18.2% high likely on water and soil conservation practices. *Jarsumma*(informal conflict resolution) group recorded 17.8% and 12.87% likelihood to the adoption of the aforementioned practices respectively. They concluded that the transfer of modern agricultural techniques to the rural households should consider different types of social capital as a key option to the prevailing top-down approaches with the aim of improving smallholder livelihoods.

In the investigation of probability impacts of dummy social capital on the adoption of productivity-enhancing technologies (PET) in Ethiopia, Nizamet al., (2017) utilized the probit model. The results showed that being knowledgeable raises the chances/likelihood of PET adoption by 10.65% as differentiated to illiterate farmers. The findings had a strong similarity with Yu & Nin-Pratt findings that indicated the education level of non-adopters and adapters are significantly different. According to Yu & Pratt, the more literate respondents adopted new agricultural techniques with ease. Additionally, having extension services, and access to credit services increased the likelihood of adoption by 28.8% and 28.6% respectively.

Munasib and Jeffrey (2011) on social capital effects on farmers' choice on modern agricultural practices to adopt found out that involvement in community-based organizations had a positive effect on the extent adoption to sustainable agricultural practices. Additionally, community involvement had a positive effect on sustainable agricultural practice farmers' adoption decision. These findings establish benefits that would accrue to the rural farmers whenever they engage in practices that support social interaction.

2.3.2 Institutional factors in technology adoption

Belonging to a social group influences social capital enabling idea, trust and information change. Farmers in a social group are able to learn diverse techniques of agricultural production from each other. Mignouna et al. (2009) argue that social networks are key for personal decisions and that in agricultural innovation, farmers learn from each other through information exchange. Studying the influence of CBO of corn-paired banana technology adoption in Uganda, Akankwasa and Katungi (2010) found out that CBO participant farmers were more

likely to participate in social learning about agricultural innovations and thus raising their probability to adopt new technologies. Although according to many researchers working on the adoption of new agricultural techniques and practices report that social group has a positive influence on technology adoption, there is a negative impact of a social group on technology adoption specifically in cases where there is free-riding behavior.

Foster and Rosenzweig (1995) studying the adoption of effective Green Revolution technologies in India found that adoption profitability is achieved as a result of learning externalities within social networks. According to the study, it was evident that free-riding behaviours existed among the farmers on their neighbours' costly experimentation. Bandiera and Rasul (2002) suggest that learning externalities are contradictory since they generate opposite impacts, in that the higher number of persons engage in experimentation, the higher beneficial chance it is to join in, but the more beneficial it is to actively free ride on others' experimentation. Therefore, Bandiera and Rasul (2002) propose individual adoption curve that is inverted U-shaped, implying that at low adoption rates the network impacts are positive and negative at high adoption rates.

2.3.3 Access to Credit in technology adoption

Mohamed and Temu (2008) suggest that credit access stimulate technology adoption. Credit access enhances the risky technologies adoption through liquidity constraint relaxation and raising of household's ability to bear risk. This thereby with a choice of alternative capital through borrowing, a specified household may concentrate on efficient and risky investments and opt out of risk-reducing inefficient income diversification approaches. However, access to credit has been found to be a challenging task for female-headed households. It is stipulated that credit institutions discriminate persons based on gender and women are unable to fund high output return technologies hence adoption rates is low. In line with this assertion, there is a need for policymakers to strengthen the credit systems in order to ensure a wider spectrum of farmers especially from female-headed households gets access to credit. This may encompass, designing credit packages effected to meet the requirements of specific vulnerable or disadvantaged target groups.

2.3.4 Gender Issues in technology adoption

Gender-related matters in agricultural approaches and technology uptake have previously been researched severally. Researchers have however found mixed evidence regarding the diverse tasks played by women and men in technology adoption. Morris and Doss (2009) while

investigating the impact of gender aspects on uptake of agricultural technology in Ghana found no substantive relation between likelihood to adopt technology adoption and gender among smallholder maize farmers. They concluded that decision to adopt primarily depends on access to resources rather than gender. Also, ease of obtaining labour, land access, and several diverse resources led to improved maize production and high new technologies adoption in farming. In this instance, men are advantaged more than women since they have access to most of the resources, in such context, the adoption of new technologies fail to benefit women and men equally. On the other hand, according to studies by Tesfaye et al. (2014) argues that gender may have a substantive effect on technology adoption. Gender tend to impact technology adoption since in most households men are primary decision-makers since they are head of the households and have access to vital resources of the household due to socio-cultural norms and values. Furthermore, a study by Obiesan (2014) on technology adoption among Nigeria's smallholder cassava farmers established that gender had a positive and substantive effect on improved cassava production adoption. He agreed with early studies that indicates male farmer's higher probability to adopt organic fertilizer unlike women.

2.3.5 Labor availabilityin technology adoption

Household size serves as a critical labour availability measure. According to Obiesan (2014),labour availability relaxes the labour constraints required during new technology introduction and thus facilitates the adoption process.

2.3.6 Experience and cumulative farming knowledge in technology adoption

Age is argued to be a crucial aspect of adoption of new technologies and participation in social groups. Older farmers are argued to have vast experience and cumulative farming knowledge gained over a long period. Thus, they are able to easily evaluate new agricultural practices than younger farmers. On the contrary, age has a negative effect on technology adoption and group participation (Adesina, 2009). According to him, there is a sharp rise in risk aversion and less focus in long term farm investment as farmers tend to grow older. Aged farmers take less interest in future investment and often do not participate actively in social groups aimed at enhancing new technologies adoption. On the other hand, young farmers are quite willing to engage in new technologies, invest and borrow loans in social groups and are typically less risk-averse.

2.3.7 Role of CBOs and SHGs in the lives of small scale farmers

DeTray (2008), using aggregate-level data in rural Tanzania, looksat the connection between an individual's action on new agricultural practices and social capital. He finds that participatory associations such as community-based organizations in two regions in Tanzania had a substantive positive effect on individual farmers' market orientation. Isham (2010) showsthat social capital has an impact on fertilizer adoption of farmers in rural Tanzania. Using the same data, Narayan and Pritchett (2008) calculated social capital on farmers' individual levels and their effects on household expenditures. They find that households in villages with high social capital levels (based on organizational memberships) are quite likely to take part in farming with new technologies. Also, these households are more likely to use modern agricultural inputs.

2.3.8 Benefits of collective action on small scale farmers

Saxton and Benson (2005) in their extensive literature studies on environmental awareness in form of cross country comparisons at aggregate levels findthat aggregate social capital, through collective action mechanisms, plays a significant role in diverse societal issues. However, behind any well-structured and organized group or association, there are individuals who still solve their problems by making personal decisions.

2.4 Overview of the literature

Empirical studies focusing on specific development aspects at micro-levels have been more prudent than aggregate studies in explaining the relationships between technology adoption, development and social capital. The most recurrent fields of studies and application in less developed economies as identified by literature are; diffusion of innovation, common pool of resources, the effectiveness of social groupings and market information. As for the adoption of new agricultural practices, from literature's analytical point of view, it emerges that, most studies found a positive correlation between social capital and the uptake of new agricultural practice.

CHAPTER THREE: RESEARCH METHODOLOGY

3.0 Introduction

3.1 Theoretical Framework

CSA adoption is a discrete variable. The most used count data models include Negative Binomial Regression (NBR), Poisson regression, Zero Inflated Poisson regression and the Zero Inflated Negative Binomial regression. It is noted that in order to analyze response variables with non-negative integers, Greene (2008) postulate that NBR and Poisson models are the most appropriate.

According to Octavio et al. (2000), the researchers often lump the critical levels of adoption into two main categories (0 represents no adoption and 1 is adoption) in order to use Logit or Binomial Probit models. This results serve to give measurement errors that are quite undesirable. Ganguly et al. (2010) argue that the use of OLS regression or Tobit models when dealing with a non-negative integer dependent variable produces biased results.

Poison regression could be used to assess how social capital affects CSA adoption by smallholder farmers in Nyando. CSA practices in this study include: membership to social group(s), improved crop/animal varieties use, intercropping, use of cover crops, contour ploughing, use of terraces, micro-catchments, burning crop residues, irrigation, use of mulching, hedges, ridges and bunds, organic fertilizers, diversified improved crops and animal breeds. These CSAs could be grouped into 4 categories: social capital; Livestock breed improvement; soil protection; soil enrichment; and water management. The CSA practices' number adopted by a farmer is arguably count data. Smallholder farmers adopt CSA technologies sequentially (Ramirez & Shultz, 2000).

3.2.1 Poisson Regression

The Poisson regression model (PRM) rests on the assertion that the identified dependent variable *y* with a given predictor variables *x* set has a Poisson distribution.

It is assumed that each farmer makes a choice on a given bundle of CSA practices that offer the highest utility. Ganguly et al. (2000) postulates that utility obtained from a particular bundle depend on a vector of household characteristic (Q), and a vector of observed farm characteristics (F). This could be represented as shown;

$$U_{IJ} = \gamma(Q_i, F_i) + \varepsilon_{ij} j = 0, \dots, 1 \dots, mi = 1, 2, \dots, n(i)$$

From the equation, *j* indicates the number of CSA practices adopted by i^{th} farmer and ε_{ij} is the error term. A farmer is assumed to adopt *j*>1. The probability that a farmer will adopt a number of CSA practices could be expressed as follows;

$$\text{prob}(Y_{i=j}) = \frac{e^{-\lambda i}\lambda^{ij}}{j} \quad j = 0,1,\dots,m.\, i = 1,2,\dots,n \qquad \text{(ii)}$$

In equation *ii* the anticipated number of events, Y_i, (in this case, the CSA practices number adopted), and *j* represents number of factors that influence the expected event *Y*.

λ_i is both the variance and conditional mean of the Poisson distribution and *m* is the number of CSA practices maximum that could be adopted.

From Wooldridge (2002) and Greene (2008) the number of events expected, Y_i, (in this case, the number of CSA practices adopted) is given below:

$$E(Y_i) = \text{var}(Y_i) = \lambda_i = e^{\alpha(Q,F)} \qquad i = 1,\dots,n \qquad \text{(iii)}$$

The i^{th} farmer's linear conditional mean value function is $E(Y_i)$ for the dependent variable. Then β is the unknown parameters' vector and *n* as the smallholder farmers' number. This takes assumption on equi-dispersion of the dependent variable. The dependent variable may be truncated at zero since it involves practices that are already in practice among the smallholder farmers. The practices range from 1 to 9. Failure to take into account truncation may lead to inconsistency and biased estimates (Mulwa et al., 2018). Thus, truncation at zero and equi-dispersion requires Poisson distribution that is truncated at 0 for the count (y), noted by

$$\Pr\{Y = y(Y > 0) = \frac{e^{-\lambda i}\lambda^{ij}}{j} .\{1/(1-e^{-\lambda i})\} \qquad y = 1,\dots,n \qquad \text{(iv)}$$

PRM requires that variance and mean be identical. If not, under-dispersion or over-dispersion is present and PRM fail to offer prudent results in such a case.

In such an instance, the Negative Binomial Regression (NBR) model is a betteralternative. NBR is defined by

$$\text{var}(Y_i) = \lambda_i + \alpha\lambda_i^{\,2} \qquad \text{(v)}$$

The dispersion parameter α is stated such that if $\alpha = 0$ then NBR=PRM and PRM becomes a unique case of NBR (Green, 2002).

3.2.2 Over-dispersion in the Residual Errors

In the Poisson distribution, it is established that mean and variance are equal. In a Poisson regression model, the mathematical equation tend to equate conditional mean (predictor variables' mean control) with the conditional variance. However, there is a high skewness degree more than is assumed by the Poisson distribution in most actual distributions. The sample variance is likely greater than the mean. According to Lord et al., 2005 the Poisson model gives a calculation whereby a standard error, as if the variance tend to equal the mean. Therefore, the Poisson model underestimates the standard error and, thus, the significance tests are higher or greater than they actually should be.

The challenge of Over-dispersion in the PRM is as a result of two assumptions (Winkelmann et al. 2008). First, the supposition that the Poisson process does not allow for the unobserved heterogeneity since it is a deterministic factor or function of the predictor variables. Secondly, that events comprising each count occurs randomly in a period and are independent thus ignoring the argument that present occurrences may affect the future occurrences. In a Poisson multiple regression model, individuals often may end up selecting diverse variables that ought not to be selected as a result of the assumption and tendency to think they are significant statistically when really, they are not (Lord et al., 2005). Furthermore, violation of two vital assumptions may lead to under-dispersion.

3.2.3 Negative Binomial Regression Model

The second critical correction type on dispersion involves a mixed-function model. Here, different assumptions for the variance (dispersion) and for the dependent variable mean are made instead of adjusting the standard error by adopting dispersion correction. In the NBRM model, there is a supposition that the number of observations Y_i follows a specified Poisson distribution of $\lambda_i$mean. Furthermore, it is assumed that dispersion follows a Gamma distribution. The negative binomial distribution is a derivation whose function sign is simply negative, thus the term *negative*.

Since the equi-dispersion assumption is often found in rare cases in empirical studies particularly in presence of over-dispersion on a dependent variable, choosing NBRM introduces an unobserved heterogeneity which allows for over-dispersion for the i^{th} observation (Mulwa et al., 2018). To correct for both over-dispersion and truncation the zero-truncated negative binomial distribution for the observation/count (y) is most appropriate, and it's given by;

$\Pr\{Y = y(Y > 0)\} = \{T(y + \alpha^{-1})\}/T(\alpha^{-1})T(Y_{i+1})$. $\alpha\lambda_i{}^{y}(1 + \alpha\lambda_i)\{\frac{1}{\left(1-(1+\alpha\lambda_i)^{\alpha^{-1}}\right\}}\}$ (vi)

With

$$\left[E(y_i|x_i)\right] = \lambda_i + 1 + \alpha_i\lambda_i \quad \text{(vii)}$$

$$Var\left[(y|x)\right] = \lambda_i(1 + \alpha_i + \alpha_i\lambda_i + \alpha_i^2\lambda_i \quad \text{(viii)}$$

Where T represents the gamma distribution and α denotes the under/over-dispersion parameter.

Equation (vi) can be wholly extended to a framework of regression by modelling λ_i as a semi-logarithmic function of x_j explanatory variables,

$$\ln \lambda_1 = \beta_0 + \beta_1 S_i + \sum_{j=1}^{j} \beta_j x_{ji} + \varepsilon_i \quad \text{(x)}$$

Analytical framework

The analytical model in the study was an NBR model of the form:

$Ci = \beta_0 + \beta_1\, GrpM + \beta DistMrkt + \sum \beta_j\, x_{ji} + \varepsilon_i$(xi) (xi)

Where C_i is the CSA practices' number adopted by a household, Group membership, distance to the market and x_{ji} are household socio-economic characteristics. They encompass; the age, education of the household head, family size, gender of household head, size of family-owned land, credit access and to extension services. βs are parameters to be estimated.

3.4 Variables Description

Table 1: Description of Variables that determine adoption CSAs in Nyando

Variable	Description	Measurement	Expected sign
CSA	The No. of CSA practices	Number of CSAs	
AGE	Age(in Years) of the household head	Number of years	+/-
GENDER	household head's gender	Dummy. =1 if male 0=female	
EDUC	Years of household head's schooling	Number of Years	+/-
H/SIZE	Household members' numbers in the household	Number of Members	+/-
LAND	Owned farm size in acres	Number of Acres	+
ACCESS TO CREDIT	Whether household accessed credit in the last one year	1= yes 2=no	+/-
GRPMSHIP	A number of groups household members are involved in.	Number of Groups	+/-
DISTANCE	Kilometres to the output and input market	Number of Km	+/-
TRNG/EXTN	No. of annual contacts with extension agents	Number of Training	+/-
FARMASSOC	If the household head is a member of an association or farmer-related group	Dummy=1 if a member, 0=otherwise	+

3.2 Research Design and Sampling

The sampling encompassed stratified random sample of 222 households from CCAFS 2017 end line survey. The sample stratified followed the following variables: Goats/sheep ownership- The household lacks goats/sheep or there is indigenous but not improved sheep/goats or Household has improved sheep/goats. The household location; It involves whether the household is not located or located in Climate Smart Village; Land management

practice and crop management by household (low/high) - Household practices low land/crop management: No improved seeds / No fertilizer / No use of pesticides ('low crop management') and didn't introduce intercropping or end burning / adopt ridges or case of terraces/bunds / use of hedges / planted a under-median trees' number per acre, in past 10 years ('low land management'); Household activities/approaches on high land/crop management otherwise.

3.1 Area of Study

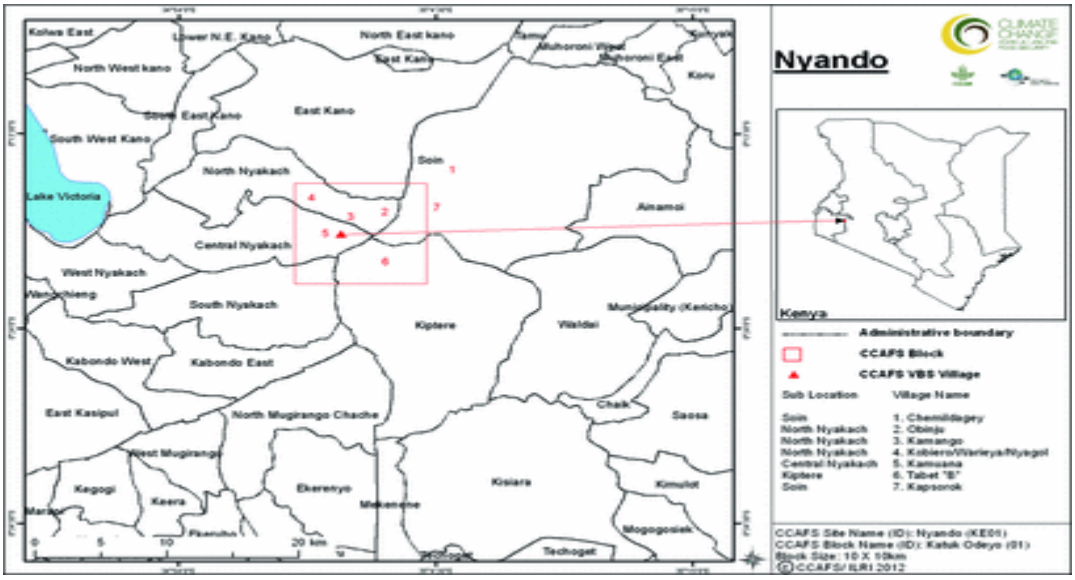

Figure 1: Nyando Basin

Nyando basin lies in both Kericho and Kisumu counties. The region, which is sandwiched by the Nyabondo plateau, Kano plains and Nandi Hills comprises moderate fertile black cotton soil that easily forms deep cracks in the dry season. Therefore, with an inefficient drainage system, these soils lead to the development of deep gulley that arises from heavy soil erosion during the rainy seasons. According to GoK (2009), despite the cultivable land in the basin, shortage of food is widely experienced as a result of unreliable rainfall, prolonged dry seasons with maximum temperatures ranging from 25-35^{o}C and minimum of 9-18^{o}C of cold seasons. Land degradation adversely affects farming in Lower Nyando during the rainy season. The region experiences short rains in September-November and long rains in March-May. However, Abuto (2018) points out that mean annual rainfall ranges from 1,100 to 1,600 mm. The upper Nyando basin experiences higher rainfall compared to the lower and middle basin. Livestock rearing and farming are key sources of food and income in the region. To achieve high returns and productivity in farms, some smallholder farmers have diversified farming through the adoption of CSA practices.

3.3 Data Collection

Primary data was sought from respondents through baseline survey conducted in three weeks. The data was collected from two strata encompassing two un-identical groups of farmers, i.e "Non-participating" non-CSV farmers and the participating (CSV) farmers. The households in the non-CSV's and the CSV villages have same features in terms of soil conditions, climate, and the agricultural farming techniques. The Open Data Kit (ODK) was used to collect data by the University of Nairobi students who had prior to research, underwent training on data collection by use of ODK tool by ILRI staff.

CHAPTER FOUR: RESULTS AND DISCUSSION

This chapter presents an in-depth discussion on the study results. It entails descriptive statistics of the households, different forms of social groupings and regression analysis of effects of social capital on the adoption of CSA by smallholder farmers.

4.1 General Household Characteristics

Table 2 Characteristics of Households in Nyando

VARIABLE	OBS	MEAN	STD.DEV.	MIN	MAX
Gender	122	.189	.393	0	1
Age	122	54.033	16.256	25	94
Education	122	3.303	1.646	1	7
Plots Ownership	122	1.025	.202	1	3
Distance To Animal Market	122	8.839	3.722	2	20
Distance To Food Market	122	3.046	2.73	.003	12
Household Size	122	6.008	2.586	1	19
Household Group Membership	110	2.91	11.069	-66	5
Group Size	110	42.9	67.441	7	400

The population's descriptive statistics are presented in table 4.1 above. It is shown that on average, the households' head was 54.033 years with 25 years as the youngest and 94 years as oldest age. Male-household headed were 81.15 % while approximately 18.85 % were female-headed. Accordingly, on average, every household size had six persons and the largest household comprised of 19 persons while the smallest household had one person. Households headed by female had averagely had five people whereas male headed households had averagely six people.

The majority of household heads were primary school dropouts, that is, 29.51% while (27.87%) had completed primary education. Those who had completed tertiary education were only eleven (7%) of household heads. On crop farming, 54.10% of the household heads had this as their primary occupation whereas 8.20 % opted to rear livestock. In the statistics, 13.11 % were engaged in formal employment that tends to give information as salaried employment while relative proportion engaged in other self-employment, majorly non-farm practices.

Averagely, it is considered that land holdings had 4.409 hectares, while 1/2 hectares smaller size of land and the larger land size was at 70 hectares. Most of 120 households/respondents had at least a plot used in farming whereas two had at least three or two plots for farming. The plots were often rented or owned by diverse households. A number of persons/ households who owned and worked on pieces of land were 54.46 % while 45.90 % of the respondents rented plots for farming. Additionally, 1.64 % of persons with plots rented out.

Respondents had varying access to diverse markets namely nearest shopping centre, food and livestock markets. With a mean of 3.046 kilometres, the distance to food markets was quite nearer compared to animal markets distance that averaged at 8.839 kilometres.

4.2 CSA Practices

This study focused on four main categories of CSA practices. These are; Animal and Land management, improved variety of animals and agro-forestry. The diverse animal management entails feeding animals with fodder crops, practicing farming of improved pastures, enhancing animal cross-breeding with diverse quality breeds, checking of animal health by farmers themselves or by veterinary personnel, whereas the category of improved animals entailed keeping drought resilient and breeds of animals that are fast-maturing like sheep and goats. Again, those considered were the improved and pure varieties of animals such as sheep, cattle, chicken and goats. Arguably, the animal management techniques and practices have an impact on the increase of farm output.

It is established the land management practices encompasses diverse vital practices of Conservation Agriculture (CA) that have always been considered. These entails; terracing, intercropping, mulching, crop residue retention, burns and ridges, and the water catchment. In the category of agro-forestry, the fruit trees and several non-fruit trees that tend to grow well in the area were considered. Agroforestry boosts farm improved yields and incomes within household. Thorlakson, (2011) posits that it is the trees that always give quite unique coping

mechanism to diverse shocks; fruits from trees serve as the only vital subsistence in the case of flooding when crops are wholly submerged in water.

An in-depth CSA adoption analysis shows the majority of the respondents used land management practices at (97.54 %). Animal management practices and Agro-forestry had been equally adopted at (96.72 %). However, the keeping of improved or pure or livestock was less (46.72 %) adopted. Table below gives a summary of the uptake of different practices.

Table 3 Summary of CSA practices adopted by Nyando farmers

CSA Practice	Percentage of users	Components
Land Management	97.54%	Water harvesting, inter-cropping, crop residue retention, planting cover crops, mulching, building ridges and burns, hedges, terraces, and contour ploughing.
Animal Management	96.72%	Growing improved pastures, storing fodder, Stall keeping, growing fodder crops, and the cross-breeding animals
Agro-Forestry	96.72%	Avocado trees, Mango trees, banana plants, other fruit trees, and non-fruit trees
Improved breeds	46.72%	Galla goats, Red Masai sheep, improved chicken and improved breeds of cow

Source: Author

It is evident that farmers are at diverse CSA practices adoption levels. Farmers have a greater scope of adopting CSA practices in the Nyando basin, this helps them increase farm productivity and uplift their livelihoods. Davies (2010) stipulates that farm diversification is a prudent norm among many farmers. Table 5 shows the diverse practices that have been adopted in the region with their respective percentages. Highest adoption level is 23 with less than simple percentage of the farmers adopting, and the lowest being one practice with equally 0.82 % of the farmers adopting. Results indicate farmers who have adopted utmost nine practices are low (22.96) %.

4.3 Forms of Social Groupings among farmers in Nyando

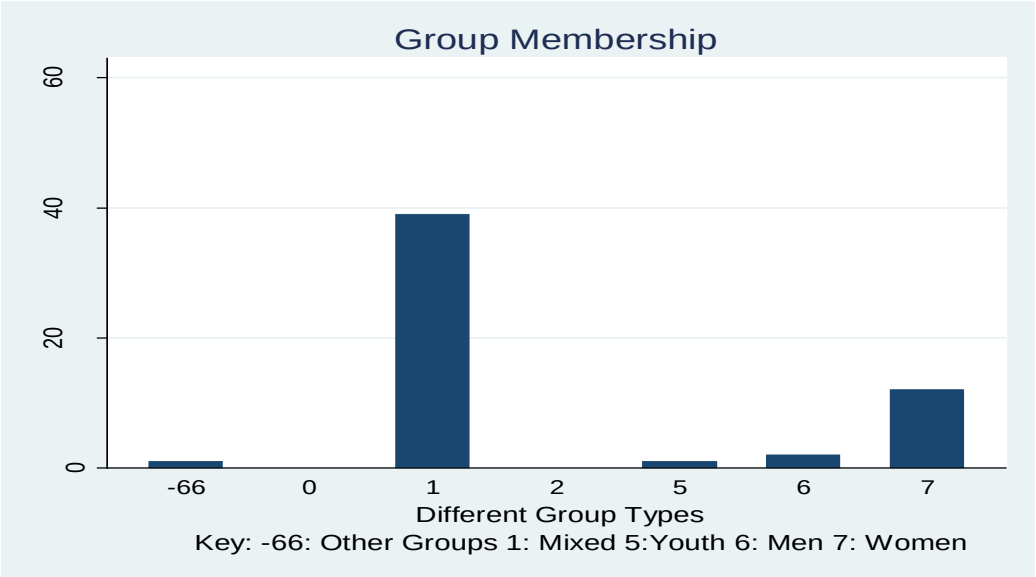

Figure 2.0: *Forms of social groupings among farmers in Nyando basin, Kenya.*

In figure 2.0 above, a mixed-gender group at 50% had a higher percentage of farmers than the 26% women-only groups. Also, 14% of farmers were in adult men group whilst 8% of farmers were in youth groups. Majority of households had members in both a mixed group and women-only groups. The group that formed a paltry 2.73% classified, as others comprised of people with special cases and young person's only.

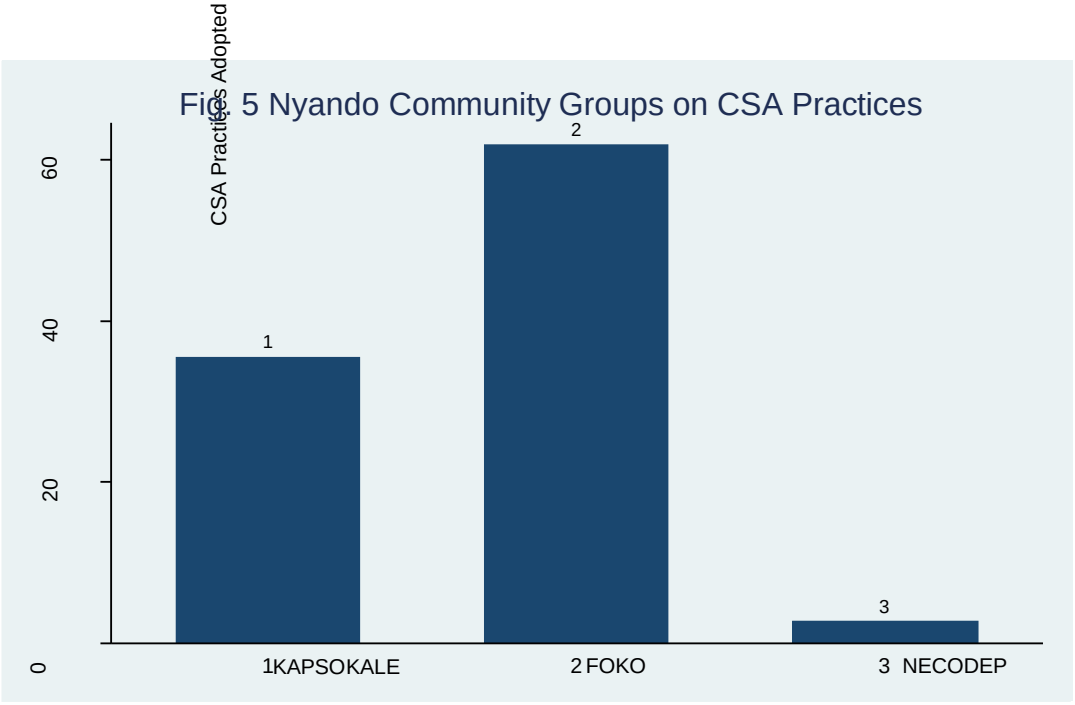

Fig. 5.5 gives a preview of each group in the Nyando basin that had adopted diverse CSA Practices. 54% of farmers in the FOKO community group actively adopted CSA practices. This implies that majority of FOKO farmers have knowledge of the essence of CSA practices adoption. On the other hand, 32% of Kapsokale Community group farmers adopted CSA practices. Additionally, 13.64% of NECODEP farmers were engaged in CSA adoption practices.

According to the results, only 8.8% of the households were not engaged actively in any community groups, whilst 90.16% of the households were involved in diverse community groups. The majority (45%) of the household heads were group members. This implies that most farmers adopting CSA practices obtained the necessary information from the groups. Furthermore, the efforts by the development agents such as CCAFS has borne fruits in enhancing value additions and high agricultural productivity through the active participation of farmers in the social groups. Across Nyando basin, according to Kinyangi et al. 2013 and Baseline data survey 2019, there has been a slight rise in enrolment to groups by 20, 22 and 24 % in FOKO, Kapsokale and Agoro North East Communities CBOs respectively.

The rising level of membership to farmer groups and CBOs is partially attributed to the existence of non-governmental organizations that have been involved in sensitization of farmers on new agricultural practices. It was established that farmers in groups were largely women than men; own a relatively large number of plots; had more education; accessed extension and credit services; had bigger families and reported higher yields in crop and livestock production. Generally, the adoption of CSA practices in Nyando basin is greatly attributed to the farmer groups.

4.4 Regression results on the effect of social capital on the adoption of CSA practices.

Table 4Negative Binomial Regression results of adoption of CSA practices

CSA Count	Coef.	Std.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Group size	0.000	0.001	-0.39	0.694	-0.002	0.001	
Hh group member	**-0.005**	**0.003**	**-1.68**	**0.092**	**0.012**	**0.001**	*****
Gender	-0.120	0.117	-1.02	0.308	-0.350	0.111	
Age	**0.003**	**0.003**	**1.05**	**0.294**	**0.002**	**0.008**	******
Age							

Education	**0.044**	**0.027**	**1.66**	**0.097**	**0.008**	**0.097**	*****
Plots Nos.	0.052	0.174	0.30	0.766	-0.290	0.394	
Distance to Food Market	0.005	0.015	0.37	0.713	-0.023	0.034	
Distance to animal market	**-0.031**	**0.012**	**-2.52**	**0.012**	**0.054**	**0.007**	******
Constant	1.925	0.268	7.19	0.000	1.401	2.450	***
Constant	-3.833	1.102	.b	.b	-5.992	-1.673	

Mean dependent var	6.682	SD dependent var	2.946
Pseudo r-squared	0.026	Number of obs	110.000
Chi-square	14.382	Prob> chi2	0.109
Akaike crit. (AIC)	555.457	Bayesian crit. (BIC)	585.163

**** p<0.01, ** p<0.05, * p<0.1*

Group Membership: Being in a group has a significant effect on adoption of CSA practices by households at 10% significance level. It was observed that farmers in groups irrespective of the size of their group tend to have adopted many CSA practices. Davis et al. (2012) in the study of the adoption of new improved technologies pointed out those group members had substantively higher crop yields than non-members in Uganda. In addition, De Jalón et al. (2017) in the subsequent studies showed that group membership results in higher crop yields among group members in Kenya and Tanzania. Therefore, these results are consistent with other studies where a group extension influences the adoption of new technologies and farming practices.

Age: The age of household head has a significant and positive effect on the CSA practices adopted at 5% significance level. The higher the household's head age is the higher the chances of adopting CSA practices and involvement in groups. It is stipulated that the majority of middle-aged persons be actively involved in groups. They also form a large percentage of members in CBOs and social community groups. However, this contradicts Roco et al. (2014) assertion that younger household heads adopt new technological farming practices. In Roco's study, he concluded that the majority of young people are household heads and form a larger

percentage of the workforce in Central Chile. Nevertheless, in both instances, group membership greatly influenced the adoption new farming practices.

Education: Results indicate that education has a positive and significant effect on adoption of CSA practices at 10% significance level. The positive effect of education to the adoption of these practices could be due to knowledge that enables a household member to get access to credit, loan, engage in savings through various platforms such as community groups, and support from donor agencies in Nyando basin. These findings affirm Pretty et al. (2004) findings that education has a significant effect since individuals are able to easily adopt high yielding crop varieties as demonstrated in the farmer group pieces of training. In addition, they effectively utilize extension services.

Distance to animal Market: Distance to the animal market has a significant effect at 5% significance level on the adoption of CSA practices. The greater the access to animal market the higher the chances of adoption of CSA practices since the individuals are able to get information on community groups, access to credits and loans then diversify or adopt various CSA practices. These findings affirm Teklewold et al. (2016) assertions that easy access to markets motivates farmers to diversify so that they take advantage of the already existing market demand for agricultural outputs.

CHAPTER FIVE: CONCLUSION AND POLICY RECOMMENDATIONS

Initially, the low rate participation in groups had been a great concern to policymakers since the non-governmental organizations and local governments have over longtime invested in agricultural extension services through community-based groups. The adoption of CSA practices because of membership to groups ought to be an initial step aimed at farmer's sensitization to join groups, adopt CSA and secure funding from various agencies in order to boost their agricultural practices.

In Nyando, development agencies need to undertake a detailed community-based organizations audit and all farmer group operation, organization, leadership, formation, dynamics and sources of modern agricultural techniques disseminated to members. It is evident that CSA practices have been critical in curbing negative climate change effects, equally boosting farmers' livelihood. A crucial link between non-adoption and CSA adoption besides non-governmental agencies for instance CCAFs is the community-based groups. Hence, the study point out that membership to farmer groups has been on a rise steadily as evidenced in the data. It concludes that membership to farmer groups has a positive influence on the CSA adoption. In addition, it was observed that membership to farmer groups leads to the achievement of higher yields.

Promoters of CBOs and farmer groups should direct efforts in enhancing the efficacy of productivity strategies thereby uplifting farmers' welfare. Failure to such crucial interventions would lead to farmers developing negative perceptions on group approach of CSA adoption and agricultural information dissemination. A negative perception of the influence and effectiveness of group strategy will not only discourage more farmers from joining and adopting CSA practices but also lead to a decline in membership in established CBOs and small groups.

Results further demonstrate, a significant relationship between awareness and education, also with adoption. Moreover, it is key to note that investment increase in key aspects of education tend to improve its quality is thus boosting the adoption of CSA practices. Education should be extended to farmer groups that are well organized to heighten their uptake of new farming techniques. The farmer groups ought to be supported to ensure sustainability of their operations.

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APPENDIX

QUESTIONAIRE

Household Demography

Respondent's Name:

What is the household head's age (in Years)?

1. Female
2. Male

What is the household head's highest level of education?

1. Lack of formal schooling
2. Primary complete
3. Primary incomplete
4. Secondary complete
5. Secondary incomplete
6. Tertiary/university complete
7. tertiary/University incomplete
8. Adult education complete
9. Adult education incomplete
10. Don't know

What is the primary occupation of household head?

1. Livestock farming,
2. Crop farming,
3. Employment (Salary),
4. Off-farm Self-employment,
5. On-farm casual laborer,

6. Off-farm Casual labor,
7. School/college,
8. Non-school child,

Land Ownership

What is the household's size of the land? [ ]

What is the number of household's farming plots? [ ]

What is farming plot's ownership status?

1. Worked and owned,
2. Rented out and owned,
3. Community land
4. Rented

Connectivity

What is the Local food market distance (Km) [ ]

What is goat/sheep/sheep market distance (Km) [ ]

Savings

Who has savings in the household?

- Husband , Wife, Joint husband/wife, Others

What is the Savings amount in Kenya shillings?

Loans

Who has an outstanding loan in the household?

1. Husband
2. Wife
3. Joint husband/wife

4. What is the amount of the loan? (KShs) [ ]

Social Capital

Who is a member of a group in the household?

1. Wife
2. Husband
3. Joint husband/wife

What is the number of group members? [ ]

What are group's key activities?

1. Tree nursery
2. Savings and credit
3. soil improvement,
4. marketing agricultural products,
5. women empowerment,
6. Other, specify