SOCIAL CAPITAL EFFECTS ON THE UPTAKE OF SUSTAINABLE AGRICULTURAL INTENSIFICATION PRACTICES AND MAIZE AVAILABILITY AMONG SMALLHOLDER MAIZE-LEGUME FARMERS IN SELECTED COUNTIES, KENYA

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DECLARATION AND RECOMMENDATION

Declaration

This thesis is my original work and has not been presented for an award of diploma or degree in this or any other University.

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Recommendation

This thesis has been submitted with our recommendation as University Supervisors.

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DEDICATION

I dedicate this work to my late father Samson Mayaka, my caring mother Sarah Mayaka and my sisters, Hyline, Agnes, Dinah, Grace, and Venny for their sincere support.

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I am responsible for errors of omission and commission.

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ABSTRACT

Kenya's smallholder maize-legume farmers are faced by many challenges in production, among them soil mining, input acquisition, and low soil fertility. In an attempt to address these challenges, the use of Sustainable Agricultural Intensification Practices (SAIPs) has been promoted widely. However, their uptake has remained low among smallholder maize-legume farmers and it is unclear whether social capital influences SAIPs uptake. Using secondary data from Australian International Food Security Centre (AIFSC) through International Maize and Wheat Improvement Center (CIMMYT) supported Adoption Pathways (AP) project, a Three Least Squares (3SLS) estimation, a Seemingly Unrelated Regression (SUR) procedure, and an ordered logistic model were used: to determine factors that significantly influence a household decision to invest in social capital forms; to establish the social capital effects on the uptake of SAIPs combinations; and to analyse the social capital effects on maize availability among smallholder maize-legume farmers, respectively. The findings of the study show that membership score positively and significantly influenced network density (P< 1%). Furthermore, the level of social capital was influenced by the age, education, and gender of the household head, credit received and income of a household. The results further show that, except for cognitive and participation in social capital, the aggregate social capital variable was insignificant in explaining the adoption of SAIPs combination. Moreover, the age of the household head, whether a household received information about SAIPs and input markets, income and household positively and significantly influenced the adoption of SAIPs. On household maize availability, social capital forms were insignificant influencer. However, age, income, and education stock positively and significantly influenced household maize availability. The study results imply that enhanced information dissemination on the benefits of SAIPs adoption and use, through social capital, would lead to improvements on SAIPs adoption rates and levels, and this will improve maize availability, as well.

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LIST OF ABBREVIATIONS

ADB	African Development Bank
AIFSC	Australian International Food and Security Center
AP	Adoption Pathways
CF	Conservation Farming
CIMMYT	International Maize and Wheat Improvement Center
DEC	Average per person Dairy Estimated Consumption
DD	Dietary Diversity
GoK	Government of Kenya
HFIAS	Household Food Insecurity Access Score
KNBS	Kenya National Bureau of Statistics
MoA	Ministry of Agriculture
PCA	Principal Component Analysis
SAIP	Sustainable Agricultural Intensification Practices
UN	United Nations
SDG	Sustainable Development Goals
SIMLESA	Sustainable Intensification of Maize and Legume in Eastern and Southern Africa
SPSS	Statistical Package for Social Sciences
WCP	Water and Conservation Practices
3SLS	Three Stage Least Squares

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CHAPTER ONE
INTRODUCTION

1.1. Background of the Study

By the year 2050, the world population is projected to be 9.9 billion people (UN, 2015). Ninety-three percent of the targeted population rise is thought to take place in developing countries, whose share of the global population was projected to increase from 78% in the 1990s to 83% by 2020 (UN, 2015). This rise in population will require approximately 40% increase in food production to meet their demand (UN, 2015). This implies that there is a need to develop a shared vision and consensus for action on how to meet the world's future food needs, reduce poverty while protecting and conserving the environment. In sub-Saharan Africa, food insecurity, poverty, and low agricultural productivity are key challenges facing many households. The likelihood of food insecurity is greatest in arid and semi-arid lands due to flimsy and impulsive rainfall patterns and poor resource endowment (Alila and Atieno, 2006). Other factors like drought, nutrient mining, limited availability of resources to farmers and low soil fertility are also linked to low agricultural productivity in Sub-Saharan Africa (Mucheru *et al.*, 2009).

Like many sub-Saharan Africa countries, Kenya's economy is supported by Agriculture (KNBS, 2015). It contributes 26% of the Gross Domestic Product (GDP) and about 65% of the country's export earnings. The sector also contributes a further 27% to the GDP through linkages with other sectors like manufacturing, distribution, and service related sectors. The sector also employs about 70% of the labor force either directly in production or indirectly in the service industry (GoK, 2014). The Kenya Vision 2030 also continues to recognize agriculture as an essential sector of the economy, emphasizing on food security initiatives and providing a source of employment to many people. The target will be achieved by orienting it to commercialization, modern ways of production and concentration on more and better ways of value addition of agricultural produce (GoK, 2007). All these outcomes are possible by improving yields in core food crops like maize and beans. This is because maize and legumes are major crops grown in Kenya and the fact that maize is a staple crop in the country (Kirimi *et al.*, 2011). Smallholder farmers are the chief producers of the cereals supplied, hence, need to improve productivity in main production potential areas to reduce the deficit experienced in the country almost every year (Kirimi *et al.*, 2011). The high yields can be realized if farmers use the Sustainable Agricultural Intensification Practices

(SAIPs) that optimize harvest (Pretty *et al.,* 2011). These practices will help in improving and sustaining food security, increasing household income and improving welfare, hence economic development. The SAIPs are particularly relevant to smallholder farmers who are constrained by a number of factors like low and unpredictable rainfall; infertile soils; soil erosion; destitute infrastructure; lack of or poorly developed institutions; problems of input procurement and sale of output; credit access difficulties; climate change; and soil mining (Mwangi and Kariuki, 2015).

Despite its importance, the agricultural sector in Kenya has remained low in production. This is attributed to weak technology diffusion and innovation in Kenya with 0.129 scores (Salami *et al.,* 2010). Alila and Atieno (2006) postulate that the inability of farmers in Kenya to afford readily available modern farming technologies results in low productivity. This is evidenced by low yields per acre. Poor institutions, marketing facilities, and information flow are some of the constraints facing agricultural production (Alila and Atieno, 2006). A declining trend in agricultural productivity has implications for income inequality, unemployment and food insecurity (Alila and Atieno, 2006). Higher earnings; lower poverty; improved nutritional status; increased employment activities and lower staple food prices are associated with the adoption of improved agricultural technologies (Mwangi and Kariuki, 2015). It has been argued that intensification of production through the increased use of improved inputs, diversification from low to high-value crops, commercialization of smallholder agriculture and increased valued addition through stronger linkages with other sectors will result in increased agricultural production (Alila and Atieno, 2006).

Social capital refers to relationships of trust, communications, and cooperation that facilitate collective action in a community (Ville *et al.,* 2016). According to Katungi (2006), social capital influences information diffusion and social learning, which are pertinent to SAIPs adoption. It allows cooperation and willingness to share information. As a result, it reduces the cost of acquiring information since it can be acquired during social interactions. Social capital also reduces the uncertainty about the dependability of information from well-established sources to learning by seeing or doing. Information from trusted people is likely to be given higher value by recipients (Kassie *et al.,* 2015). Social capital is useful for individual decision making in a household. It is also important in enhancing agricultural innovations, sharing crucial information and learning from each other (Mwangi and Kariuki, 2015). According to Mwangi and Kariuki (2015), access to the social network has been reported to stimulate the adoption of technology. It

also reduces information doubt about a technology's performance. It may change a person's assessment overtime from purely subjective to objective. Social capital can increase the possibility of access to various forms of social support during times of need (Martin *et al.*, 2004). Groups like cooperatives, farmers associations and clubs are ways through which the government and NGOs give the vital agricultural inputs to the rural communities in the form of loans or at times for free as a safety net. Local institutions at a community level and social capital have a vast role in maintaining food availability at household and individual levels (Dzanja *et al.*, 2015).

1.2. Statement of the Problem

The rapid population growth especially, in the less developed countries like those in Sub-Saharan Africa is posing a challenge of feeding everyone. This is deepened by the fact that there is declining soil fertility, soil mining, environmental degradation, and global climate change while arable land is shrinking or remains constant. SAIPs are considered as the remedy to this challenge and have been promoted widely by the government, non-governmental organization, and scientists, but their uptake has remained low among smallholder maize-legume farmers. As a result, there is a need to explore whether social capital, which encourages the sharing of information and innovation, promotes SAIPs uptake. The study was also motivated by the fact that, there are little empirical studies that explore the interrelationship between the social capital, SAIPs uptake and of context-specific food security challenge among smallholder maize-legume farmers in Kenya. The study aimed at filling this gap by identifying social capital forms among smallholder maize-legume farmers and whether they promote SAIPs combinations uptake and ultimately improve the productivity of maize and legumes in Kenya

1.3. Objectives

1.3.1. General Objective

To improve the productivity of maize-legume system in Kenya, through enhanced use of SAIPs, among smallholder maize-legume farmers in selected counties in Kenya.

1.3.2. Specific Objectives

i. To determine factors influencing household decision to participate in one or more form(s) of social capital among maize-legume farmers in selected counties in Kenya

ii. To determine social capital effects on the uptake of SAIPs combinations among smallholder maize-legume farmers in selected counties in Kenya.
iii. To determine social capital effects on maize availability equivalent among smallholder maize-legume farmers in selected counties in Kenya.

1.4. Research Questions

i. What are the factors that influence a household decision to participate in one or more form(s) of social capital among smallholder maize-legume farmers in selected counties in Kenya?
ii. What are the social capital effects on the uptake of SAIPs combinations among smallholder maize-legume farmers in selected counties in Kenya?
iii. What are the social capital effects on maize availability equivalent among smallholder maize-legume farmers in selected counties in Kenya?

1.5. Justification of the Study

Agriculture is an important sector, enshrined in the Kenya vision 2030 to deliver a 10% annual economic growth rate under the economic pillar (GoK, 2007b). Maize and legumes are staple crops in Kenya and the most widely grown. This is because of favorable environmental conditions and the fact that, *ugali, mukimo, muthokoi* and g*itheri* are common meals on most household dinner tables (Kirimi *et al.,* 2011). Legumes account for 5% of the total food calories in the national diet, making it rank the most important source of dietary protein in many rural and urban households. On the other hand, maize accounts for 65% of the total calorific intake (Kirimi *et al.,* 2011; IFPRI, 2016). Due to the high demand for maize and legumes, therefore, there is need to adopt sustainable practices that will improve production.

The sessional paper number 4 of 1981 and number 2 of 1991, on national food security in Kenya, emphasized on increased maize productivity in the high potential areas. This was an attempt to meet the consumption needs of the country. To increase maize availability, the government of Kenya initiated an irrigation project Galana-Kulalu in 2016. To empower the smallholder farmer, the government through treasury allocations in the budget, subsidized fertilizer to boost the productivity of maize and legumes. Also, to curb the high deficit of maize experienced currently in the country, the government introduced a duty-free import on maize (GoK, 2016). There are

efforts by research institutions to develop drought-resistant and early maturing varieties, due to unpredictable rainfall patterns.

This study is in line with sustainable development goals that aim at: ending poverty and hunger of all forms; attain food security; improve nutrition; promote sustainable agriculture; promote well-being while realizing equality and empowering women (UN, 2015)

1.6. Scope and Limitation

The study was limited in scope in that, only sampled farmers from selected counties (Embu, Meru and Tharaka Nithi counties in Eastern region and Bungoma and Siaya counties in Western and Nyanza regions respectively) were used in the analysis. This meant that the results could only be generalized for smallholder maize-legume farmers, from the potential production regions. It also excluded large-scale maize-legume farmers. Again, attrition rates were beyond the control of the researcher, however, it was not high enough to compromise the generalizability of the results.

1.7. Definition of Terms

Social Capital: The sum of resources, actual or virtual that accrue to an individual or a group by possessing a durable network of more or less institutionalized relationships of mutual acquaintance and recognition (Sseguya, 2009; Ville *et al.*, 2016).

Household: A social unit composed of people who live together in the same compound and, have similar arrangements of making meals, and answer to one person who happens to be the household head (FAO, 2014).

Food security: This is when all people always have access to enough, safe, nutritious food to maintain a healthy and active life. It also incorporates the physical and economic food access that meets people's dietary needs as well as their food preferences (World Food Sumit, 1996; FAO, 2008).

Maize availability equivalent: This is the amount of maize cereal available to the household at a given point for consumption or selling. It is expressed from all the maize produced, bought or given on donation plus if all the legumes sold at current prices, the amount of maize they can be able to buy.

Network density: The number of people a household knows within and outside the village, including those in leadership positions from where they can get beneficial information from or any kind of help which they can use in the production of maize and legumes.

Participation score: This was a score generated from the level of participation or involvement of a household, in the institutional groups where they were members.

CHAPTER TWO
LITERATURE REVIEW

2.1. Introduction

This chapter covers the empirical work on social capital; adoption of agricultural technology; theory in which this work was based on; and the conceptual framework. It also reviewed the weaknesses that informed the gaps handled herein.

2.2. Empirical Studies

2.2.1. Social Capital

Social capital is defined as enduring connections of networks, reciprocity and social norms that exist among a group of social actors (Grootaert and Van Bastelaer, 2001; Ville *et al.,* 2016). It is viewed differently in different situations and different people which makes it ideal be defined contextually (Krishna and Uphoff, 1999). Despite the multi-facet views, social capital can be viewed as a form of trust, norms of society and connections envisaged among people in forms of networks (Sseguya, 2009). These forms of social capital enhance cooperation, willingness to work together and share information in any setting (Kuku *et al.,* 2013). Social capital is composed of two aspects which include: structural and cognitive. The structural aspect is in the forms of networks, linkages, and practices within the community. It is observable and extrinsic and arises from cognition. Structural aspect further includes institutions, associations, and groups where households are members and participate in decision making. The cognitive aspect explains why community members act in a certain way guided by culturally prescribed principles, values, norms, and aspects of trust (Tsai, 2014). Therefore, social capital has the capacity of improving resource management for collective action while improving access to resources through linkages to relevant institutions (Gulati, 1998; Krishna and Uphoff, 1999; Grootaert and Van Bastelaer, 2000; Tscharntke *et al.,* 2012).

Despite the benefits that are attached to social capital, there has not been invented a standardized way of measuring it. Researchers, however, converge at a point that social capital measurement varies by context just like definitions does (Krishna and Uphoff, 1999; Grootaert and Van Bastelaer, 2001). The contextual kind of measurement, therefore, allows for variations in dimension. The variability arises from the definition of the main social capital concepts of ‘trust’;

'norms'; 'values' and 'networks' which differ substantially from place to place (Rupasingha *et al*., 2006). Various measures have been used in measuring social capital. For instance, Mwakubo *et al.* (2005) measured social capital by categorizing it into four forms: density of association, group membership diversity, participation in decision making and cognitive social capital, at a group level. Rupasingha *et al.* (2006) used the rates of crime, voter turnout, civic engagements, individual volunteering, and charitable-giving as measures of social capital. Other studies have also used corruption index, asset ownership, friends in a different ethnic group and communication level with neighbors as a measure of social capital (Krishna and Uphoff, 1999; Uphoff and Wijayaratna, 2000; Grootaert and Van Bastelaer, 2001). This study followed Grootaert and Van Bastelaer, (2001) approach of having social capital measured in four different forms at a household level. They include: group membership; participation in decisions making in groups; networks density and finally the cognitive aspect of social capital, which highlights who a household can trust. Network density involves the number of people (friends, relatives, and non-relatives) within and outside the village that a household can rely on in times of need. Membership and participation involved the number of institutional groups a household is a member and the level of participation in each one of them.

The household characteristics define the nature and type of involvement of an individual in social activities and groups (Pratiwi and Suzuki, 2017). Older family members are likely to know many people in and outside the villages from whom they can receive help in times of need (Wendy, 2003). The sources of income of an individual in the household may broaden the ability to know people whom they work together and develop ties that are long lasting as well as trustworthy (Pratiwi and Suzuki, 2017). However, Pratiwi and Suzuki (2017) did not find friendship ties to be significant in promoting social connectivity. Wealth or the assets owned by household will enable one to take part actively due to the status they have earned in society. According to Cassidy and Barnes (2012), a household resilience comes about due to the number of people one knows. They also found out that gender, age, and household size have a positive and significant correlation with social connectivity.

The experience gained over time can influence one's decision to join a group which they perceive to get help from (Ville *et al.*, 2016). Groups are of various nature depending on the agenda that is being advanced. They can be homogeneous, where information sharing is horizontal and

composed of people of the same characteristics or heterogeneous in which information sharing is vertical. A heterogeneous group is better in learning new ideas or agricultural innovations while homogeneous is good at handling the plight of people who are faced with the same challenges (Charness *et al.,* 2017). Gender differences occur in membership and general participation. According to Padmaja *et al.* (2006) men belong to more formal networks while women belong to relatively more informal groups, which mostly center on kinship and family. Women develop more bonding social capital like those found among family members or ethnic group. Their counterparts men tend to advance more of bridging social capital which cuts across farmers, friends outside their ethnic group and friends of friends groups (Padmaja *et al.,* 2006). It is in these groups, from where farmers can receive training from either NGOs or government (Anyiro and Ajuka, 2014; Genius *et al.,* 2014). The findings from Uganda by Adong *et al.* (2012) showed that educational attainment, availability of extension services and the general infrastructure to be significant factors to membership and participation in groups. Nasution *et al.* (2017) found age, gender of the household head, household size and status to explain membership and participation. To facilitate the participation of the illiterate, Adong *et al.* (2012) proposes the use of local language or a translator.

2.2.2. Adoption Studies

Smallholder maize-legume farmers in Kenya face multiple challenges in production. The challenges include: soil mining; input acquisition difficulties; drought and climate change effects; information and training deficits; and financial constraints (Kassie *et al.,* 2015). Due to this multiplicity of the constraints faced, there is a need to investigate if social capital among other explanatory variables influenced the adoption of Sustainable Agricultural Intensification Practices (SAIPs) combinations (UN, 2015a). The SAIPs have been promoted as the solutions to production problems being faced by households in the maize-legume system, yet their uptake has remained low over the years (Nato *et al.,* 2016). Previous studies focused on single sustainable practice, however, smallholder farmers adopt a mix of strategies to handle the multiple problems they face (Kassie *et al.,* 2015; Mungai *et al.,* 2017).

Due to the rapidly rising world population, there is a need for stringent measures in production to meet their food requirements (Melorose *et al.,* 2015). In fact, Hulvey (2005) estimated that 40%

rise in food production would be required to meet the demand of the world's population by the year 2050. There are also environmental concerns as much as production levels must increase. Therefore, policymakers, NGOs, and environmentalists promote sustainable agriculture, to feed the current population without compromising the ability of the future generation to meet their food requirements too. Maize is a staple food in many households and legumes are sources of cheap protein to many households in the country. Much production comes from smallholder farmers who account for over three-quarters of production. This implies that to increase production, attention has to be given to these households to enhance their productivity for their own use and selling the surplus (UN, 2015a).

The social capital element is important in information sharing, innovations, cooperation, and collective action. It promotes society's wellbeing and enhances social support (Nato *et al.*, 2016). Household trust, reliance for help, group membership and group participation, may drive a household decision to undertake certain specific actions (Sidique and Hadi, 2016). For instance, a household in savings and credit groups may find it easy to obtain credit to buy inputs or any other equipment needed in production. Similarly, when people are in groups, it is easy to articulate the plights they are facing to the government, receive help by NGOs and training from extension officers. If the household is aware of someone whom they can learn from, it will ease information acquisition through seeing or participation. It was, therefore, crucial to link adoption of a combination of SAIPs and social capital. The combination of SAIPs that were considered in this study included Variety of Seed (V), Fertilizer (F), Manure (M), Intercropping (I), Crop Rotation (R) and Minimum Tillage (T).

Network density of a household and who they trust to get reliable information from is important in adoption decision (Njuguna and Michael, 2012). This could also be enhanced through media, agricultural shows and attempts to increase access to finances (Nkebe and Shankar, 2014). According to Arslan *et al.* (2013), agricultural extension services and households unobservable such as openness to agricultural innovations and new ideas are highly correlated with the adoption of agricultural technologies. Collective action is enhanced through group membership and participation (Willy and Holm-Müller, 2013). Groups are of various compositions depending on the motive. Some are homogeneous and are effective in handling common challenges while others are heterogeneous which allows people to learn from diverse ideas and innovation from people of

various backgrounds. However, homogeneous groups may be too conservative disallowing new ideas and innovation, while homogeneous groups may make members dormant due to an inferiority complex. Conservative groups inhibit growth while inferiority feeling of some members in a group decreases participation and brings about a feeling of neglect (Willy and Holm-Müller, 2013). Teklewold *et al.* (2014) found membership to institutions, credit accessibility, and spatial distance from household home to where they can get extension services, credit organizations and market to be important in decisions to adopt multiple practices in Ethiopia. He also found the spatial distance from a household homestead to where they own land or do farming significantly too. They cited that the distance affects the SAIPs that a household chooses to adopt.

Other household factors such as age of the household head or decision makers, sources of information and credit availability were found to be significant in adoption decisions (Challa *et al.,* 2014; Cochrane and Lake, 2014; Teklewold *et al.,* 2014). However, Arslan *et al.* (2013) did not find age of the household head, to be significant in adoption. The number of years of schooling was not found to be explaining adoption by Ainembabazi and Mugisha (2014), citing that years of experience outweighs individual education level. Challa *et al*. (2014) found that the ease with which a household can access credit, the household perceived benefit of adoption and off-farm income levels to additionally influence adoption decisions. They, however, did not find the family size to be significant. This was contrary to the findings of Mignouna *et al.* (2011) who found that the more members a household had, the more likely they were to adopt labor-intensive practices such as organic manure and fertilizer applications. Income, cost of production and leadership roles or participation and training by extension services were among the factors found significant for adoption decisions by Sidique and Hadi (2016). Many of these findings cited were based on cross-sectional data and smaller sample sizes.

2.2.3. Food Availability

Food security is a multidimensional concept and encompasses food availability, accessibility, utilization and stability (Watson II and Pinstrup-Anderson, 2009; Yeyo *et al.*, 2014). The availability of food can be achieved from own household production, market, food aid, and domestic stock reserves. Accessibility to food is achieved through the purchasing power of an individual subject to the budget constraint. The ease with which one can access resources or credit can also increase access to food. Lastly, food utilization is dependent on a household decision to

purchase, prepare, and consume (Sseguya *et al.,* 2013). The stability aspect depends on all the other three aspects. Food insecurity has always been associated with low agricultural productivity, high poverty levels, and poor policies in agricultural sectors (Watson II and Pinstrup-Anderson, 2009). Food aid and importation are not sustainable due to rapidly fluctuating world food prices. This is because of changes in international oil prices and other macroeconomic instabilities. In addition to these, constant conflicts like the post-election violence in Kenya in the 2007-08 reduced food production adversely and after that, followed a global food crisis that led to the starvation of many people across the country (IGAD, 2008). The global demand for biofuels is another challenge straining world food supplies because people have diverted from growing food crops to profitable biofuel (Melorose *et al.,* 2015). Other unforeseen encounters like floods and drought, all because of global climate change have reduced the amount of productions, hence demanding measures to mitigate the effects.

According to Matshe (2009), food security is predominantly determined by external factors affecting the household and household characteristics. Related are factors such as resource access which include: soil quality; household labor per hectare cultivated; income of the household; land area cultivated; and health status of household members. External factors are prices of farm inputs and outputs, availability and quality of health services and the existence of formal and informal networks (Ali *et al.,* 2014). Different studies have used different methods to measure food security. For instance, Pokharel *et al.* (2016) found food accessibility to be affected by the geographical location of a household; education levels; assets owned by a household; production methods employed; market accessibility and household income. Different indicators have been used across the globe to measure food security such as Average per person Dairy income (ADI), Average per person Dairy Consumption (DEC), Household Food Insecurity Access Score (HFIAS), Dietary Diversity and Food Frequency Score (DD) among others (Gowele, 2011).

According to the World Bank, investments in a combination of sustainable agricultural intensification practices have an impact on farm output (World Bank, 2006). It follows therefore that a household can increase production to meet her requirements or be able to buy non-food items from the market. When production improves for everyone, the supply increases and prices will be lower hence the ability of all households to obtain maize and legumes. Therefore, to reduce the deficiency of maize and legumes, which happen to be the main source of food to many households

in Kenya, then, production must increase. The adoption of these SAIPs, on the other hand, is seen as the best way of mitigating the effects of climate change (Melorose *et al.*, 2015).

Social capital also plays a role in increasing production (Kuku *et al.*, 2013). This can be in form of eased adoption or ability to obtain help from friends and relatives when in need. Who the household knows and can contact to get help from in times of need, is important in acquiring food (Uphoff and Wijayaratna, 2000). This is because no household lives in a single autonomous unit but there exists interdependence. The mutual co-existence between the households call for care for each other. The groups where households are members increases the network of friends for each household, and learning from each other (Ville *et al.*, 2016). In the process, they can interact and even be aware of the places where they can get information about fair prices of the cereals to buy. The people who the household trusts enhance transactions and willingness to share information.

2.3. Critique of the reviewed literature on social capital, adoption and food availability

From the reviewed literature, it was concluded that most studies used binary choices and count variables to model adopters and non-adopters of agricultural technologies. Some studies centered on one technology only. The samples also used in most of them were small and drawn from one single region and used cross-sectional data. This meant that households had not been tracked over time. The use of count variables to order SAIPs also motivated this research because farmers may not be having an equal probability of using the SAIPs. Ideally, some SAIPs could be compliments of each other while some are substitutes. Again, smallholder farmers were faced with multiple constraints, hence don't adopt just a single SAIP but a combination (Wollni, 2013). The extent of intensification of SAIPs has also been approached in different ways. This ranges from an area under a technology and the amount of usage of the technology for instance amount of fertilizer used and the frequency of harvesting per annum among other techniques. Nevertheless, intensification in terms of the number of SAIPs that a farmer is practicing in combination has not been handled in Kenya. Therefore, based on the gaps identified, this study modeled SAIPs combinations and social capital as explanatory among other variables. It also modeled maize availability equivalent ordered as a function of social capital, socio-economic factors using household-level panel data set. An index was created on different SAIPs combination, based on the area they were applied over time and space. This formed a continuous variable that was tracked over time.

2.4. Theoretical Framework

Two theories informed this study: the social capital and random utility maximization theory. However, to understand technology adoption by household, it was important to highlight diffusion theory by Sahin and Rogers (2006). With diffusion theory, farmers learn of new technology from sharing with neighbors, friends outside the community or through information sharing in a social network scenario. Roger's diffusion theory starts with innovation, that is, a state of being uninformed to a state where one is fully informed. Then, it proceeds to persuasion by advising or seeing and finally to a decision to uptake an agricultural technology (Sahin and Rogers, 2006; Osei, 2015). The diffusion theory is based on mutual trust and majorly work by extension officers whose ratio to farmers in Kenya is too low. This is its first shortcoming and the fact that it ignores the social support and resources owned by an individual, intensifies its limitation hence not applicable (Osei, 2016).

The social capital theory is based on the aggregated relationships of mutual recognition and acquaintances (Osei, 2016). Osei (2016) views it as an asset shared by members of a defined group with clear goals, and mutual recognition. The major theme of the theory is how individuals gain access to resources owned within and outside the village and how they use them for their benefit. Bonding social capital is homogeneous and can be formal or informal while linkages and bridging social capital is heterogeneous and is majorly characterized by the elements of trust (Osei, 2016). This theory has however been challenged based on the multiplicity of its definition and mode of measurement (Hines, 2009). This study used social capital to set up the linkages, bonding, and bridging of individual households to other actors who are within and outside the village.

According to the random utility maximization theory, rational households will choose a given combination, if the expected greater utility from the adoption of the combination. Similarly, a household will invest in social capital form which they expect to gain from. Assuming $j = 1,2,3,\ldots,N$ represent possible SAIPs combination bundle available to a household, then, a household i will choose combination j^{th} whose utility is greater than zero.

$$U_{ij} > 0 \tag{2.1}$$

Again, if a household chooses combination one or a given form of social capital, then, the utility they assume to get from that specific combination is greater than any other combination. A household will equally have more maize equivalent if they are in the right social capital or use the best combination.

$$U_{x1} > U_{x2} >, \ldots > U_{Xn} \quad (2.2)$$

The choice of a given combination of the SAIPs was a function of social capital and socio-economic factors of a household and the utility they derive from that combination bundle. A household chose a given bundle of SAIPs based on what they learned from neighbors, groups and extension services from whom they got information. If a household *i* chooses the j^{th} combination, then;

$$X_{ij} = f(SC, SE, U) \quad (2.3)$$

where *SC* is social capital elements, *SE* is socioeconomic factors and *U* represent the utility a household derives from adoption and use of that specific combination which is unobservable.

2.5. Conceptual Framework

In this study, it was conceptualized that a household invests in social capital, if the information that they perceived to receive from the network is crucial and it would improve their utility (Grootaert and Van Bastelaer, 2000). It is was further conceptualized that the household socio-economic factors influence social capital in terms of the kind of groups a household joined, the participation level in those groups, and the network density (Figure 2-1). Social capital was categorized into four different forms, which included: group membership; network density; participation in groups; and cognitive social capital. Group membership highlights the different groups that a household is a member, while participation involves decision-making level of an individual in the group where they are members. Network density of household is expressed as the number of relatives, nonrelatives and friends living in the village and outside and those in a leadership position from whom they can get information. The cognitive social capital aspect is based on who the household trusts and can rely upon. These different forms of social capital together with the socioeconomic factors influence the SAIPs combinations that a household adopt.

The combination of the SAIPs that a household chooses is also influenced by institutional factors, tenure security, and infrastructural development. The choice of the combination household i made from $j = 1,..., N$ was intervened by weather conditions, labor legislation and government policy. The optimal choice of the combination of the SAIPs made by the household would have a change in the yield on the maize and legumes produced (Kassie *et al.*, 2011).

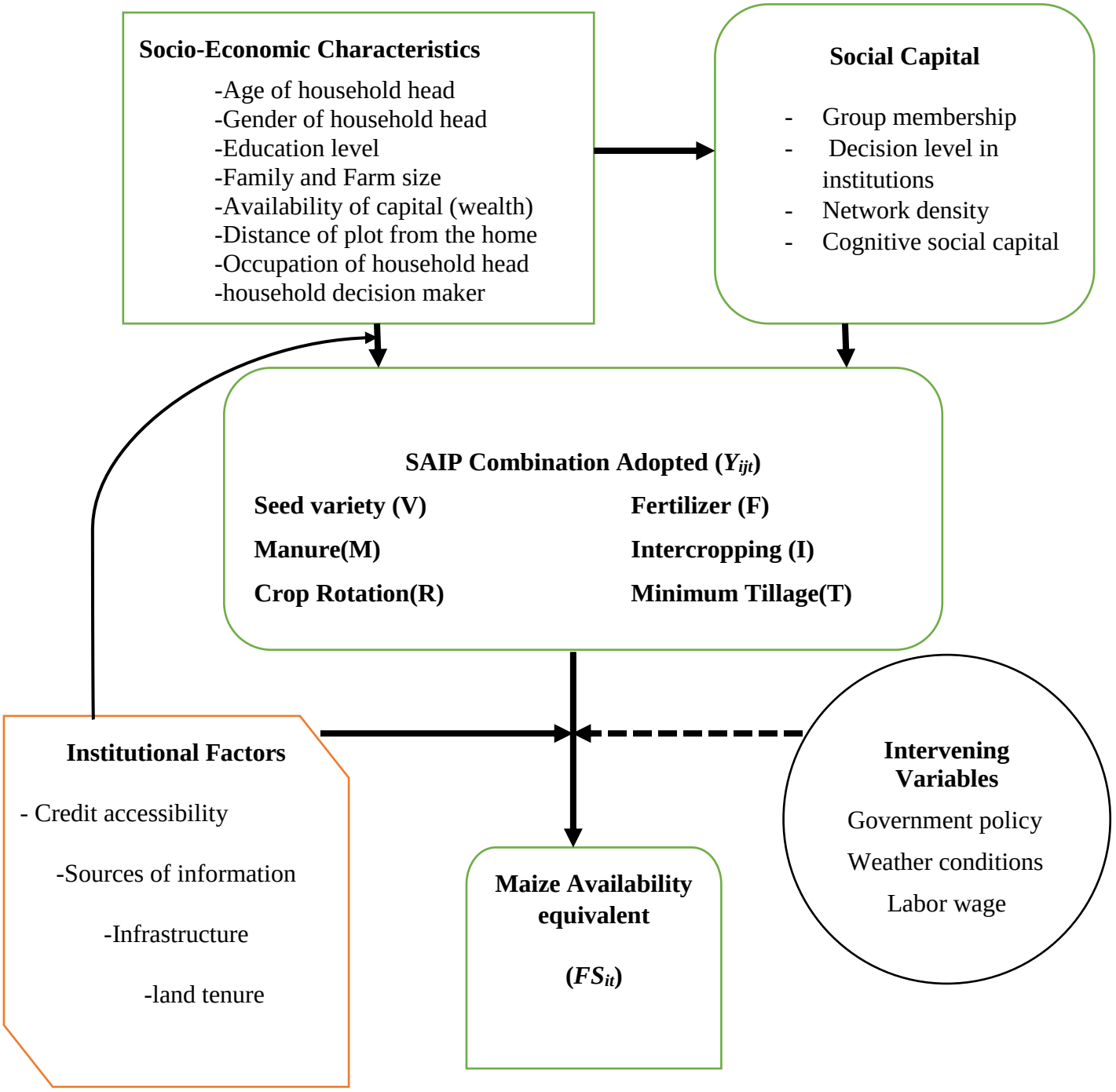

Figure 2-1: Conceptual Framework

CHAPTER THREE
METHODOLOGY

3.1. Study Area

The data that were used in this study were adopted from Adoption Pathways (AP) project. The project was funded by Australian International Food Security Centre (AIFSC), through International Maize and Wheat Improvement Center (CIMMYT). Data were from Siaya and Bungoma in the Western region and Embu, Meru and Tharaka Nithi counties in the Eastern region. Figure 3-1 shows the map.

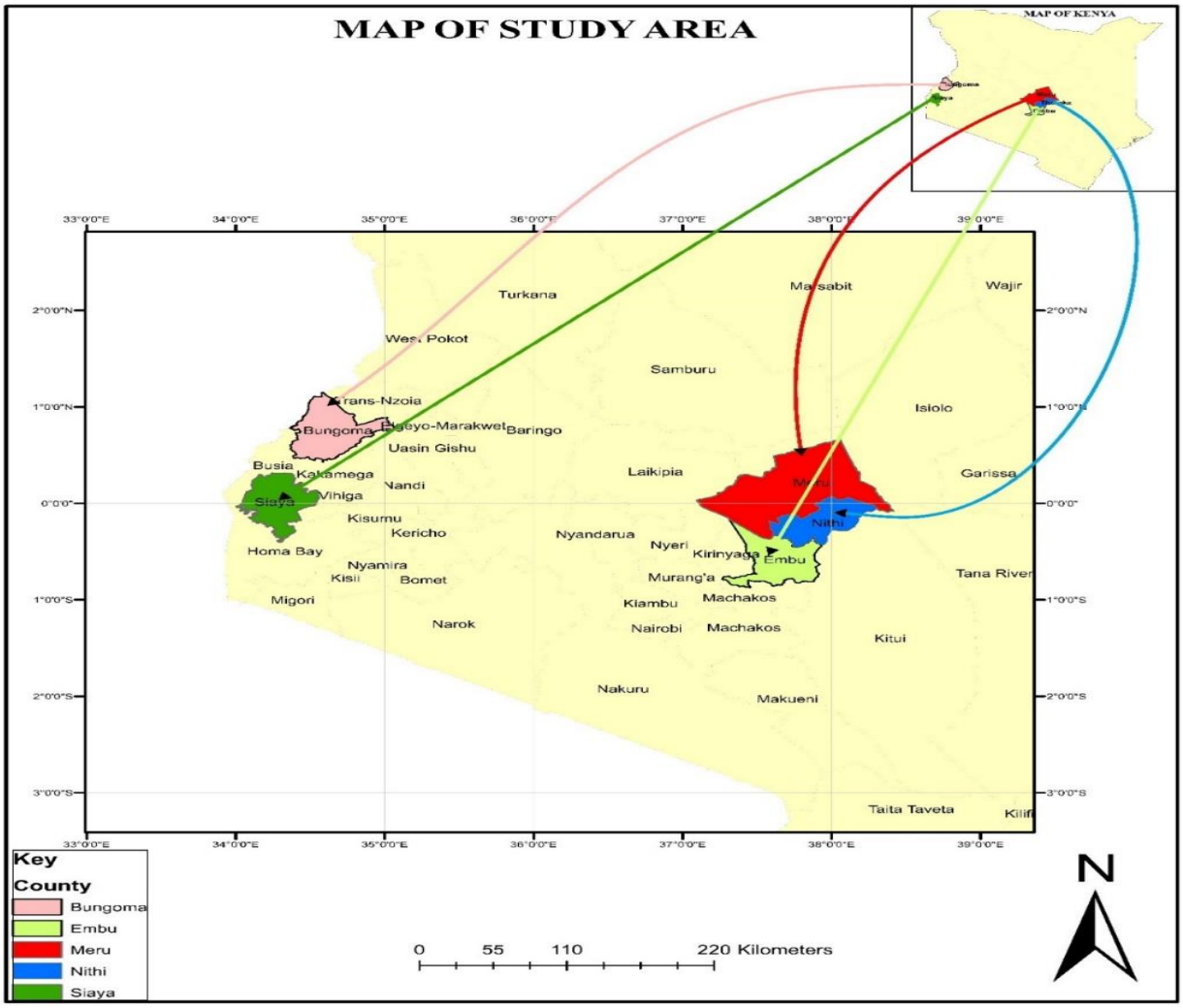

Figure 3-1: Map of Study Area

Source: Virtual Kenya and Google Earth Pro

Siaya County has a total population of 842,304, with a population density is 332/km^2 with 57.9% of the population living below the poverty line. The county receives an annual rainfall of between 1,170 and 1,450 mm with a temperature range of between 15°C and 30°C. Other than agricultural land, the area has other vital resources such as fisheries, indigenous forests, rivers, and timber. The main economic activities include: subsistence farming, livestock keeping, fishing, rice farming, and small-scale trading (GoK, 2009).

Bungoma County has a population of 1,375,000, with a population density of about 454/km^2. The county's economy is primarily agricultural, with sugarcane and maize as the main subsectors. The county receives high amounts of rainfall almost throughout the year that ranges between 1200 mm and 1800 mm of rainfall. The temperature ranges from a minimum of between 15 to 20°C. With the agricultural production of sugarcane, coffee, maize, milk, tobacco, bananas, and sweet potatoes. Poverty level stands at 53% below the poverty line (GoK, 2009).

Embu County covers an area of 2,818 km^2 and has a population density of 183/km^2. The county is characterized by a bimodal rainfall pattern, with the peak rainfall between March and June. The rainfall ranges between 610 mm and 1500 mm. Temperatures range from the lowest 12^0 C to a maximum of 30^0 C. The major economic activity of the people is growing crops such as maize, legumes, fruits and even cash crops such as coffee and tea. The county has approximately 40% of her population living below the poverty line (GoK, 2009).

Meru County covers an area of 6,936.9 km^2 with a population density of 200/km^2. Temperature range between a minimum of 16°C to a maximum of 23°C. The county receives rainfall between 500 mm and 2600 mm per annum. The main agricultural activities include dairy, French beans, yam, cassava, pumpkin, millet, and sorghum production. The county has approximately 41% of her population living below the poverty line (GoK, 2009).

Tharaka Nithi has a population of about 356,000 and a population density of 138/km^2. It has a temperature range of between 11°C and 25.9°C. It receives rainfall of between 200 mm to 800 mm per annum. The county has 65% of her population living below the poverty line. The major income earning activity in the county include farming, pastoralism, gemstone mining, and stone quarrying (GoK, 2009).

The conditions in these five counties give a conducive climate that is suitable for maize and legume production. Despite ample rainfall and maize-legume production potential of these counties, they still record high levels of their population living below the poverty line. There is need therefore to help improve the productivity of each household through the adoption of SAIPs and general use of land. This will help improve real income, food sufficiency, nutrition and reduce poverty within these counties and the country at large (GoK, 2010).

3.2. Sampling Size

Secondary panel data were available from for 613 households in the baseline (2011), 535 households in the midline (2013) which represented an attrition rate of 13% and 495 households in the end line (2015), with a higher attrition rate of 19%. A higher attrition rate was reported in eastern Kenya counties of Meru, Tharaka Nithi and Embu compared to western Kenya counties (Table 3-1).

Table 3-1: Sample Size and Respective Attrition Rates per County

County	Baseline 2011	AP Midline	Attrition (%)	End line (2015)	Attrition (%)
Bungoma	150	137	9	120	20
Embu	111	93	16	85	23
Tharaka-Nithi	101	81	20	81	20
Meru	102	81	21	67	34
Siaya	149	143	4	142	5
Total	**613**	**535**	**13**	**495**	**19**

3.3. Data Management

The Data contained basic household characteristics and institutional factors, crop inventory, access to farm inputs and markets access. The household income and savings, income generating activities, and credit access status of the household. It also contained information about the different combination of Sustainable Agricultural Intensification Practices (SAIPs) that a household was using. The data were analyzed using Statistical Package for Social Sciences (SPSS) and STATA statistical software.

3.4. Analytical Framework

For the first objective, a simultaneous equation approach was used to model the factors that influenced a household decision to participate in one or more form(s) of social capital. The model was used because the objective involved a system of equations where two of the endogenous variable were used as explanatory variables in another equation (Wooldridge, 2013). In this case, network density, participation score and membership score which were endogenously determined, were used in another equation as exogenous variables. The reverse causation of the variables necessitated an estimation of the model using a simultaneous equations approach.

For the second objective, a Seemingly Unrelated Regression (SUR) method was used in the analysis. SUR analytical procedure was preferred over other methods because of its ability to handle different continuous dependent variable against a set of explanatory variables, where there are potentials of error correlations (Zellner, 1962). A Three Stage Least Squares (3SLS) estimation method could not be used here because there was no anticipated reverse causation. The idea behind the combination of the SAIPs was because households were faced by many different constraints in production process hence needed a mix of different SAIPs to address these challenges (Teklewold *et al.,* 2013). The number of SAIPs adopted by a household should have been handled as a count variable that uses poison regression model, but, its assumption of an equal probability distribution (one sixth) of all SAIPs adopted (Wollni, 2013) ruled it out. This is because a household could be having different probabilities of choosing a specific SAIP from another based on: the household unobservable; information acquired or available to the household; the social networks of the household; and experience a household has over time in the use different combinations.

Principal Component Analysis (PCA) approach was used to identify the various combinations that were adopted in this study. The PCA run a regression of the various combinations and obtained different loading factors associated with each combination (Birhanu *et al.,* 2011).

$$PC_m = \alpha_{m1}x_1 + \alpha_{m2}x_2 + \ldots + \alpha_{mn}x_n \qquad (3.1)$$

where α_{mn} represent the weight of the n^{th} combination of the SAIPs for the m^{th} principal component. The components produced were ordered such that the first ones explain more variance than the next one subject to the constraint that the sum of their squares equates a unit

$$(\alpha_{m1}^2 + \alpha_{m2}^2 + \ldots + \alpha_{mn}^2 = 1) \quad (3.2)$$

Lastly, an Ordered Logistic Regression Model (xlogit) was used in the third objective of determining social capital effects on maize availability equivalent among smallholder maize-legume farmers. The model was ideal because the maize availability equivalent was ranked from below average (deficit), those above the average (sufficient) and those along the average. This was to find the factors associated with a household to related to any of the categories.

CHAPTER FOUR
FACTORS INFLUENCING HOUSEHOLD DECISION TO PARTICIPATE IN ONE OR MORE FORM(S) OF SOCIAL CAPITAL.

4.1. Introduction

In this chapter, literature on social capital and its influence on household outcomes is reviewed, the description and specification of the Three Stage Least Squares (3SLS) estimation method is presented, and finally, the estimation results are presented and discussed

4.2. Social Capital

Social capital has been defined differently depending on the context that is being implied. However, most researchers agree that it entails building networks with enduring connections, which encourages reciprocity among the actors (Ville *et al.,* 2016). It is also beneficial in enhancing cooperation, lowering the cost of acquiring information and promotes collective action (Krishna, 2004; Sseguya *et al.,* 2013).

Social capital has the potential of improving resource use and management. It can invoke different actors to cooperate in the agricultural sector and generally improve output (Tscharntke *et al.,* 2012). Despite the benefits of social capital, there has not been devised a standardized prescribed means of measurement of its variables. However, some researchers agree that it can be defined by context (Rupasingha *et al.,* 2006). Some studies have used corruption index, group membership, the density of association, number of people a household knows among other indicators, as a means of measuring social capital (Uphoff and Wijayaratna, 2000; Genius *et al.,* 2013; Anyiro and Ajuka, 2014; Pratiwi and Suzuki, 2017). Due to the benefits that accrue because of social capital, there was a need to find out the factors that influence the development of its forms. This work considered four forms of social capital and regressed them simultaneously as endogenous variables as a function of household socio-economic characteristics.

4.3. Econometric Model Specification and Estimation

A simultaneous equation approach was used to model the factors that were significant in explaining household participation in one or more form(s) of social capital. This system of equations was ideal because of the likelihood of the correlation of the error term and the

explanatory variable in the model, because of reverse causation (Greene, 2002). In a simultaneous equation case, at least one of the endogenous variable in one equation may be an explanatory variable in another equation (Greene, 2002). In estimating the model, the outcome variables network density and participation score was explained by membership score while membership score was also explained by network density. In such a circumstance, the data generation process by the classical linear regression model or single equation estimators such as: Ordinary Least Squares (OLS); Instrumental Variables (IV) Estimator; Two Stage Least Squares (2SLS) and Generalized Method of Moments (GMM) could not be used (Leon-Gonzalez, 2003; Wooldridge, 2013). A 3SLS was used to estimate a system of equations instead, because of its ability to take care of reverse causation in variables and potential error correlations (Greene, 2002). Some variables were excluded or included in some equations using intuition and theory to attain identification.

$$y_{it} = y'_{it}\alpha_i + x_{it}\beta_i + \mu_{it} \tag{4.1}$$

where i= 1, 2, 3, and 4 representing the number of equations estimated, t is the time period under consideration, x_{it} is a vector of exogenous variables in equation i in time t. y_{it} are the dependent variables representing the four forms of social capital in equation i in time t. y'_i are endogenous variable which might be exogenous in an i^{th} equation, and μ_i is a vector of error terms.

The study estimated structural equations only because they provide more information about economic processes of interest than it does reduced forms (Greene, 2002). However, before estimating a structural equation, it had to be identified. An equation is identified if there is enough information to get meaningful estimates of its parameters. A structural equation can be of any of the three forms, which include: Over identified implying it has more than enough information to get a meaningful estimate, an unidentified equation which means that an equation does not have enough information to get a meaningful estimate, and lastly exactly identified equation which has just enough information to get a meaningful estimate (Poldaru *et al.,* 2013). In testing for identification of the structural equations, a prior idea from economic theory and intuition was used to put exclusion restriction (Henningsen and Hamann, 2007). This was done by restricting the coefficient value of the variable to be excluded to zero, to be able to obtain identification. Following the order condition, and assuming G = total number of endogenous variables in the

model (in all equations making the model) and K = total number of variables (endogenous and exogenous) excluded in the equation being examined for identification (Gujarati and Porter, 2009). Then an equation is exactly identified if K = G – 1, over-identified if K > G – 1 and unidentified if K < G – 1.

In estimating the first equation, 4 variables both endogenous and exogenous were excluded from the model among them the social capital forms with α_0 coefficient. Implying that the equation was exactly identified. The variables to be excluded were informed through intuition and logic as well as their significance in the model. The first structural equation of the 3SLS was estimated as in equation 4.2. in this equation, K=4 and G=4, which implies 4 > (4-1) hence the equation is overidentified.

$$network\_density = \alpha_1 Mershp\_score + \alpha_0 Prtcpn\_score + \alpha_0 Cognscore + \alpha_2 Genderhh + \alpha_3 Agehh + \alpha_4 Farmsiz + \alpha_5 Educhh + \alpha_6 hh\_needcrdt + \alpha_7 Hhsiz + \alpha_8 lTOTAL\_sav + \alpha_9 got\_ext + \alpha_{10} ltotal\_credit\_rcvd + \alpha_{11} recvd\_info\_saips + \alpha_{12} Lsalaryemploy + \alpha_{13} lincom\_lbr + \alpha_{14} lrent\_out\_land + \alpha_{15}\ lremitt\_inkind + \alpha_{16} yrs\_lvd\_vlg. \quad (4.2)$$

The structural estimation of the second equation of the 3SLS was estimated as equation 4.4. Equally, four variables were excluded from the model, such that K=4 and G=4, therefore, 4 > (4-1). This equation was also overidentified.

$$prtcpn\_score = \beta_1 Mershp\_score + \beta_0 network\_density + \beta_0 Cognscore + \beta_2 Genderhh + \beta_3 Agehh + \beta_4 Farmsiz + \beta_5 Educhh + \beta_6 hh\_needcrdt + \beta_7 Hhsiz + \beta_8 lTOTAL\_sav + \beta_9 ltotal\_credit\_rcvd + \beta_{10} recvd\_info\_saips + \beta_{11} Lsalaryemploy + \beta_{12} lincom\_lbr + \beta_{13} lrent\_out\_land + \beta_{14} lremitt\_inkind + \beta_{15} yrs\_lvd\_vlg + \beta_{16} Llegumepdn \quad (4.3)$$

Equation three of the 3SLS estimation had five variables excluded from the model to attain identification such that, K = 5 and G=4, therefore 6 > (4-1). This equation was overidentified as well.

$$Cognscore = \mu_1 Genderhh + \mu_2 Farmsiz + \mu_3 hh\_needcrdt + \mu_4 Hhsiz + \mu_5 lTOTAL\_sav + \mu_6 got\_ext + \mu_7 ltotal\_credit\_rcvd + \mu_8 recvd\_info\_saips + \mu_9 Lsalaryemploy + \mu_{10} lincom\_lbr + \mu_{11} lrent\_out\_land + \mu_{12} lremitt\_inkind + \mu_{13} yrs\_lvd\_vlg + \mu_{14} Llegumepdn + \mu_{15} Lmaizepdn. \quad (4.4)$$

Lastly, the structural equation of the fourth equation had 3 variables excluded from the estimation. In testing for identification, K= 3 and G=4, therefore 3 = 4, which meant that the equation was exactly identified.

$$mbrshp\_score = \pi_1 network\text{-}density + \pi_0\, prtcpn\_score + \pi_0 Cognscore + \pi_2 Genderhh + \pi_3 Agehh + \pi_4 Farmsiz + \pi_5 Educhh + \pi_6 hh\_needcrdt + \pi_7 Hhsiz + \pi_8 lTOTAL\_sav + \pi_9 got\_ext + \pi_{10} ltotal\_credit\_rcvd + \pi_{11} recvd\_info\_saips + \pi_{12} Lsalaryemploy + \pi_{13} lincom\_lbr + \pi_{14} lremitt\_inkind + \pi_{15} yrs\_lvd\_vlg + \pi_{16} Llegumepdn + \pi_{17} Lmaizepdn. \quad (4.5)$$

In testing for the rank condition of the equations, all the endogenous variables and exogeneous variables were moved to the left-hand side, such the equation was represented as:

$$\omega\Gamma + BX = 0 \quad (4.6)$$

where $\omega\Gamma$ is the vector of the endogenous variables and BX a vector of the exogenous variables. Since all the variables were linearly independent, then the rank condition was calculated from the number of rows of each equation. The rows (r) were 4 and were less than the number of columns in both endogenous and exogenous variables, hence the rule of the thumb is that the rank of the matrix equals the number of rows (Greene, 2007).

$$Rank\ (\omega\Gamma) = 4 = Rank\ (BX). \quad (4.7)$$

The equations estimated were either overidentified or exactly identified. This implied that using the 3SLS in estimating the system of equations would yield correct estimates that can be relied on. The rank condition which is not only necessary but also sufficient was met by the system of equations.

4.4. Results and Discussion

4.4.1. Household Sizes per County

The first part of this section described the main features of smallholder maize-legume farmers. The second part show the results of the 3SLS regression model. The unit of study is a household. A household was composed of members living together for a specified period making decisions together under one household head. The household members included parents, children and or

relatives living with the family. It was worth to note that some households did not have children or relatives. The household size varied from a minimum of a single member in a family to a maximum of 20 members. More household members were recorded in the western counties of Bungoma and Siaya while Tharaka Nithi households recorded fewer household members. On average, each household had six members (Table 4-1).

4.4.2. Gender of the Household Head

The gender of the household head on average across the panel showed that about 19% of the respondent household was headed by the female while counterpart males headed 81% (Figure 4-1). More female-headed households in Siaya County of the Western region while Meru of the Eastern region recorded the least female headships (Table 4-2). The Pearson chi-square test showed significant differences in household headship within the counties across the panel ($\chi^2(4)= 43.8$). Similarly, there were significant differences in household headship within the counties in the baseline ($\chi^2(4) = 12.3$), midline ($\chi^2(4) = 14.0$) both at 1% level of significance and end line ($\chi^2(4) = 26.7$) at 10% level of significance (Table 4-2). Female household headship remained low across the panel. These findings imply that there were limited or no efforts in empowering women to take up headship roles or the men who were away working could have come back home and taken all the household headship roles. The results are shown in (Table 4-2).

Table 4-1: Household Sizes per County across the Panel

Household size	**Baseline**					**Midline**					**End line**					**Total**
	Number of households corresponding to household size					Number of households corresponding to household size					Number of households corresponding to household size					
	BUNG	THARA	EMBU	MERU	SIAYA	BUNG	THARA	EMBU	MERU	SIAYA	BUNG	THARA	EMBU	MERU	SIAYA	
1	1	0	5	1	7	1	2	2	0	6	3	0	1	0	2	**31**
2	4	7	15	3	10	3	2	8	3	9	4	4	10	2	5	**89**
3	11	25	11	7	11	9	14	16	7	16	4	13	17	9	11	**181**
4	15	20	32	20	16	9	14	28	21	11	6	11	18	17	11	**249**
5	21	21	24	18	18	16	22	18	18	19	11	15	18	18	16	**273**
6	24	12	13	10	19	17	16	9	14	29	22	14	12	12	17	**240**
ABOVE 6	68	18	13	16	72	71	12	8	8	58	61	19	12	13	63	**516**
TOTAL	**144**	**103**	**113**	**75**	**153**	**126**	**86**	**89**	**71**	**148**	**111**	**76**	**88**	**71**	**125**	**1579**

Table 4-2: Household Gender Headship per County

County	Baseline		Midline		Edline	
	Female	Male	Female	Male	Female	Male
Bungoma	19.0	125.0	21.0	105.0	12.0	99.0
Tharaka	14.0	89.0	12.0	74.0	10.0	66.0
Embu	24.0	89.0	15.0	74.0	21.0	67.0
Meru	10.0	65.0	15.0	56.0	3.0	68.0
Siaya	40.0	113.0	46.0	102.0	36.0	89.0
Total	**107.0**	**481.0**	**109.0**	**411.0**	**82.0**	**389.0**
% gender	**18.2**	**81.8**	**21.0**	**79.0**	**17.4**	**82.6**
Test	$\chi^2(4) = 12.3^*$		$\chi^2(4) = 14.0^*$		$\chi^2(4) = 26.7^{***}$	
Aggregate			$\chi^2(4) = 43.8^{***}$			

***, and * are significant at 10%, and 1% probability levels, respectively.

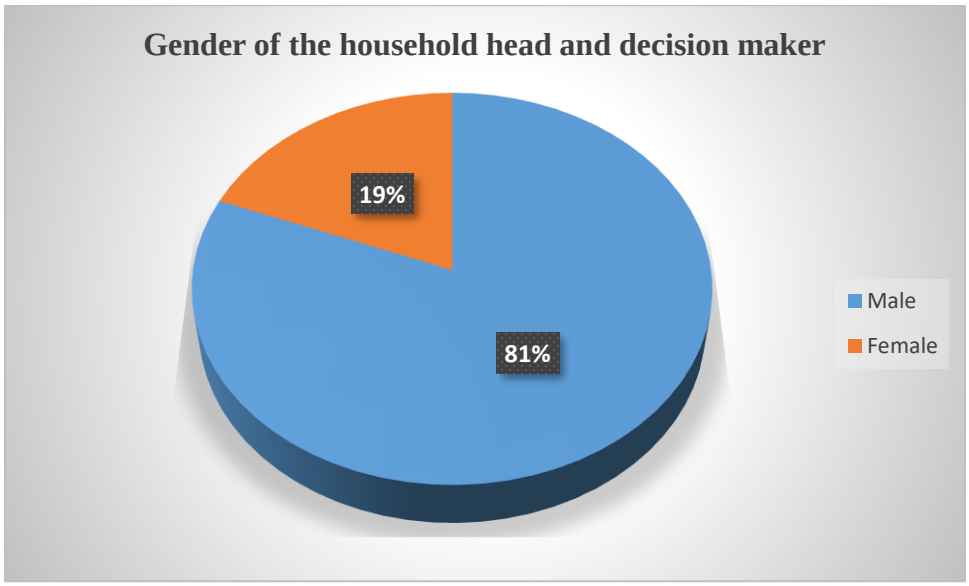

Figure 4-1: Gender of the Household Head

4.4.3. Descriptive Statistics

The results show that on average, the age of the household head was 52 years old, with 8 years of schooling and a family size of 6 members. The average farm size per household was 2.3 acres with

a maximum range acreage of 120. Some household did not attend school at all while others do not own land. The household size varied from one member to twenty members (Table 4-3).

In terms of access to credit, 57.76% reported that they wanted credit to buy seeds and 64.91% to buy fertilizer. For the proportion (42.24%) that did not require credit for seeds were either not cash constrained or were using local or recycled seeds. The proportion (35.09%) that did not require credit for fertilizer were using manure as a substitute or planted without fertilizer. However, there are people who applied for credit but did not receive it for reasons such as lack of collaterals (6.17%) and the fact that one cannot get the exact credit applied for (0.5%). Among those who did not apply for credit, gave reasons such as; borrowing was risky, required too much paperwork or procedures, and the fact that interest rates charged on the loans were too high (53.98%). Others argued that there were no credit association or money lenders from where they could apply for credit (25%). For those who did not want credit at all were not cash constrained or had their own source of money (88.3%). The remaining percentage (11.7%) either did not think of the investment or just felt that the investment was not profitable (Table 4-4).

Information is important for the adoption of modern agricultural technologies. It can be vertical or horizontal information sharing. Most farmers, however, tended to trust the vertical source of information, for example from government and extension officers and NGOs than horizontal one from fellow farmers and neighbors. Despite the benefit that accrues from government extension officers, only about a quarter of the respondents received training about maize and legumes (Table 4-4). This was attributed to the few numbers of extension officers compared to the many households that required their services. It was noted too that the distance that they had to travel to meet individual farmers was long, compounded by poor infrastructure. In reality, it is not possible that each household gets extension services individually. This can be improved if farmers were organized around groups or SACCOs and called for an extension officer to come and address a given issue at stake.

Table 4-3: Descriptive Statistics and Variable Measurement

Variable Name	Obs	Mean	Std. dev	Min	Max	Description	Measurement
Agehh	1589	52.0	14.3	18.0	95.0	Age of the household head (years)	Continuous
Educhh	1589	8.0	3.9	0.0	23.0	Years of schooling of the household head (years)	Continuous
Hhsiz	1589	6.0	2.6	1.0	20.0	Household size (members)	Discrete
Farmsiz	1589	2.3	4.2	0.0	120.3	Farm size of the household (acres)	Continuous
Network density	1589	47.0	44.0	0.0	613.0	The number of people, relatives, and nonrelatives, friends and people in leadership that a household can rely on help in times of need	Discrete
Prtcpn_score	1589	0.5	0.4	0.0	2.2	The score of participation in groups where a household is a member	Continuous
Cognscore	1589	7.9	2.8	1.0	14.0	The score of cognitive-based on who the household trust	Continuous
Mbrshp_score	1589	1.4	0.9	0.0	6.0	The score of membership in groups	Continuous
lTOTAL_sav	1589	7.4	3.9	0.0	13.8	The logarithm of the amount of savings a household made	
Yrs_lvd_vlg	1640	30.0	17.7	0.0	86.0	The number of years a household has been living in the village	
Llegumepdn	1589	4.6	1.9	0.0	12.4	The logarithm of the amount of legume produced	
Lmaizepdn	1589	5.9	1.9	0.0	10.6	The logarithm of the maize produced	
lTOTAL_incom	1589	9.4	4.0	0.0	14.4	The logarithm of the total amount of money income a household got	
nd_crdt_seed	1589	No	694	42.2		If the household needed credit to buy seeds	Dummy
		Yes	949	57.8			
Ndcrdt_fert	1564	No	320	64.9		Whether the household needed credit to buy fertilizer	Dummy
		Yes	173	35.1			
Info_farmr_org	809	No	623	77.0		Household got information from farmer organizations	Dummy
		Yes	186	22.1			
got_ext	1642	No	571	34.8		Household received extension or information or training	Dummy
		Yes	1071	65.2			

Table 4-4: Reasons Why Household did not Apply for Credit

Reason for not applying for credit	Baseline/County					Midline/County					End line/County					Total	%
	BUNG	THARA	EMBU	MERU	SIAYA	BUNG	THARA	EMBU	MERU	SIAYA	BUNG	THARA	EMBU	MERU	SIAYA		
Borrowing risky	10	6	13	6	20	9	5	10	6	14	12	4	5	4	12	136	37
High interest	3	2	4	1	3	3	1	3	4	1	3	0	0	3	2	33	9
Too much paper work	2	2	6	3	0	3	1	1	2	2	1	2	1	0	0	26	7
Expected to be rejected	4	5	5	1	2	3	3	1	3	3	3	1	0	0	4	38	11
No assets	1	3	2	1	1	3	2	0	2	3	4	1	0	0	1	24	7
No money lenders	9	1	3	3	8	4	4	2	0	5	1	2	3	5	4	54	15
No credit association	4	2	3	3	6	4	2	0	1	2	5	0	3	2	3	40	11
Not available in time	0	1	2	0	0	1	0	2	2	1	1	0	1	0	1	12	3
TOTAL	**33**	**22**	**38**	**18**	**40**	**30**	**18**	**19**	**20**	**31**	**30**	**10**	**13**	**14**	**27**	**363**	**100**
Why household did not need credit																	
Not cash constrained	17	11	11	10	16	9	9	11	3	22	13	6	11	8	17	174	53
Activity isn't profitable	3	0	0	1	0	0	0	0	0	1	1	0	0	0	0	6	2
Never thought of the investment	2	4	2	0	3	5	1	2	2	3	1	1	3	1	2	32	10
own source of money	12	5	7	4	6	12	7	11	4	5	8	12	11	3	8	115	35
TOTAL	**34**	**20**	**20**	**15**	**25**	**26**	**17**	**24**	**9**	**31**	**23**	**19**	**25**	**12**	**27**	**327**	**100**

Households were more likely to take up the SAIPs which they were aware of. Majority of the farmers did not have information about the SAIPs over time (67.52%), but the number had greatly decreased from 2011 across to 2015 (Table 4-5). This can be attributed to the efforts of the project and the people responsible for extension services in disseminating information about SAIPs. For those who had information also seemed to decrease across the panel. The likelihood scenario could be that the efforts were targeted on reaching new households who may not have received information in the previous year or due to attrition rate. The chi-square test showed that, there were statistical differences between those who received training and those who did not in the baseline and midline ($\chi^2(4) = 8.3$ and $\chi^2(4) = 8.2$) ,respectively within the counties, both at 10% level of significance (Table 4.5). Overall, the chi-square test cross the panel showed statistical differences within the counties ($\chi^2(4) = 11.2$) at 5% level of significance .

Table 4-5: Households that Received Information about SAIPs

COUNTY	Baseline		Midline		Endline		Total	YES/
	No	Yes	No	Yes	No	Yes		County
Bungoma	16.67	7.82	81	8.65	17.83	5.73		24.13
TharakaNithi	9.86	7.65	59	5.19	10.83	5.31		16.78
Embu	13.61	5.61	59	5.77	12.95	5.73		18.37
Meru	8.50	4.25	42	5.58	10.19	4.88		13.74
Siaya	18.88	7.14	113	6.73	19.53	7.01		26.98
Total	**397**	**191**	**354**	**166**	**336**	**135**		
% total/category	67.52	32.48	68.08	31.92	71.34	28.66		100
Test	$\chi^2(4) = 8.3$***		$\chi^2(4) = 8.2$***		$\chi^2(4) = 2.7$			
Aggregate	$\chi^2(4) = 11.2$**							

*** and ** are significant at 10% and 5% probability levels, respectively.

The tabulation of the results in Table 4-6 show that Siaya County consistently across the panel recorded few households which received information while Embu received the most across the panel. Over 50% of the respondents relied on government extension as a source of information

and extension. Farmer cooperatives, relatives, NGOs, family members, neighbors and model farmer together provided information to over 20% of the respondents. Media also played a role in information dissemination, as about 11% of the respondents relied on it for information. There were significant differences in the source of information per county in the baseline and midline at 10% level of significance but in the end line, there were no such differences.

There were significant differences on average on the sources of information per county at 10% level of significance. Embu County across the panel benefitted greatly from government extension by having 33% of the respondents who received government extension while Siaya took only 4%. From all the sources of information, again, Embu County took the lion share of more respondents receiving information at 31%, followed by Tharaka Nithi at 29%. Siaya County again took the least households that received information at 3%. Generally, Eastern region had more sources of information and benefited from it compared to Western region. There were significant differences within the counties for those who received information in the baseline and midline at 10% level of significance . The households which did not receive information were consistent across the panel. This implies that almost a third of the households in all the counties across the panel did not get into contact with an extension officer. This is a huge proportion of the people and more needs to be done to address this challenge.

Table 4-6: Sources of Household Information by County

Sources of Information	Baseline					Midline					Endline					Total
	BUNG	THARA	EMBU	MERU	SIAYA	BUNG	THARA	EMBU	MERU	SIAYA	BUNG	THARA	EMBU	MERU	SIAYA	
Government extension	2.8	4.9	6.0	4.2	0.8	2.4	3.8	5.5	3.2	0.8	3.0	3.3	4.8	4.0	0.7	50.1
Family member	0.0	0.4	0.9	0.6	0.0	0.3	0.2	0.6	0.6	0.0	0.0	0.8	0.2	0.3	0.0	4.9
Farmer coop/group	0.0	0.0	0.1	0.2	0.0	0.1	0.2	0.2	0.3	0.1	0.2	0.0	0.1	0.2	0.0	1.9
Neighbor farmer	0.1	0.9	0.6	0.2	0.0	0.0	0.4	0.3	0.6	0.0	0.0	0.4	0.2	0.3	0.1	4.2
Seed trader/agro-dealer	0.1	0.9	1.1	0.8	0.0	0.1	1.1	0.6	1.0	0.0	0.0	1.0	1.4	1.1	0.0	9.2
Relative farmers	0.3	0.2	0.0	0.1	0.0	0.0	0.3	0.0	0.0	0.0	0.1	0.1	0.2	0.1	0.0	1.6
NGOs	0.6	1.0	0.8	0.1	0.1	0.6	0.3	0.6	0.4	0.0	0.4	0.4	0.7	0.3	0.2	6.5
Research centers	0.0	0.2	0.9	0.4	0.0	0.0	0.8	0.3	0.6	0.0	0.1	0.8	0.8	0.4	0.0	5.3
Media	0.3	1.9	1.4	0.9	0.1	0.3	1.4	1.2	0.3	0.0	0.2	1.1	1.0	0.3	0.1	10.7
Farmer field school	0.4	0.6	0.4	0.1	0.1	0.4	0.8	0.2	0.6	0.0	0.1	0.4	0.3	0.2	0.1	5.0
Model/lead farmers	0.0	0.4	0.0	0.1	0.0	-	-	-	-	-	-	0.0	0.0	0.0	0.0	0.7
TOTAL	**4.7**	**11.4**	**12.2**	**7.8**	**1.1**	**4.3**	**9.4**	**9.5**	**7.5**	**0.9**	**4.3**	**8.4**	**9.7**	**7.4**	**1.3**	**100**

Capital was limitation to many households in the study areas. Credit was necessary to buy inputs and supplement other household consumption expenditures. On average more than 50% of the households across the panel needed credit to buy seeds (Table 4-7). This was encouraging if they found a credit organization to extend the services to them. Some needed credit but did not qualify to be awarded for lack of collaterals among other hinderances. More farmers in the western region (Siaya and Bungoma) recorded a higher percentage of those who needed credit for seed (82% and 96% respectively). This was attributed to the fact that there may be many credit organizations in the Western region compared to Eastern or many farmers in Eastern region were not cash constrained. The chi-square test ($\chi^2(4) = 8.8$) showed significant differences between counties and across the panel on the need for credit to buy seeds at 10% level of significance (Table 4-7).

Table 4-7: Household that Needed Credit for Seeds per County across the Panel

County	Baseline		% needed	Midline		% needed	Endline		% needed
	No	Yes	credit for seed 2011	No	Yes	credit for seed 2013	No	Yes	credit for seed 2015
Bungoma	57	82	13.8	51	86	16.1	51	69	14.0
Tharaka Nithi	48	60	10.1	37	49	9.2	36	45	9.1
Embu	54	64	10.7	38	57	10.7	39	46	9.3
Meru	43	45	7.6	35	40	7.5	34	33	6.7
Siaya	47	96	16.1	52	90	16.8	61	81	16.4
Total	**249**	**347**	**51.2**	**213**	**322**	**60.2**	**221**	**274**	**55.4**
Aggregate test				$\chi^2(4) = 8.8$***					

*** is significant at 10% probability level.

4.5. Post-Estimation Diagnostics

Before estimating the 3SLS, a diagnostic check was done. To test for multicollinearity, the highest variance inflation factor (VIF) was 1.29 for the age of the household head, which was within the acceptable range. The Woodridge test of autocorrelation in panel data failed to reject the null hypothesis of no autocorrelation of the error term. Equally the Cumby-Huizinga test of

autocorrelation confirmed that the data did not have a serial correlation. The above tests confirmed that the regression results will produce unbiased, efficient and least variance estimates

4.6. Econometric Results

The econometric findings of the 3SLS were as represented in Table 4-8. The result shows that **Agehh (**the age of household head) influenced the number of people a household knew within and outside the village, whom they could call on for help in times of need at 10% level of significance. Increase in one year of the household head increased chances of knowing more people by 0.269 times. Older family heads may have lived in the village for a relatively long time and had identified friends, relatives, and non-relatives whom they could rely on for help when need arose.

Family heads who were slightly older were more likely to command respect among the villagers. This could increase the likelihood of knowing many people who may come for advice or any other insights. They may have also developed trust among the relatives and non-relatives or even helped them at one point in time, therefore, obligated through the spirit of reciprocity. The findings were consistent with Wendy (2003) and Nasution *et al.* (2017) who found older people much networked in the villages and hence knowing many people. The older household heads had the ability to trace the family lineage and embrace relations which could be by birth or marriage than younger household heads (Cassidy and Barnes, 2012). However, Wendy (2003) further found that beyond a certain age, the connectivity networks begin to drop, citing that old age may lead to memory loss or maybe one is incapacitated. This means that, as the household head exceeds a given age, the chances of having new connections or even maintaining the old ones lowers.

Table 4-8: Econometric Results of the 3SLS Regression

VARIABLES	network_density		prtcpn_score		Cognscore		mbrshp_score	
Network_density	-		-		-		-0.0175	(0.0365)
Mershp_score	22.55*	(11.66)	0.0585	(0.217)	-		-	
Prtcpn_score	-		-		-		-	
Cognscore	-		-		-		-	
Genderhh	10.56***	(3.523)	0.0174	(0.0390)	0.453**	(0.186)	0.00377	(0.289)
Agehh	0.269***	(0.0931)	-0.0000079	(0.000833)	-		0.00695	(0.0112)
Farmsiz	0.159	(0.311)	0.00557	(0.00348)	0.0132	(0.0171)	0.0191	(0.0185)
Educhh	-0.330	(0.498)	0.0142**	(0.00688)	-		0.0355**	(0.0146)
hh_needcrdt	-4.097	(2.563)	-0.0171	(0.0219)	0.349**	(0.156)	-0.0466	(0.156)
Hhsiz	-1.329***	(0.458)	0.00966**	(0.00422)	0.0463*	(0.0276)	-0.0121	(0.0431)
lTOTAL_sav	-0.274	(0.503)	0.00509	(0.00728)	0.0418**	(0.0186)	0.0398**	(0.0171)
got_ext	2.363	(2.523)	-		-0.0909	(0.149)	-0.0415	(0.0757)
ltotal_credit_rcvd	-0.229	(0.449)	0.00857*	(0.00491)	0.0324	(0.0255)	0.0184	(0.0124)
recvd_info_saips	1.012	(2.620)	0.00733	(0.0241)	0.309**	(0.153)	0.0935	(0.104)
Lsalaryemploy	-0.318	(0.396)	-0.000281	(0.00501)	0.0149	(0.0200)	0.0208**	(0.00993)
lincom_lbr	-0.138	(0.249)	-0.00375*	(0.00220)	-0.00147	(0.0150)	0.00138	(0.00708)
lrent_out_land	0.762	(0.756)	0.00550	(0.00663)	-0.0271	(0.0455)	-	
lremitt_inkind	-0.147	(0.275)	0.000361	(0.00235)	0.00747	(0.0164)	-0.00137	(0.00860)
yrs_lvd_vlg	0.0355	(0.0622)	0.000468	(0.000549)	-0.00492	(0.00378)	0.00148	(0.00251)
Llegumepdn	-		0.00192	(0.0119)	0.0481	(0.0438)	0.0785*	(0.0471)
Lmaizepdn	-		-		-0.0185	(0.0444)	-0.0151	(0.0219)
Constant	6.993	(11.94)	0.168	(0.133)	6.583***	(0.387)	0.969	(0.711)

Note: Standard errors are in parentheses.

***, **, and * are significant at 10%, 5% and 1% probability levels, respectively.

In addition to the age of the household head, **Educhh** (Education of the household head) significantly explained membership and participation in groups. Education enlightens one in making a precise decision and actively participate in the decision-making process. Educated individuals help in bringing their synergies, expertise, and know-how in people who are organized around groups or SACCOs. The study found out that, one year of schooling increased one's ability to join groups and participate in decision making by increasing membership and participation score by 0.0355 times and 0.0142 times respectively, both at 5% level of significance. A group is viable based on the policies that they come up with, in propelling it to prosperity. Membership in groups that do not have new ideas will always stagnate and won't implement any beneficial project. The results correspond to the findings of Nasution *et al.* (2017) that higher education attainment increases one's chances of participation in groups, and increases chances of being a member of multiple beneficial groups.

In support of this findings, Nasution *et al.* (2017) alluded that formal education is important in imparting knowledge and technical know-how. It helps in arguing out issues based on facts from a professional background, hence significant in participation levels in groups through contributions in decision-making (Adong *et al.*, 2012). An educated person is more likely to articulate their views in a more precise and be understood easily (Adong *et al.*, 2012). It is therefore important noting that groups will have sound decisions and contributions when members are educated. However, Adong *et al.* (2012) argued that illiterate people can be made to participate, if local language is used in communication, equality is enhanced, and members are accorded equal chance. The experience one has gained over time in the same field can outweigh the years in school (Owusu *et al.*, 2013). Beard (2005) also found that having university education improved knowledge about the beneficial organizations and groups but reduces their participation level. This could be because of many work engagements or just a feeling of being out of place in the local setting (Owusu *et al.*, 2013).

Trust is an important element of social capital and it is cultivated through the frequency of transactions, past experiences, and levels of correlation. Members of a household are thought to be more cohesive and easily trusted as compared to non-household members (Groenewald and Bulte, 2013). It is easy to confide in household members that one trusts than otherwise. People who can be trusted increases chances reliability and instills confidence. A bigger household size

increases the ability to be in multiple groups through diversification or membership and participation. In case of a common pool resource, a household with many members are likely to participate in offering labor and related services than a household with fewer members. The findings of this study showed that **Hhsiz** (household size) improved the cognitive score of a household by 0.0463, if a household had one more member at 1% level of significance. It also improved participation score by 0.00966 at 5% level of significance. The results were in line with the findings of Anyiro and Ajuka (2014) that household with many participants in a group increased trust, and participation in self-help groups. The study also supported findings of Cassidy and Barnes (2012) that households with many members are more likely to be connected the most and have many people whom they can trust. According to the findings of this study, one additional household member reduced the ability to know 2 extra people at 10% level of significance. The basis for this finding could be that the household had enough capital and information, hence did not rely on anyone. This was also explained by Ostrom (2014) that individualistic and egocentric behaviors reduce network links that a household is having in instances of self-sufficiency.

Households received information through training, extension services, learning from each other and or exhibitions. They needed information about the benefits of the SAIPs and the best combination that will maximize on the yield. Those households which **recvd_info_saips** (received information about SAIPs) had a higher cognitive score than those who did not. Information was important in deciding on optimal combination of SAIPs. Additional sources of information were from neighbors, government extension officers, NGOs organizations, and farmer field schools. The results of the study show that the household had more trust of 0.309 scores higher at 5% level of significance, if they received information about SAIPs. This findings support Owusu *et al.* (2013) allusion that extension services received makes one to join a groups and participate. Those who give reliable information tend to be trusted by the recipients and the fact that vertical information is easy to be trusted than a horizontal one (Owusu *et al.*, 2013).

The study found **Genderhh** (gender of the household head/decision maker) to be significant in explaining the number of people a household knows, can rely on and trusts. The male knew more people they could rely on in times of need than the female counterparts. In most Africa setting, female are confined to household chores, narrowing their network density (Beard, 2005). Male-headed households knew 11 more people than female ones at 10% level of significance and had a

higher cognitive score of about 0.453 at 5% level of significance. The higher cognitive score among men can be explained from the perspective that most at times they are out of the homestead. This makes them be able to interact with many people and as a result, developed trust in them (Beard, 2005).

Legumes are a major source of proteins to many households in Kenya. They substitute commercial sources of proteins. The legumes that were produced included common bean, cowpea, groundnuts, pigeon peas, and haricot beans. When a household increased **Llegumepdn (**legume production) by one bag of 50-kilogram, membership scores in institutional groups improved by 0.0785 at 1% level of significance. Most small-scale farmers produced legumes for sale hence, need to be in groups to help in marketing and sale of the surplus (Sseguya e*t al.,* 2013). Marketing groups helped in the transportation of the product to the markets, negotiate prices and as a result reduced the transportation cost (Sauun and Zhang, 2010).

Maize-legume system households from the sampled counties applied for credit to enable then carry out many activities including and not limited to buying farm inputs and equipment. Various groups, SACCOs, and commercial banks offered credit upon assessing the creditworthiness of the household, based on the collaterals provided. Group that provided credit such as a merry-go-round, women and youth saving groups, and credit associations required that one be an active member through participation to qualify for a loan. This may have explained the reasons behind a higher score of the cognitive social capital of the households that received credit. In fact, households **ltotal_credit_rcvd** (the natural logarithm of the total amount of credit received) recorded a higher cognitive score of 2.57 at 1% level of significance when credit received increased by KES 1000.

Savings are increasingly becoming paramount in investments and subsequent household expenditures. Maize-legume system households in the sampled counties saved their money in savings groups, SACCOs and commercial banks for account holders. A household made a saving to a group which they had trust in that they will get the value of their money in form of interest, dividends or increase in share value. In a savings group, one had to be a member to save with them or buy shares. The **lTOTAL_sav** (the natural logarithm of the total amount of money that a household saved) was significant in explaining membership and cognitive scores. The households saved in different savings groups and SACCOs to diversify the risks. This may have informed the

results that a household that made an extra one thousand Kenyan shillings improved their membership score by 0.119 at 5% level of significance. Groups are at times characterized by egocentric and opportunistic behaviors, therefore, a household had to have some level of trust before committing an extra coin to savings. The study found out that for an extra one thousand Kenyan shillings committed to savings, a household must have developed a higher cognitive score of 0.1254 at 5 % level of significance.

Mershp_score (membership score) was one of the endogenous variables that was used as an explanatory variable. It significantly explained the number of people that a household knows within the village and outside and those in leadership, from whom they can get help in times of need. The number of groups a household was a member determined the number of people that a household knew and could rely on for help in times of need. This was so because, in groups, a household member could be able to interact with many people who could be relatives, non-relatives, and friends from whom they bond. This could increase chances of extending a hand of help, when one was in need. The variable (mership_score) precisely showed that an extra-institutional group one decided to join, increased the scope of network density by roughly 23 individuals whom they can rely on in times of help at 5% level of significance.

Those households that received their income from **Iincome_lbr** (received income from labor activities) recorded lower participation scores than their counterparts who got income from elsewhere. This contradicted an earlier assumption that if one's income increases, their level of participating increases. The assertion was because one could be able to meet the group obligations. However, this was not the case because income from labor activities may be lower and therefore used to meet household expenses. Again, casual labor engagements reduce the time available for one to participation in group activities. The findings vividly showed that an increase in one thousand shillings of income from labor reduced participation score by 0.0113 at 1% level of significance. Contrary to the households that got their income from casual labor, those who received from **Lsalaryemploy** (income from salaried employment) had higher chances of taking part in multiple groups. This was confirmed by higher membership score of 0.0624 for every extra one thousand shillings. An employed household can be able to contribute freely to group activities and may be members of more savings or credit giving groups. It is also possible that they may

have learned about the benefits of various groups where they are members from workmates or the people they interact with.

4.7. Conclusion

Social capital is important in household decision making, information sharing, and agricultural innovations. The study analyzed household characteristics and how they influence the household decision to participate in social capital. The social capital forms included: network density, participation score, cognitive score, and membership score. The descriptive statistics showed that on average the sampled household had 6 members, with 52 years of age for the household head and 8 years of schooling. The average landholding was 2.3 acres. More households were male-headed at 81%. The result showed that 65% of the smallholder maize-legume farmers needed credit to buy fertilizer and 57% to buy seeds. Those households which did not apply for credit at all had views that borrowing was risky, needed a lot of paperwork and collaterals, which they did not have. They also had views that interest rate charged on the loans was high. However, some did not consider applying because they were not cash constrained or did not think of taking a loan for a maize-legume system investment. In receiving information and training, 50% of the respondents relied on government extension training as a source of information across the panel. The econometric results from the 3SLS by equations showed that network density equation was influenced by gender and age of the household head, household size, and membership score. Participation score equation was explained by household head education level, household size, the total amount of credit a household applied for and received, and income they received from labor activities. Membership score was explained by the education level of the household head, amount of legume a household produced and amount of money which they saved and received from salary employment. Lastly, Cognitive score equation was found to be influenced by gender of the household head, household size and the total amount that a household made savings on, and whether the household received information or training on SAIPs. Policymakers should consider encouraging and promoting better access to agricultural extension services among smallholder maize-legume farmers. They should also encourage membership and participation in groups that can benefit farmers and finally help farmers in diversification strategies to improve on income.

CHAPTER FIVE

SOCIAL CAPITAL EFFECTS ON THE UPTAKE OF SUSTAINABLE AGRICULTURL INTENSIFICATION PRACTICES COMBINATIONS

5.1. Introduction

This chapter covers a rationale for multiple Sustainable Agricultural Intensification Practices (SAIPs) uptake, descriptive statistics of the variables used in the regression, econometric modeling, and a Seemingly Unrelated Regression (SUR) model estimation of the different SAIPs combinations.

5.2. Multiple SAIPs Uptake

According to Kassie *et al.* (2015) smallholder maize-legume farmers in Kenya are facing multiple challenges that call for multiple approaches rather than the adoption of a single SAIP. The use of SAIPs has received a lot of emphasis due to its environmentally friendly approach in the recent past. However, the uptake has remained low (Nato *et al.,* 2016). Since the SAIPs can improve production, there is a need to know the factors that influence their rapid uptake. Higher agricultural production must be realized to cater for the rapidly rising population in Kenya and across the globe (Melorose *et al.,* 2015).

Smallholder maize-legume farmers produce the highest proportion of the maize and legumes requirements in the country (Kirimi *et al.,* 2011), hence need to create awareness on the SAIPs combination (Sidique and Hadi, 2016). Adoption of agricultural practices has been previously attributed to networks that households have and whom they trust to get reliable information from. Agricultural shows and access to finances were also found to be significant by Nkegbe and Shankar (2014). Arslan *et al.* (2014) found extension services and household unobservable such as openness to innovations to be significant in the adoption of agricultural practices. Participation in collective action and membership to groups were also significant in a study by Willy and Holm-Müller (2013).

Other factors which influence the adoption decision of agricultural technologies or practices include the age of the household decision maker or head, sources of information and credit availability (Challa and Tilahun, 2014; Cochrane, 2014). However, Arslan *et al.* (2014) did not find age of the household head to be significant in explaining adoption. Ainembabazi and Mugisha

(2014) also argued that stock of education is not as important as years of experience in an agricultural setting. This study considered a combination of different SAIPs, unlike other earlier studies that handled the adoption of a single practice. The motivation was that smallholder farmers adopt different SAIPs in combination, as opposed to one by one (Teklewold *et al.*, 2013). The reason behind the adoption of different combinations is that different farmers face different challenges in production. The challenges are also multiple in nature and require multiple SAIPs to address them.

Majority of these reviewed studies based their conclusions on single agricultural practices, using binary choices. Samples that they used were small and most of them were cross-sectional except Teklewold *et al.* (2013) which used panel data and dealt with multiple SAIPs adoption in Ethiopia. This objective handled the above weaknesses and considered the fact that SAIPs could be substitutes or compliments of each other. The idea of combining the SAIPs using the PCA approach was addressing the idea that household maize-legume producers adopted the SAIPs in combination and not in piecemeal.

5.3. Descriptive Statistics

The number of households that received information across the panel was low (30%) as represented in Table 5-1. There is a need to improve the dissemination of information on the appropriate combinations that can be applied to obtain optimal yield. Information about input prices had even fewer household which received information. It is important for farmers to have knowledge about the market prices of farm inputs. This can help them in planning their expenditures in farming operations. Different dealers or agro-vets sell same inputs at different prices due to price discrimination. A rational farmer who is out to reduce the cost of production of the maize-legume system could wish to know where prices are low. On the other hand, different brands of seeds of maize and legumes could be available at different prices and potential expected yield. This makes knowledge about the prices of inputs crucial to a household, in the calculation of cost and revenue streams. Any person involved in the production must know the prices of inputs because that is where the cost of production starts to pile up.

The results further indicated that in Bungoma the households who received information dropped to 10% in the end line from 16% in the baseline (Table 5-2). Other counties generally had an improvement in disseminating information to households across the panel, with Embu and Tharaka

Nithi recording the highest improvement change from 6% to 23% and 14% to 27%, respectively. At least, agents involved in creating awareness and training tried to reach many households after the baseline. However, more needed to be done to reach more households.

Table 5-1: Received Information about SAIPs

County	Baseline	Midline	Endline
Bungoma	31.9 (68.1)	34.4 (65.6)	31.1 (68.9)
Tharaka Nithi	29.7 (70.3)	29.5 (70.5)	30.8 (69.2)
Embu	31.5 (68.5)	30.6 (69.4)	23.5 (76.5)
Meru	36.6 (63.4)	29.4 (70.6)	26.9 (73.1)
Siaya	31.0 (69.0)	33.1 (66.9)	29.4 (70.6)

Note: Figures in parenthesis are percentages of those who did not receive information about SAIPs.

Table 5-2: Received Information about Input Prices

County	Baseline	Midline	Endline
Bungoma	16.2 (83.8)	16.3 (83.7)	10.2 (89.8)
Tharaka Nithi	13.7 (86.3)	19.2 (80.8)	27.3 (72.7)
Embu	6.1 (93.9)	23.3 (76.7)	20.5 (79.5)
Meru	18.4 (81.6)	17.1 (82.9)	21.6 (78.4)
Siaya	10.1 (89.9)	18.7 (81.3)	14.5 (85.5)

Note: Figures in parenthesis are percentages of those who did not receive information about SAIPs.

The results of Table 5-3 showed the summary of the variables that were included in the regression and their description. The average age of the household head was 52 years and the natural logarithm of the total amount of money a household saved and the amount they got as income was 7.4 and 9.3 respectively across the panel. The trend for saving and income was relatively higher in the beginning, with a slight drop in the midline and a rise in the end line. Plots, where most of the households were cultivating, were generally near with an average walking distance of 10 minutes. However, some household had to walk for over 5 hours to the plots and these were probably rented in plots. The distance a household member had to travel influenced the bulk inputs like manure and fertilizer. This could require additional cost for transportation, raising the cost of production. On average households had lived in the village for 30 years. This is a relatively longer period that people have had an idea of the production patterns and the possible SAIPs combinations for

optimal yield. However, it was noted that some household had just migrated there and did not have any experience living in the village hence learning from others and extension services were crucial.

Even though information is key in the production of goods and services, a few households received information about input prices and SAIPs combination. This was evidenced by a low percentage showing those who received information averaging at 31.2% for information about SAIPs and 16.2% for information about input prices. A greater percentage of household received training from government extension officers, relative to other information sources. It was noted that the extension visits were of a range of issues and did not particularly handle the SAIPs aspect only. The training was done in Barazas and groups and therefore the farmers did not get that physical touch with officers and engage on a personal level. Follow-up was also minimal, evidenced by the frequency of visits or training hence difficult to track and know if a given aspect of the training was taken seriously.

A social capital factor was captured in four aspects that included: membership score, network density, cognitive score featuring those that a household trust, membership score, and participation in groups in which a household was a member. Network density involved friends, relatives and those in leadership positions in and out of the village that one can call on to get help from. The help could be in form of seed sharing, food, finance or advice. It is important to note that a household could also learn from these people upon visiting. Some households had over 200 people whom they could rely on while others had less than 10 people. It was important to know the level of trust a household had on other people in the society. This would determine where they make savings to buy inputs, the sellers in agro-vets from where they could get inputs and advice as well as from whom they could get reliable information. Membership in a diverse group also could broaden the chances of getting multiple aids, interacting with many people on possible combinations and learn from each other with ease. Finally, participation in groups where they were members could increase the chances of getting loans, to be able to organize for inputs.

Table 5-3: Data Definition and Descriptive Statistics

Variable	Description	Measurement	Baseline		Midline		End line	
			Mean	**Std**	**Mean**	**Std**	**mean**	**std**
Agehh	The age of the household head	Age in years of the household head	51.60	14.20	53.50	14.40	52.00	14.20
lTOTAL_sav	Log of money a hh saved	Natural logarithm of money	7.40	3.90	7.30	4.00	7.60	4.00
lTOTAL_incom	Log of money hh get as income	Natural log of money	9.60	3.80	9.20	4.10	9.30	4.10
avrg_plot_dist	Average plot distance from home	Measured in walking minutes	10.00	5.40	7.80	5.70	6.00	3.76
yrs_lvd_vlg	Number of years hh has lived in the village	Years	30.00	19.10	30.10	14.30	29.60	18.70
network_density	The number of people a hh knows and can rely on for help in times of need	A discrete number of people	48.00	39.00	48.00	41.00	44.00	38.00
prtcpn_score	The score of participation in group in which hh are members	Score	0.49	0.41	0.50	0.43	0.50	0.41
Cogniscore	The score of trust of a household	Score	7.91	2.95	7.80	2.73	7.88	2.82
mbrshp_score	The score of membership in which a hh is a member	Score	1.31	0.90	1.41	1.00	1.40	0.93
Dummy variables (represented as a percentage of the respondent)			**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
got_ext	Household got an extension from government and other sources.	Dummy: 1- Yes, 0- No	66.90	33.10	62.80	37.20	66.60	33.40
info_inpt_mkt_price	If hh had information about input prices	Dummy: 1- Yes, 0- No	12.30	87.70	19.20	80.80	18.90	81.10
recvd_info_saips	If a hh received information about SAIPs	Dummy: 1- Yes, 0- No	32.50	67.50	32.20	67.80	28.40	71.60

5.4. Econometric Model Specification

A Seemingly Unrelated Regression (SUR) method was used in the analysis. The method was preferred over others because of its ability to handle different continuous dependent variable, against a set of explanatory variables where the error term has a potential of possible correlation (Zellner, 1962; Henningsen, 2012). The possible correlations could arise from the different combinations which did not differ substantially in clustering. For instance, Rotation (R) made VRMFI and VMFI be in different clusters. This had a potential of correlation which SUR could handle. The model was estimated using equation 5.1.

$$Y_{ijt} = x_{ijt}^{T}\beta_t + \varepsilon_{it} \tag{5.1}$$

where $j = 1, 2, \ldots, m$ represented the number of equations and Y_{ij} is the index associated with each equation for a given combination of SAIPs in a cluster in different equations for different households.

Following the innovative approach of Birhanu *et al.* (2011) and Cavatassi *et al.* (2014), An index of the SAIPs various combinations were created as per equation 5.2

$$Y_{ji} = \sum_{l=1}^{p} \left[f_{ij}\left(\frac{l_{ji} - \bar{l}_j}{s_j} \right) \right] \tag{5.2}$$

where Y_j is the j^{th} combination of SAIPs, f_{ij} is the weight of the associated household i using j^{th} combination from the PCA model. I_{ij} is the land where i^{th} household was using j^{th} SAIP combination while $\bar{l}_j$ and S_j were the mean land size and standard deviation where the j^{th} combination was applied. Since the study used panel dataset from three rounds, then, to incorporate the time factor and variability of the index over time, the data were pooled for the three-round and estimated the principal component over the combined data. The weights that resulted from the combined data were applied to the variable values of each round of the data. This constructed a continuous variable index for the different combinations as shown in equation 5.3.

$$Y_{ijt} = \sum_{l=1}^{p} \left[F_{ijt}\left(\frac{l_{ijt} - \bar{l}_{jt}}{s_{jt}} \right) \right] \tag{5.3}$$

The variables were as defined previously in equation 5.2, with *t* representing time factor in equation 5.3. The created index was then used as the dependent variable and a SUR method fitted with social capital and socioeconomic factors as explanatory variables. The social capital which formed part of the explanatory variables were divided into four forms. They included: Group membership, decision level of a household in groups, Networks density and cognitive social capital (Krishna and Uphoff, 1999; Grootaert and Van Bastelaer, 2001). Group membership score was obtained by adding the weight assigned to each group in which a household is a member. Decision level of a household in groups and cognitive social capital was calculated as a weighted score. Network density was the cumulative of the people that the household knew within the village and outside, from whom they can rely upon help in times of need (Bjomskov and Svendsen, 2000; Birhanu *et al.,* 2011; Rotaru et al., 2012).

The results of Table 5-4 represent the Principal Component Analysis (PCA) clustered combination. PCA helps to reduce data dimensionality without loss of information (Reise *et al.,* 2000). It is a better approach compared to conventional grouping practice which may make it difficult to make a conclusion about a given group. The PCA ran a regression of the various combinations and obtained different loading factors associated with each combination (Birhanu *et al.,* 2011). The PCA components that had a value greater than one were chosen to form combinations. The components were rotated to obtain orthogonal varimax. The rotation was to help obtain combinations which are highly correlated with each component for easy interpretation and generalization (Rotaru *et al.,* 2012). From the rotated varimax, different combinations used by the households in different plots were identified and put in different heterogeneous principal clusters by use of PCA which are homogeneous within (Chatterjee *et al*., 2015).

The Kaiser- Meyer- Olkin measure of sampling adequacy was 0.6134 which was above the minimum requirement of 0.50, hence the results from PCA were reliable and it was worthy to conduct a PCA analysis to help in clustering. The Orthogonal Varimax (Kaiser off) Rho = 0.5537 which is above the acceptable minimum of 0.5. PCA was conducted to help in data reduction through clustering to get combinations that were homogeneous within and heterogeneous in the next cluster, based on the two assurance. The seven SUR model equations estimated were:

$$factor\_1 = \alpha + \alpha_1 network\_density + \alpha_2 prtcpn\_score + \alpha_3 Cognscore + \alpha_4 mbrshp\_score + \alpha_5 Agehh + \alpha_6 recvd\_info\_saips + \alpha_7 lTOTAL\_sav + \alpha_8 lTOTAL\_incom + \alpha_9 avrg\_plot\_dist + \alpha_{10} yrs\_lvd\_vlg + \alpha_{11} got\_ext + \alpha_{12} info\_inpt\_mkts\_price. \quad (5.4)$$

$$factor\_2 = \beta + \beta_1 network\_density + \beta_2 prtcpn\_score + \beta_3 Cognscore + \beta_4 mbrshp\_score + \beta_5 Agehh + \beta_6 recvd\_info\_saips + \beta_7 lTOTAL\_sav + \beta_8 lTOTAL\_incom + \beta_9 avrg\_plot\_dist + \beta_{10} yrs\_lvd\_vlg + \beta_{11} got\_ext + \beta_{12} info\_inpt\_mkts\_price. \quad (5.5)$$

$$factor\_3 = \pi + \pi_1 network\_density + \pi_2 prtcpn\_score + \pi_3 Cognscore + \pi_4 mbrshp\_score + \pi_5 Agehh + \pi_6 recvd\_info\_saips + \pi_7 lTOTAL\_sav + \pi_8 lTOTAL\_incom + \pi_9 avrg\_plot\_dist + \pi_{10} yrs\_lvd\_vlg + \pi_{11} got\_ext + \pi_{12} info\_inpt\_mkts\_price. \quad (5.6)$$

$$factor\_4 = \mu + \mu_1 network\_density + \mu_2 prtcpn\_score + \mu_3 Cognscore + \mu_4 mbrshp\_score + \mu_5 Agehh + \mu_6 recvd\_info\_saips + \pi_7 lTOTAL\_sav + \pi_8 lTOTAL\_incom + \pi_9 avrg\_plot\_dist + \pi_{10} yrs\_lvd\_vlg + \pi_{11} got\_ext + \pi_{12} info\_inpt\_mkts\_price. \quad (5.7)$$

$$factor\_5 = \Upsilon + \Upsilon_1 network\_density + \Upsilon_2 prtcpn\_score + \Upsilon_3 Cognscore + \Upsilon_4 mbrshp\_score + \Upsilon_5 Agehh + \Upsilon_6 recvd\_info\_saips + \Upsilon_7 lTOTAL\_sav + \Upsilon_8 lTOTAL\_incom + \Upsilon_9 avrg\_plot\_dist + \Upsilon_{10} yrs\_lvd\_vlg + \Upsilon_{11} got\_ext + \Upsilon_{12} info\_inpt\_mkts\_price. \quad (5.8)$$

$$factor\_6 = \phi + \phi_1 network\_density + \phi_2 prtcpn\_score + \phi_3 Cognscore + \phi_4 mbrshp\_score + \phi_5 Agehh + \phi_6 recvd\_info\_saips + \phi_7 lTOTAL\_sav + \phi_8 lTOTAL\_incom + \phi_9 avrg\_plot\_dist + \phi_{10} yrs\_lvd\_vlg + \phi_{11} got\_ext + \phi_{12} info\_inpt\_mkts\_price. \quad (5.9)$$

$$factor\_7 = \psi + \psi_1 network\_density + \psi_2 prtcpn\_score + \psi_3 Cognscore + \psi_4 mbrshp\_score + \psi_5 Agehh + \psi_6 recvd\_info\_saips + \psi_7 lTOTAL\_sav + \psi_8 lTOTAL\_incom + \psi_9 avrg\_plot\_dist + \psi_{10} yrs\_lvd\_vlg + \psi_{11} got\_ext + \psi_{12} info\_inpt\_mkts\_price. \quad (5.10)$$

5.6. Econometric Model Estimation

Before analysis, the possible 18 combinations of SAIPs were reduced to seven components by PCA data reduction technique that formed clusters that were homogeneous within and heterogeneous in different clusters (Smith, 2002; Walde, 2014). The PCA reduces data dimensionality to a manageable level without loss of information (Reise *et al.*, 2000). This reduced the equations to be estimated to a manageable number of 7 as shown in Table 5-V. The selection of the 7 combinations were based on the eigen values chosen that had a value greater than 1. The seven clusters formed each having different combinations of the SAIPs (Table 5-4).

The econometric results of the SUR model were represented in Table 5-5, and it showed that **Cognscore** (Cognitive social capital) which comprised of who the household trusts were significant in improving uptake of SAIPs combinations in cluster 3, 4, 5 and 6. The people a household trusts improves transactions, reliability, and ease of taking risks. Households that trust extension officers are more likely to take up the advice given by them and put it into practice. Similarly, they can take up their money and make savings in various groups without fear of fraudulent behaviors among the leaders or the lenders. They can adapt and continue using combinations that the people they trust advice and therefore more likely to realize higher adoption rate and yield. The findings of the study further found out that those whose level of trust is relatively higher, and one can rely on the advice they get from them are more likely to adopt combinations in cluster 3, 4, 5 and 6. The combinations in this clusters generally shows how households combined variety and conservation agricultural practices to realize higher yield. These practices have an advantage that they are environmentally friendly, and they increase the output level of the farmer. Empirically, increase in one unit in the score of cognitive, will improve uptake of combinations in: cluster 3 by 0.182 units at 5% level of significance; cluster 4 by 0.018 units at 1% level of significance; cluster 5 by 0.012 units at 5% level of significance and cluster 6 by 0.022 units at 1% level of significance. Conversely, Nato *et al.* (2016) did not find social trust form of social capital to be significant in explaining adoption decision, citing that strong social trust leads to reluctance in adoption until others have significantly adopted.

Table 5-4: Clusters of SAIPs from which an Index was Formed

Clusters	Combinations	Description of the combinations
Cluster 1	Vrm	Seed variety+ crop rotation + manure application
	Vrmf	Seed Variety+ crop rotation + manure application +fertilizer application
	Vrmfi	Seed Variety+ crop rotation + manure application +fertilizer application + intercropping maize and legumes
Cluster 2	Vfi	Seed Variety + fertilizer application +intercropping maize and legumes
	Vmfi	Seed Variety + manure application + fertilizer application +intercropping maize and legumes
	Vrfi	Seed Variety + rotation+ fertilizer application +intercropping maize and legumes
Cluster 3	Vm	Seed Variety + manure application
	Vmt	Seed Variety + manure application + minimum tillage
Cluster 4	Vi	Seed Variety+ intercropping maize and legumes
	Vit	Seed Variety+ intercropping maize and legumes +minimum tillage
Cluster 5	Vf	Seed Variety+ fertilizer application
	Vt	Seed Variety+ minimum tillage
	Vmi	Seed Variety + manure application + intercropping maize and legumes
	Cluster 6	
Cluster 6	Vr	Seed Variety + crop rotation
	Vri	Seed Variety + crop rotation + intercropping maize and legumes
	Vrmi	Seed Variety + crop rotation + manure application + intercropping maize and legumes
Cluster 7	V	Seed Variety

Table 5-5: SUR Model Estimation Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
VARIABLES	**factor_1**	**factor_2**	**factor_3**	**factor_4**	**factor_5**	**factor_6**	**factor_7**
network_density	-0.00025	1.96e-05	0.000232	-0.000265	0.000914	0.000446	-0.000302
	(0.0003)	(0.000364)	(0.000626)	(0.000725)	(0.00152)	(0.000906)	(0.00175)
prtcpn_score	-0.02540	0.00838	0.0917	0.167**	0.109	0.101	0.381**
	(0.0311)	(0.0331)	(0.0570)	(0.0660)	(0.138)	(0.0825)	(0.159)
Cognscore	0.00115	0.00197	0.0182**	0.0179*	0.0415**	0.0223*	0.0313
	(0.0044)	(0.00467)	(0.00804)	(0.00931)	(0.0195)	(0.0116)	(0.0225)
mbrshp_score	0.01430	0.00960	-0.00538	-0.0314	0.0539	0.0123	-0.0217
	(0.0141)	(0.0150)	(0.0258)	(0.0299)	(0.0625)	(0.0373)	(0.0721)
Agehh	-0.00092	-0.00119	-0.00119	0.000186	-0.00217	-0.00475**	-0.00142
	(0.0009)	(0.000931)	(0.00160)	(0.00186)	(0.00388)	(0.00232)	(0.00448)
recvd_info_saips	-0.0550**	0.0500*	-0.105**	-0.0787	-0.174	-0.0396	-0.235*
	(0.0273)	(0.0290)	(0.0500)	(0.0579)	(0.121)	(0.0723)	(0.140)
lTOTAL_sav	0.00435	-0.00747**	-0.00237	0.00188	-0.000251	0.00250	0.000872
	(0.00316)	(0.00337)	(0.00580)	(0.00672)	(0.0141)	(0.00839)	(0.0162)
lTOTAL_incom	0.000374	-0.00109	-0.0143**	-0.0106	-0.0332**	-0.0148*	-0.0339**
	(0.00321)	(0.00341)	(0.00588)	(0.00681)	(0.0142)	(0.00850)	(0.0164)
avrg_plot_dist	0.000137	-0.000368	0.00446***	0.00743***	0.00991***	0.00638***	0.0177***
	(0.000691)	(0.000736)	(0.00127)	(0.00147)	(0.00307)	(0.00183)	(0.00354)
yrs_lvd_vlg	-0.000982	-0.00103	-0.00226*	-0.00272*	-0.00662**	-0.000324	-0.00419
	(0.000666)	(0.000709)	(0.00122)	(0.00141)	(0.00296)	(0.00177)	(0.00341)
got_ext	-0.0214	0.00290	0.0682	0.0958*	0.142	0.00986	0.138
	(0.0263)	(0.0280)	(0.0482)	(0.0558)	(0.117)	(0.0697)	(0.135)
info_inpt_mkts_price	0.118***	0.0330	0.0445	-0.0672	0.0218	-0.0862	-0.305*
	(0.0335)	(0.0357)	(0.0615)	(0.0712)	(0.149)	(0.0889)	(0.172)
Constant	0.197**	0.284***	0.207	0.102	0.470	0.360*	0.682*
	(0.0773)	(0.0823)	(0.142)	(0.164)	(0.344)	(0.205)	(0.396)

Note: Standard errors in parentheses.

***, **, and * are significant at 10%, 5% and 1% probability levels, respectively.

Additionally, **prtcpn_score** (Participation score) which was another component of the social capital, influenced uptake of combinations in cluster 4 and 7. Participation score was calculated from the participation level in groups where they were members. The maximum participation level was 6 and the least was 1. The combination of cluster four was majorly dominated by a variety of seed, intercropping, and minimum tillage while cluster 7 was only variety. When a household participation score improved by 1 value, adoption of combination in clusters 4 and 7 increase by 0.17 and 0.38 units respectively at 5% level of significance each. Participation in groups improve chances of interaction and learning. Inactive members are less likely to learn a lot from a group. Through the interactions of group members, a household could know many people from whom they could acquire seeds and other farming practices beneficial in the production of maize and legumes. They are also able to organize for cheap transportation of seeds from dealers and at a subsidized rate and cheap transport. The study agreed with that of Pratiwi and Suzuki (2017) who found that individuals who occupy a central position in their neighborhood and networks such as groups were better in learning outcomes. In their study, Sidique and Hadi (2016) found out that active participation in leadership roles in the community and institutions is important to adoption decisions to many people in the community especially where extension services are inefficient. They cited that the leaders and active participants do not only act as opinion leaders but also reference point from where other people learn from. Nato *et al.* (2016); Willy and Holm-Müller, (2013) on their studies also found active group involvement and social support to be forms of social capital that significantly influenced adoption of optimal and appropriate agricultural practices. Similarly, they too did not find social networks and collective action to be significant in the adoption decisions of optimal agricultural practices. This is because it involved personal responsibility and boldness to take up the initiative to undertake the practices trained in practice.

The variable **recvd_info_saips** represented those households that received information about SAIPs. It was significant in the uptake of combinations in cluster 2. The combinations in this cluster were variety of the seeds, fertilizer, and intercrop which were common but with some adding manure and rotation. In fact, a household that received information improved chances of adopting combinations in cluster 2 by 0.05 but reduced chances of adopting combinations in cluster 1, 3 and 7 by 0.06, 0.11 and 0.24 respectively, all at 5% level of significance. Information about SAIPs was important in the uptake of the optimal combination that will yield output. The possible

scenario in this context was that the extension officers or groups from where households got training emphasized on the combinations in cluster 2. This cluster composed of commercial inputs blended with manure, rotation, and intercrop. The study supports earlier findings by Challa *et al.* (2014); Cochrane and Lake (2014); Teklewold *et al.* (2014) who found that source of information about any agricultural production technique is important in adoption decision. They all cited that information is an important aspect of the decision-making process of a household. The information also had to be from a reliable source to make an impact in the lives of the household.

Like receiving information about SAIPs, **info_input_mkts_price** (Received information about input market prices) was significant in the uptake of cluster seven which comprised of the variety of seeds. For a household to know the prices of inputs in the market, awareness was important. This could be done through advertisements, individual trips of traders and agro-vets to the village and or extension officers. Other informants could be friends or relatives who may have bought these inputs or received this information and shared with those whom they thought could be in need. Just like information about SAIPs, awareness about the prevailing market prices were important too. This could help in assessing the cost of production and alternatives available. Inputs are of varied types hence needed a decision on the best variety and at the lowest price. This was important because of price discrimination. A rational farmer whose motive is to minimize the cost of production, must know where the prices were low for the same item. The finding of the study showed that those who got information about input prices improved adoption of combinations in cluster 1 by 0.12 at 10% level of significance and cluster 7 by 0.31 at 1 % level of significance. These combinations essentially composed of a variety of seed, manure, and fertilizer. The result agrees with Sidique and Hadi (2016) that training in forms of extension services is central in the adoption of Sustainable Agricultural Practices in less developed economies. They continued to argue that SAIPs packages that are likely to yield more output should be encouraged to be adopted to improve yield and reduce hunger of any kind. Access to and quality information is key to adoption decisions.

A household made savings to use in the future. They made savings in commercial banks, savings group, SACCOs, and microfinance. **lTOTAL_sav** (The total amount of money that a household saved) influenced uptake of combinations in cluster 2. The result indicated that an increase in savings of a household by KES 1000 reduced chances of adopting combinations in cluster 2 by

0.22 at 10% level of significance. The study however expected that the more savings one makes could increase chances of one adopting more of commercial inputs in cluster 2. An explanation could be that some household made savings to fixed accounts or retirement benefits rather than saving to buy inputs. It is also possible that some households have been planting maize and legumes over time and do not realize returns on their investments and therefore opt to save for other business ventures. Similarly, they could be practicing production majorly for consumption, while doing business to raise income.

Smallholder maize-legume households received income from farming, salary employment, businesses, offering labor, through remittances in kind and from renting out plots. Just like savings, **lTOTAL_income** (The natural logarithm of the total amount of income that a household received) was significant in the uptake of combinations of cluster 3, 5 and 7. An extra KES 1000 in form of income to the household reduced chances of practicing combinations in clusters 3 by 0.14 units, cluster 5 by 0.03 units and cluster 7 by 0.03 all at 5% level of significance and cluster 6 by 0.01 units at 1% level of significance. Cluster 3 and 5 are more of variety and conservation practice whereas cluster 7 is variety alone. This implies that when income increases, a household is more likely to combine variety and other conservation practices. When income rises one is able to purchase more commercial inputs and combine them in the production of maize and legumes (Sidique and Hadi, 2016). This is so especially, when the extra income comes from sales of the production of the previous season. Higher incomes in the household were also found to be significant in the adoption of maize-legume rotation and residue retention by Manda *et al.* (2015) in Zambia. It is easy to purchase and transport farm inputs when one has money or has a higher income. Those who also supplement their income from credit borrowing are also more likely to improve on commercial inputs because of improved financial capacity.

Households in the maize-legume system had plots in different locations from the homestead. Some were near, while others were far away. It was worth noting that, some did not own land and therefore, rented in for farming and this could depend on where they found it. The findings of the study indicated that **avrg_plot_dist** (the distance of the plot from household homestead) was significant because, a household that had their plots far were more likely to adopt combinations in clusters 3, 4, 5, 6 and 7. An extra 100 minutes' walk distance from the homestead increased adoption of combination in cluster 3 by 0.44 times; cluster 4 by 0.74; cluster 5 by 0.99 times;

cluster 6 by 0.64; and finally cluster 7 by 1.77 times. All of them were significant at 10% level of significance. Most of the combinations in this clusters included variety and conservation practices. The justifications behind this could be that they do not want to invest so much in plots that are far since they incur a cost in transportation. This is because, the far the plot is, the less one is to manage it effectively. That is why they may have opted for minimum tillage, manure which is less expensive compared to fertilizer and intercropping. According to Teklewold *et al.* (2014), plot distance from the homestead was significant, alluding that the far the plot was from the homestead, the less likely one could choose practices that are labor intensive like manure or capital intensive inputs like fertilizer.

The time one household had lived in the village varied from one household to the other. The **Agehh** (the age of the household head/ decision maker) and **yrs_lvd_vlg** (the years a given household has lived in the village) also influence the uptake of given specific cluster. These variables could be pegged to the experience one has gained over time. The empirical results of the study showed that household that had lived more years in the village were less likely to adopt combinations of SAIPs in cluster 3, 4 and 5. When a household lived in the village for 10 years, it reduced chances of adopting combination in cluster 3 by 0.02 times at 1 % level of significance, cluster 4 by 0.03 times and cluster 5 by 0.06 times both at 5% level of significance. The reason behind the low uptake of those clusters could be because experience has shown that the combinations in them yield less.

On the other hand**,** households that were 10 years older practiced less of combinations in cluster 6 by 0.05 times compared to those which were younger, at 5% level of significance. This cluster had combinations that were more soil conservation. They include crop rotation, intercropping and manure in addition to variety. It could be that over time, they have practiced these combinations and realized low output, hence shying away from them. It is also possible that some of these households have saved over time and therefore can afford more of commercial inputs. The study confirmed earlier findings by Challa *et al.* (2014); Cochrane and Lake (2014); Teklewold *et al.* (2014) that age of the household head is important in adoption decision making. However, Arslan *et al.* (2013) did not find the age of the household head to be significant, citing that only extension services and rainfall variability affect adoption of conservation practices.

5.7. Conclusion

Adoption of a combination of SAIPs is considered as a remedy to the many production challenges that smallholder maize-legume farmers are facing in Kenya. The study analyzed different combinations that were clustered into seven components, composed of homogeneous combinations that were formed using PCA. The index of different SAIPs combination for the household was used as the dependent variables against social capital among other explanatory variables. The descriptive statistics showed that 32% of the respondents in Bungoma; 30% in Tharaka Nithi; 29% in Embu; 31% in Meru and 31% in Siaya received information about SAIPs. This is an average of 31% across the panel. A further lower percentage of those who received information about input prices was reported at 16.2%. This implies that many of the households in the maize-legume system in Kenya do not receive information which is important in adoption decision. On average the natural logarithm of the total amount of money a household saved and the amount they got as income was 7.4 and 9.3 respectively across the panel. The trend for saving and income was relatively higher in the beginning, with a slight drop in the midline and a rise in the end line. Average distance from household homestead was ten minutes' walk. The regression results showed that except for the cognitive aspect of social capital and participation score in groups, the aggregate social capital variable was not significant in explaining adoption of SAIPs combinations. However, age of the household head, whether the household received information about SAIPs and input prices, amount of money that a household saved and that which they received as income positively and significantly influenced adoption of SAIPs combinations. The number of years one had lived in the village was also significant in explaining adoption decisions of a combination of SAIPs. Policy recommendation to government is to consider encouraging and promoting better access of information to smallholder maize-legume farmers. They should also encourage membership and participation in groups.

CHAPTER SIX

SOCIAL CAPITAL EFFECTS ON MAIZE AVAILABILITY EQUIVALENT

6.1. Introduction

In this chapter, the importance of maize and legumes in Kenya is reviewed, an econometric model specification of the ordered logit regression, results and discussions are covered.

6.2. Maize and Legumes in Kenya

Maize and legumes are major crops grown by many households in Kenya. The smallholder maize-legume farmers contribute a bigger percentage of aggregate production in the country. Maize and legume form a major component of many dinner tables. Their availability, accessibility, and stability are vital in many households since their absence implies food insecurity (Yeyo *et al.*, 2014). Maize availability equivalent can be achieved through own production, by buying or and through donations in kind. Accessibility is achieved through the household purchasing power while utilization is dependent on household decision to purchase, prepare and consume (Andersen and Watson, 2011).

The amount of available cereal in the household for use is dependent on factors such as access to essential production resources Yahaya *et al.* (2016), household characteristics and land cultivated (Matshe, 2009). There was a need to evaluate whether social capital, among other factors, makes a household to produce enough for consumption or produce a surplus or have a deficit. This was based on the household cereal requirement per year relative to what they produced, bought or received in form of donations.

6.3. Econometric Model Specification

The maize availability indicator was specified as a measure of the cereal, converted in maize availability equivalent. From intuition and theory, the amount of food (maize availability equivalent) consumed by an individual depends on factors such as age, sex, and occupation subject to availability of food (Mccrory *et al.,* 2000). The average household cereal requirement was estimated using the adult equivalent indicator. The WHO (2008) and FAO (1996) recommends dairy amount of maize cereal of about 400 grams per person per day, which approximates 140 to

146 kilograms per person per year (2100 kilocalories per person per day) (FAO, 1996). If z_i is a household maize requirement for the i^{th} household per day, then, household maize requirement in one year was given as;

$$z_{i1} = f(Hh) \times 365 \quad (6.1)$$

where Z_{i1} represents the amount of maize equivalent that a household needs in one year for consumption purposes. *Hh* is the size of the household expressed as an adult equivalent. This was for calculating the amount of maize that a household required. An ordered logistic regression model was used to analyze factors associated with a household having adequate available maize cereal all the time, sometimes and not having adequate available cereal all the time. The model was ideal because the outcome variables were made ordinal. The threshold for adequacy was be calculated from the average of individual cereal requirements (Owino *et al.*, 2014).

1 – Not having adequate cereal all the time (deficient)
2 – Having adequate cereal sometimes (average/sufficient/break-even)
3 - Household having adequate cereal always (surplus)

If y is an ordered response, taking values 1, 2, 3 and y^* is the latent value of y, then;

$$y_{it}^* = x_{it}\beta_i + \varepsilon_{it} \quad (6.2)$$

The *j* cut off point will be given as $\alpha_1 < \alpha_2 < \alpha_3$ such that;

$$y_{it} = \begin{cases} 1if, y_{it}^* \le \alpha_1 \\ 2if, \alpha_1 \le y_{it}^* \le \alpha_2 \\ 3if, y_{it}^* \ge \alpha_2 \end{cases} \quad (6.3)$$

6.4. Descriptive Statistics

Food scarcity is a major problem facing many households in Kenya. The economic measurement of the scarcity is a challenge because of the differences in calories among food groups. This study measured the household food scarcity using maize availability equivalent. That is, the food

consumption needed in a year was estimated per the adult equivalents for each household. Maize is a staple food in Kenya hence most valuable food commodity which is produced and consumed by many smallholder farmers. Amount of maize required for consumption by each adult equivalent in a household is 400 grams per day (FAO, 1996). The total food production by each household was converted to maize availability equivalent. Therefore, the difference between maize needed for consumption and what is produced by the household represents maize availability equivalent scarcity or surplus. Table 6-1 shows the percentage of households with respective levels of maize availability equivalent.

Table 6-1: Maize Equivalent Balance by Year

	Baseline	Midline	End line
Deficit	34.06	33.47	30.63
Sufficient/break-even	15.94	18.80	16.44
Surplus	50.00	47.73	52.93

About half the households had a maize equivalent surplus in the year 2011. Further, about 15.94% were at risk of food scarcity being with almost just enough food for the family. However, about a third of the households in 2011 had high maize equivalent deficits. The results also revealed that in 2013, there was low food production in the country with the percentage of households experiencing maize equivalent surplus reduced to about 47%. The low production levels of maize in 2013 could be explained by extended electioneering period which had potentials of clashes. This led to more than a half of the respondents being at risk of falling into deficit or just had a deficit of the maize equivalent. Maize availability equivalent production improved in 2015 with about 53% of the households being maize secure with a maize equivalent surplus. This showed that in 2015, there were efforts to increase household food production. This was shown by only a third of the respondents having a deficit in their households and about 16% having exactly what they needed in their households.

6.5. Econometric Results

The maize availability equivalent was ordered into three categories and they included: households with deficits (1), those that are sufficient (2) , and those with surpluses (3). An ordered logistic

regression (xtologit) in STATA 14 was used to determine socioeconomic, institutional and social network factors affecting household maize availability equivalent. An ordered regression model was used to incorporate the time element of the food production in the households. The results of the ordered logistic regression were presented in Table 6-2.

Table 6-2: Ordered Logistic Regression

Variable	Coef.	Std. Err.	P>z
network_density	.0006864	.0013424	0.609
prtcpn_score	-.0377995	.1450644	0.794
Cognscore	-.0018575	.0203964	0.927
mbrshp_score	.0082769	.0646329	0.898
Age	.0096493	.0044119*	0.029
Genderhh	-.2448951	.1527659	0.109
Hhsiz	-.0201322	.0221911	0.364
Educstock	-.0247845	.0031337***	0.000
Farmsiz	.0307633	.0211687	0.146
lTOTAL_sav	.0014828	.0150629	0.922
lTOTAL_incom	.0309805	.0145687*	0.033
got_ext	-.0637267	.120474	0.597
ltotal_credit_rcvd	-.0044538	.0202748	0.826
/cut1	-1.227502	.3749669**	0.001
/cut2	-.5185405	.3737866	0.165

***, **, and * are significant at 10%, 5% and 1% probability levels, respectively.

The results revealed that the higher the **Agehh** (age of the household head), the more maize availability equivalent the household had which was statistically significant at 1% level of significance. This implies that old household heads are more able to secure food for their families compared to the young ones. That is, the new families are faced with many challenges in terms of farming such as inadequacy of farming land and financial resources. The old households have accrued experiences in farming and are well prepared for food shortages. Therefore, it is expected that the old families are more likely to have food surpluses as compared to the upcoming families. The results were consistent with the findings of Abdullah (2017) who alluded that older members of the society are aware of production techniques and patterns of production, hence have a surplus.

The old too could have developed links with other members of their families and friends who can give food donations in times of need. However, this was contrary to the findings of Zakari *et al.* (2014) who found out that age of the household head negatively influenced food security in Bangladesh. According to Zakari *et al.* (2014), young people are energetic and have gathered knowledge on the production techniques, which places them above the older people.

Additionally, the more the **Educstock** (education stock) a household had the less likely they were to have surplus food. The variable was statistically significant at 10% level of significance. The explanation here could be that, the more educated members of a family are, the less likely they are to engage in farming. That is, many smallholder farmers perceive farming to be a meager job hence educate their children and members of the family with the objective of getting greener pastures through employment and diversification in business ventures. Once someone is employed or start a business, the less likely they are to concentrate on subsistence farming. Therefore, the more education stock a household has, the less likely they are to produce food through subsistence farming. The results contradict the findings by Abdullah *et al.* (2017) who found that education positively influenced household food security.

The **lTOTAL_Income** (income received by the household) positively and significantly influenced the amount of maize availability equivalent of a household at 5% level. That is, when the aggregate income of the household increases, the amount of maize availability equivalent in the household increases too. This implies that family with higher income have more financial resources to invest in subsistence farming hence producing more food. This increases their probability of operating on a surplus all the time. The findings are consistent with those of (Babatunde *et al.* 2007; Mannaf* and Uddin, 2012; Zakari *et al.* 2014).

6.6. Conclusion

Almost a third of the respondents across the panel were experiencing maize deficiency. An average percentage of 17% had just enough and only about half of the respondents had a surplus. There was a slight rise in the household having a surplus in 2015 compared to 2011 and 2013. The year 2013 recorded the lowest surplus available maize across the panel. For small-scale maize legume-system, aggregate social capital variable was insignificant in influencing household maize availability equivalent. However, age of the household head and income received by the household

positively and significantly explained household maize equivalency while education stock of a household negative and significantly explained maize equivalency in the household. Policy opportunities targeting improvement maize availability equivalent in smallholder households need to consider age group production, targeting on those with low education levels and diversifying income of these households.

CHAPTER SEVEN

RECOMMENDATIONS AND POLICY IMPLICATIONS

The study recommended the following policies to support smallholder maize-legume farmers in Kenya: First, encouraging and promoting better access to agricultural extension services and training services by government especially in groups. This will improve awareness and reduce the cost of information since most households have more trust in them than other sources. This is also coupled with the fact that information acquisition is very costly. Secondly, encourage membership and participation in beneficial groups where they can acquire beneficial information. Smallholder maize-legume farmers need to be informed on how social capital can benefit them and use it for their gain. They need to develop input and output markets for ease of transactions by farmers. In groups for example, they will be able to know the best SAIPs combinations which they can apply for optimum yield. Lastly, promote and focus on different age group and education levels production in ensuring adequate maize and legumes in the household for consumption. They also need to consider income diversification efforts for these households. Generally, policymakers should enhance information dissemination on SAIPs through social capital forms to maize-legume farmers, as a means of meeting maize and legume requirements now and in the future.

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APPENDICES

Appendix 1: PCA Result

Combinations	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Comp7	Commonality
V	0.0933	-0.0018	0.0523	-0.0853	0.2633	-0.3786	**-0.4729**	0.455019
Vf	-0.0851	0.0537	0.0462	-0.0475	**0.5054**	-0.1780	0.0631	0.305611
Vfi	-0.0600	**0.4963**	-0.0732	0.0958	-0.0067	-0.1378	0.1118	0.295983
Vi	-0.0884	0.0481	-0.0767	**0.6367**	-0.0953	0.0003	-0.0614	0.434250
Vm	0.0138	-0.0335	**0.6939**	-0.0696	-0.0511	0.0079	0.0013	0.490329
Vmf	0.0719	0.0131	0.0374	-0.0622	0.0447	-0.0489	0.7541	0.583665
Vmfi	0.0020	**0.5492**	0.0444	-0.0558	-0.1400	-0.0615	0.0273	0.330837
Vmi	-0.0406	0.0833	0.0807	-0.0769	**-0.5841**	-0.0644	0.0462	0.368468
Vr	0.0346	0.2588	0.0658	-0.0827	0.3202	**0.3824**	-0.1964	0.366674
Vri	-0.0476	-0.0330	-0.0159	0.0144	0.0121	**0.7007**	0.0198	0.495334
Vrm	**0.5036**	-0.0458	0.0458	0.0054	0.0653	0.1311	-0.0003	0.279289
Vrmf	**0.5566**	0.0211	0.0015	-0.0434	0.0416	-0.0629	0.0868	0.325356
Vt	-0.0221	-0.0356	-0.0148	0.0325	**0.3686**	0.1458	0.2719	0.234084
Vit	0.0857	-0.0306	0.0833	**0.7244**	0.0833	0.0083	0.0001	0.546983
Vmt	-0.0354	0.0302	**0.6879**	0.1093	0.0278	-0.0194	0.0270	0.489196
Vrfi	0.0470	**0.6033**	-0.0046	-0.0003	0.0656	0.1005	-0.0496	0.383065
Vrmfi	**0.5939**	0.0297	-0.0637	0.0818	-0.0805	-0.0984	0.0218	0.380986
Vrmi	0.1861	-0.0093	0.0366	-0.0681	-0.1943	0.3094	-0.2460	0.234694

Appendix 2: PCA Estimation; Rotation (unrotated = principal)

Components	Eigen values	Difference	Proportion	Cumulative
Comp1	2.193170	0.343849	0.1218	0.1218
Comp2	1.849320	0.500198	0.1027	0.2246
Comp3	1.349130	0.049361	0.0750	0.2995
Comp4	1.299760	0.130551	0.0722	0.3717
Comp5	1.169210	0.066572	0.0650	0.4367
Comp6	1.102640	0.099333	0.0613	0.4980
Comp7	1.003310	0.007395	0.0557	0.5537
Comp8	0.995912	0.036584	0.0553	0.6090
Comp9	0.959328	0.030797	0.0533	0.6623
Comp10	0.928530	0.051007	0.0516	0.7139
Comp11	0.877523	0.087142	0.0488	0.7627
Comp12	0.790381	0.088364	0.0439	0.8066
Comp13	0.702017	0.025043	0.0390	0.8456
Comp14	0.676974	0.018447	0.0376	0.8832
Comp15	0.658526	0.044164	0.0366	0.9198
Comp16	0.614362	0.169086	0.0341	0.9539
Comp17	0.445275	0.060650	0.0247	0.9786
Comp18	0.384625		0.0214	1.0000

Appendix 3: PCA Components with Eigenvalues >1 Rotated Orthogonal Varimax

Components	Eigenvalue	Difference	Proportion	Cumulative
Comp1	1.98247	0.0701775	0.1101	0.1101
Comp2	1.91230	0.5781040	0.1062	0.2164
Comp3	1.33419	0.0171671	0.0741	0.2905
Comp4	1.31703	0.1091720	0.0732	0.3637
Comp5	1.20785	0.0177580	0.0671	0.4308
Comp6	1.19010	0.1674900	0.0661	0.4969
Comp7	1.02261		0.0568	0.5537

Appendix 4: Component Combinations

Compo1	Compo2	Compo3	Comp4	Compo5	Comp6	Compo7
Vrm	Vfi	Vm	Vi	Vf	Vr	v
Vrmf	Vmfi	Vmt	Vit	Vmi	Vri	
Vrmfi	Vrfi			Vt	Vrmi	

Appendix 5: Conversion Factors to Compute Adult Equivalents

	Adult Equivalence	
Age	**Males**	**Females**
Under 1 year	0.33	0.33
1-1.99	0.46	0.46
2-2.99	0.54	0.54
3-4.99	0.62	0.62
5-6.99	0.74	0.70
7-9.99	0.84	0.72
10-11.99	0.88	0.78
12-13.99	0.96	0.84
14-15.99	1.06	0.86
16-17.99	1.14	0.86
18-29.99	1.04	0.80
30-59.99	1.0	0.82
60 and over	0.84	0.74

Source: World Health Organization

Appendix 6: Three Stage Least-Squares Regression

	Coef.	**Std. Err.**	**z**	**P > z**	**95% conf. Interval**	
network_density						
hh_needcrdt	-4.097163	2.562907	-1.60	0.110	-9.120368	.9260415
lTOTAL_sav	-.2738911	.5030702	-0.54	0.586	-1.259891	.7121084
got_ext	2.362932	2.522593	0.94	0.349	-2.581259	7.307123
ltotal_credit_rcvd	-.2293361	.449034	-0.51	0.610	-1.109426	.6507544
mbrshp_score	22.54674	11.66069	1.93	0.053	-.3077848	45.40127
Genderhh	10.55764	3.522902	3.00	0.003	3.652874	17.4624
Agehh	.2689004	.0930743	2.89	0.004	.0864781	.4513227
Educhh	-.3304109	.4983024	-0.66	0.507	-1.307066	.646244
Hhsiz	-1.328599	.4578447	-2.90	0.004	-2.225958	-.4312398
Farmsiz	.1589368	.311021	0.51	0.609	-.4506532	.7685268
recvd_info_saips	1.011831	2.619776	0.39	0.699	-4.122836	6.146499

lsalaryemploy	-.3182589	.3956792	-0.80	0.421	-1.093776	.4572582
lincom_lbr	-.1378833	.2491903	-0.55	0.580	-.6262874	.3505207
lrent_out_land	.7624524	.7559051	1.01	0.313	-.7190944	2.243999
lremitt_inkind	-.1468854	.2751072	-0.53	0.593	-.6860856	.3923147
yrs_lvd_vlg	.0354888	.0621997	0.57	0.568	-.0864204	.157398
_cons	6.992692	11.94082	0.59	0.558	-16.41089	30.39628
prtcpn_score						
lsalaryemploy	-.0002814	.0050121	-0.06	0.955	-.010105	.0095422
lincom_lbr	-.0037477	.0021956	-1.71	0.088	-.0080511	.0005556
lrent_out_land	.0054997	.0066342	0.83	0.407	-.007503	.0185024
lremitt_inkind	.0003609	.0023463	0.15	0.878	-.0042377	.0049595
mbrshp_score	.05851	.2166126	0.27	0.787	-.3660429	.4830628
Genderhh	.0174267	.0390105	0.45	0.655	-.0590326	.0938859
Agehh	-7.99e-06	.0008328	-0.01	0.992	-.0016403	.0016244
Educhh	.0142167	.0068815	2.07	0.039	.0007293	.0277041
Hhsiz	.0096616	.0042151	2.29	0.022	.0014001	.017923
Farmsiz	.0055651	.0034779	1.60	0.110	-.0012515	.0123817
recvd_info_saips	.0073283	.0240661	0.30	0.761	-.0398404	.0544969
lTOTAL_sav	.0050927	.0072784	0.70	0.484	-.0091728	.0193582
ltotal_credit_rcvd	.008568	.0049141	1.74	0.081	-.0010634	.0181995
llegumepdn	.0019238	.0118789	0.16	0.871	-.0213583	.025206
yrs_lvd_vlg	.0004681	.0005485	0.85	0.393	-.000607	.0015432
hh_needcrdt	-.0171395	.0219291	-0.78	0.434	-.0601197	.0258407
_cons	.167686	.1331108	1.26	0.208	-.0932065	.4285785
cognscore						
Genderhh	.4533008	.1864203	2.43	0.015	.0879237	.8186779
Hhsiz	.0462841	.0276063	1.68	0.094	-.0078233	.1003915
Farmsiz	.0132167	.0170532	0.78	0.438	-.020207	.0466404
recvd_info_saips	.3094196	.1529152	2.02	0.043	.0097114	.6091278
lsalaryemploy	.0149362	.0200227	0.75	0.456	-.0243076	.05418
lincom_lbr	-.0014717	.0150065	-0.10	0.922	-.030884	.0279405
lrent_out_land	-.0271191	.0455472	-0.60	0.552	-.11639	.0621518
lremitt_inkind	.0074659	.0163652	0.46	0.648	-.0246093	.0395412

lTOTAL_sav	.0417606	.0186287	2.24	0.025	.0052491	.0782722
ltotal_credit_rcvd	.0323646	.0255394	1.27	0.205	-.0176918	.082421
lmaizepdn	-.0185366	.0443608	-0.42	0.676	-.1054822	.0684089
llegumepdn	.0481334	.0438233	1.10	0.272	-.0377586	.1340255
yrs_lvd_vlg	-.0049153	.0037809	-1.30	0.194	-.0123258	.0024952
got_ext	-.0909422	.1485684	-0.61	0.540	-.3821309	.2002465
hh_needcrdt	.34938	.1556784	2.24	0.025	.044256	.654504
_cons	6.582874	.3870008	17.01	0.000	5.824366	7.341381
mbrshp_score						
nd_crdt_seed	-.066329	.0645905	-1.03	0.304	-.1929241	.0602662
network_density	-.017524	.0365098	-0.48	0.631	-.0890819	.0540338
Genderhh	.0037727	.2888597	0.01	0.990	-.5623819	.5699273
Agehh	.0069526	.0112465	0.62	0.536	-.0150901	.0289953
Educhh	.0355245	.0145624	2.44	0.015	.0069828	.0640663
Hhsiz	-.0120996	.0431124	-0.28	0.779	-.0965983	.0723991
Farmsiz	.0191069	.0185486	1.03	0.303	-.0172477	.0554614
recvd_info_saips	.0935271	.1035796	0.90	0.367	-.1094852	.2965393
lsalaryemploy	.020814	.0099257	2.10	0.036	.00136	.0402681
lincom_lbr	.0013819	.0070766	0.20	0.845	-.012488	.0152517
lremitt_inkind	-.0013742	.0085983	-0.16	0.873	-.0182266	.0154782
lTOTAL_sav	.0397563	.0171145	2.32	0.020	.0062125	.0733002
ltotal_credit_rcvd	.0183889	.012419	1.48	0.139	-.0059519	.0427297
lmaizepdn	-.015119	.0218745	-0.69	0.489	-.0579922	.0277543
hh_needcrdt	-.0466432	.1558825	-0.30	0.765	-.3521673	.2588809
got_ext	-.0415496	.0757288	-0.55	0.583	-.1899753	.1068762
yrs_lvd_vlg	.0014758	.0025079	0.59	0.556	-.0034396	.0063912
llegumepdn	.0785194	.0470518	1.67	0.095	-.0137004	.1707391
_cons	.969037	.7106633	1.36	0.173	-.4238374	2.361911

Appendix 7: Seemingly Unrelated Regression (SUR) Model

Equation	**Obs**	**Parms**	**RMSE**	**"R-sq"**	**chi2**	**P**
factor_1	780	12	.344552	0.0304	24.43	0.0178
factor_2	780	12	.3667739	0.0162	12.81	0.3828

factor_3	780	12	.6316	0.0407	33.12	0.0009
factor_4	780	12	.7313576	0.0556	45.91	0.0000
factor_5	780	12	1.530184	0.0348	28.09	0.0054
factor_6	780	12	.9136515	0.0312	25.13	0.0142
factor_7	780	12	1.764494	0.0524	43.11	0.0000

	Coeff	Std err	Z	P>|z|	[95% Conf.	Interval]
factor_1						
network_density	-.000025	.0003417	-0.07	0.942	-.0006947	.0006446
prtcpn_score	-.0253642	.0311011	-0.82	0.415	-.0863212	.0355928
cognscore	.0011467	.0043847	0.26	0.794	-.0074472	.0097406
mbrshp_score	.0142606	.0140729	1.01	0.311	-.0133218	.041843
Agehh	-.0009152	.0008743	-1.05	0.295	-.0026289	.0007985
recvd_info_saips	-.0549657	.0272703	-2.02	0.044	-.1084146	-.0015169
lTOTAL_sav	.0043498	.0031647	1.37	0.169	-.0018529	.0105524
lTOTAL_incom	.0003735	.0032063	0.12	0.907	-.0059108	.0066578
avrg_plot_dist	.0001365	.0006914	0.20	0.843	-.0012186	.0014916
yrs_lvd_vlg	-.0009822	.0006657	-1.48	0.140	-.0022869	.0003226
got_ext	-.0214387	.0262926	-0.82	0.415	-.0729712	.0300939
info_inpt_mkts_price	.1182009	.033539	3.52	0.000	.0524656	.1839362
_cons	.1971315	.07735	2.55	0.011	.0455284	.3487347
factor_2						
network_density	.0000196	.0003637	0.05	0.957	-.0006932	.0007324
prtcpn_score	.0083834	.033107	0.25	0.800	-.0565051	.0732718
cognscore	.001969	.0046675	0.42	0.673	-.0071791	.0111172
mbrshp_score	.0095985	.0149805	0.64	0.522	-.0197628	.0389598
Agehh	-.001189	.0009307	-1.28	0.201	-.0030132	.0006352
recvd_info_saips	.0500359	.0290291	1.72	0.085	-.0068601	.1069319
lTOTAL_sav	-.0074668	.0033688	-2.22	0.027	-.0140695	-.0008641
lTOTAL_incom	-.0010904	.0034131	-0.32	0.749	-.00778	.0055993
avrg_plot_dist	-.0003675	.000736	-0.50	0.618	-.00181	.001075
yrs_lvd_vlg	-.0010256	.0007087	-1.45	0.148	-.0024145	.0003634
got_ext	.0029014	.0279883	0.10	0.917	-.0519547	.0577576

info_inpt_mkts_price	.0329956	.0357021	0.92	0.355	-.0369793	.1029706
_cons	.284069	.0823387	3.45	0.001	.1226882	.4454498
factor_3						
network_density	.0002322	.0006263	0.37	0.711	-.0009952	.0014597
prtcpn_score	.0916751	.0570116	1.61	0.108	-.0200655	.2034158
cognscore	.0182165	.0080376	2.27	0.023	.002463	.03397
mbrshp_score	-.0053797	.0257971	-0.21	0.835	-.0559411	.0451817
Agehh	-.0011879	.0016027	-0.74	0.459	-.0043292	.0019534
recvd_info_saips	-.1050735	.0499894	-2.10	0.036	-.2030508	-.0070962
lTOTAL_sav	-.0023699	.0058012	-0.41	0.683	-.01374	.0090002
lTOTAL_incom	-.0142576	.0058776	-2.43	0.015	-.0257774	-.0027378
avrg_plot_dist	.004459	.0012674	3.52	0.000	.001975	.006943
yrs_lvd_vlg	-.0022572	.0012203	-1.85	0.064	-.004649	.0001346
got_ext	.0681876	.0481971	1.41	0.157	-.0262769	.1626522
info_inpt_mkts_price	.0444579	.0614806	0.72	0.470	-.0760418	.1649577
_cons	.2065787	.1417906	1.46	0.145	-.0713258	.4844832
factor_4						
network_density	-.0002651	.0007252	-0.37	0.715	-.0016865	.0011563
prtcpn_score	.1670498	.0660162	2.53	0.011	.0376603	.2964392
cognscore	.0178917	.0093072	1.92	0.055	-.00035	.0361334
mbrshp_score	-.0314205	.0298716	-1.05	0.293	-.0899678	.0271268
Agehh	.000186	.0018559	0.10	0.920	-.0034515	.0038234
recvd_info_saips	-.0786847	.0578849	-1.36	0.174	-.1921371	.0347676
lTOTAL_sav	.0018786	.0067174	0.28	0.780	-.0112874	.0150445
lTOTAL_incom	-.0105565	.0068059	-1.55	0.121	-.0238958	.0027828
avrg_plot_dist	.0074316	.0014676	5.06	0.000	.0045552	.010308
yrs_lvd_vlg	-.0027172	.0014131	-1.92	0.054	-.0054868	.0000524
got_ext	.0957687	.0558095	1.72	0.086	-.013616	.2051534
info_inpt_mkts_price	-.0671763	.0711911	-0.94	0.345	-.2067084	.0723557
_cons	.101728	.1641857	0.62	0.536	-.22007	.4235259
factor_5						
network_density	.000914	.0015173	0.60	0.547	-.0020598	.0038879
prtcpn_score	.1094378	.1381225	0.79	0.428	-.1612774	.380153

Cognscore	.0415014	.0194729	2.13	0.033	.0033352	.0796675
mbrshp_score	.0539305	.0624989	0.86	0.388	-.0685652	.1764261
Agehh	-.0021651	.003883	-0.56	0.577	-.0097756	.0054454
recvd_info_saips	-.174085	.1211097	-1.44	0.151	-.4114557	.0632857
lTOTAL_sav	-.0002509	.0140546	-0.02	0.986	-.0277974	.0272955
lTOTAL_incom	-.0332363	.0142396	-2.33	0.020	-.0611454	-.0053271
avrg_plot_dist	.0099061	.0030705	3.23	0.001	.003888	.0159242
yrs_lvd_vlg	-.0066175	.0029565	-2.24	0.025	-.0124122	-.0008228
got_ext	.1424433	.1167676	1.22	0.223	-.0864169	.3713036
info_inpt_mkts_price	.0218123	.1489497	0.15	0.884	-.2701237	.3137482
_cons	.470291	.3435176	1.37	0.171	-.2029911	1.143573
factor_6						
network_density	.0004464	.000906	0.49	0.622	-.0013293	.002222
prtcpn_score	.1010954	.0824711	1.23	0.220	-.0605449	.2627357
cognscore	.0222917	.011627	1.92	0.055	-.0004968	.0450802
mbrshp_score	.012255	.0373172	0.33	0.743	-.0608855	.0853954
Agehh	-.0047531	.0023185	-2.05	0.040	-.0092972	-.000209
recvd_info_saips	-.0395904	.0723129	-0.55	0.584	-.1813211	.1021404
lTOTAL_sav	.0024961	.0083918	0.30	0.766	-.0139515	.0189437
lTOTAL_incom	-.0147518	.0085023	-1.74	0.083	-.031416	.0019123
avrg_plot_dist	.0063814	.0018334	3.48	0.001	.0027881	.0099747
yrs_lvd_vlg	-.0003242	.0017653	-0.18	0.854	-.0037841	.0031357
got_ext	.0098568	.0697203	0.14	0.888	-.1267925	.1465061
info_inpt_mkts_price	-.0862174	.0889358	-0.97	0.332	-.2605284	.0880935
_cons	.3595526	.2051096	1.75	0.080	-.0424548	.76156
factor_7						
network_density	-.0003021	.0017496	-0.17	0.863	-.0037314	.0031271
prtcpn_score	.3809799	.1592726	2.39	0.017	.0688112	.6931485
cognscore	.0313356	.0224547	1.40	0.163	-.0126747	.075346
mbrshp_score	-.0217254	.0720691	-0.30	0.763	-.1629782	.1195275
Agehh	-.0014218	.0044776	-0.32	0.751	-.0101977	.0073541
recvd_info_saips	-.2347905	.1396547	-1.68	0.093	-.5085088	.0389277
lTOTAL_sav	.000872	.0162067	0.05	0.957	-.0308926	.0326365

lTOTAL_incom	-.0338864	.0164201	-2.06	0.039	-.0660692	-.0017036
avrg_plot_dist	.0176516	.0035407	4.99	0.000	.010712	.0245912
yrs_lvd_vlg	-.004193	.0034092	-1.23	0.219	-.010875	.002489
got_ext	.1375313	.1346477	1.02	0.307	-.1263733	.4014359
info_inpt_mkts_price	-.304698	.1717577	-1.77	0.076	-.6413369	.0319408
_cons	.6816033	.3961189	1.72	0.085	-.0947755	1.457982

Appendix 8: Ordered Logistic Regression

Varisble	**Coef.**	**Std. Err.**	**Z**	**P>z**	**[95% Conf. Interval]**	
network_density	.0006864	.0013424	0.51	0.609	-.0019445	.0033174
prtcpn_score	-.0377995	.1450644	-0.26	0.794	-.3221205	.2465215
Cognscore	-.0018575	.0203964	-0.09	0.927	-.0418337	.0381188
mbrshp_score	.0082769	.0646329	0.13	0.898	-.1184012	.134955
Age	.0096493	.0044119	2.19	0.029	.0010021	.0182965
Genderhh	-.2448951	.1527659	-1.60	0.109	-.5443109	.0545206
Hhsiz	-.0201322	.0221911	-0.91	0.364	-.0636259	.0233615
Educstock	-.0247845	.0031337	-7.91	0.000	-.0309265	-.0186425
Farmsiz	.0307633	.0211687	1.45	0.146	-.0107265	.0722531
lTOTAL_sav	.0014828	.0150629	0.10	0.922	-.0280399	.0310056
lTOTAL_incom	.0309805	.0145687	2.13	0.033	.0024264	.0595346
got_ext	-.0637267	.120474	-0.53	0.597	-.2998513	.172398
ltotal_credit_rcvd	-.0044538	.0202748	-0.22	0.826	-.0441916	.0352841
/cut1	-1.227502	.3749669	-3.27	0.001	-1.962424	-.4925806
/cut2	-.5185405	.3737866	-1.39	0.165	-1.251149	.2140678