EFFECTS OF AREA - YIELD INDEX CROP INSURANCE (AYII) ON FOOD SECURITY: A CASE STUDY OF NJORO SUB-COUNTY

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DECLARATION

This research paper is my original work and has not been previously published or presented in any other university.

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This paper has been submitted for examination with my approval as the University Supervisor.

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DEDICATION

To my family for their love, care and endless support throughout the entire academic period.

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ACRONYMS

ADBs	Agricultural Development Banks
ASALs	Arid and Semi-Arid Areas
ATE	Average Treatment Effect
ATU	Average Treatment for the Untreated
AU	African Union
AYII	Area Yield Index Insurance
CI	Crop Insurance
ESR	Endogenous Switching Regression
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GMRS	Guaranteed Minimum Returns Scheme
GoK	Government of Kenya
HFIAS	Household Food Insecurity Access Scale
IAIA	International Association for Impact Assessment
IMR	Inverse Mill's Ratio
IPWRA	Inverse Probability Weighted Regression
IV	Instrumental Variables
MoALF	Ministry of Agriculture, Livestock, and Fisheries
NFNP	National Food and Nutrition Policy
OLS	Ordinary Least Squares
PPP	Public-Private Partnership

PSM	Propensity Score Matching
SDGs	Sustainable Development Goals
SSA	Sub-Saharan Africa
UAI	Unit Area of Insurance
UNCFS	United Nations' Committee on World Food Security
UNHCR	United Nation High Commission for Refugee
WFO	World Food Organization
WTP	Willingness to Pay

ABSTRACT

Achieving food security in developing countries is the main objective of every country especially those whose economy is largely controlled by the agricultural sector. Nevertheless, the escalating impacts of climate change are compromising the achievement of this objective due to dwindling agricultural output. This has necessitated the institution of a number of policy reforms and initiatives guide to effectively address food insecurity problems and ensure a healthy labour force. Some of the initiatives include a number of pilot programs for index insurance that has increased massively in recent years, but little has been done to estimate the effects and overall performance. Although crop insurance has been promoted as a prospective tool to suffice production risks associated with weather variability, its uptake evidence is limited, thus, this study sought to unpin the drivers of adoption decisions, resultant effects and suggest alternatives for improving the scheme. Data was collected from 233 small-scale farmers where AYII had been promoted. Results indicated that the uptake rate for crop insurance is relatively low and decreasing, as farmers do not understand the concept of AYII well due to its complexity. Additionally, basis risk hinders the uptake as farmers displayed discontent with their compensation claims due to loss. Furthermore, the size of land under maize, nearness to the motorable road, age, membership to a farming group and awareness significantly increase the probability of engaging in crop insurance. In terms of the effects of participating in AYII and the vulnerability of being food insecure, the study revealed that participating in crop insurance reduces the food insecurity index thus making households better off with insurance than without. Therefore, the results highlight the necessity to train farmers about the concepts of insurance and related goods since insurance is one of the risk management mechanisms. Similarly, the selection of target crop enterprises and designing of crop insurance products need to include all relevant participants to boost uptake.

Keywords: Area yield index, crop insurance, food security, risk management, and basis risk.

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CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

Food security occurs when at all times, all people have physical, social and financial access to sufficient, safe and nutritious food for meeting their dietary requirements and food tastes for a healthy and active life (FAO, 1996a; UNCFS, 2011). The concept of food security is based on four pillars of food that include availability, access, utilization, and stability. At the national level, different factors, for instance, the level of farming production, nature of infrastructure, government policies, and gender concerns among others play a critical part and affect food consumption patterns, health services, and the environment specifically for the households and communities at a lower level. Enhanced food availability and access, together with care determine an individual's food consumption. Consequently, the inclusion of the aspects of care, health and sanitation affects the health status of an individual. Additionally, food consumption and health status define an individual's level of food and nutrition security (Maxwell & Smith, 1992; Edward, 2002).

Food security as an elementary human right encompasses the right to safe and nutritious food (FAO, 1996; WFP/UNHCR, 1997). Entitlement to safe and nutritious food translates to adequate food distribution or purchasing power to get food (Sen, 1994 and 1996, FAO; 1996; Pretty *et al.*, 1996). For a country to be food secure, it must have reliable production and storage capacity, ensure fairness in food and productive resources access for all subject to entitlement and ensure sufficiency or ability to cope up with insufficiency (Maxwell, 1991; Barraclough, 1996; FAO, 1996). Food insecurity is evidenced by famines and food emergencies due to a decline in food production. It can be chronic (long term) due to continuous inadequate consumption as a result in low production, limited income and poor health or transitory (current) due to a temporary decline in consumption as a result of instability in food production and changes in food prices, income and health conditions.

Economically, Kenya still struggles with agriculture as a crucial driver to long-term economic transformation. The majority of Kenya's population live in rural parts where their livelihood mainly depends on agriculture, earning all or part of their income from this sector (Olila & Pambo, 2014). Over 75 percent of Kenyan farmers are subsistence smallholder whose farming systems are highly constrained by factors such as low investment capacity and adoption of modern technology,

low access to credit and essential inputs, inadequate value addition and markets infrastructure, and high vulnerability to agricultural risks and hazards (GoK, 2017). In order to transform the agricultural sector in line with the Vision 2030 Development Agenda and the Big Four Agenda, the majority of vulnerable smallholder farmers require support to transit from subsistence farming to commercially oriented farming. This is possible through access to financial and insurance services, adoption of technology and the use of improved inputs (MoALF, 2015).

Farmers remain vulnerable to natural disasters, a fact that poses serious social-economic problems. Several studies show that about 16 percent of Kenyan landmass is a potentially highly agricultural productive area while the remaining part represent semi-arid and arid area with low production potential. Semi-arid areas are merely favourable for rain-dependent crop farming and livestock rearing majorly for subsistence producing barely enough food for human survival (Kinyua, 2004). Rain-fed crop farming has a high probability of failure with semi-arid areas having a 25-75 percent risk while the arid regions have a 75-100 percent risk (Biamah, 2005). Therefore, as noted by Ngaira (2005), the most adversely affected sector by climatic variability is agriculture, which has dire implications on food security.

Kenya faces conditions of adverse weather effects twice and severe drought once in almost every decade. For instance, more than 12 serious droughts have been recorded since 1990, each affecting more than 5 million individuals and an estimated annual average loss of about US$1.25 billion, while at the same time decreasing the gross domestic product (GDP) by an average of 3.3 percent (GoK, 2017). Such devastating conditions of droughts push better off farmers into a vicious cycle of poverty making it more difficult or costly to access loans thus limiting opportunities to invest in better tools and technologies for increased productivity.

In Kenya, food sustainability largely depends on the accessibility and availability of maize, which is an essential measure of food security (NFNP, 2011). Countrywide, for every three (3) farmers, two (2) of them grow maize making maize farming the main agricultural activity to most rural households (Kibaara, 2005). However, key challenge experienced with maize production is the variability of weather, which has adverse effects of crop failure. Since maize serves as the main source of food, livelihood and as a major agricultural crop, this has necessitated government interventions in enacting agricultural reforms (Nzuma & Sarker, 2010). Therefore, risk transfer

through agricultural insurance is an important mechanism for unlocking access to credit and investment in yield boosting tools and technologies adoption among smallholders.

Naturally, agriculture is a risky business and farmers experience various risks and uncertainties including weather variability, incidents of pest and disease outbreak, input supply and market-related risks (Hazell, 1992). In developing countries, whether related perils poses pervasive risks to millions of poor rural households particularly those whose livelihood primarily depends on agriculture. Several studies, for example, Anderson *et al*. (2004), Hazell & Skees, (2005), Thornton *et al*. (2011) and Harvey *et al*. (2014) show that prevalence and severity of livestock death and crop loss due to weather variability is on the rise. Increased weather variability harms the economy by decreasing demand for agricultural investment resulting in declined agricultural productivity, high cases of food insecurity and reduced resilience of the households heavily relying on rain-dependent farming (Alderman & Haque, 2007; Mahul & Stutley, 2010).

However, the problem is worsened by the absence of institutions that provide formal financial services including credit, deposit, and insurance services in these regions. This, in turn, force the poor to employ traditional mechanism such crop diversification, risk avoidance, and information risk-sharing practices that offer inadequate risk protection or are costly, especially against widespread catastrophic weather events (Dubois, Julien & Magnac, 2008). In developing countries, extreme weather variability is a major cause of uncertainty in agriculture providing researchers and policymakers an opportunity to rethink the issue of risk management (Anton *et al*., 2013). For most of sub-Sahara African (SSA) countries, almost 86 percent of the households primarily rely on farming for income (Alderman & Haque, 2007; Nnadi *et al*., 2013). Insurance in agriculture is one of the financial mechanisms designed to mitigating risks within the agricultural sector by enhancing farmers' welfare (Nahvi *et al*., 2014).

Weather variability and external shocks result in economic loss for poor households whose livelihood largely depend on agriculture (Nnadi *et al*., 2013). This is because, in SSA, farming is highly weather or rainfall reliant and any variations in climatic conditions cause great agricultural loss and compromised livelihood (Barnett *et al*., 2006). This inhibits human development and the realization of Sustainable Development Goals (SGDs) especially no poverty and zero hunger by 2030. Recently, these impacts have increased because of global warming (Barnett *et al*., 2007).

Within East African region, several research findings show that episodic floods and droughts have led to substantial economic damages with an estimated long-term decrease in GDP of about 1-3 percent annually and based on forecast, by 2030, these economies will incur losses of 5-10 percent of GDP due to climate change (Smith & Glauber, 2012).

Dependence on rainfall for agriculture intensifies the tendency of agrarian-based SSA economies to face production and price perils due to unfavourable weather conditions (Barnett & Mahul, 2007). Recently, policymakers and scientists have recognized the importance of using index-based (weather or yield) insurance to offer farmers risk reduction alternatives to hedge themselves against the effects of climate change. Area/yield index-based crop insurance gives a favourable alternative against traditional risk mitigation mechanisms by supporting households who are resource-poor deal with weather-related risks better through income growth (Cole *et al*., 2012). Recently, index-based insurance in the agricultural sector has been promoted as a potential tool capable to improve farmers' prosperity, use of improved farming input, technology adoption and small-scale farming investments (Alderman & Haque, 2007; Hazell & Hess, 2010). In developing countries, reducing susceptibility to weather-related shocks is imperative to assure food security and reduce GDP loss due to adverse weather change by 20 percent (Barnett *et al*., 2006).

1.1.1 Food Security in Kenya

The problem of food insecurity is evidenced by famines and food emergencies associated with low food production as a result of weather variability. In almost every decade, Kenya faces conditions of adverse weather effects twice and severe drought once (Nyamwange, 1995). For instance, more 12 serious droughts have been recorded since 1990 and over the past 100 years, the country has faced more than 28 major droughts, of which three of them were recorded in the 1990s. However, the incidence and severity of droughts appear to intensify as time pass by (Murungaru, 2003). In the last half of the 20th century, droughts incidence in Kenya occurred in the year 1951, 1952-55, 1957-58, 1974-76, 1980-81, 1983-85, 1987, 1992 93, 1995-96, 1999-2000 and 2004-06 (Ngaira, 2004). For example, from 1990, the country has experienced seven national disasters due to drought and flood-related effects in the year 1992-93, 1995-96, 1999-2001, 2004-2006, 2008-09, and in 1997-98 and 2003 respectively. According to Oxfam (2006), in ASALs regions, incidents of droughts in Kenya are becoming common nowadays while cases of non-drought years the exception.

The reasons for food insecurity are diverse ranging from war, poverty, limited agricultural technology, inappropriate policies, high population, and environmental issues among others. Hunger in Kenya can be attributed to insufficient resources to purchase food based on available supplies and population growth rates. High-income inequality aggravates the problem of food insecurity especially chronic hunger. Agricultural production has been declining sharply, for example, in 2018 there was a slow growth rate of 2.3 percent due to delayed long rains and low volume of short rains (GoK, 2018). Small-scale farmers dominate the agricultural sector accounting for more than 75 percent of total production and at least 30 percent of marketed output. Additionally, smallholding averages to 2-5 hectares while large scale averages to 50 hectares and above.

The main objective of the agricultural sector is the realization of national food security. However, in recent years, particularly starting of 2008, Kenya has been facing severe food insecurities problems associated with extreme weather variability leading to years of droughts and sometimes floods. This is evident by the high percentage of the population with limited or no access to enough and nutritious food. Countrywide, a population of more than 10 million experiences conditions of food insecurity where nearly all depending on relief foodstuff especially during extreme years. Generally, problems of food insecurity are worsened by incidents of frequent drought in many areas of the nation leading to low supply and limited choice for other foodstuffs, high food prices, low purchasing power and increased cost of local food production due to the increased expenditure on inputs. This, in turn, makes households to incur high food bills.

Although the country is now considered as a lower-middle-income country, there still exists an inequality gap in terms of income. Having a population of more than 47 million people, more than 33% of the people still lives under less than US$ 1.90 a day (the international poverty line) making them food insecure as social, economic and gender inequalities remain. Access to the right amount and quality of food for a greater number of households, predominantly in semi-arid and arid regions remains a challenge. Having a high population growth rate of about 2.9 percent annually, low and deteriorating agricultural production, inefficient food systems and exposure to climate change significantly contribute to food problems (GoK, 2017; WFP, 2016). However, the Government of Kenya through the agricultural institutions has initiated a number of policy

interventions related to supply, prices and income with an overall aim of addressing food insecurity problems.

1.1.2 Kenyan Agricultural Insurance

Agricultural insurance refers to a risk management instrument that offers farmers' economic or financial safety against production losses due to weather-related peril, through risk transfer from one individual to another in exchange for a premium (Hazel, 2000; Mahul & Statley, 2010; Rao, 2010; Nnadi *et al*., 2013). Therefore, crop insurance covers or insures farmers against losses associated with crop failure and acts as an alternative to relief measures. Risk aversion has, for a very long time seen as a limiting factor to farmers' decision to technology adoption, investment and welfare enhancement in agriculture (Lipton, 1989). However, since the colonial time, Kenya has introduced a number of reforms in the agricultural sector designed at boosting or enhancing agricultural output to ensure food security and improve citizens' well-being.

1.1.2.1 Guaranteed Minimum Returns (GMR) Scheme

In the 1930s, the colonial government introduced the initial or first-ever insurance to cover farmers. It had an overall objective of compensating farmers against inevitable crop failure associated with nature by offering a well-interlinked system of insurance, credit and marketing services. However, unfortunately, in 1978, stakeholders decided to scrape off the program due to misuse (Kerer, 2013).

1.1.2.2 Kilimo Salama

In the early 2000s, some of the leading insurance firms or corporations in Kenya entered into crop and livestock insurance business. Consequently, in 2009, efforts by the private sector to revive the agricultural insurance program bore fruits through the launch of an insurance scheme dubbed *"Kilimo Salama"* meaning safe farming. The program offered crop-related insurance products such as Loan-Linked Insurance, Contract Seed Grower Insurance, and Replanting Guarantee Scheme (Syngenta Foundation for Sustainable Agriculture, 2018).

1.1.2.3 Kenya Agricultural Insurance and Risk Management Program

Private-sector efforts to insure farmers against crop loss paved the way for the government to provide a funding window as a partnership with the private sector for crop insurance. In 2015, the Ministry of Agriculture launched this program to insure or hedge farmers practicing small-scale farming against risks and uncertainties such as crop failure and livestock mortality. The program

addresses the challenges that farmers experience in presence of high production shocks and targets at improving their financial resilience to production shocks and facilitate the adoption of improved farming technologies. The program provides for area/yield index insurance for semi-commercial cereal producers such as maize and wheat, with payments subsidized by the government (MoALF, 2015). During the initial or pilot stages of area/yield crop insurance, maize and wheat were selected as pilot crops due to their relevance in terms of food security, impact on the agricultural economy, and suitability for coverage with Area Yield Index Insurance (AYII) products.

The scheme was piloted for maize in three counties namely; Embu (West-Embu and Runyenjes), Bungoma (Bumula) and Nakuru (Rongai) before expanding to other counties. Through AYII, insured farmers within a defined Unit Area of Insurance (UAI) receive a payout if the area average yield for that UAI is lower than a predetermined threshold. AYII is preferred to traditional insurance solutions, due to its advantages of low information asymmetry and low administration costs. Moreover, this type of crop insurance has the potential to unlock finance and inputs access amongst smallholder subsistence farmers if seasonal production credit is linked to insurance through public and private banks. However, "Basis Risk" is the main drawback of this type of insurance where an individual farmer suffers severe crop yield losses due to a localized peril, but because these localized losses do not affect the average area-level yield, the farmer does not receive any compensation.

1.2 Problem Statement

Weather variability, risks and limited investment in agriculture lead to a declined in agricultural production. Consequently, this undermines food availability and access leading to the overall problem of food insecurity. To address this problem, it is paramount to ensure efficient crop production through increased investment particularly increasing yields on the small farm level which represents the biggest part of agricultural production in most countries and can provide higher incomes with decreased income differentiation. This, therefore, provides an opportunity for institutions, companies, and firms in the insurance sector to offer coverage against agricultural risks and uncertainties. AYII has been introduced to enable resource-poor farmers' primarily those whose livelihood depends on rain-fed agriculture to better deal with weather-related shocks, by enhancing their wellbeing and improving their income growth opportunities.

However, nearly in all developing countries, full implementation of crop insurance program(s) has been coupled with a number of challenges such as sustainability, although, this provides opportunities for sustainable livelihood if well designed, implemented and managed. Despite seamless determinations to revive agricultural insurance sector in Kenya, a gap of a clear practical proof exists on the contributions of crop insurance on food security as well as factors affecting farmers' decisions to take agricultural insurance. Therefore, it is important to assess these effects as well as determinants for the adoption with the objective of providing evidence-based policy recommendations appropriate for sustainability of agricultural risk mechanisms.

1.3 General Objective

The purpose of the study is to evaluate the role of area-yield index crop insurance on food security.

1.3.1 Specific Objectives

i. To investigate whether social-economic factors affect farmers' decision to take up crop insurance.
ii. To estimate the effects of the area- yield index crop insurance on food security.
iii. To recommend relevant policies aimed at enhancing the feasibility of crop insurance programs for food security sustainability.

1.4 Research Hypotheses

The null hypotheses are;

i. Social-economic factors have no effect on farmer's decision to take up crop insurance.
ii. Area-yield crop insurance has no effect on food security.

1.5 Justification

The GoK identifies agriculture as the main driver to economic prosperity and has introduced different measures to promote agricultural growth through mitigating climate change risks. Some of the approaches include allocation of resources and production choices that are market-oriented, awareness creation to farmers to embrace farming technologies and use of improved inputs, and environmental sustainability. Climate change presents a multifaceted situation that poses serious risks towards the growth and development of the agricultural sector by affecting production through interruption of agrarian practice especially planting and harvesting patterns, all linked to rainfall.

The sector contributes to food security by providing income for a large number of the rural residents thus the achievement of the Big Four Agenda and Sustainable Development Goals (SDGs) 1 and 2. Food security provides for a healthy workforce thus leading to improved productivity. The problem of food insecurity can be solved through efficient design and implementation of relevant policies together with proper budgetary allocation. Therefore, this research study aims to unearth the effects and determinants of crop insurance (AYII) adoption and formulate evidence-based policy recommendations that will be of relevance to the government in designing different methods and measures to facilitate increased adoption thus boosting food security and promoting agricultural growth.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of relevant literature to this study both theoretical and empirical used to identify existing research gaps.

2.2 Theoretical Literature Review

2.2.1 Agricultural Household Theory

Most developing countries' economies are characterized by the agrarian system, which, serves as a key source of earnings especially to most of the rural households and a source of foreign exchange. This makes the agricultural sector a central point for government policies, which, affect and are affected by farm households behaviour. Agriculture in rural areas is often subsistence where households produce mostly for own consumption, partly for sale and buy some inputs such as labour and fertilizer. Therefore, the concept of agricultural households covers a continuum of households' ranging from pure subsistence to commercial farming. Any alteration in policies governing agricultural activities affects production, consumption and labor supply.

Generally, any study examining farm households' consumption or labour patterns has to take into consideration the interdependency between production and consumption behaviours. Agricultural or farm household modeling consists of the household and the firm where the two are linked since farm enterprise activities contribute to household income, and therefore affect household consumption patterns. Under certain circumstances, the only interdependence between economic agents' activities is through income. However, to analyze household behaviour based on consumption and production activities, the model is split into utility-maximizing and profit-maximizing components. In a production cycle, the household maximizes utility function subject to the level of income, production capacity and time (Singh *et. al.*, 1986).

The Theory of Household Production, therefore, posits that households act as both consumers and producers of goods with the aim of maximizing utility. This therefore simplifies the theory to the study of household's decisions on production, consumption and time allocation. In a static model, households are assumed to be price takers for every commodity including labor and commodities being homogenous. By maximizing utility, households choose the optimal consumption level of agricultural staple good, a market purchased good together with leisure subject to constraints.

Budget/income constraint shows that the household's expenditure on the three goods cannot exceed the available income. Time constraint means that it's not possible to spend more time than available. Production or technology constraint represents the farm's output given the available resources or inputs. However, the model assumes single crop, perfect substitution between on-farm and non-farm labour and risk-free production. Therefore, the household's production employs the interdependency of all constraints to maximize efficiency and offer the highest utility.

2.2.2 Rational Choice Theory

This theory refers to the basis for understanding and modelling human behaviour in a social-economic setting. The theory assumes that an individual has preferences that are complete and transitive, and depend on rational calculations to attain outcomes that are consistent with own personal objectives. In this theory, rationality is the basic guiding decision making among alternatives whose result maximizes pleasure or profit by choosing the best choice of action. However, according to rational choice theorists, the theory simply foretells the outcome and sequence of choices rather than description of the choice process. An important assumption often included in this model is that individual preferences are self-centered where individuals act as if balancing benefits and costs to arrive at a decision that maximizes expected utility subject to relevant information (von-Neumann & Morgenstern, 1944).

The theory specifies that all decisions are guided by preferences, beliefs, and constraints. Preferences represent individuals' value attached to the possible outcomes of their actions. The theory's core was subsequently developed by what is now referred to as neoclassical economics. Three key assumptions are important: (i) individuals have selfish preferences, (ii) they maximize their own utility, and (iii) they act independently based on full information. The theory has been widely applied in many disciplines of the social sciences to model and understand human behaviour ranging from consumer and producer choice, managerial decision-making, financial investments in business, education, among others (Becker & Becker, 1997).

In a decision-making model or approach, a choice represents a decision made by an agent capable of consideration rather than merely an event that occurs (Pettit, 1991). The primal objective of this theory is to predict and explain human behaviour in terms of laws governing expected utility and resultant actions (Eells, 1982). Rational choice theorists argue that individuals must predict the outcomes of different actions and choose the alternative with the possibility of producing the

highest utility (Heath, 1976; Carling, 1992; Coleman, 1973). The theory is, therefore, relevance in understanding choice behaviours such as a decision to take insurance or not and determining consumption and production choices.

2.3 Empirical Literature Review

Various studies have looked at the relationship between agriculture, welfare, and development. For instance, finding by Hazell (1992) showed that insurance plays a key role in enabling farmers allocate resources in an efficient manner in order to maximize farm profit leading to increased value addition in agriculture, increased income and decline in poverty levels. However, the success of the insurance program was attributed to the nature of risks insured- insurable or uninsurable while failure was attributed to high premium and administration costs (small farms), investment in uninsurable risks, incentive problem, moral hazard, political interference and too high cost due to over-specialization. For the success of the program, the study proposed insurer to be financially responsible, coverage to be strictly on insurable risks, compensation to be only on actual loss and inclusion of deductible of at least 20 percent to compel farmers to take actions that minimize loss.

Hess and Hazell (2010) found that climate risks threaten household income, debt repayment, and food security. Additionally, the study highlighted intercropping, changing planting dates, farm diversification, engagement in off-farm employment, use of relief fund, forming of credit groups and sharecropping contracts as the main risk management strategies pursued by households and rural communities although diversification was noted to limit farming specialization.

Further, review of studies on empirical evidence of impacts of droughts in Ethiopia, by Webb & Braun (1994) and in South and Eastern India by Hazell & Ramasamy (1991) and Pandey *et al*. (2007) respectively provided a vivid indication of the inefficiency of traditional risk mechanism in mitigating agricultural risks. The three studies showed the possibility that income losses can surpass the initial production losses by far in percentage terms due to a fall in local rural employment affecting asset prices, wages, and off-farm income. In drought-prone areas, most households face consumption shocks with impact affecting the poor most. In addition, prevalent failure to repay loans during drought years contribute to low lending level for agriculture in dryland areas leading to slow agricultural development.

Although most crop insurance still relies greatly on subsidies from the government, a review by Mahul and Stutley (2010) indicated advancement related to the economic performance of the

schemes. In addition, Carter and Barrett (2006) linked an increase in income and farm productivity with the ability to boost poor households out of poverty cycles and promote the growth of farm business. This is linked to the willingness of banks and input suppliers' to provide financial and extension services to farmers. The two studies showed that crop insurance's greatest payoff lies in its ability to facilitate the process of credit access, adoption of modern technologies in farm and the application of improved inputs, which together have an overall effect of increasing farm productivity and income.

By synthesizing different studies, Hess and Hazel (2010) pointed that for index insurance to work efficiently, there is a need for minimizing basis risk, developing efficient and credible delivery channels and provision of adequate and early training for all implementing entities. On the other side, the government has a role of providing an enabling legal environment, educating and creating awareness to farmers on the importance of insurance, provision of subsidies and support of impact studies for the systematic learning and better implementation.

Rao (2010) did a study focusing on index-based crop insurance in India. The study revealed that the agriculture sector faces many risks such as crop yield loss. However, despite these risks and uncertainty, the livelihood of most people in developing countries depends heavily on the agricultural sector compared to other sectors. In addition, the study highlighted the importance of agriculture in the provision of raw material to industries as well as a significant contribution to the share of total export hence contributing towards economic growth and development. He noted that agriculture, being particularly susceptible to co-variant and systemic risks, does not simply lend itself to insurance. The absence of past production data, small-scale farm holdings, low-value yields, and relatively high premium, have further complicated the design of a feasible crop insurance scheme. Index insurance is subject to key challenges including basis risk (geographical, product and design risk), infrastructure and labour requirement in conducting crop cutting experiments (administration costs), delay in indemnity payment, and pre-planting and post-harvest practices not factored in an indemnity payment. Consequently, despite these limitations, the area yield index is imperative as it can minimize information asymmetry problems and be effective for small-size holder farmers.

De Nicola (2010) used a dynamic stochastic optimization model to evaluate the effects of weather-based insurance on farmers' investment, consumption, and wellbeing in Malawi. The finding

showed that consumption increased by roughly 17 percent indicating that insurance has the potential to contribute to significant welfare change or gain. Additionally, by extension, the study proved that farmers adopted riskier but highly productive and better-quality seed thus enhancing their welfare through increased income associated with higher productivity. Although the author evaluated the effect of weather-based insurance on farmers' investment, consumption, and wellbeing, he did not consider the determinants influencing the adoption of weather-based insurance. In addition, increasing consumption does not necessarily translate to being food secure. It is possible to increase consumption without necessarily being food secure. This model suffers from the dependence of outcome and assumes that a wrong choice made in the first stage can be corrected but this is not always true at all the time. Using ESR, this study assesses the effects by trying to ascertain whether households who are insured are more food secure compared to their counterparts by use of average treatment effect (ATE).

In China, Cai (2012) adopted both triple difference and difference-in-differences techniques to measure and determine the effect of agricultural insurance scheme on the household's production level, saving and borrowing behaviour. Findings indicated that the introduction of insurance positively increased production acreage of insured crops by about 20 percent while at the same time decreasing production diversification by 10 percent. Further, the study showed that the availability of insurance increased demand for credit by 25 percent while on the other hand decreasing the household level of saving by 30 percent. From the study, the adoption of crop insurance was linked with a positive effect on agriculture. Although the model is designed to control for selection bias and extraneous factors, this technique may still be subject to certain biases such problem of missing data, which is common to most studies. This method ignores the fact that a difference can occur even in the absence of treatment due to the endogeneity problem or time period thus the model estimates could be biased. This study, therefore, adopts the ESR method, which is able to account for endogeneity and selection bias problems.

Varadan and Kumar (2012) used the Simpson Index of Diversification (SID) method to analyse the impact of insurance on rice farming and the extent of crop diversification in India. According to the study, crop insurance had a positive impact of effectively absorbing most of the production risks associated with rice farming and promoting specialization among farmers. Additionally, adoption of insurance was linked to increased use of better-quality inputs leading to increased

farming returns. Crop insurance adoption contributed to a significant change in revenue among non-insured and insured rice growers. Further, education level, credit access, non-farm income, and locality significantly affected farmers' decision to insure crops. A major limitation of this method is computation or selection of relevant index since the index used depend on comparative studies. Additionally, the method doesn't account for heterogeneity effects which are important in program evaluation.

Miranda and Farrin (2012) carried out a study on index insurance for developing countries. According to the study, weather-related perils pose pervasive risks to millions of the poor in the rural area in developing countries especially those whose income primarily relies on farming. The absence of institutions that provide formal financial and insurance services in these areas forces the poor to employ traditional mechanisms such as crop diversification, risk avoidance among other activities that are expensive or provide insufficient risk safety against pervasive catastrophic weather occurrence. Miranda and Farrin used a static expected utility framework to analyze the demand for and possible benefits of index insurance and review of empirical studies or research on pilot programs in developing countries. The analysis summarized some lessons for effective implementation of index insurance including increased awareness of both farmers and agents, careful design of policy to minimize moral hazard, bundling index with credit to decrease loan default and capacity building. However, the authors did not consider the treatment effect and heterogeneity effects for adopters and non-adopters.

Ali (2013) conducted a study in Pakistan to determine whether farmers were in any way more ready to buy insurance or not in rain-dependent areas of Soon Valley and Talagang. Using the social welfare function approach, the findings indicated that economic status, assets ownership, and membership to a group significantly affected the willingness of the farmers to pay for premium and consequently the adoption of crop insurance. Additionally, by use of the PSM approach, the results showed a positive impact of index-based insurance whereby insured farmers were willing to increase farming acreage for both food and cash crop production compared to non-insured farmers. The method employed suffers from bias as it only shows willingness to increase farming acreage but no willingness to adapt to modern technologies and use of improved seeds, thus affecting actual production and consequently effects on food security. Education level also affects

farming practices and decisions but in this study, there is no consideration as a factor influencing WTP for premium and consequently the adoption of crop insurance.

Awel and Azomahou (2014) carried a study in Ethiopia on the effects of Weather Index-Based Insurance on farmers' productivity, adoption of technology, and welfare improvement for insured households. The study showed a positive benefit by altering farmers' risk-taking behaviour. Additionally, the study showed a positive effect on technology adoption where insured farmers were using inorganic fertilizers more unlike their counter-part farmers who were non-insured. By use of IPWRA method, the study showed a positive impact of insurance on farmers' welfare by increasing farm productivity leading to increased farm income but the same results could not be confirmed using PSM and IV method.

Olila and Pambo (2014) used a binomial logit model to evaluate the factors affecting farmers' awareness about crop insurance. Results showed that education, gender, and income significantly influenced the household's decision to take crop insurance. Higher education was associated with a higher level of insurance uptake as households understood the benefits of insurance in agriculture. Additionally, the study highlighted two relevant policies necessary for crop insurance adoption. First, the study proposed the promotion of credit accessibility for agricultural transformation and secondly, dissemination of knowledge to farmers through extension services that provide great opportunities for increased awareness and high uptake of crop insurance. Though the paper sites only social-economic factors, demographic factors especially locality has a significant influence on decisions concerning crop adoption. Further, although the model is globally concave thus attaining optimal easily, in case of full separation in the data, the likelihood function won't converge.

2.4 Overview of Literature Review

The decision to take part or not in an insurance program is largely centered on expected utility by farmers, which is also dependent on individual and socio-economic characteristics. Within agrarian economies, major farming objectives consist of increased food availability for food security, improved household income, and poverty reduction. In order to make a decision on either to participate in area yield index-based insurance or not, farmers evaluate their expected utility of the intervention/program subject to available constraints. Consequently, farming objectives together with government policies, for instance, taxes and subsidies, and available infrastructures

act as elementary or intervening factors that affect farmer's decision to take part or not in a program. This therefore through the input-impact pathway leads to desired impacts, that is, increased income, food security, and poverty reduction.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This section summarizes procedures and methods employed during the study; details of the theoretical and empirical framework, research design, study population, data collection procedures, and processing methods.

3.2 Theoretical Framework

This study is centered on utility modeling where the household maximizes welfare subject to constraints by choosing optimal consumption good (staple and purchased), allocation of optimal time between on-farm and off-farm labor as well as leisure. In a static model, households are assumed to be price takers for every commodity, the decision taken by a single head and homogenous commodities. Household is presumed to maximize utility based on income/budget, production and time restrictions

$$\mathbf{U = U (X_a, X_m, X_h)} \quad \text{(3.1)}$$

where X_a is an agricultural good, X_m is a market good and X_h is leisure. The household faces a budget constraint expressed as:

$$\mathbf{P_m X_m = P_a (Q_a - X_a) - P_h (L - F) - q_v V + E} \quad \text{(3.2)}$$

where $\mathbf{P_m}$ and $\mathbf{P_a}$ are the prices of the market and agricultural good respectively, Q_a is the production of the household's agricultural good ($Q_a - X_a$ is its marketed surplus), P_h is the market wage rate, L is total labor input, F is family labor (so that L - F, is hired labor, if positive, and is off-farm if otherwise), V is a variable input, and q_v is its market price. Finally, E is non-labor, non-farm earnings. Households face time constraint where it is not possible to spend more time to either on-farm, off-farm labour or leisure rather than the total available time:

$$\mathbf{X_h + F + H = T} \quad \text{(3.3)}$$

where X_h is leisure, F is on-farm, H is off-farm labor and T is the household's time total. The production function is concave and twice differentiable and presents a different combination of inputs and output given by;

$$\mathbf{Q_a = Q (L, V, A, K, S, Z)} \quad \text{(3.4)}$$

where ***A*** represents the quantity of land for households, *K* is its capital stock (fixed), *S* is household's characteristics influencing production decision and *Z* is a set of locational

characteristics. The model assumes a single crop, perfect substitution between hired and family labour and production is riskless. The three restrictions on household's behaviour are reduced to a single constraint to form a simplified budget constraint expressed as

$$\mathbf{P_m X_m + P_a X_a + P_h X_h = Y^*} \quad \text{.....(3.5)}$$

The solution to the maximization problem yields the demand equations for X_m, X_a, X_h as functions of prices (P_a, P_m, P_h) and full income (Y^*).

3.3 Estimation Technique

The conceptualization of the study is centered on a dynamic household model of likelihood and farm decisions. The model considers a household that seeks to maximize its expected welfare subject to available constraints. In modelling farmers' behaviour in this study, farmers are faced with a discrete choice, that is, either to take up crop insurance or not where the decision made relies on the expected utility of farm activities. The utility of goods consists of an observable deterministic element (U_{ik}) and unobservable the random error (Ɛ) (Jabbour *et al*., 2003; Yang, 2014). Assuming that household with insurance derives utility U_i from farm activities and those without U_k, the n^{th} household will insure if and only if $U_i > U_k$. Accordingly, the possibility that n^{th} household will insure can be represented as:

$$\boldsymbol{Pn^{th} = U_i + \mathcal{E}_i > U_k + \mathcal{E}_k} \quad \text{... ... ...} \quad (3.6)$$

In estimating the effects of the adoption of crop insurance on food security, a dummy variable equal to one is included if a farmer adopted crop insurance. This method assumes that the adoption of crop insurance is exogenous but the adoption is potentially endogenous due to a causal relationship between the adoption of crop insurance and food security. Instrumental variable estimation technique is effective in eliminating endogeneity bias but the method greatest challenge is finding the correct or suitable instruments and also assumes that crop insurance adoption has a similar effect for both adopters and non-adopters.

Therefore, it's important to estimate the two equations for the outcome independently for adopters and non-adopters while taking into account both endogeneity and sample selection problems. Propensity Score Matching (PSM), Regression Discontinuity and Double Difference method among others have been developed as impact evaluation techniques. Although PSM can eliminate selection bias, its impact estimators are inefficient while the regression discontinuity approach assumes a certain cut-off point as a selection to program, and the double-difference technique

assumes selection bias to be time-invariant. Thus, to control for both sample selection bias and endogeneity problem, this study adopted the Endogenous Switching Regression (ESR) estimation technique.

ESR does not only account for the problems of sample selection bias and endogeneity but also permits for interactions between adoption and other covariates in the outcome equation (Freeman, 2001, Alene & Manyong 2007). The selection or participation equation is specified as;

Participation decision equation;

$\boldsymbol{Z_i^* = \alpha W^T + \mu_i}$ where $\boldsymbol{Z_i = \{ 1 \text{ if } Z_i^* > 0, \text{ otherwise}}$ …… (3.7)

where, Z_i^* is latent (unobserved) variables defining the decision of household's to take up insurance, Z_i is its observed counterpart (adoption of crop insurance equals one if farmer adopts insurance and 0 if otherwise), W^T is a vector of factors influencing household's participation decisions, α.is a vector of parameters to be estimated and $\boldsymbol{\mu}$ is the error term associated with crop insurance adoption.

Outcome equation;

Regime 1 (adoptors)

$\boldsymbol{Y_{1i} = \beta X_{1i}^T + \varepsilon_{1i} \ \ if\ Z = 1}$ …… (3.8a)

Regime 2 (non-Adopters)

$\boldsymbol{Y_{2i} = \beta X_{2i}^T + \varepsilon_{2i} \quad if\ Z = 0}$ …… (3.8b)

Where $\boldsymbol{Y_{1i}, Y_{2i}}$ represents the dependent variable that measures food security for insured and non-insured respectively. ESR assumes that the dependent variable in the outcome equation is a continuous variable, thus this study used food insecurity index as an indicator of food security status. X^T is a vector of factors that determinant food security. *β's* are parameters to be estimated ε_{1i} and ε_{2i} are the respective error terms for adopters and non-adopters. We assume that the error terms, ε_{1i} and ε_{2i} have a tri-variate normal distribution with a mean vector of zero and a covariance matrix (Ω) shown in equation (3.9).

$\boldsymbol{\Omega = [\sigma^2_u \ \ \sigma_{1u} \ \ \sigma_{2u} \ \ \sigma_{1u} \ \ \sigma^2_1 \ \ . \ \sigma_{2u} . \ \sigma^2_2]}$ ……(3.9)

Where σ^2_u is the variance of the error term in participating equation (3.7), σ^2_1 and σ^2_2 are variances of the outcome equations (3.8a) and (3.8b) respectively. The covariance between $\boldsymbol{\mu}$ and ε_{1i} is given by σ_{1u} while the covariance between, $\boldsymbol{\mu}$ and ε_{2i} is given by σ_{2u}, However, the covariance between ε_{1i} and ε_{2i} cannot be estimated since Y_{1i} and Y_{2i} are never simultaneously observed. Due to the

potential correlation of the error terms in both equations, we assume them to be jointly and normally distributed with a finite covariance and zero mean (Greene, 2012). The log-likelihood function is specified as

$$\mathbf{lnL = \Sigma_i(Z^*_i w_i [\ln \{F(\eta_{1i})\} + \ln \{f(\varepsilon_{1i}/\sigma_1)/ \sigma_1 \}] + (1 - Z^*) w_i [\ln \{1 - F(\eta_{1i})\} + \ln \{f(\varepsilon_{2i}/\sigma_2)/ \sigma_2 \}]} \quad \text{.....(3.10)}$$

where F denotes cumulative normal distribution function (CDF), *f* is normal density distribution function, w_i is weighted observation *i* and

$$\eta_{1i} = \frac{(\alpha W + \rho_j \varepsilon_{ji}/ \sigma_j)}{\sqrt{1-\rho_j^2}} \text{ where j = 1,2 .....(3.11)}$$

from equation (3.11), $\rho_1 = \sigma^2_{1u}/\sigma_u\sigma_1$ and $\rho_2 = \sigma^2_{2u}/\sigma_u\sigma_2$ denotes the coefficient of correlation between μ_i, ε_{1i} and ε_{2i} respectively. In ESR, it's possible to estimate both conditional and unconditional expectation using Full Information Maximum Likelihood (FIML) as the model has the ability to capture the expected outcome for the observed and the counterfactual (Lokshin & Sajaia, 2004). Estimation of the unconditional expectations is defined as;

$$\mathbf{E(Y_{1i} \mid X_{1i}) = \beta_1 X_{1i}} \text{.....(3.11a)}$$

$$\mathbf{E(Y_{2i} \mid X_{2i}) = \beta_2 X_{2i}} \text{.....(3.11b)}$$

Therefore, conditional expectation fall under two regimes

Regime 1 (observed case)

$$\boldsymbol{E(Y_{1i} \mid Z_i = 1, Y_{1i}) = \beta_1 Y_{1i} + \sigma_1\rho_1 f(\beta X_i)/F(\beta X_i)} \text{.....(3.12a)}$$

$$\boldsymbol{E(Y_{2i} \mid Z_i = 0, Y_{2i}) = \beta_2 Y_{2i} + \sigma_2\rho_2 f(\beta X_i)/\{1 - F(\beta X_i)\}} \text{.....(3.12b)}$$

Here we estimate the actual expected food insecurity index for households who participated in crop insurance (3.12a) and for those who did not participate (3.12b)

Regime 2 (counterfactual case)

$$\mathbf{E(Y_{2i} \mid Z_i = 1, Y_{1i}) = \beta_2 Y_{1i} + \sigma_2\rho_1 f(\beta X_i)/F(\beta X_i)} \text{.....(3.12c)}$$

$$\mathbf{E(Y_{1i} \mid Z_i = 0, Y_{2i}) = \beta_1 Y_{2i} + \sigma_1\rho_2 f(\beta X_i)/\{1 - F(\beta X_i)\}} \text{.....(3.12d)}$$

Similarly, we estimated the counterfactual expected food insecurity index for households who participated in crop insurance if they did not (3.12c) and for those who did not participate, if they had (3.12d). Based on the work of Lokshin &Sajai (2014) and Heckman (2004), the study estimated the average treatment of the treated (ATT) and the untreated (ATU) as given.

$$ATT = E(Y_{1i} \mid Z_i = 1, Y_{1i}) - E(Y_{2i} \mid Z_i = 1, Y_{1i}) = Y_{1i}(\beta_1 - \beta_2) + \rho_1(\sigma_1 - \sigma_2) f(\beta X_i)/F(\beta X_i) \quad (3.13a)$$

$$ATU = E(Y_{1i} \mid Z_i = 0, Y_{1i}) - E(Y_{2i} \mid Z_i = 0, Y_{1i}) = Y_{2i}(\beta_1 - \beta_2) + \rho_2(\sigma_1 - \sigma_2) f(\beta X_i)/F(\beta X_i) \quad (3.13b)$$

Equation (13a) gives the treatment effect of the treated (TT), which is, the difference between expected food insecurity index for households who actually adopted crop insurance (a) and the counterfactual case of a farmer who adopted crop insurance if did not adopt (c). Similarly, equation (13b) represents the effects of the untreated (TU), which is calculated as the difference between expected food insecurity index in counterfactual case (d) for the household that did not adopt insurance if adopted and the expected food insecurity index of non-adopters (b).

3.4 Area of Study

Njoro sub-county falls under the former Rift Valley Province, the main basket of Kenyan stable food. The area experiences two climatic conditions with one part being low agricultural potential and with foreseeable weather patterns of average temperatures oscillating between 10°C in the cold months and 26°C in the hot months. Additionally, having two rainy seasons, the area receives a minimum of 700mm and a maximum of 1200mm of rainfall annually, with a mean of 800mm. Major agricultural activity is maize and wheat farming mostly at subsistence level (GoK, 2017). Most farmers have a landholding of approximately 1.9 acres (0.77 hectares) of which 49 percent are poor, while 36 percent of the whole population are being food insecure. Further, livelihoods of above 60 percent of the entire county's population that largely depends on the agricultural sector are endangered due to inadequate access to healthy and nutritious food. In the last five years, the production of maize has been low due to a number of factors such as a change in rainfall pattern and prevalence of pests and diseases. Nevertheless, if farmers embrace modern farming techniques to increase production per unit area, they can harvest atleast 30 bags per acre (GoK, 2018).

3.5 Research Design

Both explanatory and descriptive research design was employed during the study. It helped the researcher in collecting data from selected respondents by administering the questionnaires and conducting interviews with the sampled individuals (Orodho, 2003). Survey research was used because the study population was relatively large and might pose a challenge if observed or

handled directly. This research design ensured that the results obtained from the sample could be used to give a general overview of the whole population.

3.6 Target Population and sample size

A target population represents the whole group of individuals or objects that a researcher uses to draw the conclusions. Similarly, a sample represents a smaller collection of units from a population used to determine truths about that population (Kothari, 2008). This study targeted households practicing small-scale maize farming in Nakuru, Njoro Sub-County consisting of both participants and non-participants in an AYII program. A total of 233 households was sampled from the four wards and interviewed for data collection.

3.7 Sampling Method

The study adopted a simple random sampling approach in selecting both the area of study and the category of farmers. Njoro Sub County was purposively selected for the study due to its relevance for paying indemnity to a significant number of farmers who insured their crops and was part of the three counties where the program was piloted. A systematic random sampling method was employed to draw a pool of target households from a sampling frame of farm groups and a list of group members from the agricultural extension office and local insurance trainers. Each respondent either insured or non-insured had a 50 percent selection probability. Starting from a random point but with a fixed, periodic interval, a sampling interval of every $\boldsymbol{n}^{th}$ household or respondent was interviewed followed by establishing whether the household had ever taken any agricultural insurance and if not, qualifies as a control group, otherwise, considered as a treatment group. The same process was repeated until a sample of 233 was surveyed.

3.8 Data Collection Method

Primary data at the household level was collected via interviews using self-administered structured questionnaires (see appendix 1). The questionnaire comprised five sections namely: identification, demographic and social-economic characteristics, farming and risk management tool, agricultural insurance and finally food security. The identification section entailed respondents' personal details such as name, contacts, and locality. The demographic and social-economic characteristics section captured household details, for instance, gender, age, household size, household head, education level, income and distance to the nearest market and motorable road. Farming and risks management tool captured details such as the size of land under maize farming, farming system,

farm income, land tenure, the risk faced and management, membership to Sacco's (saving/credit). The agricultural insurance section included detail concerning insurance. Lastly, the food security section addressed the four aspects of food security that included availability, accessibility, utilization, and stability.

3.9 Pilot Testing

Reliability is concerned with the consistency of measure and the ability of instruments to produce the same results when used repeatedly (Shanghverzy, 2003; Treiman, 2009). A sample of five respondents was drawn from the target population to participate in the pilot study but their data were excluded in the final sample. A Cronbach's alpha index value of 0.7 was used as a threshold for determining the reliability of the questionnaire as noted by Field (2009).

In determining the validity of the instrument, the questionnaire was subjected to the views of specialists in the field of study specifically agricultural extension officers. This contributed to the necessary review and modification of the questionnaire thereby enhancing and refining its validity as noted by Mugenda and Mugenda (2003). Factor analysis was used to ascertain construct validity for all of the variables used in the study (Kerlinger & Lee, 2000).

3.10 Variables Description

The following table shows variables used in the model for the analysis of farmers' participation in AYII and its effects on food security. Household's decision to adopt crop insurance and food security status was modelled as dependent variables - discrete while the rest as independent variables.

Variables	**Measure**	**Expected sign**	**Reference**
Dependent			
Food security Food insecurity index (Y)	Based on the raw score of Rasch measurement (scale) model		Hill *et al.* (2013)
Crop insurance participation (Z)	If participating in crop insurance or not; 1=Yes, 0=No	+	Mathenge, M. (2018).

Independents			
Household head has primary education (no education used as reference)	Dummy; 1 if yes, 0 otherwise	+	Sherrick *et al*., (2004)
Household head has secondary education	Dummy; 1 if yes, 0 otherwise	+	Sherrick *et al*., (2004)
Household head has tertiary education	Dummy; 1 if yes, 0 otherwise	+	Sherrick *et al*., (2004)
Household size	Number of members	+	Oila &Pambo (2014)
Household head gender (1=male)	Dummy; 1 if yes, 0 otherwise	+	Jairo (2013)
Land under maize (acres)	Number of acres	+	Nahvi *et al.* (2014)
Nonfarm income	Dummy; 1 if yes, 0 otherwise	+	Sargazi *et al.* (2013) Hill *et al.* (2013)
Distance to the nearest market (km)	Number of kilometers	-	Ali (2013)
Land size (acres)	Number of acres	+	Nahvi *et al.* (2014)
Land under maize tenure	Dummy variable; I if yes, 0 otherwise	-	Kassie *et al*. (2012)
Irrigation	Dummy variable; I if yes, 0 otherwise	+	Sherrick *et al*. (2004)
Access to agricultural credit	Access to agricultural credit; 1=Yes, 0=No	+	Oyinbo *et al*. (2013)
Land tenure	Dummy variable; I if yes, 0 otherwise	+	Kassie *et al*. (2012)
Farming system	Dummy variable; I if intercrop, 0 otherwise	-	Sherrick *et al*. (2004) Ashimwe (2016)

Distance to a motorable road (km)	Number of kilometers		
Household age (years)	Age of household head; number of years	+	Sargazi *et al.* (2013
Group membership (1=yes)	Membership in farming group, 1=Yes, 0=No	+	Getachew (2010)

1Table 3.1: Measurement variables

3.11 Diagnostic Testing

3.11.1 Testing for multicollinearity

Linear dependency or inter-correlations among the independent variables lead to statistical inferences being unreliable (Wooldridge, 2002; Gujarati, 2009; Greene, 2003). In testing linear dependency, the study employed correlation matrix analysis (see annex 3) where variables that were found to be strongly correlated were dropped from the model. This was to prevent inflation of the variances of the estimated parameters hence avoid getting biased estimators which could lead to the wrong conclusions. Dropping the correlated variables helped improved the model by reducing multicollinearity.

3.11.2 Testing for heteroscedasticity

The classical linear regression model assumes that the error term should have constant variance and violation of this assumption lead to the problem of heteroscedasticity causing parameters to be asymptotically inefficient. The presence of heteroscedasticity was tested and corrected using robust standard errors.

3.11.3 Sample selection bias

The selection bias was tested using the values of the correlation between the error term of the participation or adoption equation and the error term of the food insecurity index equation for adopters and non-adopters of crop insurance. Test results showed that error term of the participation equation and error term of food insecurity index equation for adopters (Rho_0) was -0.4049 and the correlation value of the error term of the adoption equation and error term of food insecurity index equation for non-adopters (Rho_1) was 0.7027 (Table 4.3). Both correlation coefficients were insignificant implying absence of selection bias. The selection or sampling bias leads to an inaccurate conclusion thus undermining the external validity of a test.

3.11.4 Falsification test

In a regression analysis, correct model specification is important as it leads to unbiased estimates. Falsification testing has great potential as a method for assessing the internal validity of comparative effectiveness research (CER) studies for randomized controlled trial (RCT) results. The study used the exclusion restriction method whereby a variable is included in the selection equation (participation) but excluded from the outcome equation (food security). Using the falsification test, age, group membership and distance to the motorable road were used as instrument variables. This was because they were statistically significant in the participation equation but not in the outcome equation (Jairo, 2013; Issahaku &Abdul-Rahaman, 2018).

CHAPTER FOUR
DATA ANALYSIS, PRESENTATION AND DISCUSSION

4.1 Introduction

This section presents both descriptive statistics and econometric analysis of data, interpretation, and discussion of the research findings.

4.2 Descriptive statistics

4.2.1 Household summary characteristics

The study analyzed the demographic and socio-economic characteristics of the insured and the non-insured (control) households to determine whether they were in any way different. Both table 4.1 and table 4.2 were used in the descriptive analysis. Table 4.1 present the mean for the sample on a general way while table 4.2 show the statistical difference between the treated and control groups. Although the focus of this study was to estimate the effect of the adoption of crop insurance on food security through econometric analysis, descriptive statistics were equally important.

The descriptive statistics indicated that the mean food insecurity index was 5.39 (table 4.1) implying that the majority of respondents were food insecure or their food security status was very low. However, results in table 4.2 indicated that the insured participants had a lower mean compared to non-insured households with a mean of 4.95 and 5.78 respectively implying that the insured households were more food secure. Additionally, insured households represented 47.6 percent of the respondents compared to 52.4 percent non-insured.

2Table 4.1: Household summary statistics

Variable	Mean	Std. Dev.	Min	Max
Dependent Variable				
Food insecurity index	5.38721	1.45814	2.86	8.48
Insured (1 if yes)	0.4763948	0 .5005177	0	1
Independent variable				
Household characteristics				
Age of the household (years)	55.9485	11.51412	27	87
Household head is male (1 if yes)	0.4291845	0.4960253	0	1
Household head has primary and no education (reference category) (1 if yes)	0.6437768	0.4799132	0	1
Household head has secondary education (1 if yes)	0.223176	0.4172718	0	1
Household head has tertiary education (1 if yes)	0.0515021	0.2214954	0	1
Household size (number of people)	3.965665	1.60243	1	9
Size of land under maize (acres)	1.982833	1.600857	0.25	20
Household head (1 if yes)	0.5965665	0.4916424	0	1
Non-farm income (1 if yes)	0.2145923	0.411423	0	1
Distance (km)				
Farm produce market	6.995708	3.891334	0.9	17
Motorable road	0.4766524	0.2147271	0.05	1.2
Land size (acres)	2.171459	1.601256	0.5	10

Land under maize tenure (1 if yes)	0.639485	0.4811836	0	1
Irrigation (1 if yes)	0.0171674	0.1301745	0	1
Group membership (1 if yes)	0.6566524	0.4758486	0	1
Access to agricultural credit (1 if yes)	0.0815451	0.2742595	0	1
Information on insurance (aware)	0.695279	0.4612801	0	1
Land ownership (1 if yes)	0.9227468	0.2675676	0	1
Farming system (1 = intercrop)	0.9871245	0.1129803	0	1
Access to credit facilities (1 if yes)	0.1576577	0.3652433	0	1

The results (table 4.1) showed a significant difference in age where households were as young people aged as low as 27 years and the old people whose age was as high as 87 years. Similarly, mean separation test (table 4.2) for adopters and non-adopters showed that on average, insured households were older by about 8 years with a mean of 60 years compared to non-insured with 51 years. Gender was also a key factor where results indicated that the sample had more females than the males with the later accounting for 42.9 percent of the household (table 4.1). However, mean test results showed that males represented the highest number of the insured housed heads than the female with 49.5 percent and 36.9 percent respectively (table 4.2). This difference shows a typical African culture where most men are the decision-making unit for the households.

For non-farm income, the study revealed that only 21.5 percent of the household head earned non-farm income (table 4.1) with insured accounting for 28.8 percent and non-insured representing 14.8 percent making the latter less food secure (table 4.2). Non-farm income represents disposable income thus those with income have to spend.

Land ownership and farming are related where those who do not own the land lease from their counterparts. Results (table 4.1) showed that 92 percent of the households had land with title deeds with 48.1 percent growing maize on lease land. Similarly, (table 4.2) insured households with land ownership represented 99 percent and owned an average of 2.6 acres for maize as compared to

non-insured who was 86 percent with average land under maize of 1.67 acres. Further, the mean separation test (table 4.2) indicated that insured households owned an average of 2.3 acres of land under maize where 80 percent owned it compared to non-insured practiced maize farming on an average of 1.7 acres and only 49 percent owning that land.

Concerning household size, the mean size was 4 people for the entire sample (table 4.1) but the insured households were significantly different from non-insured with an average of 3.5 and 4.3 respectively (table 4.2) with the later having a higher number of family members. Though 65.6 percent of the respondents were members of farming or cooperative group (table 4.1), group membership was also significantly different between two groups with 90.9 percent of the insured being member of a farming group or cooperative compared to non-insured who represented 42.6 percent (table 4.2). This implies the relevance of being a group member where it possible to get information concerning farming and related products through agricultural extension services hence better farming methods and increased harvest.

3Table 4.2: Two-sample t-test with equal variances level.

Variable	**Overall (N=233)**		**Test of difference**	
	Insured	**Non-Insured**	**t-stat**	**sig.**
Food insecurity index	4.951892	5.783279	4.5256	0.0000***
Age of the household (years)	60.03604	51.36036	-5.9968	0.0000***
Household head is male	0.4954955	0.3688525	-1.9583	0.0257**
Household head has primary (no education reference category)	0.5945946	.6885246	1.4961	0.0680
Household has head secondary education (1 if yes)	0.204918	0.2432432	-0.6994	0.2425
Household head has tertiary education (1 if yes)	0.0810811	0.0245902	-1.9562	0.0258**
Household head (1 if yes)	0.6846847	.5163934	-2.6431	0.0044***
Household size (no of people)	3.540541	4.352459	3.9847	0.0000***
Maize production (acres)	2.331081	1.665984	-3.2312	0.0007*
Non-farm income (1 if yes)	0.2882883	0.147541	-2.6414	0.0044***

Distance (km)

Farm produce market	6.736036	7.231967	0.9715	0.1662
Motorable road	0.4201802	0.5280328	3.9477	0.0001***
Land size	2.67973	1.709016	-4.8398	0.0000***
Land under maize tenure (1 if yes)	0.8018018	0.4918033	-5.1774	0.0000***
Irrigation (1 if yes)	0.018018	0.0163934	-0.0949	0.4622
Group membership (1 if yes)	0.9099099	0.4262295	-8.9817	0.0000***
Access to agricultural credit (1= yes)	0.1441441	0.0245902	-3.3980	0.0004***
Information on insurance (aware)	1	0.4180328	-12.3775	0.0000
Land ownership (1 if yes)	0.990991	0.8606557	-3.8209	0.0001***
Farming system (1 = intercrop)	0.981982	0.9918033	0.6619	0.2543
***,**,* significance at 1%, 5% and 10%				

The result showed that only 8.1 percent (table 4.1) of the households under survey had access to agricultural credit. However, the mean separation test (table 4.2) indicated a statistical difference between adopter and non-adopter where insured households had better access to credit than their counterpart non-insured with a 14.4 percent and 2.4 percent access rate respectively. Access to credit implied information on available financial derivative goods offered such as loans and as crop insurance.

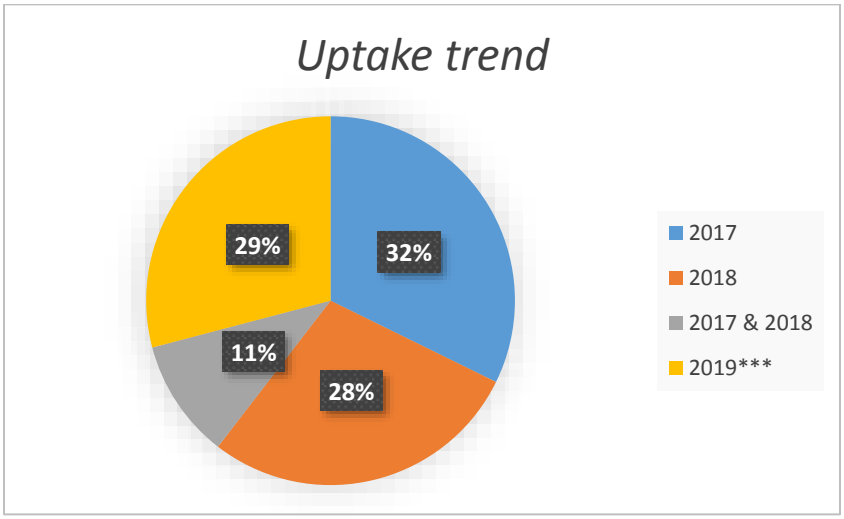
Geographic proximity to the nearest produce market and motorable road is a key factor influencing both transaction costs and the basis risk for households under AYII. The average geographical vicinity to the nearest produce market and motorable for the households was estimated to 7 km and 0.48 km respectively (table 4.1). Using the mean test (table 4.2), insured households covered a shorter distance with an average of 6.73 km and 7.23 km to the nearest market and 0.42km and 0.53 to the motorable road as compared to non-insured respectively.

Although education showed mix results, households with higher education (tertiary level) were significantly different from the two groups. For example, 8.1 percent of insured households had tertiary education compared to non-insured who represented only 2.5 percent (table 4.2). Higher education implied an understanding of the benefits and opportunities associated with insurance.

Results indicated that 69.5 percent of the respondents were aware of crop insurance (table 4.1). However, all insured households were aware as compared to 41.8 percent non-insured with knowledge (table 4.2). This makes awareness a prerequisite factor for crop adoption.

4.2.2 Insurance uptake trend

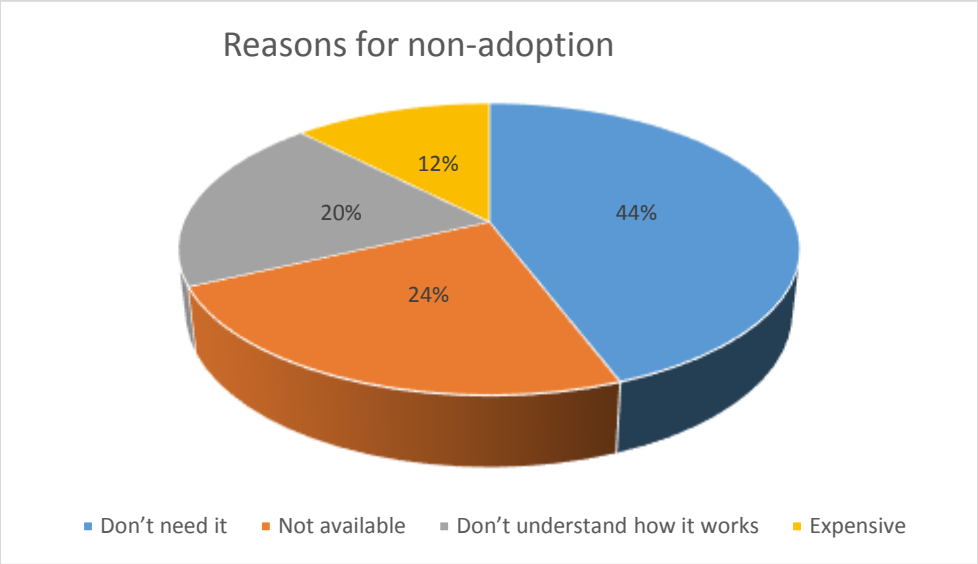
Although insurance was rolled out in 2017, the trend for uptake has been low and declining. For example, 2017 had 32% insured farmers but in 2018 the number declined to 28% with only 11% reenrolling again. Based on feedback, the majority of the farmers attributed non-enrollment to non-compensation despite suffering losses (basis risk) while the rest cited insurance not meeting their expectations or not being available when needed. The study tried to establish the main reason for non-compensation and the result indicated that since registration was done remotely via phone, the selection of farms for crop cutting exercise was done remotely through GPRS where both insured and non-insured farmers had an equivalent probability of being selected. The number of non-compensated increased from 33% in 2017 to 95% in 2018. For example, out of all those who insured for the year 2018, none received a payout reason being that farmers harvest above average in respective UIAs.



*1Figure 4.1: Insurance uptake trend 2017-2019****

Reasons for non-adoption

Although the analysis showed that 69.5 percent of the respondents were aware of or had information on crop insurance, only 47.6 percent adopted it (table 4.1). Additionally, 41.8 percent (table 4.2) of the non-insured households were aware but did not adopt citing various reasons for non-adoption as illustrated in the figure below (figure 4.2). However, the majority of farmers considered insurance payout as a gamble where the payout is 50-50 hence could not risk losing their limited resource. To them, farming is highly dependent on rainfall patterns and in case of a "good year", that is, a year with normal rains, insuring land is a risky business as the probability of compensation in nearly zero hence loss of insured amount.



2Figure 4.2: Reasons for non-adoption

4.3 Determinants of insurance participation and food security

The decision to participate in any scheme such as crop insurance program is largely influenced by several factors ranging from demographics to social-economic ones. In determining these factors, ESR was used and results for the analysis tabulated as depicted in table 4.3.

As shown, the table presents the determinants of crop insurance uptake and its effects on food security for both insured and non-insured. Therefore, model 1 shows the adoption results, model 2 shows food security for adopters and model 3 shows the food insecurity index for non-adopters of crop insurance. The study employed Full Information Maximum Likelihood Estimator in calculating determinants. Self-selection bias was tested using correlation values between error

terms of adoption equation and error terms of food insecurity index for adopters and non-adopters of crop insurance. Test results showed that error term of the participation equation and error term of food insecurity index equation for adopters (Rho_0) was -0.4049 and the correlation value of the error term of the adoption equation and error term of food insecurity index equation for non-adopters (Rho_1) was 0.7027. These two values were insignificant implying absence of selection bias. Wald Chi-square test was 127.34 and significant at 1 percent implying that jointly, the independent variable influence the dependent variable. Further likelihood ratio test had a value of 72.44, which was significant at 1 percent implying dependency of the two equations. The significance of the value for both the Wald Chi-square test and the likelihood ratio test justified the use of ESR in estimating the effects of crop insurance adoption on food security.

4Table 4.3: ESR results for the adoption of crop insurance and food insecurity index.

	(1)	(2)	(3)
		Farmers adopted	**Farmers did not adopt**
Variables	**Adoption**	**Food insecurity index**	**Food insecurity index**
Household head is male (1 if yes)	-0.1115	0.1146	-0.3654*
	(0.2713)	(0.2292)	(0.2141)
Household head has primary education (1 if yes)	0.8585*	0.7752	0.9382***
	(0.4565)	(0.5455)	(0.3190)
Household head has secondary education (1 if yes)	1.0640*	0.8571	0.4626
	(0.5765)	(0.6063)	(0.3729)
Household head has tertiary education	1.6959**	0.7861	0.1664
	(0.7430)	(0.7528)	(0.3734)
Household size (number)	-0.0992	0.3086**	0.4333***
	(0.1008)	(0.1231)	(0.0642)
Land under maize (acres)	0.3370***	-0.0611	-0.7155***
	(0.1160)	(0.0640)	(0.1385)

Nonfarm income (1 if yes)	0.6647**	-0.1481	-0.1578
	(0.2995)	(0.3150)	(0.2611)
Distance to the nearest market (km)	-0.0249	0.0702**	0.0239
	(0.0258)	(0.0292)	(0.0255)
Land size (acres)	-0.1607	-0.1450*	-0.0545
	(0.1039)	(0.0821)	(0.1201)
Land under maize tenure (1=yes)	0.7253**	0.4384	0.2761
	(0.2872)	(0.3797)	(0.2584)
Irrigation (1=yes)	-0.6743	-1.0917*	0.6651
	(0.7659)	(0.6307)	(0.4439)
Access to agricultural credit (1=yes)	1.1660**	0.4960	-0.9400***
	(0.5299)	(0.4962)	(0.3017)
Land tenure (1=yes)	0.1363	0.7488	-0.1618
	(0.5352)	(0.6976)	(0.2567)
Farming system (1=intercrop)	1.3228	-1.6825**	0.2197
	(1.0943)	(0.8493)	(0.5446)
Distance to motorable road (km)	-1.7363***		
	(0.4331)		
Household age (years)	0.0396***		
	(0.0137)		
Group membership (1=yes)	1.3607***		
	(0.2942)		
Constant	-5.1229***	3.2596**	4.0573***
	(1.5916)	(1.5325)	(0.8861)
Observations	233	233	233
Likelihood test of independent equations: $Chi^2(1)=7.76$***			
Rho_0= -0.4049 and Rho_1 = 0.7027, r0= -0.4295 and r1= 0.8726, lns0 = -0.0794 and lns_1 = 0.2128*			
Standard errors in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			

Regression analysis showed that gender or being a male reduces the likelihood of adopting or participating in crop insurance. Female-headed households have higher chances of adopting crop insurance than males due to limited resources of the former for investment. In Kenya, male-headed households have more resource endowment than female-headed hence vulnerability of the latter to the problem of food insecurity due to low incomes. Females, therefore, have higher chances of adopting crop insurance as a means to reduce exposure to problems of food insecurity. However, for non-adopter, gender has a negative effect thereby making them more food secure.

The results indicated that education level positively influences the decision to adopt crop insurance. Taking primary education as a reference category, as household progress with higher education level, they increase the chances of adopting crop insurance. This result supports findings by Sherrick *et al*. (2004) that better educated and more experienced farmers have greater uptake of insurance. Similarly, in the USA, Dhanireddy (2012) found a positive correlation between education and purchase of crop insurance. This implies that advancement to education makes households aware of benefits and opportunities associated with insurance product thus adopting insurance as a means of hedging themselves against production risks. Although education is positively related to the food insecurity index for both adopters and non-adopters, an increase in education reduces the food insecurity index thus making households better off. However, the impact of reduction is more on non-adopters than adopters.

Though not significant, household size negatively affects the decision to participate in crop insurance. An increase in the size of the household by one member reduces the chance of participating with a probability of 0.0992. The results support finding by Okoffo *et al.* (2016) who did a study on cocoa farmers in Ghana and found a negative relationship. Similarly, a study done by (Guo, 2015) in Nepal showed that household with one more member undermined uptake of weather-index insurance by 0.8 to 1.1 percent. However, the result showed a significant positive effect on the food insecurity index both for the adopters and non-adopters. Higher food insecurity index translates to households being more food insecure since the index measures household food insecurity access (HFIA). An increase with one member increases expenditure on food and by comparison, although household size increases food insecurity index, the impact is more on non-insured since in case of production shocks, they are not subject to compensation unlike their

counterpart insured households. For instance, one more member increase food insecurity index for adopters and non-adopters by 0.31 and 0.43 respectively implying effect is more on non-adopters.

Land size under maize farming positively influences crop insurance adoption decision, whereby an increase in acreage under maize significantly increases the chance of insurance by 0.337. Knight and Coble (1997), Fallah *et al.* (2012) and Onyimbo *et al*. (2013) presented similar results of a direct association between the size of land under crop farming and insurance uptake. However, contrary to the expectation, the size of the land is negatively related to insurance whereby an increase in land size reduces the chance of insurance by 0.16. This result can be attributed to the fact that crop insurance in Kenya is in its pilot stages where farmer insures less size of land initially and later increase the insured size of land based on payment of indemnity trends. This behaviour depicts a risk-averse individual who before making any decision, first considers all possible solutions based on the outcome. The statistically inverse relationship between the land under maize farming and food insecurity index for adopters and non-adopters implies its relevance in improving their food security status. These results are in line with the finding of Kassie *et al*. (2012) who noted that farmers only increase their acreage size of the land on farming for only relevant crops.

Non-farm income positively and significantly influences the household's decision to participate in the crop insurance program. This is attributed to the fact that non-farm income increase household disposable income that can be used to hedge or address production shocks. This supports the findings of Hill *et al.* (2013) who found that the rate of adoption for crop insurance was higher for wealthier farmers than poorer households in Ethiopia. As noted by Jairo (2013), off-farm income increases disposable income and consequently reduce poverty, which is related to food security. However, although not significant, non-farm income has a negative effect on the food insecurity index for both adopters and non-adopters with the impact being more for non-adopters. This finding implies that having an extra source of income increases total disposable income hence making households more food secure.

Distance to the nearest produce market had a negative impact on the adoption decisions. This implies that as the distance increases, the likelihood of insurance adoption by the household drops since proximity to the nearest market has financial implications on-farm activities. The results correspond to finding by Njue, Kirimi, and Mathenge (2018) that distance to the market negatively affects adoption decisions due to related transaction costs. High transaction costs such as cost for

accessing produce market increase household's farm business expenditure, consequently reducing earning thus making it an expensive activity. On the food insecurity index, distance is positively related meaning that as distance increases, accessibility becomes a problem hence farmers become more food insecure.

Results for land tenure indicated that owning land was positively related to crop adoption though not significant. This implies that its easier for a household to insure own land rather than lease land. This can be attributed to the extra costs associated with the lease form of tenureship. Contrary to expectation, land tenure was found to increase food insecurity index for the adopter thus making them less food secure but to non-adopters, results showed a negative relationship between land tenure and food insecurity index implying an improvement in food security status.

Irrigation had a negative relationship with insurance adoption suggesting that practicing irrigation reduces the chance of household adopting insurance. This is true since farming is heavily rain-fed and if rain is enough or there is a watering system, there will be enough harvest hence no need for insurance. This finding support De Nicola (2010) result that practicing irrigation reduced farmer's participation in insurance. For farmers with stable farm production, there was less tendency to buy insurance. For adopters, irrigation negatively affects the food insecurity index implying an improvement in food security status. Conversely, this is not the case for the non-adopter as irrigation increases their food insecurity index thus making them less food secure.

Access to agricultural credit was found to positively influence crop insurance adoption decisions at a 5 percent significant level. Its effects on adopter's food insecurity index were found to be positively related implying that the adopters were less food secure. This can be attributed to the fact that agriculture is a risky business and in an event of adversity, farmers can experience huge loses. But for non-adopter, agricultural credit though not significant had a negative effect of lowering food insecurity index thus making non-adopters more food secure. Access to credit signifies ownership of a bank or savings account and the findings are similar to those of (Cole *et al.*,2012) where bank account ownership reflects financial literacy which is a key component in evaluating financial derivatives such as loans and insurance. Rhine *et al*. (2014) noted that ownership of savings accounts can serve as a pathway for the liquidity of wealth hence easing financial constraints when making farm investment.

The farming system was found to be positively related to crop insurance adoption. This is consistent with farming behaviour where the majority if not all farmer practice intercrop to maximize output for a defined piece of land and minimize production shock of a single crop. Those who practice intercropping easily insure their crop so as to diversify risks and maximize compensation in case of loss as compared to those who practice monocrop. Further, intercropping acts as a means of diversification and reduces exposure to production risks. This finding corroborates results by Ginder and Spaulding (2009) who found a positive relationship between diversification and purchase of premium where farmers in USA considered insurance as a coping mechanism for production and market risks, and food security problems. Intercropping had a negative effect on the food insecurity index thus implying food security for adopters contrary to non-adopters.

Results showed that membership to a farming group or cooperative positively and significantly affected farmers' decisions to adopt AYII. This could be attributed to the availability of information concerning farming and related farm products and agricultural extension services. These results are consistent with Olila & Pambo (2014) findings that group membership increases the level of awareness of crop insurance hence influencing farmers' adoption decisions. Similarly, Gine *et al*. (2007) findings showed that in India, group membership had a positive influence on farmers' decision to participate in crop insurance compared to non-members.

Distance to the nearest road significantly influenced farmers' decision to participate in AYII in a negative way. This implies that those located near to motorable road had a higher tendency of participating in crop insurance compared to those located far to the road. Shorter distance reduces transaction costs and enhances access to varied agricultural interventions and opportunities. Ali (2013) found similar results where in Pakistan, farmers closer to the road were able to engage in different agricultural initiatives and activities. Similary, Birinci and Tumer (2006) findings support the negative relationship where he argued that in Turkey, farmers located in the interior parts little engaged in agricultural schemes.

The age of the household significantly influences the decision to participate in crop insurance. This result showed that as age increases, farmers increase the possibility of insurance by 0.0396. This finding supports results by Onyimbo *et al*. (2013) and Sargazi *et al*. (2013) who argued that as farmers get old, their probability of taking insurance increases.

4.4 Effects of crop insurance on food security

The study used ESR to compare the expected food security status of the household using the food insecurity index under two regimes. First, the study compared the expected food insecurity index for households who actually adopted or participated in crop insurance (a) with the counterfactual case of a farmer who did not adopt crop insurance if adopted (d). Secondly, a comparison of the expected food insecurity index for non-adopter (b) with the counterfactual hypothetical case where a farmer who actually adopted crop insurance did not adopt (c). The actual observed cases are represented by (a) and (b) while unobserved or counterfactual hypothetical cases are represented by (c) and (d).

The results indicated that the expected mean of food insecurity index for the household that participated or adopted crop insurance was 4.963022 while the counterfactual case of adopter if not adopted is 5.781565 (see table 4.4). Thus for the treatment effect of treated (that is if an adopter of crop insurance did not adopt), adopter of insurance would have experienced a significant increase in food insecurity index by 0.818543. These results imply that households that adopted crop insurance would be more food insecure if they had not adopted the insurance. Similarly, results show that the expected mean of food insecurity index in the counterfactual case that households who did not adopt crop insurance is 4.364557 and for the counterfactual case of the household who did not adopt insurance adopted is 4.319364. Therefore the treatment of untreated (if household that did not adopt crop insurance adopted), their food insecurity index would have decreased by 0.0451931 making them more food secure. This finding shows that crop insurance has an effect on improving food security status by reducing the food insecurity index.

5Table 4.4: Results for treatment

	(1)	(2)	(3)	
Sample		**Decision Stage**		
	To adopt	Not to adopt	To Treatment	t-value
	(a)	(c)	ATT	
Farmers who adopted crop insurance	4.963022	5.781565	-0.8185436***	-6.4324
	(0.0861333)	(0.0926894)	(0.1272538)	
	(b)	(d)		
Farmers who did not adopt crop insurance	4.319364	4.364557	-0.0451931*	-0.2783
	(0.0689441)	(0.1524882)	(0.1623989)	
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1				

CHAPTER FIVE

SUMMARY FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter gives the summary and conclusions derived from the study findings and finally some recommendations relevant for adoption by key policymakers and also for further research based on the findings.

5.2 Summary findings

The research set out to investigate the determinants of crop insurance adoption and its effects on the household's food security status. Many indicators are used in assessing the household's food security status, however, this study used a food insecurity index based on the Rasch measurement (scale) model that measures household food insecurity access (HFIA). In the face of ever-increasing weather variability and climate change, smallholder farmers require risk management tools to enhance their resilience against related income shocks due to declined agricultural production.

Understanding of the effects helps in making informed decisions concerning paths of dissemination, uptake trends, and effects. Therefore, our study assessed drivers of adoption of crop insurance, uptake trends and the effects on food security at the household level. From the findings, although awareness is an important determinant for the uptake, only a small number of farmers fully understand how it works thereby limiting their capacity to make the decision regarding uptake decisions. Similarly, the inaccessibility of crop insurance services especially due to distribution or availability problem has also stalled its uptake. Age, membership to a group and distance to motorable road significantly influence the decision to insure. As people get old, they tend to take insurance and reduce the prevalence of related shocks in agriculture. Similarly, membership to a farming group exposes one to information on agricultural methods and related products hence influencing decision-making. Further, nearness to motorable road reduced transaction costs thus significantly influencing adoption decision.

With respect to how participation in crop insurance affects household's food security status, the study found out from ATT that the household who participated in crop insurance would have had their food insecurity index increased by 0.81854 if had not participated thus making them less food secure as the higher the index implies higher vulnerability to food insecurity. Similarly, result from

ATU indicated that the household who did not participate in crop insurance would have had their food insecurity index reduced by 0.0451931 if they had participated thus making them more food secure. Therefore, insurance has an effect of reducing households' food insecurity index thus making them more food secure.

Since the age and experience of the farmers are paramount in the adoption of agricultural innovations, few youths engage in agricultural activities. Despite insurance being a useful tool to stabilize incomes and provide a fallback recovery mechanism after a crop failure, transforming rural agriculture into agribusiness through the youths will require seamless efforts.

5.3 Conclusion

Generally, the number of households insuring their crops is marginally small and declining. This trend is to a large extent worsen by the fact that most of the farmers find it hard to comprehend the concept of insurance, partly due to the complex form of insurance or due to insufficient knowledge on the potential benefits and opportunities associated with the uptake. This indicates that despite awareness being vital, training is required to encourage adoption for the sustainability of the scheme. Though the majority of farmers grow maize as the main crop despite practicing intercrop farming system, the insurance targeted only one crop thus restricting farmer's choice on what to insure as insuring some crops within the same piece of land deemed inappropriate. In addition, there was minimal or little engagement by smallholders to offer responses concerning the type of insurance products offered and preference.

5.4 Recommendations

Therefore, according to the results, the study recommends the following for such a scheme to be effective, viable, sustainable and able to achieve the aim of the insurer and the target group:

i. All relevant stakeholders should be part and contribute to the design of derivative insurance products. This is possible through the use of a feedback mechanism where farmers are involved to promote conceptualization and establishment of feasible and outcome-oriented methods to adapt to the effects of climate change. A participatory tactic is advantageous in the planning process of products that reflect farmers' wide range of demographic and socio-economic conditions to enhance acceptance whilst accelerating uptake.

ii. Provision of a mechanism for continued awareness and training of farmers on crop insurance together with related risk management techniques or alternatives to minimize climate change impacts on the livelihood of the households depending on farming.

iii. Additional to the support of developing relevant laws aimed at promoting the growth of the insurance sector and provision of fundamental investment infrastructure, the government should ensure that the insurance company performs its due diligence of compensating farmers in real-time when a loss occurs and that farmers are not taken advantage of.

iv. Bundling crop insurance with other related services such as credit, loans and continued provision of agricultural extension services. Services like credit can act as an incentive for enticing farm households to buy more insurance whilst ensuring they get value for their investment.

v. Lastly, basis risk is a major drawback towards the implementation, management, and sustainability of crop insurance. Approaches aimed at minimizing basis risk require attention or consideration in developing and designing the index. These include using a more accurate sample that is nearer to the majority of the insured farmers within a defined UAI for better results robust triggers towards ascertaining the connection between actual output and the predetermined output, and review of the predetermined average yield for all UAIs. The current average yield for the UAIs is less in comparison to actual output thus the high probability of basis risk dominating. Therefore, it is prudent to review the yield to reflect the actual farm yield.

5.5 Limitations of the study

During the study, two major limitations were faced. First, the lack of clear records concerning farmers and payout. Different organizations kept different pieces of information that were incomplete. Data consistency is importance and any data gap poses the problem of data reliability thus the government needs to be the custodian of all data concerning farmers for easier access through the agricultural office. Secondly, the life span of a program in a specific locality was limited. For example, in most cases, members of nearly all groups got support from the program for only two years before the program shift to new members. Therefore, unless the research is conducted while the members are active, data inconsistency may be a major drawback.

5.6 Areas for further research

The study focused on one area but there are a number of areas that the program of AYII has been rolled out thus need for wider coverage. A similar study can be done in multiple areas to give a general overview of the evaluation of the program in different areas.

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APPENDIX

Appendix I: Questionnaire

Area Yield Crop Insurance and Food Security Survey Instrument Njoro Sub County

Introduction

Hello, my name is […] a student from the University of Nairobi. I am conducting research on the effects of Area yield index insurance (AYII) on food security in Njoro Sub County. We are talking with small-scale farmers specifically maize growers targeted for crop insurance. We are interviewing you as a representative of a large group of small-scale maize farmers' similar to yours. We hope that you are willing to spend about 15 minutes to discuss with me. By participating in the survey, you help increase knowledge about important issues related to crop insurance and food security within Nakuru, Njoro sub-county. I wish to assure you that all your views, opinions and personal information you will give will be held strictly confidential.

SECTION 1: IDENTIFICATION

Contact details		**Instructions**
1.1. Name of the respondent (optional)	…….	*Interviewer:* Ask ALL. Ensure the name is captured if provided
1.2. Phone number (optional)	…….	*Interviewer:* Ask ALL. Ensure telephone is captured if provided
1.3 Ward	1. Njoro 2. Lare 3.Kihingo 4. Mauche	*Interviewer:* Ask ALL. Ensure ward is captured

1.4 Location	……	*Interviewer:* Ask ALL. Ensure location is captured
1.5 Village	……	*Interviewer:* Ensure village is captured

SECTION 2: DEMOGRAPHIC INFORMATION

Questions & Answers		**Instructions**
2.1 Gender?	1. Male 2. Female	*Interviewer:* Ask ALL. One mention only
2.2 What is your age?	…….	*Interviewer:* Ask ALL. Record in years.
2.3 What is your marital status?	1. Married 2. Single 3. Divorced 4. Separated 5. Widow	*Interviewer:* Ask ALL. One mention only
2.4 What is your highest level of education?	1. No Education 2. Primary School 3. Secondary School 4. Tertiary (College/University)	*Interviewer:* Ask ALL. One mention only
2.5 Are you the head of the family?	1. Yes 2. No	*Interviewer:* Ask ALL. One mention only
2.6 How many members of the family are school-going children?	…….	*Interviewer:* Ask ALL. Record in numbers
2.7 Other than income from farming, do you receive any	1. Yes 2. No	*Interviewer:* Ask ALL. One mention only

other income on a monthly basis?		
2.8 How far is the nearest market from your home?	.....	*Interviewer:* Ask ALL. Record in kilometers
2.9 How far is the nearest motorable road from your home?	……..	*Interviewer:* Ask ALL. Record in kilometers

SECTION 3: FARMING AND RISK MANAGEMENT

Questions & Answers		**Instructions**
3.1 What type of farming system do you practice?	1. Intercrop 2. Monocrop	*Interviewer:* Ask ALL. One mention only
3.2 What is your total land size in acres?	…… …..	*Interviewer:* Ask ALL. Record in acres
3.2.a Does your land have title deed?	1. Yes 2. No	*Interviewer:* Ask ALL. One mention only
3.3 What is the size of land under maize farming	……	*Interviewer:* Ask ALL. Record in acres
3.3.a Does land where you plant maize has a title deed?	1. Yes 2. No	*Interviewer:* Ask ALL. One mention only
3.4 How long have you been practicing farming?	……..	*Interviewer:* Ask ALL. Record in years
3.5 Do you practice irrigation farming?	1. Yes 2. No	*Interviewer:* Ask ALL. One mention only
3.5.a If Yes, Do you practice irrigation on maize?	1. Yes 2. No	*Interviewer:* Ask ALL. One mention only
3.6 Are you a member of any co-operative or farming group?	1. Yes 2. No	*Interviewer:* Ask ALL. One mention only

3.6.a When did you join the group?	……	*Interviewer:* Ask ALL. Record the year
3.6.b How do you benefit from the group?	1. Production 2. Marketing 2. Input supply (fertilizers, seeds, etc) 3. Loans 4. Saving 5. Education 6. Others, please specify …….	*Interviewer:* Ask ALL. Multiple mention
3.7 In the last one year, have you borrowed money from any financial institution?	1. Yes 2. No	*Interviewer:* Ask ALL. One mention only
3.7.a If yes, have you borrowed money for agricultural production?	1. Yes 2. No	*Interviewer:* Ask ALL. One mention only
3.8 What are the common risks or challenges that you face as a farmer?	1. Adverse weather changes 2. Increased pests and diseases 3. Poor Markets 4. Lack of information 5. Inadequate financial support 6. Lack of access to agricultural inputs 7. Poor quality of agricultural inputs 8. Poor transport 9. Poor storage 10. Others please specify …….	*Interviewer:* Ask ALL. Multiple mention
3.9 What forms of risk management strategies do you use?	1. Diversification 2. Insurance 3. Others please specify ……	*Interviewer:* Ask ALL. Multiple mention

SECTION 4: AGRICULTURAL INSURANCE

Questions & Answers		Instructions
4.1 Have you heard about Agricultural Insurance?	1. Yes 2. No	*Interviewer:* Ask ALL. One mention only
4.1.a If yes, how did you get the information?	1. Radio 2. T.V 3. Newspaper 4. Internet 5. Farming group 6. Friends 7. Relative	*Interviewer:* Ask ALL. Record source. Multiple selection
4.2 Have you taken/purchased/enrolled to agricultural insurance?	1. Yes 2. No	*Interviewer:* Ask ALL. One mention only
4.2.a If yes, which year did you /purchase/enroll to agricultural insurance?	……	*Interviewer:* Ask ALL. Record the year
4.3 What size of land under maize is insured?	…….....	*Interviewer:* Ask ALL. Record in acres
4.3.a How much premium do you pay per year?	……	*Interviewer:* Ask ALL. Record amount in Ksh
4.4 How many years have you been enrolled	……	*Interviewer:* Ask ALL. Record years

4.5 Have you received any training of on crop insurance?	1. Yes 2. No	*Interviewer:* Ask ALL. One mention only
4.6 What was the average duration of the training?	……	*Interviewer:* Ask ALL. Record in days
4.7 Who conducted the training?	1. Private Company 2. Public institutions 3. Others please specify…	*Interviewer:* Ask ALL. One mention only
4.9 Compared to a period without agricultural insurance, has your maize yield (total bags harvested) on the same piece of land?	1. Increased 2. Reduced 3. Remained the same	*Interviewer:* Ask ALL. One mention only
4.10 Before you purchased agricultural insurance, approximately how many bags were you harvesting on the piece of land that is currently insured?	……..	*Interviewer:* Ask ALL. Record in 90kgs bags
4.11 After you purchased agricultural insurance, approximately how many bags did you harvest from the same piece of land?	……	*Interviewer:* Ask ALL. Record in 90kgs bags
4.12 Before you purchased agricultural insurance, were you planting hybrid maize seeds?	1. Yes 2. No	*Interviewer:* Ask ALL. One mention only

4.13 Do you currently plant hybrid maize seeds?	1. Yes 2. No	*Interviewer:* Ask ALL. One mention only
4.14 How do you pay the insurance premiums?	……	*Interviewer:* Ask ALL. Open ended
4.15 Have you received compensation due to loss?	1. Yes 2. No	*Interviewer:* Ask ALL. One mention only
4.16 If yes, how much?	……	*Interviewer:* Ask ALL. Record amount in Ksh
4.15 What challenges do you face with the current agricultural insurance program?	……..	*Interviewer:* Ask ALL. Open-ended

SECTION 5: FOOD SECURITY

Questions & Answers ***(****please tell select the statement that best suits you)*		**Instructions**
5.1 "The food that (I/we) bought just didn't last, and (I/we) didn't have money to get more." Was that often, sometimes, or never true for (you/your household) in the last 12 months?	1. Often true - more than ten times 2. Sometimes- three to ten times 3. Never true 4 DK or Refused	*Interviewer:* Ask ALL. One mention only.
5.2 "(I/we) couldn't afford to eat balanced meals." Was that often, sometimes, or never true for	1. Often true - more than ten times 2. Sometimes- three to ten times 3. Never true	*Interviewer:* Ask ALL. One mention only

(you/your household) in the last 12 months?	4 DK or Refused	
5.3 In the last 12 months, since last (name of current month), did (you or other adults in your household) ever cut the size of your meals or skip meals because there wasn't enough money for food?	1. Yes 2. No (Skip 5.3a) 3. DK (Skip 5.3a)	*Interviewer:* Ask ALL. One mention only
5.3a [IF YES ABOVE, ASK] How often did this happen?	1. Almost every month 2. Some months but not every month 3. Only 1 or 2 months 4 DK or Refused	*Interviewer:* Ask ALL. One mention only.
5.4 In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money for food?	1. Yes 2. No 3. DK	*Interviewer:* Ask ALL. One mention only.
5.5 In the last 12 months, were you every hungry but didn't eat because there wasn't enough money for food?	1. Yes 2. No 3. DK	*Interviewer:* Ask ALL. One mention only.
*****Thank you very much for your responses*****		

Responses of "often" or "sometimes" on questions 5.1 and 5.2, and "yes" on 5.3, 5.4, and 5.5 are coded as yes similar to those of "almost every month" and "some months but not every month" on 5.3a. The total number yes (affirmative) responses to the six questions represents the household's raw score on the scale.

Appendix 2: Rasch Measurement Model

Food security status is assigned as follows:

- Raw score 0-1— Marginal or High food security
- Raw score 2-4—Low food security
- Raw score 5-6—Very low food security

Based on reporting, households with raw score 0-1 are described as food secure while the rest are considered as food insecure. Scale scores representing the food insecurity index based on the Rasch measurement model for the six-question answer on food security can be represented as

Number of affirmatives	Scale score
0	N/A
1	2.86
2	4.19
3	5.27
4	6.30
5	7.54
6 (evaluated at 5.5)	8.48

Appendix 3: Correlation matrix

	age	gender	educle~1	educle~2	educle~3	educle~4	hhsize
age	1.0000						
gender	0.1835	1.0000					
educlevel1	0.3144	-0.2099	1.0000				
educlevel2	-0.0657	-0.1155	-0.3771	1.0000			
educlevel3	-0.1483	0.1600	-0.1504	-0.7206	1.0000		
educlevel4	0.0788	0.1903	-0.0654	-0.3133	-0.1249	1.0000	
hhsize	-0.4304	0.0240	-0.2004	0.0064	0.1404	-0.0679	1.0000
hhhead	0.2895	0.7131	-0.0048	-0.1550	0.1046	0.1520	-0.1982
maizacre	0.0666	0.0432	-0.0073	-0.1146	0.0800	0.1119	0.1779
nonfarminc~e	-0.1824	0.1804	-0.1064	-0.2224	0.2471	0.1620	0.0308
marktkm	0.0698	0.0059	0.0428	-0.0366	0.0378	-0.0257	0.0099
roadkm	-0.0677	-0.0532	-0.0996	0.1247	-0.0065	-0.1359	0.1026
landsize	0.4279	0.1020	0.0964	-0.2273	0.0651	0.2849	-0.1962
mtitle	0.4424	0.0912	0.1763	-0.0919	-0.0054	0.0536	-0.3068
irrigation	0.0236	0.0857	-0.0371	-0.1087	0.0879	0.1187	0.1268
grpmemb	0.2690	0.0974	0.0638	-0.0094	-0.0466	0.0867	-0.0777
creditacc	0.0255	0.1926	-0.0316	-0.3389	0.2466	0.3238	-0.0054
agricredit	0.0082	0.1535	-0.0836	-0.2041	0.1793	0.2144	0.0947
aware	0.2470	0.1219	0.0065	-0.1225	0.1309	0.0699	-0.1950
landtenure	0.2771	0.0885	0.0812	-0.0474	-0.0379	0.0674	-0.1269
farmsyst	0.0326	-0.1317	0.0320	0.1535	-0.1216	-0.1456	-0.0977

	hhhead	maizacre	nonfar~e	marktkm	roadkm	landsize	mtitle
hhhead	1.0000						
maizacre	0.0719	1.0000					
nonfarminc~e	0.1102	-0.0386	1.0000				
marktkm	0.0045	-0.1356	-0.0056	1.0000			
roadkm	-0.0725	-0.0083	-0.1553	0.1714	1.0000		
landsize	0.1786	0.3162	0.0453	-0.1019	-0.1442	1.0000	
mtitle	0.2207	-0.0724	0.1094	0.0986	-0.1548	0.5085	1.0000
irrigation	0.0413	-0.0193	0.0919	-0.0152	-0.0473	0.0685	0.0992
grpmemb	0.1792	0.1577	0.0918	-0.0120	-0.0931	0.2713	0.2477
creditacc	0.1897	0.2252	0.3164	-0.0446	-0.1198	0.2198	0.1306
agricredit	0.0852	0.3321	0.2262	-0.0049	-0.0297	0.2183	0.0604
aware	0.1588	0.1680	0.2098	0.0843	-0.1409	0.2519	0.2797
landtenure	0.1553	0.1327	-0.0054	-0.1419	-0.2033	0.2121	0.3184
farmsyst	-0.0939	-0.0966	-0.1258	0.0342	0.0409	-0.0950	-0.0065

	irriga~n	grpmemb	credit~c	agricr~t	aware	landte~e	farmsyst
irrigation	1.0000						
grpmemb	0.0260	1.0000					
creditacc	0.2138	0.1905	1.0000				
agricredit	0.3228	0.1164	0.6858	1.0000			
aware	0.0157	0.4050	0.2366	0.1973	1.0000		
landtenure	0.0382	0.2309	0.1257	0.0862	0.1926	1.0000	
farmsyst	-0.2780	-0.0826	-0.2629	-0.2442	-0.0756	-0.0330	1.0000

Appendix 4: Falsification test

	(1)	(2)
	OLS	**Probit**
Variables	**Food insecurity index**	**Crop insurance participation**
Household age	-0.0135	0.0475**
	(0.0096)	(0.0186)
Household heed is male	0.0443	-0.2056
	(0.1654)	(0.3002)
Household head has primary education	0.6155**	0.6420
	(0.2690)	(0.5075)
Household head has secondary education	0.2667	0.8376
	(0.3183)	(0.6137)
Household head has secondary education	0.2155	0.7788
	(0.5182)	(0.9003)
Size of the household	0.3997***	-0.0460
	(0.0554)	(0.1058)
Acres under maize production	-0.2105**	0.3490**
	(0.0984)	(0.1576)
Non-farm income	-0.2243	0.3814
	(0.2439)	(0.3571)
Distance to the nearest produce market	0.0464**	-0.0613*
	(0.0218)	(0.0340)
Distance to motarable road	0.5604	-1.7726***
	(0.3699)	(0.6648)
Size of land owned	-0.1400*	-0.1302

	(0.0825)	(0.1334)
Size of land under maize production ownership	0.3926*	0.7414*
	(0.2197)	(0.4104)
Irrigation	0.1001	-0.2023
	(0.4559)	(1.1655)
Membership in farming group	0.0635	1.5117***
	(0.1697)	(0.3352)
Access to agricultural credit	0.3122	0.7925
	(0.3807)	(0.5811)
Information on crop insurance (awareness)	-0.3126*	-
	(0.1729)	
Land ownership	-0.0808	-0.3047
	(0.2807)	(0.8571)
Farming system practiced	-1.0743	1.3123
	(0.8522)	(0.8858)
Constant	5.2807***	-4.5215**
	(1.1941)	(1.8875)
Observations	233	162
R-squared	0.4431	

Appendix 5: Model without standard errors (heteroscedasticity)

	(1)	(2)	(3)
		Farmers adopted	**Farmers did not adopt**
Variables	**Adoption**	**Food insecurity index**	**Food insecurity index**
Household head is male (1 if yes)	-0.1115	0.1146	-0.3654*
	(0.2486)	(0.2478)	(0.1897)
Household head has primary education (1 if yes)	0.8585**	0.7752*	0.9382***
	(0.3983)	(0.4544)	(0.3215)
Household head has secondary education (1 if yes)	1.0640**	0.8571	0.4626
	(0.4990)	(0.5365)	(0.3709)
Household head has tertiary education	1.6959**	0.7861	0.1664
	(0.7159)	(0.6653)	(0.7218)
Household size (number)	-0.0992	0.3086***	0.4333***
	(0.0788)	(0.0939)	(0.0648)
Land under maize (acres)	0.3370***	-0.0611	-0.7155***
	(0.1129)	(0.0731)	(0.1187)
Nonfarm income (1 if yes)	0.6647**	-0.1481	-0.1578
	(0.3004)	(0.2851)	(0.2594)
Distance to the nearest market (km)	-0.0249	0.0702**	0.0239
	(0.0290)	(0.0321)	(0.0227)
Land size (acres)	-0.1607*	-0.1450*	-0.0545
	(0.0936)	(0.0824)	(0.1176)
Land under maize tenure (1=yes)	0.7253**	0.4384	0.2761
	(0.3108)	(0.3586)	(0.2626)

Irrigation (1=yes)	-0.6743	-1.0917	0.6651
	(0.8833)	(1.0334)	(0.7518)
Access to agricultural credit (1=yes)	1.1660**	0.4960	-0.9400
	(0.5249)	(0.4275)	(0.6032)
Land tenure (1=yes)	0.1363	0.7488	-0.1618
	(0.6098)	(1.1466)	(0.2727)
Farming system (1=intercrop)	1.3228	-1.6825	0.2197
	(0.8602)	(1.0397)	(1.1805)
Distance to motorable road (km)	-1.7363***		
	(0.4950)		
Household age (years)	0.0396***		
	(0.0128)		
Group membership (1=yes)	1.3607***		
	(0.2568)		
Constant	-5.1229***	3.2596*	4.0573***
	(1.4300)	(1.6808)	(1.3405)
Observations	233	233	233
Wald Chi^2=127.34***, Likelihood test of independent equations: Chi^2(1)=7.76***			
Rho_0= -.4048848 and Rho_1= .7026783, r0= -0.4295 and r1= 0.8726**, lns0 = -0.0794 and lns_1 = 0.2128**			
Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1			