THE ROLE OF AGRICULTURAL INNOVATION PLATFORMS IN ACCESS AND USE OF MAIZE TECHNOLOGIES AMONG SMALLHOLDERS IN KENYA

BY

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DECLARATION

The research paper is my original work and has not been presented for any award in any other university

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DEDICATION

I dedicate this work to my parents, Philip and Winifred Kitonga, and my aunty Mary Mwikali Nzioki.

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LIST OF ABBREVIATIONS AND ACRONYMS

ATT: Average Treatment Effects on the Treated

GDP: Gross Domestic Product

NARS: National Agricultural Research Systems

KARI: Kenya Agricultural Research Institute

T & V: Training and Visiting

AIPs: Agricultural Innovation Platforms

SLM: Sustainable Land Management

NALEP: The National Agriculture and Livestock Extension Programme

SIDA: Swedish International Cooperation Agency

CBOs: Community Based Organizations

NGOs: Non-Governmental Organizations

CIGs: Common Interest Groups

EADPP: East Africa Dairy Development Program

SIMLESA: Sustainable intensification of maize-legume cropping systems for food security in eastern and southern Africa

ACIAR: Australian Centre for International Agricultural Research

CIMMYT: International Maize and Wheat Improvement Center

MTP II : Second Medium Term Plan

GOK: Government of Kenya

CBOs: Community Based Organizations

NIE: New Institutional Economics

NIS: National Innovation Systems

PSM: Propensity Score Matching

OLS: Ordinary Least Squares

WLS: Weighted Least Squares

ODK: Ordinary Tool Kit

CIA: Conditional Independence Assumption

ABSTRACT

Maize is the most important food crop for the majority of Kenyan households. However, in the past many years, the country has continued to grapple with a persistent deficit in the maize sub-sector. The majority of maize smallholder farmers, who account for over 75 % of national production, have limited participation in the access and use of maize technologies; which are important pre-requisites in increasing maize yields. Furthermore, many smallholders also have limited access to supportive services such as credit, technical and market information. It is also noteworthy that many smallholders are alienated from crucial stakeholders along the maize value chain.

The Government of Kenya (GOK), in the first phase of the vision 2030 medium term plan, identified the strengthening of farmer collective action as one of the strategies to improve input market participation, technology adoption, supportive service access and overall production. One of the many forms of farmer collective action that is anchored on fostering value chain partnerships is manifested in institutional innovations such as Agricultural Innovation Platforms (AIPs); which essentially is an alliance of the main actors along the agricultural value chain.

Their importance notwithstanding, there is however not enough empirical evidence documenting the impact of AIPs on access to and use of technologies among smallholders and ultimately their effect on maize yields. Noting this gap, this study set out to investigate the determinants of membership to AIPs and the impact that this membership has on maize yields and access to select technologies.

The study was conducted on two sites, namely Embu and Meru, which together comprise the Kyeni AIP. Through a combination of random and purposive sampling, 150 households were sampled in total. The study employed Propensity Score Matching to assess the determinants of AIP membership and also to estimate Average Treatment Effects on the Treated (ATT).

Concerning the determinants of AIP membership in Embu, the probability of membership tended to increase among households with larger landholdings. Age of the household head was also found to have a positive significant effect on membership. The key policy asset variable determining participation in the platform in Meru region was cattle, such that participation probability tended to increase among households with larger cattle ownership. A common variable determining membership in both areas was access to training on maize varieties which had a positive significant effect on the probability of membership.

The results from the ATT estimation reveal that AIP membership has a positive statistically significant effect on fertilizer quantity use and maize yield among its members in Embu, whereas in Meru AIP membership has a positive statistically significant effect on seed use quantity among members. In Embu, members on average used 21 kg more fertilizer per acre compared to non-members and also their yields per acre exceeded that of non-members on average by slightly over 250kg. In Meru region, ATT results show that AIP membership had a positive and significant effect on adoption of improved seed varieties with members on average using approximately 1.5 kg more seed per acre compared to non-members.

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

1.1.1 A review of Kenya's agricultural sector

The enduring role of the agriculture sector in Kenya's development agenda cannot be overemphasized. Agriculture, from a macroeconomic perspective, is a key income earner to the country's economy; contributing to approximately 26 % of the Gross Domestic Product (GDP) valued at 1.39 trillion shillings. The sector comprises about 65 % of Kenya's total exports, generating significant foreign exchange reserves that are instrumental in financing the country's operations (KIPPRA, 2013; Government of Kenya, 2015). Furthermore, from a microeconomic perspective, the sector is a key source of livelihood for a majority of Kenya's population; comprising of mainly poor rural smallholder farming households (Olwande et al., 2015). The prominent role played by the sector on both scales renders it very instrumental in catalyzing Kenya's economic transformation and an effective conduit in uplifting millions out of poverty. Consequently, Kenya's economic blueprint, Vision 2030, identifies the sector as one of the key pillars in realizing the country's transition into a middle income country by 2030 (Government of Kenya, 2006).

In the Kenyan agricultural context, smallholder farming commands a prominent role given that it is the dominant mode of production; accounting for 80 % of agricultural output and over 70 % of marketed agricultural output (Government of Kenya, 2007; Economic survey 2015). Nowhere is this reality well exemplified than in the maize sub-sector, whereby over 98% of Kenya's 3.5 million smallholder farmers cultivate it as a major food crop and whose output accounts for over 70 % of total production (Kirimi et al., 2011; FAO, 2014). The prominence of the maize crop in the smallholder sub-sector and on a national scale is due to its great versatility as a source of food, feed and seed. Maize is the most important food crop in Kenya (Alene et al., 2007), accounting for over 65 % of all staple food calories consumed (FAO, 2011). It is also a major ingredient in the country's feeding system accounting for over 80 % of feed rations and accounts for about 56 % of land cultivated in Kenya (Kirimi et al., 2010). In the Kenyan context, maize availability is synonymous with food security.

Given the centrality of maize in Kenya's feed system, maize production has far reaching implications on macroeconomic stability, food security and the livelihoods of millions of Kenyans. However, for many years now, the country continues to grapple with erratic patterns in maize production which often times has resulted in deficits that must be supplemented by imports (Economic survey, 2015; Ouma et al., 2014; Ogada et al., 2014; Jayne et al., 2010).The country's annual consumption- estimated at approximately 3 million metric tonnes (Nyoro, 2007) - compared to production patterns in recent times (see Figure 1) shows a deficit trend along many years .The country's maize production growth rate has been estimated at a marginal 2 % against a population growth rate of 3 % (AATF, 2010). Future projections based on current production trends do not seem promising. It is estimated that by the year 2020 the country's population will stand at 43 million with an estimated demand of 5 million metric tonnes and based on current maize production growth rates the deficit is estimated at 1.2 million metric tonnes (FAO, 2011).

This worrisome trend is a matter of concern to all stakeholders given that it jeopardizes the country's welfare from a social, economic and political perspective. Kenya's resort to importation poses serious concern for the country's macroeconomic stability, exposing it to unwarranted negative shocks of commodity price movements in international markets (Kirimi et al., 2011). Socially, declining production increases the economic vulnerability of many households dependent on maize for food and income (Ouma et al., 2014). Finally, from a stability frontier, the Arab spring revolution and the food strikes in many African countries act as a potent reminder of the political upheaval that food insecurity and the cost of living can impose on a nation (AFDB, 2014).

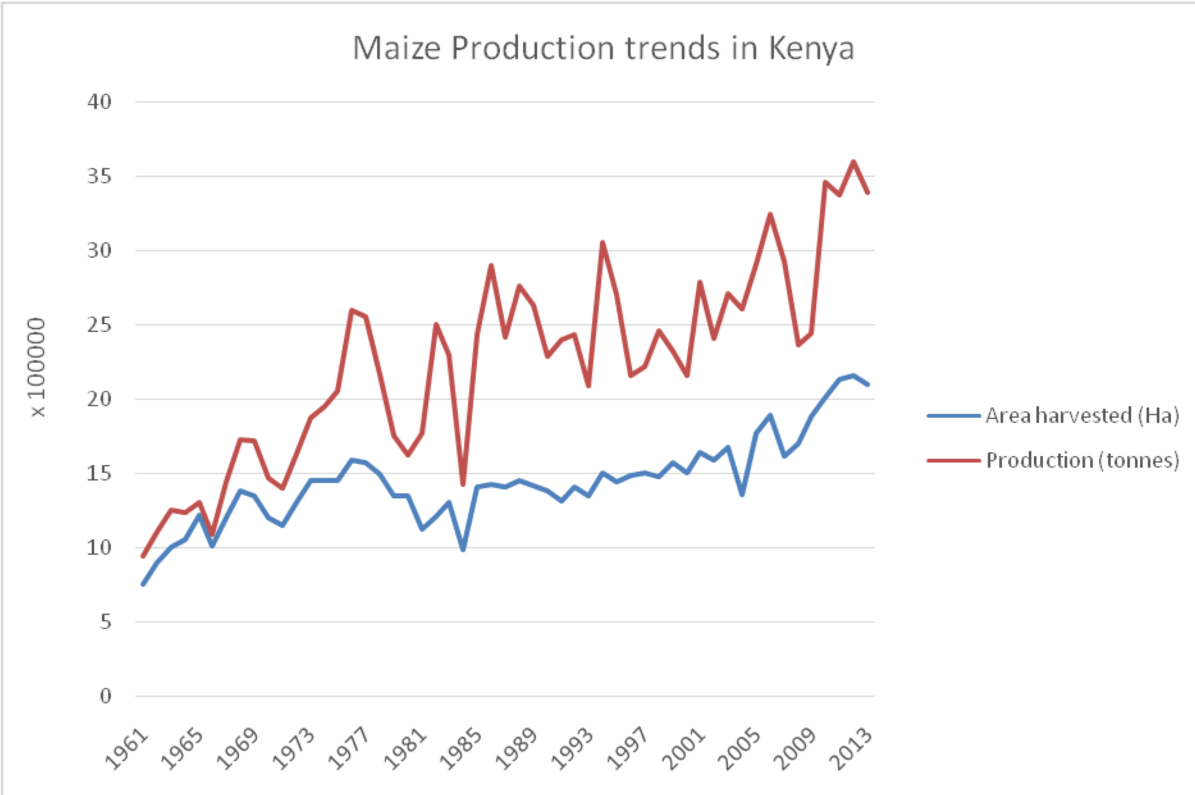

Figure 1: Annual maize production and area harvested in Kenya, 1961–2013.

Source: FAO Stat database: www.faostat.fao.org/.

The declining trend in maize production is attributed to a host of factors that are biophysical, policy, institutional, infrastructural, market related, financial and socio-economic in nature. Smallholders in Kenya, as in many parts of Sub-Saharan Africa, must contend with biophysical challenges such as declining soil quality and crop diseases that have serious implications on production (Marenya & Barett, 2009; Chemiat & Makone, 2015). The introduction of Structural Adjustment Programs (SAPs) ushered in a new institutional context that limited the traditional public sector role in offering smallholders credit, inputs and extension support (Alene et al., 2007; Ali-olubandwa et al., 2011). Smallholders must also contend with the challenge of declining land labor ratios that have seen a decline in arable land space, resulting in land units that are economically unviable for production (Ogada et al., 2014). It is estimated that land to labor ratios are half as large compared to the period 1960. (Jayne et al., 2010).

On a market frontier, smallholders contend with high transaction costs in accessing input markets that include screening and monitoring potential input suppliers in order to assess their credibility in supplying quality inputs (Alene at al., 2007; Winter-Nelson and Temu, 2005). Such market challenges may explain the low use of fertilizer among smallholder households in Africa which is estimated at less than 10 % (Misiko et al., 2011), while in the Sub-Saharan region the average use of fertilizer at 8kg/ha is the lowest in any region in the world (Marenya & Barett, 2009). Differential transaction costs have implications on farmers' access to productive assets; such that less endowed farmers face serious constraints in accessing credit to purchase inputs and also in accessing advisory services (Fischer & Qaim, 2012). Infrastructural constraints also dictate maize farmer participation in accessing technologies with farmers located further from inputs markets being less likely to adopt fertilizers (Alene et al., (2007).

1.1.2 PAST EFFORTS TO HELP SMALLHOLDER FARMERS

Innovation has and continues to be at the centre of efforts to help smallholders and the agricultural sector as a whole to improve on outcomes (Ergano et al., 2010). Traditionally, the **'Linear model of technology transfer'** has for a long time been the **research paradigm** governing the process of innovation in the sphere of agricultural research (Hounkonnou et al., 2012; Spielman et al., 2009). Under this model, scientists are considered as the primary source of innovation, whereas the extension system is viewed as the transfer mechanism through which technologies are conveyed ultimately to the recipients (farmers) (KARI, 2013). It is this model that has also dominated previous interventions/efforts to boost outcomes in Kenya's agricultural sector, as we shall see in this section.

The existence of extension services in the Kenyan context can be traced back to the early 1900's (Gautum, 2000), though it can be said that the most notable reference to agricultural research and extension in the formative years of the country's development dates back to the Swynnerton plan. During this period agricultural research was coordinated by 'local adaptive research stations' that were linked to international centres within the British Empire (FAO, 2002). The Swynnerton plan by Roger Swynnerton , introduced the era of agricultural intensification with the intention to transform the prevailing agricultural system that was subsistence in nature to one that was commercially oriented (Okoth-Ogendo, 1986).

The plan advocated for a myriad of land and political reforms, the most conspicuous being the consolidation of fragmented peasant land holdings in order to pave way to large scale cash crop production (Kariuki, 2004). The pursuit of commercial cash crop farming, targeted at international markets, necessitated advanced support services in order to ensure that farmers adhered to the stringent international requirements. Consequently, the public sector extended its support to farmers through a number of services that included technical extension support, credit supply, marketing services and the upgrading of rural infrastructure (Thurston, 1987).

In the post-independence era, the country inherited the ‘Linear model’ paradigm. Agricultural research was spearheaded by the newly independent countries under the auspice of the National Agricultural Research Systems (NARS) (FAO, 2002). The NARS constituted public research organizations such as the Kenya Agricultural Research Institute (KARI), universities engaged in agricultural research and technical departments within the Ministry of Agriculture. Public sector extension -traditionally housed under the docket of the Ministry of Agriculture- was the major conduit through which research outputs were conveyed to farmers (Anderson & Feder, 2007). Public sector extension was perceived as top-bottom (Davis, 2008) or oriented towards the ‘linear model of technology transfer’ approach where researchers were viewed as ‘sources of innovation’ and farmers were viewed as ‘technology adopters’. Extension services to smallholders typically centered on crops and livestock (Muyanga and Jayne, 2004).

This model however came under heavy criticism primarily concerning how agricultural research was conducted (the NARS system) and also the method of delivery (public sector extension). Research projects undertaken by NARS were perceived to be oriented towards a scientific agenda more than they were to addressing the pressing constraints faced by farmers (Clark, 2002). The research model-‘Linear model of technology transfer’- was perceived as top-bottom (Davis, 2008), whereby scientists were viewed as ‘sources of innovation’ and farmers were considered merely as ‘technology adopters. This resulted, often times, to limited impact of agricultural research on beneficiaries.

Public sector extension came under heavy criticism due to a of number reasons that included the incurrence of huge fiscal deficits (Muyanga & Jayne, 2004), marginalization of farmers by extension agents, a poor enabling environment and lack of continuous commitment to funding extension budgets from government dockets (Anderson & Feder, 2004). Furthermore, extension services focused primarily on improving productivity and dissemination of productivity enhancing technologies, with little regard to advisory services on market access and related support services.

In 1982, the World Bank in collaboration with the Kenyan government introduced the Training and Visiting approach (T & V).The approach endeavored to make improvements to the manner in which research and extension was conducted following the shortcomings aforementioned. The definitive features of the approach included in-house specialists, several field and supervisory staff, bi-weekly training sessions with contact farmers, seasonal meetings with researchers, better staff enumeration, villages visits over a two-week cycle and strict supervision of field officers (Anderson & Feder, 2004; Gautum, 2000). The approach endeavored to address some of the shortcomings of the public and development sector through increased reimbursements to extension agents, increased field visits to farmers, improved linkages to research and increased service reach to marginalized farmers (Anderson & Feder, 2004).

T & V initially received favorable reviews on its impact effectiveness but by the end of the second phase a lot of doubt was cast on its effectiveness and sustainability. The approach was perceived as top-down and fiscally unsustainable (Davis, 2008). Farmers grew tired of supply driven information that featured “simple agronomic information’’ conveyed during the regular extension visits (Anderson, 2007). Research-extension-farmer linkages did not see significant improvement. Extension visits were also found to retain bias with it being noted that extension agents favored progressive farmers. Moreover, it was noted that visits were infrequent and sporadic. Concerning welfare, a majority of farmers (66%) thought their welfare was lower than before, while only 25 % thought it was better. Concerning productivity, 72 % thought it was lower, while 25 % felt it had improved. As pertains to extension, 75 % thought that extension services had not transformed compared to 11 % who thought that the quality had improved. Furthermore, 39 % thought extension service quality had deteriorated (Gautum, 2000).

The ‘**Farming participatory’ research paradigm** was conceptualized on the basis of the above shortcomings with variations such as Farmer Field Schools and Model farmer approach. The intent of the approach was to integrate farmers in the research process; in essence farmers were regarded as co-creators of knowledge. A typical session featured a group of farmers congregated in a farmer's field under the guidance of a facilitator and together farmers would diagnose, experiment and identify solutions to the challenges they faced (Duveskog, 2011).The model farmer approach was also another angle to the participatory approach that deployed 'model /lead' farmers to train fellow farmers on a multitude of technologies and approaches (Muyanga & Jayne, 2004).While these have attempted to be participatory they have come under criticism of being cost ineffective, and on an empirical front there is not much hard evidence to support their effectiveness (Davis,2008). Another limitation of this paradigm is the fact that farmers' authority is limited in addressing much broader challenges concerning institutions and the broader policy environment (Hounkonnou et al., 2012). Finally the approach although deemed participatory in theory does not always materialize as participatory, with scientists perceived to still have a tight grip on the research process (Okuthe et al.,2002).

In the 1980's, the **'Systems approach' research paradigm** began to take shape and gradually in the 1990's it began gaining popularity (Kari,2013; Adekunle & Fatunbi,2012). The systems approach was favoured because it endeavored to address some of the shortcomings of previous paradigms in both theory and practice. In practice, it was noted that despite massive investments in scientific research and extension both by governments and international donors, production of cereals in Sub-Saharan Africa continues to lag behind and so does technology adoption (Spielman et al., 2009; Jayne et al., 2010). In theory, the 'Systems approach' differs fundamentally from the linear model in that it espouses that innovation is a non-linear outcome of interaction between multiple sources along and beyond the agricultural value chain system (Dolinska & d'Aquino, 2015). This implies that more actors along the value chain should be involved within the process of research beyond the traditional scientist-extension-farmer network. Furthermore, the 'Systems approach' unlike the linear model takes cognizance of the fact that innovation is not confined to technological processes but also calls for institutional, social and organizational improvements.

This is because, as we have considered, the challenges facing the agricultural sector (maize included) are not just technical; but also institutional, social, economic and policy oriented in nature. Finally unlike in the farming systems perspectives the 'Systems approach' places heavy emphasis on institutional synergies and support.

The systems approach in practice is operationalized through the establishment of Agricultural Innovation Platforms (AIPs) (Dolinska & d'Aquino, 2015). The advocacy for a systems based approach has gained momentum in recent times here in Kenya with multiple government documents such as the (National Agricultural Research Policy; Vision 2030; ASDS) calling for greater synergies and a holistic approach to the process of agricultural innovation (Gok 2007; Gok 2012).

1.1.3 Agricultural Innovation Platforms: A systems approach to improve productivity

An innovation platform is a forum that is convened in order to foster interaction among diverse stakeholders - normally from different organizations/backgrounds- around a common area of interest (KARI, 2013; Swaans et al., 2013). The stakeholders have differing but complementary (Oladele & Wakatsuki, 2011) roles geared towards the development, dissemination and exchange of knowledge (Adekunle and Fatunbi, 2012). In the sphere of the agricultural context, Agricultural Innovation Platforms (AIPs) refer to an alliance of main players along the value chain: farmers, processors, input dealers, researchers, wholesalers, transporters, development practitioners, retailers and policy makers (Dolinska and D'aquino, 2016; Klerkx et al., 2013; Swaans et al., 2013). The purpose of the platform is to enable value chain players to jointly identify bottlenecks and opportunities that pertain to production, marketing, policy and institutional frameworks. Furthermore, the platform provides a forum whereby agricultural innovations - technical, organizational and institutional- can be collectively developed to address bottlenecks along the value chain that can either be biophysical, socio-economic and policy oriented in nature (Ngwenya and Hagmann, 2011). These innovations can pertain to new agricultural technologies, market information, price information, improved agricultural policies and new institutional and organizational arrangements (Anderson, 2006).

The AIP is governed by a set of rules-formal/informal-that dictate its functionality. These rules pertain to conflict resolution, membership and decision making. The AIP is also defined by boundaries which can be thematic (e.g. boosting production, environmental conservation to name a few) (Swaans et al., 2013). It can further be defined by geographic boundaries such as at a local, regional or national level (Ngwenya & Hagmann, 2011). Local level platforms usually involve farmers and players along the value chain, whilst regional and national are more strategic and policy oriented. Furthermore, the AIP is a fluid entity in that it has an evolving membership composition depending on the capabilities required on board and also roles of members may evolve over time (KARI, 2013).

The adoption of a 'Systems approach' and subsequently the establishment of AIPs in recent times, particularly in developing country agriculture contexts, has been motivated by a number of credible realizations concerning the process of innovation both theory and practice. Innovation, as it has come to be acknowledged, in the agricultural context is a "non-linear" outcome of interactions between multiple actors along the agricultural value chain (Ayele et al., 2012). This contrasts sharply to the heavily criticized 'linear oriented research paradigm' that emphasized the centrality of scientific research as the key source of innovation (Hounkonnou et al., 2012). Furthermore, agricultural innovations are not confined to technological improvements as espoused in the 'traditional linear approach'; but also involve organizational, social and institutional improvements along the value chain system that necessitate a 'Systems approach' to the study of innovation (Klerkx et al., 2013). Moreover, agricultural innovations are not only hinged on the production and dissemination of technical knowledge, but are also dictated by other multiple factors such as policy, legislation and institutions (Klerkx & Leeuwis 2008).

In practice the AIP approach is relevant to the smallholder agricultural context in developing countries because the agricultural **system** is defined by a diverse set of players and multiple sources of innovation along the value chain -farmers, researchers, development practitioners, policy makers and the private sector (Ergano et al.,2010; Spielman et al., 2009; Oladele & Wakatsuki, 2011). Consequently, attempts to improve outcomes along the value chain system must capitalize on the synergies of these diverse players, which is done by providing a forum -(AIPs)- where these players can collectively resolve challenges and identify opportunities (KARI, 2013). Moreover, the diversity in representation of AIPs allows for the entry of non-traditional actors (Dolinska and D'aquino, 2016) representing institutions and the broader policy environment-policy makers, credit providers etc-who ordinarily would be excluded in the linear model but are nonetheless critical players in the agricultural sector and the innovation process (Anderson, 2006; Spielman, 2009). In addition to technical innovations, AIPs place heavy emphasis on social innovations and learning because experience has shown that innovation is a social process and for it to have a lasting impact it is imperative that we understand the social contextual set-up of the farmer (Ngwenya & Hagmann, 2011).

AIPs have the potential of improving farmer welfare in a number of ways. Through platforms farmers are able to liaise with researchers and benefit from technical advice concerning appropriate production techniques and technologies that can increase yields (Fischer & Qaim, 2012; Kabambe et al., 2012). Farmers are also able to interact directly with service providers such as input providers to access productivity enhancing inputs (improved seeds and fertilizer), thereby reducing transaction costs that could be introduced through third party interaction (Abebaw & Haile, 2013). In the same breadth, farmers who are sellers, are able to interact directly with marketers which may position them to get better prices for their produce as compared to engaging with middlemen (Alene et al., 2008). The platform also offers farmers other interlinked services such as access to credit which is a critical capital source in helping farmers procure productivity enhancing inputs and ensuring sustained farmer participation (Hounkonnou et al., 2012). Through the platform, farmer group entities also benefit from capacity building which enhances their organizational and institutional capacity.

The real experience in Africa and all over the world concerning AIPs offers good insight on the important role they play in addressing diverse agricultural challenges pertaining to yields, marketing, technology adoption and conservation to name a few. In South America, for instance, Plataformas as AIPs are commonly referred to, have enabled smallholders ameliorate their yields and incomes through partnering directly with important actors in the value chains such as input service providers, researchers and government (FAO, 2013). A study by Cavatassi et el., (2009) of potato farmers in Equador, found that Plataformas members' yields averaged 8.4 M/T per hectare as compared to non-members 6.3 M/T per hectare. In Ethiopia, Ergano et al., (2010) found that farmer membership to platforms increased the uptake of fodder use technologies among poor livestock keepers. The study found that farmers were able to increase their acreage under forage significantly, on average 0.5 hectares, as compared to a few stands in previous cropping seasons. Kabambe et al., (2012) found that innovation platforms played an important role in encouraging the uptake and scaling out of lime applications among farmers as a measure to address the challenge of soil acidity. Lime applications, subsequently, were found to ameliorate maize yields from 3.58 to 4.68 t/ha in 2006/2007 cropping season and 3.35 to 4.2 t/ha in 2007/2008 cropping season on average among plot trials conducted.

In Ghana, innovation platforms have played an important role in addressing marketing challenges that adversely affected the country's cocoa exports and government revenue. In 2011, the country experienced a decline in cocoa exports, a phenomenon attributed to low cocoa prices that resulted in smallholder farmers opting to smuggle their cocoa beans across the border to Cote d'Ivoire. An innovation platform set-up, managed to lobby for a 33 % increment of producer cocoa prices through one of its influential members (special assistant to the minister of finance).The price incentive resulted in reduced cocoa smuggling across the border by producers enabling the country achieve its target export level of one million tonnes of beans (Nederlof & Pyburn, 2012). In Uganda, Eneku et al., (2013) found that membership to innovation platforms had a positive impact on the adoption of Sustainable Land Management (SLM) techniques with over 80% of households in the sample area adopting these technologies. In Tanzania, Pham et al., (2015) found that platforms played an important role in fostering communication among platform members which in turn was instrumental in helping members score well on platform performance indicators (in this case -feed availability and accessibility). However, they found no significant difference between members of the platform and non-members overall, which was attributed to the early stage of the platform.

In Kenya, though the concept is still very nascent, innovation platforms have been convened to address challenges within the agricultural/environmental domain. The Kijabe Environment Volunteers (KENVO) platform for instance, was formed in 1994 with the main objective of addressing degradation within the Kikuyu escarpment forest that had a negative direct impact on livelihoods of the community majority of whom are farmers. Specifically the challenges included loss of soil fertility due to soil erosion and poor farming methods, siltation along rivers and unpredictable weather patterns facing agricultural production. The platform collaborates with a number of key partners such as government through the Ministry of Agriculture, research partners (World Agro forestry Centre), development partners (Eco agriculture partners) and farmers through various farmer groups. The platform has managed to improve livelihoods through enabling farmers set up agricultural enterprises such as bee keeping, enhancing awareness of conservation agriculture practices and integrating vulnerable groups such as women and youth into enterprises such as basket making (www.canadaworldyouth.org).

The National Agriculture and Livestock Extension Programme (NALEP) established in 2000-supported by the Swedish International Cooperation Agency (SIDA) in conjunction with the Ministry of Agriculture-can be compared to a national level 'innovation platform' inspired approach. The main objective of the initiative was to institutionalize demand driven extension services, increase effectiveness in their delivery and develop a participatory approach that integrates farmer concerns. To deliver on its mandate, NALEP capitalized on collaboration and partnerships with multiple stakeholders representing the civil society, the research fraternity, Community Based Organizations (CBO's), Non-Governmental Organizations (NGOs) and farmers through Common Interest Groups (CIGs) (Cuellar at al.,2006).

The Imarisha Naivasha platform managed by the Imarisha Naivasha board, exemplifies an environment based innovation platform. The platform, an initiative of the then Prime Minister Honorable Raila Odinga, was formed in 2011 following major concern locally and internationally of massive degradation within the Lake Naivasha basin. The Board has the mandate of convening stakeholders within the basin, creating an enabling environment for multi-stakeholder collaboration and coordination various development projects along the basin (SDAP, 2012).

There are also smaller documented AIP initiatives undertaken under development partners' projects. For instance, smallholders have benefited from value chain based innovation platforms such as the East Africa Dairy Development Program (EADPP) implemented by the Bill and Melinda Gates foundation in 2008. The program was formed in order to improve smallholder farmers' welfare through increasing their milk yields and incomes. The interventions included providing farmers with advisory services, facilitating their access to quality dairy inputs and linking them to markets. The platform functions on what is known as a 'hub model' that convenes multiple partners such as producers, government extension, universities, donors, processors and feed suppliers to name a few. It is estimated that participating farmers have earned more than 133 million dollars in dairy investments and marketing(www.heifer.org) .The platform has also been instrumental in enabling smallholders access credit through providing guarantee to dairy companies which was previously inaccessible to farmers (Kilelu et al.,2012) .In Embu and Meru, Kyeni AIP was established under the auspice of a research project known as Sustainable Intensification of Maize-Legume Cropping Systems for Food Security in Eastern and Southern Africa (SIMLESA). It is funded by the Australian Centre for International Agricultural Research (ACIAR), and led by the International Maize and Wheat Improvement Center (CIMMYT). Its core mission is sustainability of maize legume systems, especially through application of Conservation Agriculture based science and innovations (www.simlesa.cimmyt.org).

1.2 Problem Statement

Maize is the most important food crop for the majority of Kenyan households and is a key ingredient in the country's feeding system. However in the past many years, the country has continued to grapple with a persistent deficit in the maize sub-sector that necessitates importation to supplement local production. This trend is a major source of concern for policy makers and the country as a whole, because it threatens Kenya's Vision 2030 aspiration of becoming a food secure nation. Furthermore, given that a majority of the population relies on agriculture as a source of livelihood, this trend is an impediment towards realizing the developmental goals of poverty reduction and food security. Kenya's vision 2030 Second Medium Term Plan (MTP II) notes that the declining performance in the agricultural sector, including the maize sub-sector, is attributed to a host of multi-faceted challenges that are biophysical, institutional, market, infrastructural and policy oriented in nature. These challenges include low adoption of technology, uncoordinated research, erratic weather patterns, inadequate funding among many others.

A majority of maize smallholder farmers, who account for over 75 % of national production, have limited participation in the access and use of maize technologies such as fertilizer and improved maize seed varieties, which is an important prerequisite in increasing maize yields. Furthermore, many smallholders also have limited access to interlinked /supportive services such as credit access, technical and market information. It is also noteworthy that many smallholders are alienated from crucial stakeholders along the maize value chain. The Government of Kenya (GOK) noting that the challenges facing maize smallholder farming are multi-faceted, has placed great emphasis on value chain partnerships among the diverse stakeholders.

In the first phase of the vision 2030 Medium Term Plan, GOK, identified the strengthening of farmer collective action as one of the strategies to improve input market participation, technology adoption, supportive service access and overall production. One of the many forms of farmer collective action that is anchored on fostering value chain partnerships is manifested in institutional innovations such as **Agricultural Innovation Platforms (AIPs)**; which essentially is an alliance of the main actors along a value chain. These actors represent diverse institutions: Farmer Community Based Organizations (CBOs), development practitioners, research organizations, input dealers, processers, transporters, Insurance providers, policy makers and maize marketers among others. The platform provides a forum for interaction among these diverse actors whereby they can jointly identify bottlenecks and opportunities along the value chain. The AIP provides a forum where technical, organizational and institutional innovations can be harnessed for the benefit of producers. It is the association of farmers with these key institutions that helps them access credit, knowledge, markets, policy assistance and inputs at an affordable price or closer to them which in turn has positive implications on production.

Their importance notwithstanding, there is however not enough **empirical** evidence documenting the impact of membership to these platforms on increasing access to and use of technologies among smallholders and ultimately their effect on maize yields. This is because the concept of AIPs in Kenya is still very nascent. Noting this gap, this paper would like to investigate the determinants of membership to AIPs and the impact that this membership has on maize yields and access to maize technologies. This is an important matter of interest for policy makers, given that the country's economic blueprint places great importance on farmer collective action as a critical avenue to improving access of maize technologies and other crucial support services; which in turn has implications on improved maize production and overall agricultural performance. Secondly, empirical evidence will also provide a sound basis upon which policy makers can support the establishment of AIPs.

1.3 Research objectives

General objectives

The main objective of the study was to assess the role of AIPs in facilitating increased access and use of maize technologies among smallholders in Kenya.

Specific objectives

1. To identify the factors that influence farmers' decision to participate in AIPs.
2. To investigate impacts of AIP membership on the use of maize technologies and yields among smallholder farmers

1.4 Research questions

1. What are the factors that determine membership to AIPs?
2. What are the benefits that smallholder maize farmers derive from belonging to AIPs (increased access to improved maize seeds, increased use of fertilizer and increased maize yields)?

1.5 Research Hypothesis

1. Different factors influence households' choice to join AIPs.
2. Members of AIPs enjoy significantly higher benefits compared to non-members with respect to improved maize variety seed use, fertilizer use and maize yields.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of the literature. It is a consideration of both the theoretical and empirical literature that informs the study of Agricultural Innovations Platforms (AIPs). The chapter concludes by offering an overview of the literature and presenting the research gap.

2.2 Theoretical Literature

The conceptual framework underpinning the innovation systems approach is significantly informed by three schools of economic thought: The theory of economic growth, Systems theory and New Institutional Economics (NIE).

Classical economists such as Adam Smith, in their conceptualization of economic development, acknowledged the important role of innovation. Smith identified organizational innovations such as the division of labor as the source of national wealth and economic growth (Yang & Liu, 2012). Moreover, David Ricardo elaborated on the concept of innovation within the agricultural context. Ricardo pinpointed the need for technological innovation-land saving techniques-to resolve the prevailing challenge at the time of diminishing land productivity (Spielman, 2005). However, it is Schumpeter who is credited with laying the foundation for the modern day innovation systems approach. The centrality of the entrepreneur and innovation form the cornerstone of Schumpeter's theorization of economic development. In the Schumpeterian system, innovation is a multi-faceted phenomenon that embodies technological, organizational and institutional improvements (Klerkx et al., 2013) on social and economic processes. Furthermore, it is acknowledged that institutions are not exogenous to the innovative process; but to the contrary, they are critical in informing the innovative process and innovations in turn change the character of social and economic institutions (Spielman, 2005).

The innovation systems theory approach emerged in the 1980's (Adenkule & Fatunbi, 2012). The approach draws inspiration from Schumpeter's perspectives, systems theory and evolutionary economics. Development –according to the systems approach- is an outcome of innovative initiatives undertaken by individuals, organizations and societies. The extent to which all these entities are able to make improvements on their current circumstances is determined significantly by their environment (Klerkx et al., 2010). The environment in turn is a product of the prevailing social and economic institutional setup that informs policy interventions, infrastructure and market development (Ergano et al., 2010). The existence of multiple **entities-** individuals, organizations and societies-operating within their prevailing dynamic **environments** undertaking innovative activities is what gives rise to **complex systems** (Spielman et al., 2009). In Systems theory the elements of the system are interrelated in such a manner that any attempt to understand the complex system by singling out individual elements is futile (Clark, 2001). In the same breadth, given that innovation is a multifaceted phenomenon, it implies in turn that for it to have a significant social and economic impact, it is imperative that diverse actors -along the value chain system- with different resources and capabilities are engaged in the innovative process (Spielman et al.2009). In essence, innovation is a precursor to development; however understanding the process of innovation is contingent on understanding the system within which the innovative process operates. The innovation systems approach offers the appropriate analytical framework that enables us to study the diverse innovative actors, their interactions as well as the institutions that influence their interactions (Spielman, 2005).

The innovation systems approach also derives its support from strands in New Institutional Economics (NIE) literature (Mariami et al., 2015). The approach acknowledges the role of institutions (KARI, 2013) in shaping incentives and interactions among the actors within a system. Within the NIE framework institutions arise out of a need to mitigate transaction costs. Transaction costs refer to the pecuniary and non-pecuniary costs incurred in an economic exchange (Holoway et al., 2000; Alene et al., 2008). These costs refer to the costs of searching and gathering information, negotiating and monitoring and enforcement of contracts. These costs may be attributed to information asymmetry (Alene et al., 2008), opportunistic behavior of market agents (Mariami et al., 2015) among other reasons. Institutions arise out of the need to mitigate the associated transaction costs aforementioned. The systems approach endeavors to build synergies among diverse agents within the system through the formation of platforms that enable the harnessing of knowledge-technical, organizational and institutional-for the benefit of members (KARI, 2013). Through the improved synergies among interacting agents in the platform it is hoped that incidences of knowledge asymmetries are reduced (Mariama et al., 2015)

Having considered the above theoretical frameworks, it is now pertinent to consider the innovation systems approach with respect to agriculture. Agriculture continues to play a critical role in the economy of many developing countries (Olwande et al., 2015). However, many developing countries in Sub-Saharan Africa are grappling with low productivity within the agricultural sector (Abebaw & Haile, 2012). It is acknowledged that innovations play a critical role in the transformation of the sector and the economic development process (Ergano et al., 2010). However as Schumpeter and many economists pointed out innovations are not confined to technological progress but rather also encompass institutional and organizational dimensions. This would imply that development in the agricultural sector of many developing countries is hinged on the adoption of a multi-faceted (Ergano et al., 2010) view of innovation as opposed to the traditional linear approach.

The innovation systems approach was originally applied to the study of National Innovation Systems (NIS) (Spielman, 2005) but has recently been applied to developing country agriculture (Clark, 2001; Spielman et al., 2009; Alexandra & Dolinska, 2015). This is because the developing country agriculture context is defined by diverse agents (state and non-state actors), their diverse interactions and a dynamic institutional environment (markets, policy, and infrastructure) that condition agents' behavior. It is this system in turn that has a bearing on the performance of the agricultural sector. The systems approach postulates that improvements in developing country agriculture stem from continuously engaging the capabilities of diverse actors along the agricultural value chain system in harnessing innovations; be it in the generation, exchange and adoption of knowledge (Adekunle and Fatunbi,2012) Finally, by emphasizing on an institutional approach, innovation platforms help mitigate transactions costs that confront farmers and other actors in the developing country set-up by reducing knowledge asymmetries pertaining to technical, market and asset information.

2.3 Empirical literature

The previous section highlights the theoretical motivations in economic literature supporting the study of the innovations systems approach and its operationalisation through the setting up of AIPs. This section reviews the empirical literature on the methodologies employed to assess the impact of collective action interventions on farmer welfare.

The objective of this study is to empirically assess the impact of AIP membership on three outcome variables: seed, fertilizer and yield. In the context of this study, AIP membership is the treatment variable. In an experimental set-up, the impact of the treatment would be measured by comparing treated individuals to untreated individuals (the counterfactual) who share similar characteristics except for the fact that some are treated while others are not. In the case of an observational study, given that assignment into treatment is non-random; the challenge empirically lies in finding a method that can create a suitable counterfactual group (similar characteristics) to allow for estimation of treatment effects. The predominant method of impact evaluation found in the empirical literature which addresses both the treatment effects aspect and also the context of collective action (farmer groups, cooperatives and innovation platforms) is the Propensity Score Matching (PSM) Approach. It is also noteworthy to point out that while some papers included in this review did not assess impact of membership to a collective outfit in their study per se as their objective, their inclusion here is for the purpose of elaborating on the methodology which has been greatly explained in their impact studies.

Cavatassi et al., (2009) employed three model specifications –PSM, Ordinary Least Squares (OLS) and Weighted Least Squares (WLS)-in an ex-post impact assessment of platforms (plataformas) in Ecuador. The study sampled a total of 1007 farmers: 324 (beneficiaries), 359 (non-beneficiaries) and 325 (non-eligible). The study compared the members on the basis of three categories of outcome variables: primary indicators, transactions costs and secondary indicators. Average Treatment on the Treated (ATT) findings show that beneficiaries scored significantly better on primary indicators -yield, gross margins and input-output ratio- than beneficiaries. Farm yields for beneficiaries were 33 % higher on average than non-participants. Gross margins for participants were four times higher on average compared to non-participants.

With reference to transaction cost variables, price was found to be significant differently among the groups with beneficiaries' potato yields fetching 30 % more prices on average compared to non-participants. Finally, under secondary indicators, it emerged that they were significant differences among the groups particularly with respect to wearing protective gear and knowledge on toxic products. Plataforma members who had been beneficiaries of training used protective gear more frequently compared to non-members on average. Furthermore, a large proportion of members (59.4 %) were able to identify toxic products as compared to a smaller proportion among non-members (21.7%). The paper concluded that platforms improved beneficiaries' welfare through reducing transaction costs, improving agricultural techniques, increasing access to inputs (quality seeds) and fostering social capital.

Shehu & Sidique (2014) using cross-sectional data from 3380 households in Nigeria employed PSM to study the impact of non-farm enterprise activity on households' well-being. Well-being was measured by two outcome variables: consumption expenditure and food shortage. They primarily employed radius matching in their ATT estimation. Findings from the ATT estimation show that the mean consumption expenditure of households engaged in non-farm enterprise in addition to farming activity was $ 524 more than households that relied on farming activity alone. They also found that households engaged in non-farm enterprises were less likely to suffer from food shortage than their counterparts who did not engage in non-farm enterprises. They conducted a sensitivity analysis which in their case featured a comparison of results from radius matching with those of nearest neighbor and kernel matching. The results from the two other matching algorithms were similar with respect to the mean consumption expenditure leading to the conclusion that non-farm enterprises play an instrumental role in enhancing households' well-being.

Bernard et al., (2008) studied the impact of cooperatives on smallholders' commercialization behavior using evidence from Ethiopia. Similar to Cavatassi et al., (2009) they employed three methodologies to evaluate impact namely: PSM, Tobit and OLS. Measurement of cooperatives impact on commercialization was based on two outcome variables: output price and share of crop sold at the market. ATT findings reveal that cooperatives had a positive and significant effect on output with members earning 7% higher prices for their produce compared to non-members on average.

However, concerning the second outcome variable- share of produce sold at the market-ATT results were not significant from zero; in effect cooperative members did not on average supply more of their produce to the market than non-members. The PSM results were supported by the alternative model specifications. OLS results revealed that membership to cooperatives did have a significant effect on output prices. However, similar to the PSM results, tobit estimations showed that membership was not significant in increasing cooperative members' share of produce supply to the market compared to non-members.

Kassie et al. (2011) using cross-sectional data from Uganda featuring 927 households, employed PSM to study the impact of adoption of improved groundnut varieties on households' net crop income and poverty levels. In the first stage of the analysis they estimated a logit model to access the determinants of improved groundnut variety adoption. Logit model results revealed that farm size, education, membership to farmer organizations and number of plots exerted a positive significant effect on the probability of adoption. On the other hand logit findings showed that distance to the main market and seed constraint had a significant effect on reducing the probability of improved groundnut variety adoption. The ATT effects were estimated using two matching algorithms: Kernel matching (bandwidth 0.03 and 0.06) and nearest neighbor matching (one and five neighbors with replacement). The two major outcome variables were net crop income and poverty level. Concerning net crop income, the study found that adopters had a higher net crop income ranging from 239240 to 469550 Ugandan shillings per hectare (depending on the matching algorithm and variations to each) compared to non-adopters. Moreover, ATT results on poverty levels revealed that adopter households compared to non-adopters featured less prominently in the 'living below the poverty line categorization'. Specifically adoption of improved groundnut activities was found to reduce poverty levels in the range of 7-9 percentage points among adopters (depending on the matching algorithm and variations to each). Finally in their sensitivity analysis, they computed Rosenbaum bounds and found that the questionability of the validity of their positive ATT estimation would arise when two members with the same observable covariates differed in the range of 55-80% in their odds of receiving treatment.

Abebaw and Haile (2013) employed PSM to study the impact of cooperatives on technology adoption in Ethiopia using cross-sectional data gathered from 965 households. A logit model was first estimated to assess the determinants of cooperative membership. The following variables were found to significantly increase the likelihood of farmers belonging to cooperatives: access to extension, road distance, leadership position and off-farm employment. Age and road infrastructure were found to have a positive curvilinear effect on the probability of cooperative membership. Propensity scores derived from estimation of the logit model were then used to match members and non-members with similar characteristics to facilitate the comparison of ATT effects. Membership to cooperatives was found to be positive and statistically significant in adoption of fertilizer. Cooperatives improved mean adoption rate of fertilizer adoption by 9-10 percentage points among members. However cooperative membership did not have a significant effect on the other two outcome variables: pesticides and seeds. Additionally, for their sensitivity analysis they computed Rosenbaum bounds and found that the questionability of the validity of their positive ATT estimation would arise when two members with the same observable covariates differed by 280% in their odds of receiving treatment.

Wollni and Zeller (2007) studied the impact of cooperatives and specialty markets on producer prices received by coffee farmers in Costa Rica. The study methodology employed a two-stage process to investigate the impact. Firstly, two probit models were separately estimated to determine the factors influencing farmers' decision to market through specialty markets and cooperatives respectively. In the second stage an OLS regression was estimated to evaluate the impact of these two channels on marketing performance. Marketing performance was measured in terms of price received at the end of the season and was modeled as a function of exogenous variables and the two marketing channels (specialty/cooperative). Probit model results for determinants of participation in a specialty channel revealed that education, experience, land holding, access to quality training and cooperative membership had a positive and significant effect on participation . Most notably access to training and cooperative membership increased the likelihood of participation in a specialty channel by 33% and 24 % respectively.

Probit model estimates for the determinants of participation in a cooperative marketing channel revealed that membership to the marketing cooperative, membership to an agricultural cooperative and proximity to collective points had a positive and significant effect on participation. Land holding however had a negative significant effect on the probability of membership indicating the preference of small scale farmers to market through cooperatives. OLS regression results show that participation through cooperatives or special channels increased the average price received by farmers by 0.05 and 0.09 dollars/lb respectively. They also found farmers' access of information on the previous year world prices led to an increase of 0.03 in producer prices on average. The study concludes by noting that marketing through cooperatives or specialty channels did have a positive impact on producer prices.

Fischer and Qaim (2012) employed PSM in their study of the determinants and impacts of collective action among small-scale banana growers in Central Kenya. Determinants of farmer group membership were estimated using a probit model. The following variables were found to significantly increase the likelihood of farmers belonging to groups: agricultural equipment, phone, credit and self-employment. Landholding and road infrastructure were found to have a positive curvilinear effect on group membership. Probit model estimates were used to generate propensity scores that would facilitate the matching of similar members and non-members in order to estimate the ATT effects. ATT results -using radius matching- show that while both members and non-members had increased their banana plot size, it was members who had significantly increased their plot size compared to their counterparts.TC Plantlet adoption was also significantly greater among members compared to non-members. Results also revealed that group members involved in collective marketing expended significantly more resources in hiring labour and procuring inputs (fertilizer and pesticide costs) compared to non-members. Finally, total banana income for group members involved in collective marketing exceeded that of non-members by over 27 %. Concerning sensitivity analysis, they assessed the robustness of the ATT effect with extended and reduced probit models in addition to estimating the ATT with two other matching algorithms (nearest neighbor and kernel matching). Their sensitivity analysis results revealed that most of the ATT findings were consistent with the initial results that employed radius matching.

2.4 Summary of literature and research gap

The theoretical literature presented has provided an overview of the prominent economic theories -Theory of Economic Growth, Systems Theory and New Institutional Economics (NIE) - supporting the innovation systems approach. It emerges that innovation is an important catalyst of economic growth and development (Ergano et al., 2010). Furthermore, it emerges that innovation is not only confined to technological progress but that it also encompasses progressive alterations in institutional and organizational arrangements (Spielman ,2005. It is also critical to note that institutions are not exogenous to the innovative process; to the contrary it is institutions that provide an enabling environment for innovation to take place and innovations in turn alter the character of institutions. Finally, the need for a systems approach arises because innovation is a process that arises out of multiple individuals, organizations and societies endeavoring to make improvements on their present situations within a dynamic environment (Spielman et al., 2009).

Innovation systems were originally applied to the study of National Innovation Systems in industrialized countries (Clark, 2001; Spielman et al., 2009). It is only recently that innovations systems approach has been applied to agriculture due to its suitability in dealing with the complex challenges and multifaceted dimensions of the Sub-Saharan agricultural context (Alexandra & Dolinski (2015). However many studies previously have relied on the descriptive style approach to document the impact of innovation platforms. It emerges however that there is a need for the application of rigorous quantitative methods to assess the impact of innovation platforms, in order to provide robust empirical evidence supporting their establishment (Spielman et al., 2009).

An examination of the empirical literature shows that PSM is the dominant methodology used to access the impact of collective action (be it cooperatives or innovation platforms) .Furthermore it emerges that very few empirical studies have been done to assess the impact of AIPs on smallholder farmer welfare, and to our knowledge none has been done in Kenya. Yet the establishment and support of AIPs is contingent on the body of empirical evidence gathered. This study would specifically like to add to the knowledge reservoir by conducting an empirical study on the impact that AIPs have on improving smallholders maize yields in Kenya among other benefits.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 The study area

The study was conducted in two sites: Kyeni situated in Embu County and Igoji situated in Meru County. These sites were chosen for the reason that they host the successful Kyeni AIP.

3.1.1 Embu County

Embu County is one of the 47 counties in Kenya. The coordinates of the county are 0° 32′ 0″ S, 37° 27′ 0″ E. The county is characterized by lowlands and highlands with the altitude ranging from as low as 515 m in Tana River Basin to over 4,570 m towards Mt. Kenya. The county has a population of approximately 540,000 people and covers an area of 2,818 km^2. Embu has five sub-counties: Embu East, Embu West, Embu North, Mbeere South and Mbeere North. Each of these sub-counties is subdivided into divisions all totaling ten. This study is specifically interested in Kyeni division in Embu East **(**ke.geoview.info).

Kyeni division is located in Embu East, covering an area of 100.8 km^2 and stands at approximately 1,285 metres above sea level. Its coordinates are 0°27'0" (Latitude) and 37°39'0.01" (Longitude) **(**ke.geoview.info). The rainfall pattern is bi-modal with long rains in April-May and short rains in October-November. The soils in the area are mainly nitrosols. Agriculture is a significant source of livelihood for the constituents. Maize is among the major crops grown by the constituents in addition to beans, bananas, pawpaw and coffee. Farm holdings range from 2-2.8 hectares (Ouma et al., 2002).

3.1.2 Meru County

Meru County is also another one of the 47 counties in Kenya. The coordinates of Meru County are 0° 3′ 0″ N, 37° 38′ 0″ E. Similar to Embu, the county is characterized by lowlands as well as highlands with an altitude ranging from as low as 300 m to 5000 m. The county has a population of approximately a little over 1,356,000 people and covers an area of 6,936 km^2. Meru is comprised of the following nine sub-counties: South Imenti, North Imenti, Tigania East,Tigania West, Igembe South, Buuri,Central Imenti, Igembe Central and Igembe North (“Meru County”, n.d.)

Igoji is one of the administrative wards in South Imenti sub-county. It comprises of Igoji West and Igoji East. It stands on a total area of approximately 111 km^2 and has a population of approximately 49,000 people. Its coordinates are 0°10'60" S (Latitude) and 37°43'0" E (Longitude). Igoji East in particular has an area –where some platform members operate-of approximately 68 km^2 and a population of approximately 28,000. It has an elevation of approximately 1,172 metres above sea level (Infotrack East Africa, n.d.). The rainfall pattern in Meru County and by extension Igoji East is bi-modal with long rains in April-May and short rains in October-November. Moreover, smallholder agriculture is dominant in the region and maize happens to be the main cultivated food crop. Other cultivated crops include beans, pigeon peas, cowpeas, millet and sorghum to name a few (Oxford Business Group, 2014)

3.1.3 Why Kyeni Agricultural Innovation Platform (AIP)?

Kyeni and Igoji are one of several sites of a large research project called Sustainable Intensification of Maize-Legume Cropping Systems for Food Security in Eastern and Southern Africa (SIMLESA). SIMLESA is being carried out mainly in Ethiopia, Kenya, Malawi, Mozambique and Tanzania. It is funded by the Australian Centre for International Agricultural Research (ACIAR) and led by the International Maize and Wheat Improvement Center (CIMMYT). Its core mission is sustainability of maize legume systems primarily through the application of Conservation Agriculture (CA) based science and innovations. It was initiated in 2010 (see www.simlesa.cimmyt.org for fuller details). Besides Embu and Meru, SIMLESA also has sites in western Kenya. Kyeni AIP is purposively selected for this study because it has emerged as the most successful in terms of having the AIP generate more benefits for its membership (www.simlesa.cimmyt.org). These benefits are seen as critical in sustaining adoption of new technologies and practices. It therefore is seen as a success case to be documented.

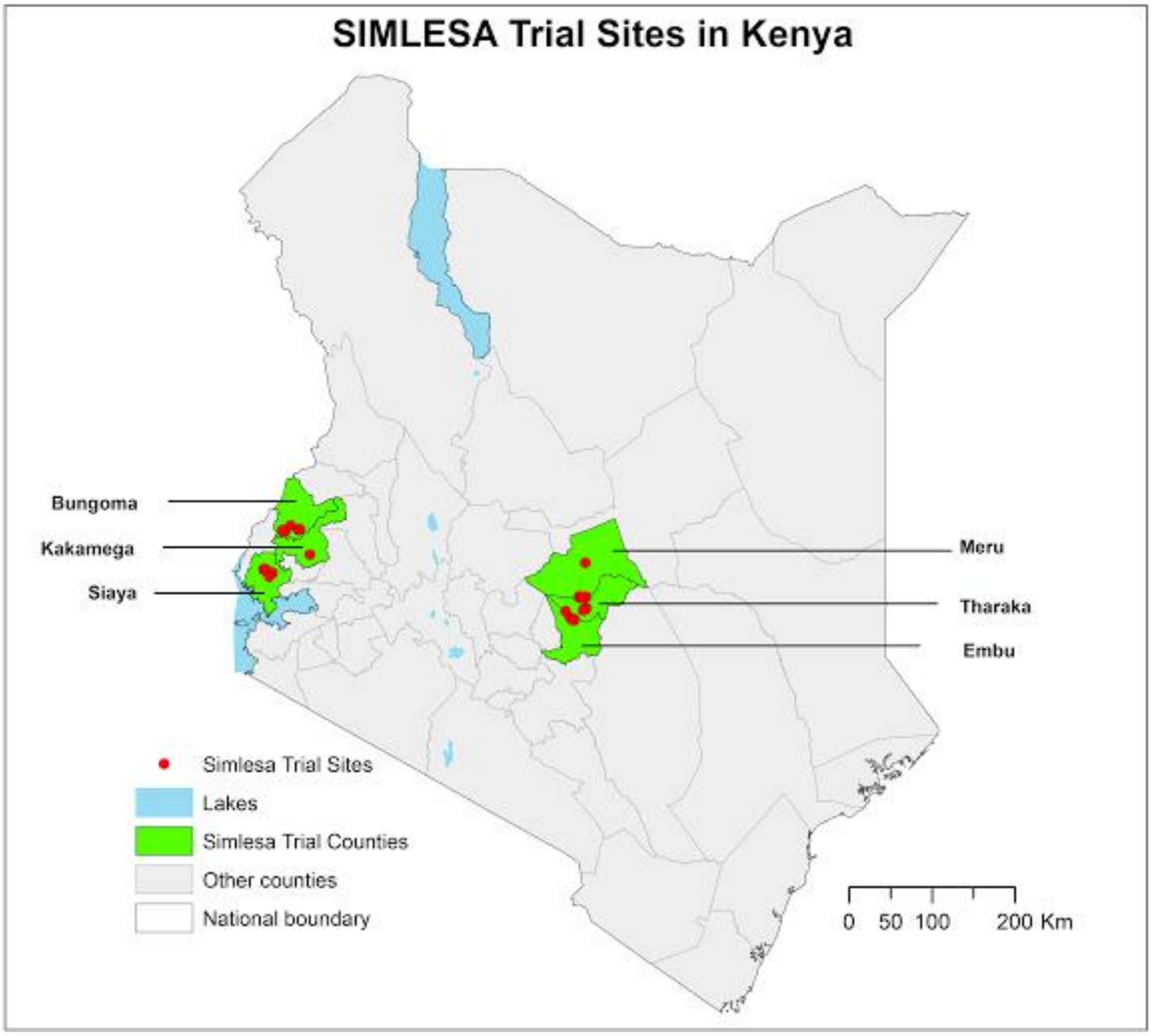

Fig: 2 Map showing the six SIMLESA study sites including Embu and Meru
Source: www.simlesa.cimmyt.org

3.2 Research Design

The study employed an evaluation survey design which involved the administration of questionnaire interviews to households for data collection purposes. The choice of this study design was informed by the study objective that targeted to evaluate the impact of AIPs (the intervention) on farmer livelihoods. The outcomes or benefits from this intervention where to be studied as being critical for improving farmer livelihoods.

3.3 Sample size and sampling design

The study employed purposive and random sampling in the selection of households that were to be interviewed in the survey within each of the respective regions. The initial sample was 152 households with an equal number of 76 interviewed in Embu and Meru respectively. However, given that this study primarily focused on households that cultivated maize that season, three households in Meru were dropped because they did not plant maize that season. The sample used in the actual analysis comprised of 149 households-76 (Embu) and 73 (Meru). The households to be sampled were divided in three categories: members, intermediary and non-members. Members were categorized as those who belonged to the AIP. The full control sample comprised of the intermediary and non-member households. The intermediary households comprised of non-member households located in close proximity to AIP member households. These households readily interacted with member households and as a result could possibly experience spillover effects. The last group comprised of non-member households located in areas that were absent of AIP activity.

In Embu, the AIP members were distributed in all of Kyeni's three sub-locations, namely, Kyeni East, Kyeni Central and Kyeni South. The number of AIP member households in Embu was 27. All the member households were purposefully selected given that their number was limited. The composition of the total 27 member-households per location was as follows: 5 (Kyeni East), 13 (Kyeni Central) and 9 (Kyeni South). 25 intermediary households were randomly selected within close proximity of nearly each of the 27 member households. The composition of the member households per location were as follows: 6 (Kyeni East), 13 (Kyeni Central) and 6 (Kyeni South).Finally, for the purposes of selection of non-members the AIP non-activity area was identified as 5 km away from the location of member households. With the 5 km caveat in consideration, 24 non-members were randomly selected with the following composition as per location: 7 (Kyeni East), 9 (Kyeni Central) and 8 (Kyeni South).

In Meru, the AIP members were distributed in two of Igoji East's six locations, namely, Kiathathi and Gikui. The number of AIP member households in Igoji East was 17.Similar to Embu region, all the member households were purposefully selected given that their number was very limited. The composition of the total 15 member-households per location was as follows: 5 (Gikui) and 12 (Kiathathi). The intermediary sample comprised of 24 households randomly selected within close proximity of nearly each of the 15 member households. The composition of the intermediary households per location were as follows: 5 (Gikui) and 19 (Kiathathi). With the 5 km caveat in consideration, 34 non-members were randomly selected with the following composition as per location: 13 (Gikui), 6 (Miruriiri), 7 (Kiathathi), 1 (Kianjogu) and 8 (Mweru).The number of households per location and sub-location for each of the regions is presented in Appendix 1 and Appendix 2.

3.4 Data collection

The data for this study was collected in October 2016.The study used a structured household questionnaire to interview the sampled households. A pre-testing exercise was carried out on 18th and 24th October in Embu and Meru respectively, with the site extension officers, to assess how well the questionnaire was suited to cover the intended study objectives. Moreover, the pre-testing exercise also included a training component in which the extension officers were trained on how to operate the Open Data Tool Kit (ODK) platform from their phones. Through this training they were taught how to download questionnaire forms from the ONA collect platform to their android mobile devises, how to navigate downloaded questionnaire forms in their phones and how to upload completed questionnaire forms to the ONA platform server from their devices.

The structured questionnaire was used to primarily collect information on the type of maize varieties cultivated by farmers, the quantity of inputs employed on the maize area, the area cultivated under maize and yield information. Moreover, the questionnaire also covered other important modules such as household demographic information, household asset information, access to infrastructure, access to extension services, access to credit services and membership to rural institutions.

3.5 Data verification and Analysis

3.5.1 Data verification

Originally the questionnaires were to be administered in hard copy which would have later on necessitated double data entry to facilitate a thorough cleaning exercise. However, for ease of entry and verification this was later changed to the use of electronic surveys which necessitated a slightly different verification exercise outlined as follows.

The household questionnaires were checked for accuracy at various stages in order to facilitate an easy verification exercise. Firstly, the team carefully went through each of the modules of the questionnaire in order to assess the effectiveness of the questionnaire in capturing the desired information. Moreover, careful consideration was also given to quantitative variables (binary and continuous) concerning their measurement and necessary modifications were made in cases where errors were detected. Secondly, one of the requirements of using ODK is that the questionnaire must be designed in Excel –in accordance with the syntax- after which it is then uploaded on the ODK platform for verification before getting a clean go-ahead. The advantage of this process is that one can put restriction on the limits of values that quantitative and qualitative variables can take which goes a long way in reducing errors that would normally appear during the entry process. The questionnaire (originally in Word) was then re-designed in excel where restrictions on the limits of quantitative and qualitative variables were imposed to further tighten error loopholes. Thirdly, on the training day, the team and extension officers went through the questionnaire module by module and necessary modifications were also made following useful suggestions from the officers. Fourthly, the team and the extension officers practically entered the questionnaire on their mobile devices in a 'mock' interview exercise. This exercise enabled the team to ascertain that the questions appeared as they were in the original questionnaire and that the restrictions on variables functioned.

A single data file form was generated and then exported to STATA version 14 for subsequent analysis.

3.5.2 Conceptual framework

The decision by a household to join a collective action unit –innovation platforms, cooperatives, farmer groups and other entities - was analyzed in a random utility framework (Wolni & Zeller, 2007; Abebaw & Haile, 2013).The decision to join the platform can be modeled as a binary choice problem assuming that the household wants to maximize its utility subject to resource constraints (Fishcer & Qaim, 2012). The household's decision to join the platform is based on a comparison of utilities; such that the utility from participation (U_i^P) exceeds that of non-membership (U_i^n).Although it is not possible to observe the actual utility that a household derives, it is possible to infer about the utility derived through observing the observable component of the utility function $V_i(\beta X_i)$.Utility is expressed as a function of a vector of exogenous variables and parameters to be estimated and a random error term assumed to be identically and independently distributed with zero mean. It is expressed as follows:

$$U_i = V_i(\beta X_i) + e_i \quad (1)$$

Where:

$U_i = Utility\ of\ household\ i$

$X_i = Vector\ of\ exogenous\ variables$

$\beta = vector\ of\ parametres\ to\ be\ estimated$

$e_i = error\ term$

3.5.3 Empirical model specification

The empirical model provides a basis upon which to assess the impact of the treatment on the outcome variables under consideration. The challenge with this type of impact assessment is twofold. The study essentially is addressing the following question: What would have been the outcome of the individuals had they not received the treatment? The first challenge is that we cannot observe the counterfactual; we can only observe one outcome at a time for the individual-depending on their treatment assignment- but not both simultaneously (Muricho, 2015) .The challenge is summarized in the following equation explaining the ATT (Caliendo & Kopeinig, 2005).

$$\tau_{ATT} = E(\tau|D = 1) = E[Y(1)|D = 1] - E[Y(0)|D = 1]. \quad (2)$$

From the above equation we can only observe the outcome variable for the treated individuals ($E[Y(1)|D = 1]$), but we cannot observe the same outcome variables for the treated individuals had they not been treated $E[Y(0)|D = 1]$.

Given the above situation one might be tempted to simply generate the difference between the average on the outcome variable for the treated and the average of the outcome variable from the untreated. However, given that this is observational data, huge biases would arise if one would simply decide to generate the differences between the treated and untreated group .In an experimental setting -randomized controlled trials- assignment into treatment is random (Garrido et al., 2014). Moreover, before the random assignment, great care is taken in ensuring that individuals in the experiment are similar in all aspects except for the random assignation into treatment and control groups. This ensures that the control group creates a suitable counterfactual that can be qualified as representative. In observational data however, treatment assignment is not random, rather individuals self-select themselves into the treatment regime (Asfaw et al., 2012).

This explains our second problem whereby because of self selection into the regime the characteristics of those in the treatment may be systematically different from those not in the treatment (Asfaw et al., 2012). Consequently, due to self-selection into treatment regime status, simply generating differences will introduce substantial bias into the results. The propensity score has emerged as a suitable antidote in addressing this twofold problem. Essentially the propensity score endeavors to balance the covariates between the treatment and control group, so as to create a suitable counterfactual group that is comparable to the treatment group (Fischer & Qaim, 2012).

Given that many variables determine assignment into treatment and the result of the outcome, it is impossible to match on each of the covariates so as to ensure balance between the treatment and control groups.

The propensity score is a single score summary of the n-dimensional covariate characteristics of an individual (Becker & Ichino, 2002). Individuals with similar propensity scores are then matched across treatment and control groups in order to facilitate the ATT estimation. Formally the propensity score is defined as the probability of an individual being assignment into treatment given pre-treatment characteristics. The following is the corresponding mathematical expression of the propensity score (Shehu & Sidique, 2014):

$$P(X_i) = P\ (D = 1|X_i) = F(X_i) \tag{3}$$

Whereby $P(X_i)$ is a summary of pre-treatment characteristics and $F(X_i)$ is the logistic or cumulative frequency distribution. The ATT equation is expanded below to factor in matching on the propensity score as follows (Fischer & Qaim, 2012):

$$\pi_{ATT}^{PSM} = E_{(P(X)|C=1)}\ \{E\ (Y(1)|C = 1, P(X)] - E(Y(0)|C = 0, P(X)]\} \tag{4}$$

Where:

$\pi_{ATT}^{PSM} = propensity\ estimator\ of\ ATT$

$Y(1) = outcome\ variable\ for\ platform\ members$

$Y(0)| = outcome\ variable\ for\ non - platform\ members$

$C = 1\ treated\ farmers$

$C = 0\ \ control\ group$

$P(X) = propensity\ score$

The above explanaion of the propensity score can now facilitate the next discussion on the methodological steps taken to assess impact. Following Fischer & Quaim (2012), Cavatassi et al., (2009) and Abebaw and Haile (2013) the estimation of the impact of AIP membership for the respective regions was implemented in two stages as follows:

Stage 1: A Logit model on the determinants of platform membership was estimated. It is expressed as follows:

$$P(C_i = 1) = P(u_i < \beta X_i) = \beta X_i + u_i \tag{5}$$

$$C_i = 1 \; when \; U_i^P > U_i^n \quad and \; C_i = 0 \; when \; U_i^n > U_i^p$$

Stage 2: From the Logit model we generated propensity scores (P(X) that enabled the matching of members and non-members with similar characteristics in order to compute the ATT. After matching we proceeded to estimate the ATT effects (see equation 2 for explanation of variables) as follows:

$$\pi_{ATT}^{PSM} = E_{(P(X)|C=1)} \{E \; (Y(1)|C = 1, P(X)] - E(Y(0)|C = 0, P(X)]\} \tag{6}$$

3.5.4 Definition of Variables

Dependent variables: For the second stage estimation –outlined in equation 4- the three dependent outcome variables (yield, fertilizer and seed) were continuous.

Treatment variable**:** The treatment variable was coded as binary i.e. 1 if the household was a member to the AIP and 0 if otherwise.

Independent variables**:** Based on both theoretical and past empirical literature, the independent variables used in this study were grouped into three main categories: socio demographic factors, economic factors, information flow and infrastructural variables.

3.5.4.1 Socio demographic factors

One of the objectives of the platform is to increase the uptake of agricultural technologies. Hence the study inferred from the literature on technology adoption to identify explanatory variables.

Human capital variables such as age were expected to enhance farmers' ability to interpret and internalize information pertaining to technology adoption and therefore also increase the probability of membership (Wollni & Zeller, 2007). Marital status of the household head was included as a factor but no a priori sign was identified to indicate the anticipated direction of influence on AIP membership. A gender variable was included to capture the differential participation between male and female headed households in platforms. It was anticipated that female headed households were less likely to be members given the 'higher opportunity costs of time' and low asset endowment that could potentially constrain their attendance and participation in platform activities (Fischer and Qaim (2012).

3.5.4.2 Economic factors

Capital variables are important variables in technology adoption and by extension determinants of the decision to join AIPs (Fischer & Qaim, 2012). They play an important role in not only helping farmers meet their costs of membership to platforms (Tolno et al.,2012) but also to meet financial obligations involved in investing in agricultural technologies (Alene et al.,2008). Physical capital variables can be divided into land, labor and financial categories. The probability of membership was positively associated with increments in land holdings, due to lower average fixed costs and also because they act as a cushion against risk (Wollni & Zeller, 2007). Labor availability, captured by household size, was expected to be positively associated with membership; because it implied that group members could afford to attend meetings and also implement recommended production techniques that could be significantly labor intensive (Wolni & Zeller,2007). Finally, financial and physical capital variables capturing liquidity- proxied by access to credit, and ownership of cattle- were expected to have a positive effect on membership (Key et al., 2000; Abebaw and Haile, 2013).

3.5.4.3 Information flow, infrastructural and transport variables

Access to extension services and participation in economic networks such as savings credit groups was expected to positively enhance the farmers' likelihood of AIP membership. It was anticipated that through contact with extension agents and these networks, farmers would be exposed to the advantages pertaining to AIP membership (Wollni & Zeller, 2007). Radio ownership was included to capture households' access to information (Degnet & Haile, 2013) on technologies. Distance from the road, captured by distance to the nearest village market, was expected to have a positive curvilinear effect on membership. This is because members located further from the road may find it beneficial to join an AIP in order to benefit from reduced unit costs in accessing information and agricultural technologies. However, beyond a certain threshold, it may be prove too costly for members in extremely remote areas to meet the obligations of platform membership (Fischer & Qaim, 2012; Abebaw and Haile, 2013). Finally, transport variables were proxied by the inclusion of an ox-cart to capture transport costs from the nearest village market (Muricho,2015).

Table 1: Variables definition and Priori expectations (Embu)

Variable	Measurement	Expected Sign
Dependent Variable		
Yield	Total maize production (kg/acre)	n/a
Fertilizer use	Fertilizer use (kg/acre)	n/a
Seed use	Improved maize variety use (kg/acre)	n/a
Treatment Variable		
AIP membership	Binary (1=member; 0=otherwise)	n/a
Independent Variables		
a) Demographic variables		
Marital status	Binary (1=married; 0=otherwise)	Indeterminate
Age of household head	Continuous (Years)	+
b) Economic variables		
Household size	Continuous (Natural logarithm of adult equivalent)	Indeterminate
Landholding	Continuous(Natural logarithm of landholding size in acres)	+
Cattle	Continuous (Natural logarithm of cattle measured in Tropical Livestock Units)	+
Credit	Binary (1=Yes; 0=Otherwise)	+
c) Infrastructure variable		
Road distance	Continuous (Natural logarithm of village market distance measured in walking minutes)	indeterminate
d) Information flow variable		
Training on maize varieties	Binary (1=Yes; 0=Otherwise)	+
Savings credit group	Binary (1=Yes; 0=Otherwise)	+
e) Transport variable		
Oxcart	Binary (1=Yes; 0=Otherwise)	indeterminate

Source: Author's compilation
Note: n/a stands for not applicable

Table 2: Variables definition and Priori expectations (Meru)

Variable	Measurement	Expected Sign
Dependent Variable		
Yield	Total maize production (kg/acre)	n/a
Fertilizer use	Fertilizer use (kg/acre)	n/a
Seed use	Improved maize variety use (kg/acre)	n/a
Treatment Variable		
AIP membership	Binary (1=member; 0=otherwise)	n/a
Independent Variables		
a) Demographic variables		
Gender	Binary (1=Male; 0=otherwise)	Indeterminate
Age of household head	Continuous (Natural logarithm of age of household head in years)	+
b) Economic variables		
Household size	Continuous (Natural logarithm of adult equivalent)	Indeterminate
Landholding	Continuous(Natural logarithm of landholding size in acres)	+
Cattle	Continuous (Natural logarithm of cattle measured in Tropical Livestock Units)	+
Credit to buy fertilizer	Binary (1=Yes; 0=Otherwise)	+
c) Infrastructure variable		
Road distance	Continuous (Natural logarithm of village market distance measured in walking minutes)	indeterminate
d) Information flow variable		
Training on maize varieties	Binary (1=Yes; 0=Otherwise)	+
Savings credit group	Binary (1=Yes; 0=Otherwise)	+
Radio	Binary (1=Yes; 0=Otherwise)	indeterminate

Source: Author's compilation
Note: n/a stands for not applicable

3.6 Diagnostic Tests

The estimation of the ATT as earlier described comprises of two steps: estimation of the propensity score and then matching similar members to non-members in order to estimate the ATT. However, the estimation of the ATT using a logit specification is conditional on the specified logit model achieving the balancing property. There exist a number of parameters upon which to evaluate whether or not the balancing property has been achieved. Caliendo and Kopeinig (2005) give suggestions on a number of methods to assess matching quality among them a comparison of the absolute mean standardized bias before and after matching, two-sample t-test and a comparison of the pseudo-R^2 before and after matching. The three diagnostics tests are further explicated below as follows:

i. **Pseudo-R^2 Comparison** - Concerning the Pseudo-R^2 , Asfaw et al., (2012), note that after matching there should be no systematic differences in the distribution of covariates among the treatment and control group ; hence the Pseudo-R^2 value should be quite low.

ii. **T-Test Comparison**- Regarding the two-sample t-test, after matching there should be no significant differences for each of the covariates between the two groups though Garrido et al., (2014) contend that this alone is not a reliable measure. This is because t-tests are affected by sample size such that even in the presence of huge bias after matching, you may find that the t-test shows that there are no significant differences in covariates between the two groups.

iii. **Mean absolute standardized bias-** The most widely used balancing test is the mean absolute standardized bias (Kassie et al., 2011), although it must be pointed out that there is no hard and fast rule on how much imbalance is to be tolerated. Stuart (2010) points out that after matching the absolute mean standardized bias should be less than 25 % whereas Kassie et al., (2011) insist that the absolute mean standardized bias should be no more than 20 %. Furthermore for individual covariates it is proposed that the mean standardized bias after matching should be less than 10 % (Abebaw & Haile,2013) whereas others propose that it should be less than 5% (Caliendo and Kopeinig (2005); Kassie et al., (2011). Concerning the absolute mean standardized differences it can be concluded from the extensive empirical literature (Abebaw & Haile, 2013; Asfaw et al., 2012; Garrido el., 2014; Kassie et al., (2011); Stuart (2010); Fischer & Qaim (2012)) that an upper bound of the absolute mean standardized bias should be no more than 25 % after matching whereas a more preferable upper bound would constitute less than 20 % after matching. Furthermore, in the case of individual covariates, the mean standardized bias for most covariates should be less than 10 % after matching though a stricter imposition of less than 5 % is considered better.

3.7 Post estimation Test

It is imperative to note that PSM is based on the Conditional Independence Assumption (CIA), which implies that the observer should be able to observe all covariates influencing both the participation decision and the outcome variable. However, PSM does not control for hidden bias whereby unobservable variables can also affect the participation decision and outcome variable. Hence the need for a sensitivity analysis which endeavors to address the concern of hidden bias.

A sensitivity analysis, it must be clarified, does not test if the unobserved variables influence the participation decision and outcome variable; rather it provides threshold bounds upon which we would have justified reason to question the validity of our results in the presence of hidden bias. Becker & Caliendo (2007) summarize the hidden bias problem in the following mathematical expressions.

The probability of participation as stipulated in our discussion in section 3.5.2 is given as follows:

$$P(C_i = 1|X_i, u_i) = \beta X_i + u_i \tag{7}$$

Becker & Caliendo (2007) further expand this equation to include the parameter γ attached to the error term which explains the effect of the unobserved characteristics (u_i) on the participation decision:

$$P(C_i = 1) = P(u_i < \beta X_i) = \beta X_i + \gamma u_i \tag{8}$$

If γ is zero then the decision to participate is determined by X_i, hence in this case there is no hidden bias. Hidden bias would arise if two individuals (i and j) who despite having similar **observable** characteristics make different participation decisions, signaling that γ in this case is not zero hence it has an **effect on the unobservable** characteristics which in turn has led to the difference in participation regimes. The odds ratio of these individuals (i and j) in terms of receiving treatment is expressed as follows:

$$\frac{\exp\ (\beta X_i + \gamma u_i\ )}{\exp\ (\beta X_j + \gamma u_j\ )} \quad (9)$$

If the observed characteristics of the individuals are the same i.e βX_i and βX_j, then they cancel out leaving the resultant expression on the right hand side as follows:

$$\frac{\exp(\beta X_i + \gamma u_i\ )}{\exp(\beta X_j + \gamma u_j\ )} = \exp\ [\gamma(u_i - u_j\ ]) \quad (10)$$

If yet the odds of treatment do not differ either because the unobserved variables u_i and u_j are equal or that γ has no effect on the participation decision the odds ratio is 1 – (as a result of $e^{(\gamma=0)} = 1$) – and hence no hidden bias. If however the odds ratio is not equal to one, $e^{(\gamma)} \neq 1$ then the assumption of no hidden bias is no longer valid.

Hence the goal in sensitivity analysis is to vary the odds ratio away from 1 (which is the absence of bias) in order to see whether the ATT results would still be significant when we factor in different degrees of bias. Such that if the odds ratio is set at say a low level of 1.05 and the results are not significant at that low level of bias then it would imply that we should report the significant results with caution, because they are very sensitive to even small departures of the no hidden bias assumption.

3.8 Ethical considerations

Consent was obtained from authorities in the area who were informed about the survey by area extension officers prior to the official exercise. Moreover, consent from individual households was also sought before administration of the survey. Finally, no interviews were administered to those aged below 18 years.

CHAPTER FOUR: RESULTS AND DISCUSION

4.1 Introduction

The descriptive and econometric results of the PSM model for each of the regions are presented and discussed in this chapter. Section 4.1 presents the descriptive statistics for each of the two regions. Section 4.2 presents the econometric results on the determinants of AIP membership and the ATT results per region. Section 4.3 provides a conclusive overview of the results and discussion section.

** **Important note**: The decision to analyze the ATT results separately per region for the Kyeni AIP as opposed to simply factoring in a geographical variable dummy was informed by the following criteria. Firstly, it was noted that the geographical differences contributed significantly to differences in a major outcome variable such as yield as well as in some covariates; which essentially would amount to a case of comparing 'apples to oranges'. Secondly, the study initially experimented with a dummy regional variable as one of the covariates in the logit specification model; however, this approach was not effective because it was impossible to achieve the **fundamental** balancing property requirement when factoring in a regional dummy variable. It is these reasons that primarily informed a separate analysis per region. Finally, it emerged in hindsight that the separate analysis gave good insight into how contextual differences-in this case geographical location- can differentially influence the determinants of membership and the performance of the AIP.

4.2 Descriptive statistics

4.2.1 Embu region

The summary descriptive statistics for Embu region, disaggregated by treatment regime (AIP members verses non-members) are presented in Table 3. A comparative look of the outcome variables between the two regimes reveals that fertilizer quantity application and yield are significantly higher for members compared to non-members. On average members have higher yields compared to their counterparts, significant at the 5 % level; and also greater fertilizer intensive use compared to their counterparts significant at the 10 % level. While it is observed that members do enjoy higher yields and intensive fertilizer use compared to their non-member counterparts, causality can only be confirmed after a consideration of the econometric results. On the other hand there is no significant difference in seed use between members and non-members.

A comparison of household head characteristics show that AIP members are significantly older compared to their non-member counterparts. On the other hand, household demographic variables such as marital status of the household head and household size show no marked differences between the two groups. Concerning wealth variables such as landholding and cattle, there is a marked difference between the two groups with members possessing larger landholdings and more cattle. Larger landholdings among members could be the factor explaining higher yields among them, whereas, more cattle among members might proxy available liquidity that may facilitate the purchase of more inputs compared to their non-member counterparts.

A look at the informational variable training reveals that AIP members are more likely to receive training on maize varieties compared to non-members, with 60 % of members having received training compared to 39 % of non-members. This is largely attributed to the fact that part of the AIP mandate is to train members on sustainable maize-legume intensification to improve their overall welfare status. Concerning membership to rural institutions, there is a marked significant difference in participation between members and non-members in savings credit groups, with 74 % of members participating compared to 51 % of non-members.

Finally, infrastructural and institutional variables, namely, village market distance and credit respectively show no marked difference between members and non-members. The same applies to the transport variable ox cart, with members and non-members having nearly similar ownership proportions.

Table 3
Descriptive statistics of sample households by AIP membership status (Embu)

Variables	Mean		Difference in means
	Members (27)	Non-members (49)	*p*-Value
Yield	588.042	392.194	0.030
Fertilizer	68.907	55.846	0.071
Seed	5.519	5.300	0.757
Marital status	0.852	0.776	0.424
Household size	1.082	1.043	0.671
Age	4.132	3.937	0.001
Landholding	1.207	0.559	0.001
Cattle	0.800	-0.892	0.014
Village market distance	2.877	2.863	0.931
Training	0.593	0.388	0.086
Credit	0.296	0.449	0.193
Savings credit group	0.741	0.510	0.050
Oxcart	0.259	0.204	0.581

4.2.2 Meru region

The summary descriptive statistics for Meru region, disaggregated by treatment regime (AIP members verses non-members), are presented in Table 4. A comparative look at the variables under consideration reveals that there are no marked significant differences between members and non-members for a majority of the variables. We note for instance that while members report higher yields and seed rates than non-members, this difference is not statistically significant between the two regimes. However, quite interestingly, fertilizer use per acre is higher among non-members compared to members; though this difference is also not statistically significant.

Household demographic variables , namely, age of the household head, household size and gender do not show marked difference between members and non-members. Concerning wealth variables such as landholding and cattle, the descriptive results reveal that on average members have larger landholdings and cattle size than non-members; though this difference is not statistically significant.

Table 4
Descriptive statistics of sample households by AIP membership status (Meru)

Variables	Mean		Difference in means
	Members (15)	Non-members (58)	*p*-Value
Yield	938.556	919.871	0.874
Fertilizer	70.944	78.307	0.314
Seed	6.126	5.315	0.249
Gender	0.333	0.224	0.382
Household size	3.147	2.883	0.362
Age	4.035	3.952	0.287
Landholding	1.967	1.943	0.950
Cattle	-0.826	-0.096	0.391
Village market distance	2.486	2.842	0.387
Training	0.867	0.448	0.004
Credit	0.067	0.034	0.576
Radio	0.933	0.810	0.252
Savings credit group	0.667	0.379	0.046
Mobile phone	1	0.914	0.239

However there are marked significant differences with respect to the institutional variables across the regimes. As observed in the Table 4, 87 % of members have received training on maize varieties compared to only 45 % of non-members, significant at the 1 % level. This statistic is not surprising as well in this region, given that one of the core mandates of the AIP is to educate farmers on CA practices on a periodic basis. Moreover, it is also observed that 67 % of members belong to a savings group compared to only 38 % of non-members, which is significant at the 5 % level. Informational variables, namely, mobile phone and radio show no market difference between the two groups.

4.3 Econometric results

4.3.1 Determinants of membership to Agricultural Innovation Platforms (AIPs)

Following the method outlined in section 3.5.2, the determination of impact of AIPs is undertaken in two stages. The first stage involves the estimation of a logit model in order to predict group membership, whereby the dependant variable is coded as 1 for members and 0 for non-members. The estimation of the logit model will be used to calculate individual propensity scores, which will then be used to estimate the ATT in the second stage. We begin our discussion on the logit results by examining Embu region after which we proceed to Meru region.

4.3.1.1 Determinants of AIP membership: Embu region

The results of the logit model estimation for Embu region are presented in Table 5. Age exhibits a positive significant effect. It is observed that older farmers are more likely to join an AIP due to their experience which is found to be positively correlated with age. This finding is consistent with Fisher and Qaim (2012) who also found that older farmers are more likely to participate in collective action initiatives such as farmer groups compared to their younger counterparts. Landholding also increases the probability of AIP membership. This finding is also consistent with Wollni & Zeller (2007) who postulated that farmers with larger coffee holdings in their study may exhibit more flexibility in crop use as well as have a greater risk-bearing capacity that comes along with the adoption of innovations.

Access to training on maize varieties increases the probability of AIP membership. This finding is consistent with Abebaw and Haile (2013) who also found that access to extension increased the probability of cooperative membership. They note that because agricultural farmers are better informed on these initiatives, they are more likely to inform and introduce farmers to collective action initiatives. Similar to Fisher and Qaim (2012) we note that household size, cattle possession and membership to other economics groups (savings credit) do not have a significant effect on determining AIP membership. Similar to Abebaw and Haile (2013) we note that marital status has no significant effect on determining membership to the AIP.

Table 5

Logit model results of factors determining AIP membership (Embu)

Variable	Odds ratio	Standard error	z-value
Marital status	2.029	1.641	0.87
Household size	1.742	1.487	0.65
Age	20.522	36.437	1.7*
Landholding	2.711	1.268	2.13**
Cattle	1.114	0.145	0.83
Village market distance	1.138	0.526	0.28
Training	2.739	1.680	1.64*
Credit	0.646	0.415	-0.68
Savings credit group	2.235	1.448	1.24
Oxcart	0.522	0.378	-0.9
Constant	0.000	0.000	-2.04**
Pseudo-R2	0.276		
LR chi2 (14)	27.330		
Prob > chi2	0.002		
Observations	76		

* Denotes significance at the 10% level.

** Denotes significance at the 5% level.

*** Denotes significance at the 1% level.

4.3.1.2 Determinants of AIP membership: Meru region

The results of the logit model estimation for Meru region are presented in Table 6. Cattle ownership increases the probability of AIP membership. This is consistent with Abebaw and Haile (2013) who also found a similar result, noting that cattle ownership is a proxy for financial capital. Asfaw et al. (2012) also classified livestock ownership as some of the wealth variables that capture the resources available to a farmer in his farming activity, more so particularly in innovation adoption as Fischer & Qaim (2012) highlighted in their study. Training has a positive effect on the probability of membership which is consistent with our earlier finding in Embu and study findings mentioned previously. Asfaw et al. (2012) explain that regular contact with extension agents enables farmers to be more progressive in adopting technologies. Household demographic characteristics such as age and household size -similar to Wollni and Zeller (2008) and Abebaw & Haile (2013) –do not have a significant effect on membership.

Gender also does not have a significant effect on membership, a finding similar to Fischer & Qaim (2012) who also did not find gender to influence the choice of participation. Similar to Embu region, institutional variables (membership to savings group and access to credit) and informational variables (village market distance and radio) do not play a significant role in determining membership.

Table 6

Logit model results of factors determining AIP membership (Meru)

Variable	Odds ratio	Standard error	z-value
Gender	0.929	0.813	-0.08
Household size	1.358	0.532	0.78
Age	6.639	10.606	1.18
Landholding	1.100	0.351	0.3
Cattle	0.723	0.125	-1.87*
Village market distance	0.908	0.232	-0.38
Training	15.903	17.940	2.45**
Credit	0.680	1.044	-0.25
Radio	3.677	4.818	0.99
Savings credit group	1.973	1.468	0.91
Mobile phone	1	(omitted)	
Constant	0	0.000	-1.89*
Pseudo-R2	0.258		
LR chi2(10)	18.49		
Prob > chi2	0.047		
Observations	68		

* Denotes significance at the 10% level.
** Denotes significance at the 5% level.
*** Denotes significance at the 1% level.

****Important note 2**: The variable mobile phone is included in the logit model specification - despite its omission in the actual estimation above- because it and the above covariates contribute to the achievement of the fundamental balancing property requirement.

4.3.2 Impacts of AIP membership

The methodology to estimate the ATT in each of the regions is summarized in the following steps outlined below:

- Estimation of a logit model to calculate individual propensity scores (members and non-members).

- Establishment of the region of common support -overlap in propensity scores- of members and non-members.
- Dropping of observations that lie outside the region of common support in order to cut-off bad matches.
- Balancing of covariates between members and non-members such that the mean standardized differences are below 25 % between the two groups to control for **observable** bias. In addition for most of the individual covariates the standardized mean difference should be less than 10 %.
- Estimation of the ATT using the two matching algorithms (radius and nearest neighbor) once the above covariate balancing property is satisfied.
- Perform sensitivity analysis on significant outcome variables to address concerns of **hidden** bias.

4.3.2.1 Impacts of AIP membership: Embu region

Following the procedure above, the estimation of the ATT was performed using two matching algorithms: radius matching and nearest five neighbors. Similar to Abebaw & Haile (2013), we used radius matching with a caliper of 0.05. It is important to note that there is no overall consensus on an exact caliper measure given that the suggestion on the caliper imposition used in various studies has ranged from as little as 0.008 (Fischer & Qaim,2012) to even 0.2 and beyond (Wang et al.2013). The main cautionary note however to the researcher is not to impose a “lenient’ caliper that tolerates too many bad matches on one hand, yet on the other hand not to impose an overtly ‘strict’ caliper that unnecessarily drops too many observations (Lunt, 2013) . In the case of this study, following practical experimentation with differing caliper measures, it was observed that a ‘tight’ caliper of 0.008 resulted in the dropping of too many observations whereas a lenient caliper of 0.2 tolerated a number of bad matches. Finally, a caliper of 0.05 similar to Abebaw & Haile (2013) was deemed to be the most effective in achieving the appropriate balance.

The estimated propensity scores generated for the logit model for the whole sample in this region ranged from 0.0098531 to 0.891909 with a mean score of .3552632 (Standard deviation 0.2723131). Members propensity scores ranged from 0.0852833 to 0 .891909 with a mean score of 0.5579069 (Standard Deviation 0.2229776). Non-members propensity scores ranged from

0.0098531 to 0.7963102 with a mean score of 0.2436023 (Standard Deviation 0.2304527).The region of overlap for the distribution of members and non-members is between 0.0098531 and 0.891909, and any observation outside the common support area - as outlined in the steps- are dropped. A visual graph of the final logit specification that satisfied all the steps is presented below in Figure 2 below.

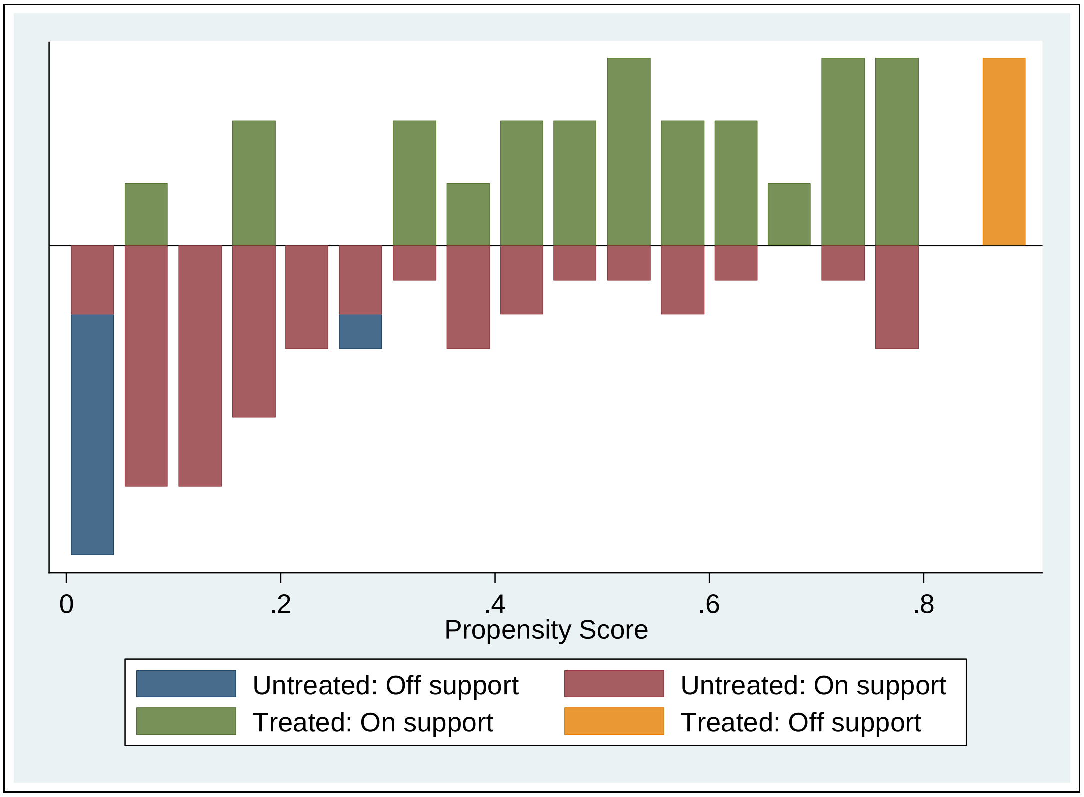

Figure 3: Distribution of propensity scores in Embu region

Source: Author's computations

Once the region of common support has been established, the next step is to ensure that the balancing property is satisfied. In the case of this study, as is the experience in many studies, a seeking process involving hundreds of logit model iterations was performed in order to finally settle on the logit specification that satisfies the balancing property (Dehejia, 2005).

That said, the achievement of the balancing property in itself is a delicate balancing act and still remains debatable especially in the aspect of variable choice .The process of achieving balance may involve re-categorization of variables, logarithmic transformation or the more controversial dropping of variables that impede the achievement of covariate balance (Garrido et al., 2014). Dropping of variables is especially unpalatable if the covariates are considered important from a theoretical perspective. Caliendo and Kopeinig (2005) caution against omitting important variables because this may increase bias in impact estimates. Rubin and Thomas (1996) also caution against omitting variables - especially important ones- in the name of trying to achieve ‘‘parsimony’’. However, they point out that the exclusion of important covariates may be permitted in a situation whereby the sample means between the treatment and control group are not statistically significantly different (for the said covariates) and also that those variables may be highly correlated with other variables included in the final logit specification.

The above discussion on the intricacies of the balancing property in general is an important precursor to our discussion informing the procedure followed and the necessary trade-offs taken in this study so as to satisfy the matching quality criteria. Initially, the original logit specification factored in approximately 20 variables that would be used in the estimation of the propensity score before arriving to a final specification of 10 variables. This decision was informed by previous empirical studies –see chapter 2 - that employed quite a number of variables in their probit / logit specification; though it must be mentioned that there is no hard and fast rule on a specific number of covariates to be included in the model specification .However, it was noted that within the context of our study, the inclusion of numerous variables in the logit specification and propensity score estimation resulted in very high biases after matching. Initially, the attempted to re-categorize a number of variables in addition to performing logarithmic transformations, which to some extent was successful in reducing the mean absolute standardized bias though not to the recommended 25 % threshold. This in turn ultimately necessitated the omission of certain covariates that were contributing to the imbalance as an action of last resort.

The decision to omit certain variables was done with the following criteria in mind. It was important to ensure that each of the categorizations of variables -household head characteristics, infrastructural, institutional, informational and wealth variables -deemed important according to the theoretical literature was represented with at least a relevant variable. For instance, household head characteristics were represented by age and marital status whereas wealth variables were represented by landholding, cattle and household size. Moreover, village market distance represented infrastructure whereas training and membership to savings credit group represented informational and institutional variables respectively. Finally, credit represented access to financial capital and ox-cart represented transport variables. We also carried out t-tests in accordance with Rubin and Thomas (1996) and noted that for a majority of omitted covariates there were no statistically significant differences between the two groups even before matching for the respective regions (See Appendix 3 &4). The balancing tests (based on radius matching) that meet the test of matching quality criteria are presented below in Table 7 and 8. Additionally, the balancing test according to nearest five neighbors matching for Embu, can be seen in Appendix 5.

Table 7

Test of matching quality (Embu)

Variables	Mean		% Bias	% Reduction |bias|	*p*-value
	Members (24)	Non-members (41)			
Marital status	0.83333	0.79065	10.9	44.1	0.712
Household size	1.0658	1.061	1.3	87.4	0.966
Age	61.875	62.55	-5.7	93.1	0.815
Landholding	1.1511	1.1218	4	95.5	0.879
Cattle	0.69402	0.57347	4.5	92.9	0.864
Village market distance	2.8575	2.9152	-8.5	-291.2	0.759
Training maize variety	0.58333	0.59346	-2	95.1	0.945
Credit	0.29167	0.27018	4.4	85.9	0.872
Savings credit	0.70833	0.71202	-0.8	98.4	0.978
Oxcart	0.29167	0.26924	5.2	59.4	0.866

Table 8

Overall summary of Matching quality statistics (Embu)

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.275	27.19	0.002	40	36.4	140.1*	0.50*	20
Matched	0.006	0.41	1	4.7	4.4	18.1	0.92	0

An inspection of Table 7 indicates that the balancing property has been satisified.An examination of the p-value of the equality of means shows that there are no significant differences between members and non-members for each of the covariates after matching. Secondly, for most of the covariates the mean standardized difference between members and non-members is less than 10%. An examination of the B-value in Table 8 reveals that the absolute mean standardized difference (bias) overall is 18.1 after matching compared to 140.1 before matching. Lastly, the Pseudo-R^2 drops significantly from an initial 28 % before matching to less than 1 % after matching. Table 9 presents the ATT estimation for Embu region on the three outcome variables using the two matching algorithms.

Table 9

Estimation of ATT of AIP membership (Embu)

Algorithm	Outcome variables	ATT	Standard error	T-statistic
Nearest 5 neighbors	Seed (kg/acre)	0.593	0.898	0.66
	Fertilizer(kg/acre)	21.015	8.848	2.38**
	Yield(kg/acre)	257.624	112.290	2.29**
Radius (caliper 0.05)	Seed (kg/acre)	0.514	0.917	0.56
	Fertilizer(kg/acre)	20.439	9.755	2.1**
	Yield(kg/acre)	249.015	107.374	2.32**

The results of the ATT estimation reveal that AIP membership has a positive and significant effect on fertilizer quantities used and also on yield. Members on average use 21 kg more fertilizer per acre compared to non-members. This finding is similar to Fischer & Qaim (2012) who also found that members in farmer groups used more inputs (fertilizer and pesticides) compared to non-members. Cavatassi et al. (2009) in their study also found a similar effect on yield, with plataforma members having 33 % more yields compared to non-members.

Finally, we ran a sensitivity analysis to check the robustness of the **statistically significant** results against hidden bias (yield and fertilizer). Table 10 presents the results of the Rosenbaum bounds sensitivity analysis. Given that the ATT results show a positive significant fertilizer impact, we are primarily interested in the (sig+) column to check for the possibility of overestimation of the ATT effect. The critical value of Gamma -upon which we would question the extent to which we can still retain a positive fertilizer conclusion- starts from the τ value of

1.70.This implies that if two individuals who have the same observable variables differ in their odds of receiving treatment by a factor of 70 %, then we would begin to question our positive fertilizer ATT estimate.

Table 10

Sensitivity analysis on fertilizer (Embu)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	0.008198	0.008198	19.6899	19.6899	5.83334	36.0417
1.05	0.010834	0.006118	18.4722	20.5	5.27778	36.6667
1.1	0.01396	0.004566	17.8056	22.2222	4.79167	37.25
1.15	0.017597	0.003409	17.25	23.1969	4.29167	37.9167
1.2	0.021757	0.002546	16.9167	23.875	3.39713	38.8636
1.25	0.026446	0.001901	16.4583	24.6471	2.40523	39.1667
1.3	0.031666	0.00142	15.625	25.1136	2.11356	39.7271
1.35	0.037409	0.001061	15	25.6111	1.5	40.4167
1.4	0.043667	0.000793	14.6401	25.8681	1.11111	40.8333
1.45	0.050426	0.000593	14.2361	26.0417	-0.833331	41.3611
1.5	0.057666	0.000443	13.7292	26.7177	-1.45833	41.5
1.55	0.065369	0.000331	13.4028	27	-2.52778	42.75
1.6	0.073511	0.000248	13.0833	27.2917	-3.08333	44.9583
1.65	0.082069	0.000185	12.4722	27.6854	-3.54167	45.625
1.7	0.091017	0.000139	11.875	28.3333	-3.85286	46.3636
1.75	0.100329	0.000104	9.51389	28.8611	-5.13889	46.8104

Table 11 presents the results of the Rosenbaum bounds sensitivity analysis. The critical value of Gamma (upon which we would question the extent to which we can still retain a positive yield conclusion) starts from the τ value of 2.35.This implies that if the individuals who have the same observable variables differ in their odds of receiving treatment by a factor of 135 %, then we would begin to question our positive yield ATT estimate.

Table11

Sensitivity analysis on yield (Embu)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	0.001783	0.001783	219.616	219.616	105.417	376.25
1.05	0.002473	0.001265	214.232	225	90.4167	381.316
1.1	0.003331	0.000898	209.167	247.264	85.4167	386.389
1.15	0.004375	0.000638	202.5	253.75	78.75	389.625
1.2	0.00562	0.000454	196.7	265	74.1667	395
1.25	0.007078	0.000323	191.25	268.75	71.3889	401
1.3	0.008761	0.00023	186.667	275.45	67.5	405.45
1.35	0.010677	0.000164	185.066	280	65	410.45
1.4	0.012834	0.000117	181.875	284.396	59.1667	417.117
1.45	0.015235	0.000083	178.089	286.7	54.3654	421.7
1.5	0.017884	0.000059	174.616	291.908	47.5	424.167
1.55	0.020781	0.000042	168.75	293.75	45	428.75
1.6	0.023926	0.00003	167.25	295.615	41.3158	438.4
1.65	0.027317	0.000022	160.417	297.917	37.6389	465
1.7	0.03095	0.000015	157.5	298.75	36.25	478.375
1.75	0.034821	0.000011	156.25	306.7	27.9167	494.2
1.8	0.038925	7.80E-06	152.5	313.75	13.75	495.45
1.85	0.043255	5.60E-06	146.25	320.45	10	499.2
1.9	0.047805	4.00E-06	143.115	325.516	2.5	506.25
1.95	0.052566	2.90E-06	135	331.7	-5	506.25
2	0.057532	2.00E-06	125.5	348.125	-19.3846	508.889
2.05	0.062693	1.50E-06	121.25	355.875	-23.9679	516.25
2.1	0.068041	1.00E-06	112.917	367.125	-25.5688	527.5
2.15	0.073568	7.50E-07	111.316	367.917	-28.75	528.4
2.2	0.079264	5.40E-07	106.25	376.25	-30.6346	528.75
2.25	0.085121	3.80E-07	105.417	376.25	-36.1111	533.816
2.3	0.091129	2.80E-07	98.75	380	-36.5	535.45
2.35	0.097281	2.00E-07	97.9167	381.292	-38.9679	540

4.3.2.2 Impacts of AIP membership: Meru region

Following the procedure elaborated on in the previous section the same estimation of the ATT was carried out in Meru region. The estimated propensity scores generated for the logit model for the whole sample in this region ranged from 0.0007858 to 0.8139904 with a mean score of 0.2054795 (Standard deviation 0.2039933). Members propensity scores ranged from 0.100245 to 0.767513 with a mean score of 0.3955943 (Standard Deviation 0.219818). Non-members propensity scores ranged from 0.0007858 to 0.8139904 with a mean score of 0 .1563118 (Standard Deviation 0.1694836).The region of overlap for the distribution of members and non-members is between 0.100245 and 0.767513, and any observation outside the common support area - as outlined in the steps- are dropped. A visual graph of the final iteration that satisfied all the steps is presented in Figure 4. Once the region of common support has been established, the next step is to ensure that the balancing property is satisfied.

The balancing tests on radius matching are presented in Table 12 and 13. An inspection of Table 12 indicates that the balancing property has been satisified.An examination of the p-value of the equality of means shows that there are no significant differences between members and non-members for each of the covariates after matching. Secondly, for most of the covariates the mean standardized difference between members and non-members is less than 10%.An examination of the B-value in Table 13 reveals that the mean standardized difference (bias) overall is 22.5 after matching compared to 138.6 before matching. Lastly, the Pseudo-R^2 drops significantly from an initial 25 % before matching to 1 % after matching. Additionally, the test on matching quality according to nearest five neighbor matching can be seen in Appendix 6.

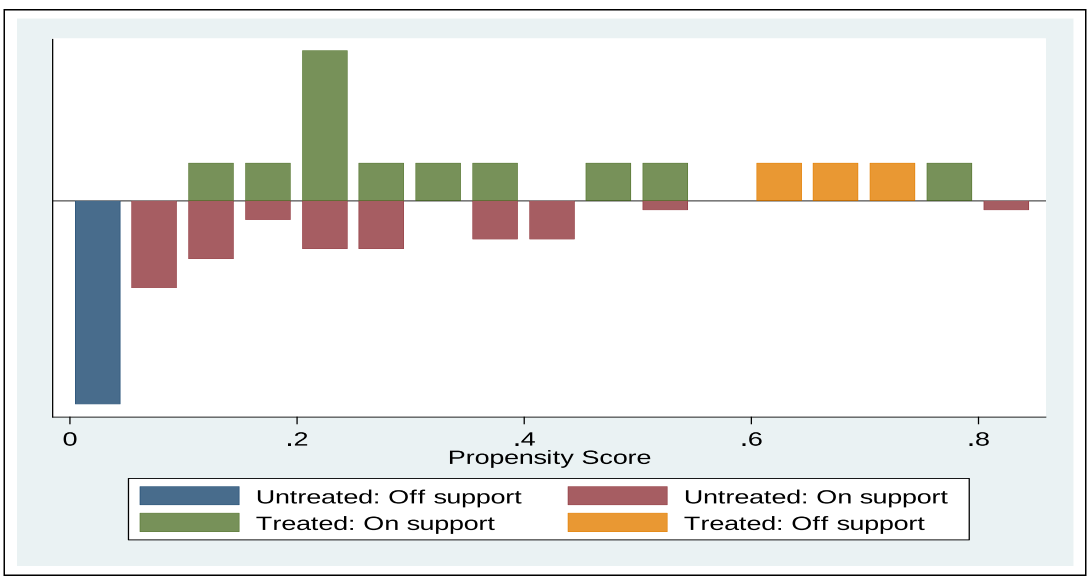

Figure 4: Distribution of propensity scores in Meru region

Source: Author's Computation

Table 12

Test of matching quality (Meru)

Variables	Mean		Bias	% Reduction |bias|	*p*-value
	Members (12)	Non-members(29)			
Gender	0.25	0.24931	0.2	99.4	0.997
Household size	3.0917	3.1332	-4.2	84.2	0.922
Age	4.0474	4.0243	9.1	72	0.823
Landholding	1.875	1.9078	-2.6	-39.2	0.941
Cattle	-0.48527	-0.50802	0.7	96.9	0.985
Village market distance	2.8812	2.7057	10.1	50.8	0.705
Training	0.83333	0.84468	-2.6	97.3	0.943
Credit	0.08333	0.05833	11.2	22.3	0.821
Radio	0.91667	0.90972	2.1	94.4	0.954
Savings credit group	0.58333	0.53819	9.2	84.3	0.833

Table 13

Sample	Ps R2	LR chi2	p>chi2	Mean Bias	MedBias	B	R	%Var
Unmatched	0.256	18.98	0.04	33.6	25.2	138.6*	0.35*	20
Matched	0.01	0.33	1	5.2	3.4	22.5	0.79	0

Table 14 presents the ATT estimation for Meru region on the three outcome variables using the two matching algorithms. The ATT results reveal that AIP membership has a positive and significant effect on adoption of improved seed varieties. Members on average use 1.5 kg more seed per acre compared to non-members. This is similar to Cavatassi et al., (2009) who also found that platform membership had an incremental effect on the use of improved potato varieties on members compared to non-members. However, with respect to fertilizer and yield we find no statistically significant difference between members and non-members.

Table 14

Estimation of ATT of AIP membership (Meru)

Algorithm	Outcome variables	ATT	Standard error	T-statistic
Nearest 5 Neighbors	Seed (kg/acre)	1.457	0.696	2.09**
	Fertilizer(kg/acre)	-1.454	9.061	-0.16
	Yield(kg/acre)	80.721	157.710	0.51
Radius Matching (0.05)	Seed (kg/acre)	1.639	0.671	2.44**
	Fertilizer(kg/acre)	-1.960	8.643	-0.23
	Yield(kg/acre)	17.604	156.123	0.11

Table 15 presents the results of the Rosenbaum bounds sensitivity analysis. The critical value of Gamma (upon which we would question the extent to which we can still retain a positive seed rate conclusion) starts from the τ value of 2.20.This implies that if two individuals who have the same observable variables differ in their odds of receiving treatment by a factor of 120 %, then we would begin to question our positive seed ATT estimate.

Table 15

Sensitivity results of seed (Meru)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	0.009301	0.009301	1.84931	1.84931	0.704118	2.70412
1.05	0.01132	0.007576	1.80677	1.89185	0.613452	2.7599
1.1	0.013545	0.006176	1.69421	1.95396	0.61256	2.87246
1.15	0.015969	0.005039	1.67914	1.97456	0.5	2.95833
1.2	0.018585	0.004115	1.63843	2.0099	0.444215	2.97894
1.25	0.021382	0.003363	1.61783	2.01723	0.423611	2.99954
1.3	0.024352	0.00275	1.61111	2.03035	0.423611	2.99954
1.35	0.027483	0.00225	1.61111	2.03035	0.305326	3.03472
1.4	0.030767	0.001843	1.49306	2.14291	0.277318	3.05533
1.45	0.034192	0.00151	1.37834	2.16667	0.277318	3.05533
1.5	0.037749	0.001237	1.37834	2.16667	0.18727	3.08292
1.55	0.041429	0.001015	1.375	2.18727	0.18727	3.08292
1.6	0.045221	0.000832	1.359	2.21516	0.148792	3.11111
1.65	0.049116	0.000683	1.34301	2.24306	0.148792	3.11111
1.7	0.053107	0.000561	1.28035	2.28472	-0.02544	3.14728
1.75	0.057184	0.000461	1.28035	2.28472	-0.02544	3.14728
1.8	0.06134	0.000379	1.16789	2.30533	-0.25	3.16789
1.85	0.065567	0.000311	1.16789	2.30533	-0.25	3.16789
1.9	0.069859	0.000256	1.16229	2.35336	-0.36157	3.22367
1.95	0.074209	0.000211	1.16229	2.35336	-0.36157	3.22367
2	0.07861	0.000173	1.10881	2.35449	-0.36157	3.22367
2.05	0.083057	0.000143	1.05533	2.35562	-0.36806	3.33623
2.1	0.087544	0.000117	1.05533	2.35562	-0.36806	3.33623
2.15	0.092066	0.000097	0.99954	2.36111	-0.36806	3.33623
2.2	0.096619	0.00008	0.999539	2.36111	-0.58076	3.35774
2.25	0.101198	0.000066	0.999539	2.3849	-0.58076	3.35774

CHAPTER FIVE: CONCLUSIONS AND POLICY IMPLICATIONS

5.1 Introduction to chapter

This chapter presents a summary of the study and policy recommendation based on the findings of the study. The chapter is comprised of three sections: summary and conclusions of the study, policy implications and recommendations, limitations of the study and recommendation of areas for future research.

5.2 Summary and conclusions

The centrality of the maize crop in Kenya's economy cannot be overemphasized enough. Maize is Kenya's main food crop and its availability or lack thereof has far reaching social, political and economic ramifications. Smallholder farmers are responsible for a majority of the country's maize production, contribution to over 70 % of production. However ,over the years and even as recently as 2017, maize production has become rather erratic resulting in deficits that must be supplemented by imports. The problems affecting maize production are multi-dimensional in nature ranging from social, institutional, economic and biophysical challenges just to name a few. The multi-faceted nature of the challenges facing the maize sub-sector necessitate that the innovations introduced to address these problems are multi-pronged as well.

In an effort to address these teething challenges multiple research paradigms have been embraced with limited success due to their affiliation to the unrealistic 'linear model of innovation'. The 'systems approach' was conceptualized in response to the shortcomings of these previous paradigms. The approach is increasingly being regarded as a suitable mechanism through which to address the challenge of declining agricultural productivity in many developing countries. The appeal of this paradigm lies in its acknowledgement that not only is innovation a non-linear process but that it is also a multi-faceted phenomenon necessitating the cooperation of diverse institutional actors. The operalisation of the 'systems approach' in practice is through the setting up of Agricultural Innovation Platforms (AIPs).

The Government of Kenya is increasingly embracing a 'systems based approach'- which has a holistic approach to the process of agricultural innovation- in order to address biting agricultural challenges such as declining maize production. However, in practice the setting up of AIPs in

Kenya as in many other developing countries is yet to take root, despite strong evidence to support their existence in theory. This is further compounded by the fact that there is very scant literature documenting **empirical** impact assessment studies carried out on AIPs in general. Moreover, to our knowledge there is no existing study that has carried an empirical impact assessment on AIPs in Kenya. From a policy perspective, the existence of empirical evidence is important in order to provide a concrete basis upon which to support the rationale to invest in the setting and scaling up of AIPs.

Using cross-sectional data, this study builds on past literature in the area of Agricultural Innovation Platforms (AIPs) by investigating the impact of these platforms on maize smallholders' access to improved technologies (seed and fertilizer) and yield. The study employed Propensity Score Matching (PSM) to assess the determinants of AIP membership and also to estimate Average Treatment Effects on the Treated (ATT). The assessment of determinants of AIP membership and measurement of ATT was preceded by three diagnostic processes to ensure adherence to the balancing property. Firstly, p-tests conducted for both Meru and Embu region showed no statistically significant differences in covariates between members and non-members after matching. Secondly, the Pseudo-R^2 values for both regions were quite low after matching standing at 0.006 and 0.01 for Embu and Meru respectively. Finally, a comparison of absolute mean standardized differences after matching for each of the regions ensured that they adhered to the recommended less than 25 % level.

Concerning the determinants of AIP membership, it is noted that landholding was a key policy asset variable influencing participation in Embu. The probability of membership tended to increase among households with larger landholdings. Age of the household head also had a positive significant effect on membership, with older farmers more likely to participate in platforms. The key policy asset variable determining participation in the platform in Meru region was cattle, such that participation probability tended to increase among households with larger cattle ownership. A common variable determining membership in both areas was access to training on maize varieties which had a positive significant effect on the probability of membership.

The results from the ATT estimation revealed that AIP membership had a positive statistically significant effect on fertilizer quantity use and yield among its members in Embu, whereas in Meru AIP membership had a positive statistically significant effect on seed use quantity among members. In Embu, members on average used 21 kg more fertilizer per acre compared to non-members and also their yields per acre exceeded that of non-members on average by slightly over 250kg. In Meru region, ATT results shows that Agricultural Innovation Platforms (AIP) membership had a positive and significant effect on adoption of improved seed varieties with members on average using approximately 1.5 kg more seed per acre compared to non-members.

Sensitivity results were conducted on statistically significant outcome variables. In Embu region, sensitivity results on the yield estimate revealed that the critical value of Gamma began from the τ value of 1.70.This implies that if two individuals who have the same observable variables differ in their odds of receiving treatment by a factor of 70 %, then we would begin to question our positive yield ATT estimate. Concerning fertilizer, the critical value of Gamma began from the τ value of 2.35. This implies that if the two individuals who have the same observable variables differ in their odds of receiving treatment by a factor of 135 %, then we would begin to question our positive yield ATT estimate. In Meru, with respect to seed, the critical value of Gamma began from the τ value of 2.20.This implies that if the two individuals who have the same observable variables differ in their odds of receiving treatment by a factor of 120 %, then we would begin to question our positive seed ATT estimate.

5.3 Policy Implications and Recommendations

The overall findings of this study do indicate that Agricultural Innovation Platforms can have an important contribution in increasing technology uptake among member households as well as increasing overall maize productivity. This is significant from a policy objective given that the country urgently requires proven interventions that can address the glaring deficit. While from a policy perspective the country has made reference to a holistic approach as echoed in its National Agricultural Research Policy document; it does not specifically make reference to how this holistic approach will be operationalized. In addition, current policy documents make mention to the importance of institutional linkages but lack specific modalities of how this is implemented in practice. Given that Agricultural Innovation Platforms greatly echo this holistic approach, policy interventions would do well to explicitly identify AIPs as one of the important pathways to addressing the challenges in the maize sub-sector. This formal recognition in turn will also help in supporting budgetary allocations towards the setting up of AIPs where deemed necessary and scaling up of already existing set-ups.

It is also important to take cognizance of the fact that policy asset variables do play an important role in influencing households' decisions to join AIPs. The particular asset variables were landholding and cattle which do point to the importance of wealth in the participation decision. Given that extensive land cultivation is no longer feasible due to declining land/labour ratios, other interventions may be necessary to deter more land subdivision. Furthermore, the importance of economic growth within the devolutionary context cannot be overemphasized enough as an important factor in enhancing economic growth in the grassroots. Social development should be a serious priority for county policy makers involved in strategizing county growth; because it is a contributing factor in facilitating an equitable distribution of resources and also in ensuring that a greater number of households expand their asset base.

The findings of this study also reveal the important role that extension network has an important role in both mobilizing farmers to participate in AIPs and also by extension introducing them to new technologies and practices that result in incremental yields. Often times the extension system has come under heavy criticism for what some feel is ineffectiveness leading to advocacy on the overall disbandment of the system. However, it appears from a policy perspective, that the system can be very effective when given more support as well as when integrated in an AIP as opposed to being a stand alone unit. Policy interventions should also be geared towards ensuring consistency in budgetary allocation to support the extension system support its role within the AIP framework. This is especially relevant within the devolution context whereby at the grassroots level devolved public units sometimes must contend with delays in disbursements that delay or curtail intended development activities.

5.4 Limitations of this study

This study acknowledges that its empirical findings cannot be generalized to be applicable to all contexts because the sample was not representative of the wider context. Furthermore, this study also acknowledges that it did not include all the hypothesized variables in the PSM estimation due to limits imposed by the balancing property. Failure to incorporate all the covariates was attributed to the small sample from which the availability of suitable matches to match all the proposed covariates was constrained.

5.5 Proposed areas of further research

Areas for future research would include investigating impact heterogeneity among member households particularly across wealth and gender stratifications. Moreover, future research could further delve on the impact of AIP membership in facilitating greater commercialization among participating households.

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APPENDICES

Appendix 1: Embu Sample

	Household category	Location	Sub-location	Village
1	Intermediary	Kyeni East	Kigumo	Ngurukiri
2	Intermediary	Kyeni East	Kigumo	Kavata
3	Intermediary	Kyeni East	Kigumo	Kirigi
4	Intermediary	Kyeni East	Kigumo	Kigumo
5	Intermediary	Kyeni East	Kigumo	Gititu
6	Intermediary	Kyeni East	Mukuria	Magaca
7	Intermediary	Kyeni Central	Kathanjuri	Karungu
8	Intermediary	Kyeni Central	Kathanjuri	Kathera
9	Intermediary	Kyeni Central	Nyagari	Nyagari
10	Intermediary	Kyeni Central	Nyagari	Mukuuri
11	Intermediary	Kyeni Central	Kathanjuri	Gacangori
12	Intermediary	Kyeni Central	Nyagari	Mumburi
13	Intermediary	Kyeni Central	Kathanjuri	Kimango
14	Intermediary	Kyeni Central	Kathanjuri	Kathanjuri
15	Intermediary	Kyeni Central	Kathanjuri	Kathure
16	Intermediary	Kyeni Central	Kathanjuri	Kathera
17	Intermediary	Kyeni Central	Kathanjuri	Kathera
18	Intermediary	Kyeni Central	Kathanjuri	Kathariro
19	Intermediary	Kyeni Central	Kathanjuri	Ndagakira
20	Intermediary	Kyeni South	Kathunguri	Kathunguri
21	Intermediary	Kyeni South	Kathunguri	Kiamboa
22	Intermediary	Kyeni South	Kathunguri	Kiamururi
23	Intermediary	Kyeni South	Kathunguri	Kamburi
24	Intermediary	Kyeni South	Kathunguri	Kiamururi
25	Intermediary	Kyeni South	Kathuguri	Kathunguri
26	Member	Kyeni East	Kigumo	Kigumo
27	Member	Kyeni East	Kigumo	Kirigi
28	Member	Kyeni East	Kigumo	Kavata
29	Member	Kyeni East	Kigumo	Gichugu
30	Member	Kyeni East	Mukuria	Magaca
31	Member	Kyeni Central	Nyagari	Nyagari
32	Member	Kyeni Central	Kathanjuri	Kathariro
33	Member	Kyeni Central	Kathanjuri	Gacangori
34	Member	Kyeni Central	Nyagari	Mukuuri
35	Member	Kyeni Central	Nyagari	Mumburi
36	Member	Kyeni Central	Kathanjuri	Kimangu

37	Member	Kyeni Central	Nyagari	Gatitika
38	Member	Kyeni Central	Kathanjuri	Karungu
39	Member	Kyeni Central	Kathunguri	Rwarari
40	Member	Kyeni Central	Kathanjuri	Kathera
41	Member	Kyeni Central	Kathanjuri	Kathera
42	Member	Kyeni Central	Kathanjuri	Kathera
43	Member	Kyeni Central	Kathanjuri	Ndagakira
44	Member	Kyeni South	Kathunguri	Kathunguri
45	Member	Kyeni South	Kathunguri	Kiamururi
46	Member	Kyeni South	Kigumo	Gititu
47	Member	Kyeni South	Kathunguri	Kathunguri
48	Member	Kyeni South	Kathunguri	Kiamururi
49	Member	Kyeni South	Kathunguri	Kathunguri
50	Member	Kyeni South	Karurumo	Ngambari
51	Member	Kyeni South	Karurumo	Kanjau
52	Member	Kyeni South	Kariru	Kaveti
53	Non-member	Kyeni East	Mukuria	Kirigi
54	Non-member	Kyeni East	Mukuria	Magaca
55	Non-member	Kyeni East	Kigumo	Gititu
56	Non-member	Kyeni East	Kigumo	Ikura
57	Non-member	Kyeni East	Kigumo	Njuri
58	Non-member	Kyeni East	Kigumo	Kirigi
59	Non-member	Kyeni East	Kigumo	Kigumo
60	Non-member	Kyeni Central	Nyagari	Kathigari
61	Non-member	Kyeni Central	Kathanjuri	Ndekere
62	Non-member	Kyeni Central	Nyagari	Mukuuri
63	Non-member	Kyeni Central	Nyagari	Kathigari
64	Non-member	Kyeni Central	Nyagari	Thau
65	Non-member	Kyeni Central	Nyagari	Kinthithe
66	Non-member	Kyeni Central	Kathanjuri	Ndagakira
67	Non-member	Kyeni Central	Kathanjuri	Kathariro
68	Non-member	Kyeni Central	Kathanjuri	Kathera
69	Non-member	Kyeni South	Karurumo	Kamavindi
70	Non-member	Kyeni South	Karurumo	Kararari
71	Non-member	Kyeni South	Karurumo	Kararari
72	Non-member	Kyeni South	Karurumo	Kararari
73	Non-member	Kyeni South	Karurumo	Murari
74	Non-member	Kyeni South	Karurumo	Karurumo
75	Non-member	Kyeni South	Karurumo	Kamitaa
76	Non-member	Kyeni South	Karurumo	Karurumo

Appendix 2: Meru Sample

	Household category	Location	Sub-location	Village
1	Intermediary	Gikui	Kinoru	Kithakua
2	Intermediary	Gikui	Kinoru	Ntakani
3	Intermediary	Gikui	Gikui	Giica
4	Intermediary	Gikui	Gikui	Ndariene
5	Intermediary	Gikui	Kinoru	Ntue
6	Intermediary	Kiathathi	Kiathathi	Gikurune
7	Intermediary	Kiathathi	Kiathathi	Geeto
8	Intermediary	Kiathathi	Kiathathi	Geeto
9	Intermediary	Kiathathi	Kiathathi	Kithakwa
10	Intermediary	Kiathathi	Kiathathi	Gikuruni
11	Intermediary	Kiathathi	Kiathathi	Geeto
12	Intermediary	Kiathathi	Kiathathi	Kireru
13	Intermediary	Kiathathi	Kiathathi	Kireru
14	Intermediary	Kiathathi	Kiathathi	Gikurune
15	Intermediary	Kiathathi	Gikurune	Kirua
16	Intermediary	Kiathathi	Kiathathi	Kireru
17	Intermediary	Kiathathi	Kiathatho	Kireru
18	Intermediary	Kiathathi	Kiathathi	Kirua
19	Intermediary	Kiathathi	Kiathathi	Gikurune
20	Intermediary	Kiathathi	Kiathathi	Gikurune
21	Intermediary	Kiathathi	Kiathathi	Kirua
22	Intermediary	Kiathathi	Kiathathi	Ikeu
23	Intermediary	Kiathathi	Kiathathi	Gikurune
24	Intermediary	Kiathathi	Kiathathi	Geeto
25	Member	Gikui	Ndariene	Geeto
26	Member	Gikui	Kinoru	Kienikiandege
27	Member	Gikui	Kinoru	Ndariene
28	Member	Gikui	Kinoru	Ntue
29	Member	Gikui	Kinoru	Kithakua
30	Member	Kiathathi	Kiathathi	Geeto
31	Member	Kiathathi	Kiathathi	Geeto
32	Member	Kiathathi	Kiathathi	Geeto
33	Member	Kiathathi	Kiathathi	geeto
34	Member	Kiathathi	Kiathathi	Geeto
35	Member	Kiathathi	Kiathathi	Geto
36	Member	Kiathathi	Kiathathi	Gikurune
37	Member	Kiathathi	Kiathathi	Gikurune

38	Member	Kiathathi	Kiathathi	Itindija
39	Member	Kiathathi	Kiathathi	Kithakwa
40	Member	Kiathathi	Kiathathi	Ndariene
41	Member	Kiathathi	Kiathathi	Ngongoti
42	Non-member	Gikui	Kinoru	Geeto
43	Non-member	Gikui	Kinoru	Kinoru
44	Non-member	Gikui	Kinoru	Mbirone
45	Non-member	Gikui	Kinoru	Ntakene
46	Non-member	Gikui	Kinoru	Kaguanyi
47	Non-member	Gikui	Kinoru	Mukuu
48	Non-member	Gikui	Gikui	Njerune
49	Non-member	Gikui	Gikui	Njerune
50	Non-member	Gikui	Gikui	Njerune
51	Non-member	Gikui	Gikui	Njerune
52	Non-member	Gikui	Gikui	Njerune
53	Non-member	Gikui	Gikui	Njerune
54	Non-member	Gikui	Gikui	Njerune
55	Non-member	Miruriiri	Kathigu	Nkuene
56	Non-member	Kianjogu	Kianjogu	Baine
57	Non-member	Kiathathi	Kiathathi	Kirigune
58	Non-member	Kiathathi	Kiathathi	Ikeu
59	Non-member	Kiathathi	Kiathathi	Kirigune
60	Non-member	Kiathathi	Gikurune	Kirua
61	Non-member	Kiathathi	Kiathathi	Kireru
62	Non-member	Kiathathi	Kiathathi	Gikurune
63	Non-member	Kiathathi	Kiathathi	Ikeu
64	Non-member	Miruriiri	Kathigu	Nkuene
65	Non-member	Miruriiri	Kathigu	Karin gene
66	Non-member	Miruriiri	Kathigu	Gakirene
67	Non-member	Miruriiri	Kathigu	Kaguma
68	Non-member	Miruriiri	Kathigu	Itumbi
69	Non-member	Mweru	Mweru	Muringo wamuthigo
70	Non-member	Mweru	Mweru	Machegene
71	Non-member	Mweru	Mweru	Muringo muthigo
72	Non-member	Mweru	Mweru	Kithangene
73	Non-member	Mweru	Mweru	Machegene
74	Non-member	Mweru	Mweru	Giitine
75	Non-member	Mweru	Mweru	Mpuinjeru
76	Non-member	Mweru	Mweru	Giitine

Appendix 3: Extended list of descriptive statistics of sample households by AIP membership status (Embu)

Variables	Mean		Difference in means
	Members (27)	Non-members (49)	*p*-Value
Yield	588.042	392.194	0.030
Fertilizer	68.907	55.846	0.071
Seed	5.519	5.300	0.757
Age	62.963	53.204	0.002
Age Squared	4043.111	3028.551	0.004
Education	9.593	8.673	0.302
Gender	0.111	0.224	0.228
Landholding	4.065	2.367	0.002
Landholding squared	22.688	9.878	0.015
Household size	3.107	3.043	0.811
Credit	0.296	0.449	0.193
Farming main occupation	0.852	0.735	0.241
Non-farm income	0.741	0.857	0.210
Nearest motorable road	5.185	5.082	0.858
Nearest motorable road squared	31.556	32.020	0.949
Distance of extension office	46.467	45.517	0.914
Training on maize variety	0.867	0.448	0.004
Total livestock unit	9.274	3.959	0.008
cattle size	5.333	3.163	0.014
Non-cattle total livestock units	6.711	2.465	0.019
Savings credit group	0.741	0.510	0.050
Radio	0.963	0.918	0.453
Mobile phone	0.963	0.980	0.665

Appendix 4 :Extended list of descriptive statistics of sample households by AIP membership status (Meru)

Variables	Mean		Difference in means
	Members (15)	Non-members (58)	*p*-Value
Yield	938.556	919.871	0.874
Fertilizer	70.944	78.307	0.314
Seed	6.126	5.315	0.249
Age	57.933	53.914	0.323
Age Squared	3509.533	3104.810	0.375
Education	11.067	9.534	0.152
Gender	0.333	0.224	0.389
Landholding	1.967	1.943	0.950
Landholding squared	5.150	5.525	0.855
Credit	0.333	0.155	0.122
Farming main occupation	0.800	0.672	0.337
Non-farm income	1.000	0.621	0.004
Nearest motorable road	3.000	3.707	0.170
Nearest motorable road squared	11.533	16.879	0.179
Distance of extension office	46.467	45.517	0.914
Training on maize variety	0.867	0.448	0.004
Total livestock unit	4.380	4.086	0.754
Cattle size	3.800	4.207	0.722
Non-cattle total livestock units	2.407	2.048	0.457
Savings credit group	0.667	0.379	0.046
Radio	0.933	0.810	0.252
Mobile phone	1.000	0.914	0.239

Appendix 5 (nearest five neighbors - Embu)

Test of matching quality

Variables	Mean		% Bias	*p*-value for equality of means
	Members (24)	Non-members (45)		
Marital status	0.833	0.797	9.4	0.749
Household size	1.066	1.082	-4.5	0.89
Age	4.115	4.107	3.3	0.874
Landholding	1.151	1.126	3.4	0.898
Cattle	0.694	0.541	5.6	0.829
Village market distance	2.858	2.911	-7.8	0.788
Training	0.583	0.624	-8.1	0.781
Credit	0.292	0.292	-0.1	0.996
Savings credit group	0.708	0.733	-5.2	0.851
Oxcart	0.292	0.292	-0.2	0.996
Ps R2	0.006			
LR chi2	0.41			
p>chi2	1			
Mean Bias	4.8			
Median Bias	4.9			
B	18.3			
R	1.33			
%Var	0			

Appendix 6 :nearest five neighbors - Meru

Test of matching quality

Variables	Mean		Bias	*p*-value for equality of means
	Members (12)	Non-members(29)		
Gender	0.25	0.292	-9.1	0.828
Household size	3.092	3.220	-12.8	0.752
Age	4.047	4.040	3.1	0.94
Landholding	1.875	1.962	-6.9	0.839
Cattle	-0.485	-0.222	-8.7	0.831
Village market distance	2.881	2.836	2.6	0.917
Training	0.833	0.850	-3.8	0.916
Credit	0.083	0.050	14.9	0.756
Radio	0.917	0.933	-5	0.883
Savings credit group	0.583	0.567	3.4	0.938
Mobile phone	1	1	0	.
Ps R2	0.011			
LR chi2	0.36			
p>chi2	1			
MeanBias	6.4			
Median Bias	5			
B	23.6			
R	1.43			
%Var	0			

Appendix 7.Survey questionnaire

THE IMPACT OF AGRICULTURAL INNOVATION PLATFORMS ON ENHANCINGADOPTION OF IMPROVED TECHNOLOGIES AMONG MAIZE SMALLHOLDERS IN KENYA

COLLEDGE OF HUMANITIES AND SOCIAL SCIENCES

SCHOOL OF ECONOMICS

THE UNIVERSITY OF NAIROBI

Introduction and Consent to Participate in the Research

Hello,

My name is-----. The University of Nairobi in partnership with the International Maize and Wheat Improvement Centre (CIMMYT) is carrying out a survey in this area to the role of agricultural innovation platforms in enhancing adoption of improved technologies among maize smallholders in Kenya. You have been selected to participate because you are living in a target area. Participation in this study is voluntary. You have the right to refuse to participate in this study; if you refuse or stop your participation at any time, there will be no consequences. If you agree to participate in this research it will take approximately two hours of your time. Feel free to let me know what you are uncomfortable to answer and also note that all information solicited from you, your household or your associates will be kept strictly confidential. We shall not in any way disclose you, your household or your associates personally in resultant documents, or data sharing processes.

MODULE 1: HOUSEHOLD AND VILLAGE IDENTIFICATION

1. Questionnaire code :					
2. Interviewer		Name		Phone Number	
3.Respondent		Name		Phone number	
4.Sex					
7. Location					
8. Sub location					
9.Village					
10. Date of interview		Time: Start		End of interview	

MODULE 2: HOUSEHOLD COMPOSITION AND CHARACTERISTICS

Household member Name	Gender 1= M 0=F	Age (Complete Years)	Relationship to the household head? (Code 1)	Marital Status (Code 2)	Education (Years) (Code 3)	Primary Occupation (Code 4)	How many months in the past year were they present in the household?	Labor To Farms Cultivated By Household In 2015/201 (Code 5)
01								
02								
03								
04								
05								
06								
07								
08								
09								
10								
11								
12								

CODE 1	CODE 2	CODE 3	CODE 4	CODE 5
1.Head 2.Spouse 3.Son/Daughter 4.Parent 5.Son/daughter –in law 6.Grandson/granddaughter 7.Other relative 8.Hired worker 9.Other,speicify	1.Married living with spouse 2.Married living without spouse 3.Divorced/separated 4.Widow/widower 5.Never Married	0.None/illiterate 100.Religiouseducation 1.Adult education or 1 year of education *Other education in years	1.Farming (crop +livestock 2.Salaried employment 3.Self-employed off-farm 4.Casual labourer on-farm 5.Casual labourer off-farm 6.School/college child 7.Non-school child 8.Other, specify…	1.Full time 2.Part time 3.Not a worker

MODULE 3: CROP PRODUCTION FOR CROPS GROWN BY HOUSEHOLD DURING 2015/2016 CROPPING SEASON

PART A: (CROPS, VARIETIES, CROPPING AREA AND INPUT USE)

Total owned farm size………. Acres   Total rented in land 2014/15………….. Acres

Plot ID	Sub-plot id	Plot name	Sub-plot area in acres	Season (code1)	Intercropping on plot 0=No 1=Yes	Main crops grown on [sub-plot]*[1] ANNEX 1	Varieties grown in sub plot *2 ANNEX 2	Herbicide Quantity (Kg/liter)	Pesticide Quantity (kg/liter)	Fertilizer Quantity (Urea) (kg)	Fertilizer Quantity (DAP) (kg)

Code 1
1.Long rains (March April 2016) 2.Short rains (Sept/October 2015)

PART B: (SEED USE & CROPS HARVESTED)

Plot ID	Sub-plot id	Plot name	Season (code1)	Seed use			Total harvested per sub-plot as per previous order	
				Quantity of non-bought seed(kg) (own saved, gift etc)	Bought seed including using credit	Main source of seed (Code 2)	Fresh or green(kg) (dry equivalent)	Dry (kg)
A1	A2	A3	A4					

Code 2	
1.Own saved 2.AIP 3.Government extension 4.Trader 5.Private seed supplier	6.Gift from family/neigh 7.Farmer to farmer 8.Farmer group/coop 9.Ngo 10.Reserah centre

PART C :Labor required for each agricultural operation(children =below 14 year,men & women =14 years and above)

Task per crop		**Month(s)**	**Labour (no. people × no. of days)**					**Draft power (no. animals x no of days)**		**Machine (no. machine × no. of days)**	
			HH Men	**Hired Men**	**HH Women**	**Hired Women**	**HH Children**	**HH owned**	**Hired in**	**HH owned**	**Hired in**
CROP 1.											
Land preparation	1st										
	2nd										
	3rd										
Planting											
Fertiliser application	1st										
	2nd										
Weeding	1st										
	2nd										
	3rd										
Herbicide	1st										
	2nd										
Pesticide	1st										
	2nd										
Harvesting											
Threshing											
Milling											

MODULE 4: INCOME SOURCES

(Part 1: Sale of agricultural produce)

Crop(Annex code)	**Season** **Long rains(2016** **Short rains (Oct 2015)**	**Market sold**(CODE1)	**Quantity sold (kg)(CODE 2)**	**Price sold(Ksh/kg)**	**Main buyer** (CODE 2)	**Sales/tax**	**Transport cost(to &fro)**

CODE 1 1.Farm Gate 2.Village Market 3.Main/district market	CODE 2 1.Farmer group 2.Farmer cooperative 3.Consumer 4.Middleman 5.Grain trader	6.Rural assembler 7.Rural grain trader 8.Rural wholesaler 9.Urban wholesaler 10.Urban grain trader

Part 2: Other Income sources

Income source	Did household earn (0=No,1=Yes)	Who earned income? CODE 1			Total income for the past 12 months		
					Cash(KSH)	In-kind	total
1.salaried							
2.Machinery							
3.Casula labour (on –farm)							
4.casual labor (off-farm)							
5.Non agric business e.g. shop							
6.Non-farm agric business(grain milling)							
7.Selling charcoal, brick making							
8.Pensions							
9.Remittances							
10.Leasing/renting out land							
11.Other sources(specify)							
12.Other source(specify)							
13.Other source (specify)							

CODE 1	
1.Self 2.Spouse 3.Self and Spouse jointly 4.Other household member	5.Self and other household member(s) 6.Spouse and other household member(s) 7.Self,spouse and other household members

MODULE 5: ASSETS (Part A: HOUSEHOLD ASSETS)

	Asset type	Does household own (1=yes, 0=No)	No owned.	Current value If it were to sold today (ksh)		Asset type	Does household Own (1=yes, 0=No)	No Owned.	Current value If it were to sold today (ksh)
1	Charcoal/wood stove					7.Phone			
2	Kerosene stove					8.TV			
3	Water carrier					9.Watch			
4	Fridge					10.Jewellery			
5	Tables, sofas, chairs, beds					11.House			
6	Radio					12.Land			

Part B: FARM &TRANSPORT EQUIPEMENT

Asset Type	Does household own (1=yes, 0=No)	No Owned	Current value If it were to sold today (Ksh)	Asset type	Does household Own(1=yes, 0=No)	No Owned.	Current value If it were to sold today (Ksh)
1.Sickle				9.Horse/mule cart			
2.Hoe				10.Donkey/ox cart			
3.spade				11.Push cart			
4.Axe				12.Bicycle			
5.Knapsack sprayer				13.Motorbike			
6.Water Pump(Motorized				14.Horse/mule saddle			
7.Water Pump(Manual)				15.Car			
8.Tractor				16.Ox-Plough			

Part C: LIVESTOCK

	Animal Type	Does the household Own (1=yes 0=no	No owned	Value of Each (Ksh)		Animal Type	Does the household Own (1=yes 0=no	No owned	Value of Each (Ksh)
1.	Indigenous cows				8	Pig			
2	Cross bred/exotic				9	Donkeys			
3	Oxen				10	Horse			
4	Bulls				11	Mule			
5	Heifers				12	Poultry			
6	Calves				13	Bee hives with colony			
7	Small livestock								

Module 6: SOCIAL CAPITAL AND NETWORKS PART 1 :(PARTICIPATION IN RURAL INSTITUTIONS)

Variable code	Institution Type	Membership to the following group? (0=No; 1=Yes)	Year joined	How much input in decision making?(CODE 1)	Frequency of attendance? (annually	**CODE 1** 1.No input 2.Input into very few decisions 3.Input into some decisions 4.Input into most decisions 5Input into all decisions
1.	AIP					
2.	Savings and credit					
3.	Merry-go-round					
4.	Crop/seed production					
5.	Water User's Association					
6.	Crop marketing					
7.	Women's group					
8.	Youth Association					
9.	Church/Mosque					
10.	Development group					
11.	Input supply group					

PART 2: INFASTRUCTURE

	Location	**Distance in walking minutes from point of residence**
1.	Village Market	
2.	Nearest main market	
3.	Nearest motorable road	
4.	Nearest source of seed dealer	
5.	Nearest source of fertilizer	
6.	Nearest source of herbicide and pesticide dealer	
7.	Nearest health centre	
8.	Nearest agricultural extension office	
9.	AIP meetings	
10.	Main water source for drinking	

PART 7: ACCESS TO CAPITAL AND INFORMATION

PART A: Credit

Reason for Loan	Did you need credit 0=No,1=Yes	If Yes, did you receive? (1=Yes,0=No)	If yes, what was the source (Code 1)	What was the amount received?	Code 1 1.Money Lender 2.Farmer group/coop 3.Merry go round 4.Microfinance 5.Bank 6.Relative 7. Other specify………
1.Buying seeds					
2.Buying fertilizer					
3.Buying herbicide					
4.Buyin g pesticide					
5.Invest in transport					
6.Buy livestock					
7.Invest in irrigation					
8.Non-farm business					
9.Pay rent					
10.Buy food					
11.Non-food consumption needs					

Part B: Access to extension services

Issue	Did you need extension Advice on the following? (1=Yes;0=No)	If No, Why did you Not need it? CODE 1	Did your household receive training during 2015/2016 cropping season?	If yes, how many contacts/training visits did you receive?	What was the main source of information? CODE 2
1.New Maize variety					
2.New legume variety					
3.Soil erosion					
4.Weed control					
5.Input markets and prices					
6.Family health					
7.Crop rotation					
8.Intercropping					
9,Minimum tillage					
10.Leaving crop residue in field					

CODE 1	CODE 2		
1.Had enough information 2.Not aware of the issue 3. Other specify……	1.Government extension service 2.Spouse/ household members 3.Farmer group/coops 4.Other farmers 5.Lead farmers	6.Seed traders 7Ngo 8.Other private trader 9.Research centre 10.Farmer training centre/school	11.Radio 12.Newspaper 13.Mobile phone

Time finished……………………………….

THANKYOU FOR YOUR TIME AND PATIENCE!